

Tabla 4.3 Proyectos Prioritarios de Micro Centrales Hidroeléctricas en La Paz y Oruro (Plan 2002 - 2011)

La Paz

Priority Ranking No.	Proposed Implementation Schedule (Time of Year)	Name of Project	Province	Canton	MHP						Annualized Investment + O&M Cost per kWh (US\$/kWh)	Study Conducted by	Stage of Project
					No. of Benef. Families by MHP	Installed Capacity (kW)	Investment Cost (MHP) (US\$)	1kW Cost (MHP) (US\$/kW)	Annual Energy (kWh/Year)	Annualized Investment + O&M Cost per kWh (US\$/kWh)			
1	2002 - 2006	Apolo (Rio Machariques) Phase - I	F. Tamayo	Apolo, Santa Cruz del Valle Amaro & Alas	1,000	350	2,000,000	5,714	970,900	0.28	JICA Study Team	2	
2	2002 - 2006	San José de Chiquimayo	Iturbide	San José de Chiquimayo	80	40	70,200	1,755	110,960	0.92	NF-Alisei (Italia), EU, Alcaldía, Muncip., Prefectura	2	
3	2002 - 2006	San Miguel	Iturbide	San Buenos Venura	80	25	66,900	2,676	69,350	0.11	Muncip., Prefectura	2	
4	2002 - 2006	25 de Mayo	Iturbide	San Buenos Venura	350	25	65,000	2,600	69,350	0.11	EU, NF, Prefectura, Alcaldía	1	
5	2002 - 2006	Yamamay	S. Yungas	Yamamay	230	88	183,561	2,086	244,112	0.10	UMSA-IBH	3	
6	2002 - 2006	Colopampa-Santa Rosa	S. Yungas	Colopampa Grande	180	160	270,513	1,691	113,840	0.08	UMSA-IBH	3	
7	2002 - 2006	Culliyayo	S. Yungas	Culliyayo	80	25	34,300	1,372	69,350	0.07	Muncip., Prefectura	2	
8	2002 - 2006	Chiriz	S. Yungas	Chiriz	200	50	80,000	1,600	138,700	0.08	ECOTEC	1	
9	2002 - 2006	Pichiri	S. Yungas	San José	163	48	100,000	2,083	133,152	0.10	ECOTEC	1	
9	2002 - 2006	Castro Terceros	S. Yungas	Villa Barricada	828	60	174,773	3,009	166,140	0.11	UNDP	3	
11	2002 - 2006	Succhos	E. Yungas	Succhos	140	100	200,000	2,000	277,460	0.10		1	
12	2002 - 2006	Curva - Calera (Rio Opatiraya)	R. Sajama	Curva	170	45	112,500	2,309	124,830	0.12	JICA Study Team	1	
13	2002 - 2006	Palmir	S. Yungas	Champaca	150	40	70,000	1,750	110,960	0.09	ECOTEC	1	
13	2002 - 2006	Villa el Cerezo	Carañavi	Rosario Entre Rios	90	40	68,100	1,703	110,960	0.08	NF-Alisei (Italia), EU, Alcaldía, Muncip., Prefectura	2	
15	2007 - 2011	Colana	Carañavi	Colana	170	50	175,204	3,504	138,700	0.17	UMSA-IBH	3	
16	2007 - 2011	Ulla Ulla	F. Tamayo	Ulla Ulla	60	20	50,000	2,500	55,480	0.12		1	
17	2007 - 2011	Chairo Pocomayo	Nor Yungas	Pacollo	100	40	56,170	1,404	110,960	0.07	NF-Alisei (Italia), EU, Alcaldía, Muncip., Prefectura, Comandante de Pocomayo,	2	
18	2007 - 2011	Pocomayo, Vilayo, Chiriquilla	Moravia	Tiampi	102	25	53,842	2,154	69,350	0.11	UMSA-IBH	1	
19	2007 - 2011	Inca Delicias	S. Yungas	Pajar Blancos	84	60	141,140	2,352	166,140	0.11	UMSA-IBH/PRUD/Solitario SRL	1	
20	2007 - 2011	Llallagua	J. Manuel Pando	Sollipalca de Machaca	10	8	4,485	1,061	22,192	0.05	PROPER, Misión Alisara	1	
21	2007 - 2011	Jachamani	Carañavi	Jachamani de Challa Kachji	70	30	150,000	5,000	83,220	0.24	Munc. De Carañavi, UMSA-IBH	1	
21	2007 - 2011	Peroma	Laracay	Santa Rosa de Chullum	350	300	300,000	1,000	832,200	0.05	ECOTEC	1	
23	2007 - 2011	Pedrito, Thronayo	Nor Yungas	Corvico	220	20	39,450	1,973	55,480	0.10	EU, Prefectura, Alcaldía	1	
24	2007 - 2011	Villa Barricada	S. Yungas	Villa Barricada	100	25	50,000	2,174	63,892	0.11	ECOTEC	1	
25	2007 - 2011	Huerfanas-Corvico (Rehabilitación)	Nor Yungas	Corvico	978	205	279,000	1,361	568,670	0.07	UMSA-IBH	1	
26	2007 - 2011	Orovalde	Carañavi	Santa Alto Beni	60	25	52,000	2,080	69,350	0.10	NF-Alisei (Italia), EU, Alcaldía, Muncip., Prefectura	2	
26	2007 - 2011	Cosni - Quesi	Carañavi	Mocumco	137	5	20,550	4,110	13,870	0.20	ORPA, Klaus Wayer y PROPER	1	
28	2007 - 2011	Nueva Esperanza	Carañavi	Nueva Esperanza	65	30	78,000	2,600	83,220	0.13	Munc. De Carañavi, UMSA-IBH	1	
29	2007 - 2011	Micozi	Nor Yungas	Mitubaya	22	8.8	29,660	3,364	34,111	0.16	UMSA-IBH	1	
30	2007 - 2011	Illimasi	Carañavi	Alto Illimasi	60	20	58,000	2,900	55,480	0.14	Munc. De Carañavi, UMSA-IBH	1	
	2007 - 2011	Apolo (Rio Machariques) Phase - II	F. Tamayo	Apolo, Santa Cruz del Valle Amaro & Alas	900	350	2,000,000	5,714	970,900	0.28	JICA Study Team	2	
					321 W/HH	11,783	3,708	12,196,207	2,708				
Sub-Total 2002 - 2006						4,240	1,096	3,496,000					
Sub-Total 2007 - 2011						3,490	1,220	3,541,000					
TOTAL (2002 - 2011)						7,730	2,316	7,037,000		Note: The total number was rounded.			
Average Installed Capacity per Household in the Selected MHP Projects (La Paz) = 300 W/HH									910 (US\$/HH)				

Oruro

1	2002 - 2006	Turbo Quevedo	Sajama	Chacabambani	69	62	239,780	3,466	171,988	0.19	JICA Study Team, ECOTEC	2
2	2007 - 2011	Juro - Vilayo (Rio Pacalirani, Est. Vilayo)	Abtafalo	Neamita / Juro	80	15	52,500	3,500	11,610	0.17	JICA Study Team	1
3	2007 - 2011	Sajama (Rio Jachta Hincollé)	Sajama	Sajama	60	25	75,000	3,600	69,350	0.15	ECOTEC, JICA Study Team	1
					314 W/HH	2,065	649	2,976,617				
Sub-Total 2002 - 2006						69	62	240,000				
Sub-Total 2007 - 2011						140	40	128,000				
TOTAL (2002 - 2011)						209	102	368,000		Note: The total number was rounded.		
Average Installed Capacity per Household in the Selected MHP Projects (Oruro) = 488 W/HH									1,761 (US\$/HH)			

Source: JICA Study Team

Note: *) Column 'c', 'f', 'g': Basic numbers are assumed.

*) Column 'e' & 'h': For the calculation of annual energy of the MHP, following parameter are used:

Effective Operation Rate (Days/year for Estimation of kWh/Year)	330
Plant Factor for MHP	0.35
Life Time of the System (Year)	20
Discount Rate (%)	10%
CFR (Capital Recovery Factor) = $(R(1+R)^n) / ((1+R)^n - 1)$	0.1178
O&M Cost for MHP (% of total investment)	1.5%

Note: *) The Apolo micro-hydro power project is one project, but is divided into two in this table for incorporating annual investment plan.

Tabla 5.1 Temperatura Media Mensual y Humedad en Apolo

TEMPERATURA MEDIA AMBIENTE °C

ESTACION : APOLO

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1987	22.2	22.9	22.8	22.7	20.4	19.7	21.1	21.2	21.2	22.4	23.0	23.3	21.9
1988	23.6	22.4	22.5	22.2	20.8	19.6	18.8	21.4	-	-	-	-	21.4
1989	22.0	21.6	21.4	21.2	19.5	20.4	19.0	20.7	21.0	22.2	22.5	22.4	21.2
1990	22.0	21.8	23.0	22.2	20.0	19.0	18.2	20.4	21.2	22.2	22.3	22.4	21.2
1991	21.9	22.6	22.1	22.6	22.2	20.3	18.2	18.8	21.2	21.2	22.9	22.4	21.4
1992	21.2	21.6	21.6	21.4	21.8	20.2	18.5	18.8	20.0	22.1	22.0	21.8	20.9
1993	20.6	21.0	21.5	21.2	20.9	19.8	18.3	19.2	21.2	23.2	22.6	22.6	21.0
1994	21.8	21.8	21.6	21.2	20.6	18.9	19.7	20.2	21.6	22.9	22.4	22.8	21.3
1995	22.8	21.8	21.8	22.4	19.5	20.7	21.4	22.6	22.0	23.4	23.8	22.4	22.1
1998	25.0	24.1	23.4	23.2	20.2	20.0	20.8	21.4	23.2	23.2	23.3	22.6	22.5
Ave.	22.3	22.2	22.2	22.0	20.6	19.9	19.4	20.5	21.4	22.5	22.8	22.5	21.5

HUMEDAD RELATIVA MEDIA (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
1979	75	72	79	73	72	72	71	63	65	64	68	71	70.4
1980	72	75	73	70	69	72	68	68	64	68	70	70	69.9
1981	77	79	76	78	73	76	73	65	66	71	73	74	73.4
1982	78	80	81	78	77	71	66	63	63	66	75	67	72.1
1983	67	72	71	76	75	76	77	66	66	69	73	65	71.1
1985	73	77	71	72	68	64	66	62	61	63	70	71	68.2
1986	79	74	75	76	65	63	60	63	64	63	66	63	67.6
1991	81	61	68	62	70	71	58	58	51	62	65	75	65.2
1992	70	69	69	66	66	68	63	61	66	56	75	71	66.7
1993	76	72	71	71	70	63	68	61	62	59	69	70	67.7
Ave.	74.8	73.1	73.4	72.2	70.5	69.6	67.0	63.0	62.8	64.1	70.4	69.7	69.2

Nota.- (-) No existen datos.

Source: SENAMHI

Tabla 5.2 Precipitación Mensual en Apolo (1966 - 2000)

ESTACION : APOLO (AEROPUERTO) LATITUD S : 14°44'
 PROVINCIA : F. TAMAYO LONGITUD W : 68°32'
 DEPTO. : LA PAZ ALTURA : 1,406 msnm.

No.	Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	Rank (/31)
1	1966	121.7	174.3	119.4	124.6	92.6	34.1	4.2	81.5	10.2	52.0	130.1	250.4	1,195.1	28
2	1967	122.3	148.7	459.7	30.7	49.6	38.2	48.0	33.8	79.2	230.0	197.6	288.1	1,725.9	14
3	1968	199.5	276.9	219.4	109.5	12.7	14.9	69.2	41.1	88.0	191.0	102.0	186.3	1,510.5	21
4	1969	166.4	99.8	127.8	138.7	48.1	67.1	37.2	36.7	57.1	90.8	180.4	234.4	1,284.5	25
5	1970	191.7	135.5	314.2	162.6	38.6	41.4	34.3	108.0	130.2	239.7	189.1	178.0	1,763.3	12
6	1971	340.2	346.7	118.2	95.1	171.2	18.4	22.0	52.0	41.0	280.7	162.9	174.1	1,822.5	9
7	1972	375.7	329.9	161.1	126.2	40.8	22.8	83.4	55.0	113.4	76.4	105.7	304.2	1,794.6	10
8	1973	263.8	197.9	222.7	139.4	101.3	10.6	36.6	73.7	124.6	129.4	181.4	182.8	1,664.2	17
9	1974	273.2	393.3	134.8	240.5	59.2	50.6	46.5	185.9	80.7	163.0	88.5	148.9	1,865.1	6
10	1975	326.2	323.3	210.0	99.6	89.1	40.7	17.8	26.2	41.6	154.5	218.2	286.9	1,834.1	8
11	1976	221.3	348.9	260.7	105.7	150.3	30.5	5.4	41.0	52.1	42.7	105.5	285.6	1,649.7	18
12	1977	198.6	342.5	206.8	178.5	45.5	26.2	8.0	25.8	69.2	161.4	257.4	325.5	1,845.4	7
13	1978	200.6	264.4	188.3	224.1	68.0	43.1	27.1	5.2	66.7	89.2	276.2	253.3	1,706.2	15
14	1979	393.9	52.7	345.9	128.0	7.6	59.3	58.7	42.1	37.6	218.5	172.5	264.9	1,781.7	11
15	1980	187.6	176.8	176.0	55.9	35.2	86.9	29.6	102.7	44.5	120.8	165.8	128.1	1,309.9	24
16	1981	247.9	419.1	243.0	194.5	121.2	74.1	67.3	65.2	70.2	261.6	97.2	192.3	2,053.6	3
17	1982	366.0	206.0	246.0	196.0	17.0	19.0	3.0	5.0	31.0	86.0	369.0	147.0	1,691.0	16
18	1983	128.0	375.0	235.0	168.0	66.0	64.0	88.0	3.0	57.0	207.0	125.0	221.0	1,737.0	13
19	1984	339.0	400.0	276.0	203.0	41.0	65.0	30.0	35.0	70.0	310.0	362.0	299.0	2,430.0	1
20	1985	407.0	199.0	204.0	178.0	84.0	56.0	29.0	18.0	104.0	203.0	338.0	352.0	2,172.0	2
21	1986	205.0	290.0	273.0	56.0	3.0	19.0	47.0	79.0	176.0	133.0	132.0	123.0	1,536.0	20
22	1987	400.0	118.0	337.0	225.0	72.0	33.0	10.0	15.0	64.0	152.0	261.0	349.0	2,036.0	4
-	1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	1989	305.0	218.0	294.0	302.0	107.0	72.4	55.5	53.0	49.9	214.0	193.0	142.0	2,005.8	5
24	1990	191.4	261.0	77.0	81.0	67.0	111.4	20.0	15.0	68.0	167.0	193.3	248.0	1,500.1	22
25	1991	348.0	89.0	93.8	37.2	66.0	36.0	2.0	28.0	37.0	33.0	193.3	248.0	1,211.3	27
26	1992	248.0	222.0	97.0	82.0	4.0	26.0	20.0	133.0	107.0	44.0	144.0	100.0	1,227.0	26
27	1993	198.0	194.0	163.0	199.0	83.0	29.0	54.2	159.9	9.0	22.0	148.0	300.3	1,559.4	19
28	1994	179.3	163.5	157.8	213.2	74.0	9.8	13.1	63.0	61.7	203.4	55.6	170.7	1,365.1	23
29	1995	83.2	158.1	115.9	35.8	43.3	29.9	16.4	12.1	20.2	77.9	70.0	173.4	836.2	31
-	1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	1998	105.6	147.8	170.5	42.9	12.4	21.6	36.6	39.0	14.1	136.9	254.5	188.0	1,169.9	29
-	1999	-	-	-	-	-	-	-	-	-	53.7	138.1	175.2	-	-
31	2000	151.9	178.3	121.7	67.8	0.4	53.1	12.2	42.7	36.8	93.6	101.5	16.0	876.0	30
	Ave.	241.5	235.8	205.5	136.8	60.4	42.1	33.3	54.1	64.9	144.9	176.5	216.8	1,618.0	-
	Max.	407.0	419.1	459.7	302.0	171.2	111.4	88.0	185.9	176.0	310.0	362.0	352.0	2,430.0	-
	Min.	83.2	52.7	77.0	30.7	0.4	9.8	2.0	3.0	9.0	22.0	55.6	16.0	836.2	-

Source: SENAMHI (2000), Aeropuerto de Apolo AASANA

Note: 1988, 96, 97, 99 are not available.

Tabla 5.3 Población Comunitaria & Familias del Área Meta en 1999

Block	Canton	Category of Area	No. of Community	Community	1999 (actual)		
					Household	Population	Population per Family
A	Apolo	Urban	4	Apolo Center Town, Porvenir - Litoral, Cotachimpa, Iltasawa	580	3,197	5.5
B	Apolo	Rural	7	Santa Teresa, Tigri Rumi, Machua, Asichaua, Chipilusani, Yalihuara, Airport (AASANA)	251	1,187	4.7
C	Apolo & Sta. Cruz de V. Ameno	Rural	11	Apacheta, Vaquería, Chuchico, Santa Cruz de Velle Ameno, Sta. Barbara, San Luis, San Andrés, San Antonio, Cruz Pata, Fátima, Mohima	336	1,712	5.1
D	Apolo	Rural	5	Cuba Santa Mería, Santa Catalina, Tanampaya, Concepción, Santa Domingo	229	1,147	5.0
E	Apolo	Rural	7	Muruagua, Yanamayo (Río Negro), Pata Salinas, San Pedro, Inca, Juan Agua, Chirimayo	335	2,067	6.2
F	Apolo	Rural	5	Liuscamayo, San José, Ubia, Pucasucho, 1 de Mayo	214	833	3.9
G	Sta. Cruz de V. Ameno	Rural	2	Altuncama, San Marcos	32	135	4.2
TOTAL in Demand Area for Apolo MHP Project					1,977	10,278	5.2

Source: "Plan de Desarrollo Municipal APOLO" (2000)

Tabla 5.4 Proyección de Familias en la Comunidad de Apolo (1999 y 2005)

Block A (only Apolo Central Town Case)

No.	Canton	Area	Community	1999		2005 (Estimated)		
				No. of Family	Population	Population per Family	No. of Family	Population
1	Apolo	Urban	Centro (Apolo Center Town)	250	1,500	6.00	262	1,574
2	Apolo	Urban	Porvenir - Litoral	28	125	4.46	29	131
3	Apolo	Urban	Cotachimpa	212	1,272	6.00	223	1,335
4	Apolo	Urban	Itasawa	90	300	3.33	95	315
Sub Total				580	3,197	5.51	609	3,355

Block B

1	Apolo	Rural	Santa Teresa	40	110	2.75	42	115
2	Apolo	Rural	Tigri Rumi	29	127	4.38	30	133
3	Apolo	Rural	Machua	60	284	4.73	63	298
4	Apolo	Rural	Asichaua	36	190	5.28	38	199
5	Apolo	Rural	Chipilusani	41	250	6.10	43	262
6	Apolo	Urban	Apolo Center & Surroundings	580	3,197	5.51	609	3,355
7	Apolo	Rural	Yallhuara	45	226	5.02	47	237
8	Apolo	Rural	Airport (AASANA)	0	0	0.00	0	0
Sub Total				831	4,384	5.28	872	4,599

Block C

1	Apolo	Rural	Apacheta	45	222	4.93	47	233
2	Sta. Cruz de V. Ameno	Rural	Vaqueria	26	159	6.12	27	167
3	Sta. Cruz de V. Ameno	Rural	Chuchico	22	109	4.95	23	114
4	Sta. Cruz de V. Ameno	Rural	Santa Cruz de Velle Ameno	44	265	6.02	46	278
5	Sta. Cruz de V. Ameno	Rural	Sta. Barbara	44	200	4.55	46	210
6	Sta. Cruz de V. Ameno	Rural	San Luis	29	147	5.07	30	154
7	Apolo	Rural	San Andrés	26	111	4.27	27	116
8	Sta. Cruz de V. Ameno	Rural	San Antonio	25	93	3.72	26	98
9	Sta. Cruz de V. Ameno	Rural	Cruz Pata	16	80	5.00	17	84
10	Sta. Cruz de V. Ameno	Rural	Fátima	3	48	16.00	3	50
11	Sta. Cruz de V. Ameno	Rural	Mohima	56	278	4.96	59	292
Sub Total				336	1,712	5.10	351	1,796

Block D

1	Apolo	Rural	Cuba Santa Mería	23	130	5.65	24	136
2	Apolo	Rural	Santa Catalina	90	452	5.02	94	474
3	Apolo	Rural	Tanampaya	40	180	4.50	42	189
4	Apolo	Rural	Concepción	44	198	4.50	46	208
5	Apolo	Rural	Santo Domingo	32	187	5.84	34	196
Sub Total				229	1,147	5.01	240	1,203

Block E

1	Apolo	Rural	Muniagua	27	116	4.30	28	122
2	Apolo	Rural	Yanamayo (Río Negro)	36	165	4.58	38	173
3	Apolo	Rural	Pata Salinas	34	195	5.74	36	205
4	Apolo	Rural	San Pedro	36	254	7.06	38	267
5	Apolo	Rural	Inca	50	460	9.20	53	483
6	Apolo	Rural	Juan Agua	118	718	6.08	124	754
7	Apolo	Rural	Chirimayo	34	159	4.68	36	167
Sub Total				335	2,067	6.17	353	2,171

Block F

1	Apolo	Rural	Liuscamayo	37	197	5.32	39	207
2	Apolo	Rural	San José	23	127	5.52	24	133
3	Apolo	Rural	Uña	32	128	4.00	34	134
4	Apolo	Rural	Pucasucho	97	267	2.75	102	280
5	Apolo	Rural	1 de Mayo	25	114	4.56	26	120
Sub Total				214	833	3.89	225	874

Block G

1	Sta. Cruz de V. Ameno	Rural	Altuncama	13	78	6.00	14	82
2	Sta. Cruz de V. Ameno	Rural	San Marcos	19	57	3.00	20	60
Sub Total				32	135	4.22	34	142

Source: "Plan de Desarrollo Municipal APOLO" (2000), and INE.

Tabla 5.5 Tasa Unitaria de Consumo de Energía por Familia en Apolo

For Urban Area

Electric Appliance	No. of unit (No.)	Capacity per Unit (Watt)	Diffusion Percent (%)	Total Capacity (Watt)	Time of connection	Evening 1800-2200 (Watt)	Midnight 2200-600 (Watt)	Day time 600-1800 (Watt)
Light Bulb	5	60	90%	270	80% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 5% during 6:00 ~ 18:00	216.0	0.0	13.5
Radio	1	20	90%	18	80% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 20% during 6:00 ~ 18:00	14.4	0.0	3.6
TV	1	60	50%	30	70% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 10% during 6:00 ~ 18:00	21.0	0.0	3.0
Refrigerator	1	250	25%	63	15 minutes in each hours 7 minutes in each hours 10 minutes in each hours	16.0	7.0	10.0
TOTAL			Pi (W)=	381		Pmax (W) = 267.4	7.0	30.1

For Rural Area

Electric Appliance	No. of unit (No.)	Capacity per Unit (Watt)	Diffusion Percent (%)	Total Capacity (Watt)	Time of connection	Evening 1800-2200 (Watt)	Midnight 2200-600 (Watt)	Day time 600-1800 (Watt)
Light Bulb	3	60	85%	153	80% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 5% during 6:00 ~ 18:00	122.4	0.0	7.7
Radio	1	20	70%	14	80% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 20% during 6:00 ~ 18:00	11.2	0.0	2.8
TV	1	60	5%	3	50% during 18:00 ~ 22:00 0% during 22:00 ~ 6:00 10% during 6:00 ~ 18:00	1.5	0.0	0.3
TOTAL			Pi (W)=	170		Pmax (W) = 135.1	0.0	10.8

Source: JICA study team

**Tabla 5.6 Tasa Unitaria de Consumo de Electricidad
para Usos No-Domésticos en Apolo (1/2)**

[for Urban Area, 2005]

No.	Category	Potential Demand (kW)	Connection Hours			Actual Demand		
			Evening 18 ⁰⁰ -22 ⁰⁰ (hours)	Midnight 22 ⁰⁰ -6 ⁰⁰ (hours)	Day time 6 ⁰⁰ -18 ⁰⁰ (hours)	Evening 18 ⁰⁰ -22 ⁰⁰ (kW)	Midnight 22 ⁰⁰ -6 ⁰⁰ (%)	Day time 6 ⁰⁰ -18 ⁰⁰ (kW)
			4	8	12			
1)	Business [kW/Block]	10.50				14.00	0.81	1.33
	Spread Trade	0.50	4.00	1.00	0.00	0.50	0.06	
	Lodging house	3.00	6.00	0.00	2.00	4.50		0.50
	Restaurants	1.00	6.00	0.00	4.00	1.50		0.33
	Cafeterias	1.00	4.00	0.00	2.00	1.00		0.17
	Bar, Caraoke, Disco etc.	3.00	6.00	2.00	0.00	4.50	0.75	
	Video theater	2.00	4.00	0.00	2.00	2.00		0.33
2)	Industrially [kW/Block]	107.00				35.23	0.88	47.74
	Mechanical Work Shop							
	Electric Welder (Soldador)	12.00	7.00	0.00	0.00	5.00		2.92
	Elect. Lathe (Torno)		4.00	0.00	0.00	4.00		1.33
	Illumination & others		1.00	1.00	0.00	8.00	0.25	0.67
	Religious house (Orden Franciscana)	17.50	2.50	0.00	0.00	5.00		1.04
	Water Pump		3.00	0.00	0.00	5.00		1.25
	Illumination & Others		12.00	2.00	0.00	8.00	6.00	8.00
	Religious house (Orden Cisterciense)	45.00	7.45	0.00	0.00	5.00		3.10
	Mill of Corn		2.24	0.00	0.00	5.00		0.93
	Electric Sierra		1.86	0.00	0.00	5.00		0.78
	Toast factory (Torrefactora)		1.12	0.00	0.00	5.00		0.47
	Refrigerator		0.75	1.33	2.67	4.00	0.25	0.25
	Illumination & Others		5.46	2.00	0.00	8.00	2.73	3.64
	Congeladoras		1.12	0.00	0.00	3.00		0.28
	Industrial Work Shop		12.00	0.00	0.00	5.00		5.00
	Peeler of Coffee		8.00	0.00	0.00	5.00		3.33
	Drying of coffee		5.00	2.00	0.00	5.00	2.50	2.08
	Illumination & Others		2.00	1.00	0.00	3.00	0.50	0.50
	Bakeries		5.00	0.00	0.00	7.00		2.92
	Carpentry		3.00	0.00	0.00	7.00		1.75
	Electric and Electronic Shops		0.50	0.00	0.00	8.00		0.33
	Seam Work Shop		2.00	6.00	2.50	13.00	3.00	2.17
	Radiate Radio Station		20.00	4.00	0.00	3.00	20.00	5.00
	General Commercials/ Water Supply/ Others							
3)	Public (Public Facilities) [kW/Block]	54.02				37.06	0.27	28.68
	Hospital							
	Equipment of X-Ray	9.70	2.00	0.00	0.00	1.00		0.17
	Sterilizer		0.50	1.00	0.00	8.00	0.13	0.33
	Centrifuge		0.20	0.00	0.00	0.50		0.01
	Refrigerator		0.80	1.33	2.67	4.00	0.27	0.27
	Illumination		3.20	2.00	0.00	3.00	1.60	0.80
	Others		3.00	0.00	0.00	6.00		1.50
	State Offices		8.00	0.00	0.00	9.00		6.00
	Military (Battalion Murillo)	1,200 people x 100 W/III5.5 people/H	21.82	4.00	0.00	4.00	21.82	7.27
	Church (Lutheran church)		2.00	4.00	0.00	4.00	2.00	0.67
	AASANA (Airport)		10.00	4.00	0.00	12.00	10.00	10.00
	DITER		2.50	2.00	0.00	8.00	1.25	1.67
	Public (Streetlight) [kW/km/HH]	0.04				0.04	0.04	0.00
	Streetlight (Public illuminations):							
	in Urban Town	800 W/km x 50 m/HH.	0.04	4.00	8.00	0.00	0.04	0.04

Source: JICA Study Team

Note: reference source: "Minicentral Hidroeléctrica en Apolo (Río Turiapu)", Regionalización Energética de Bolivia, Programa de la OEA. (1987)

**Tabla 5.6 Tasa Unitaria de Consumo de Electricidad
para Usos No-Domésticos en Apolo (2/2)**

[for Rural Area, 2005]

No.	Category	Potential Demand (kW)	Connection Hours			Actual Demand		
			Evening 18 ⁰⁰ -22 ⁰⁰ (hours)	Midnight 22 ⁰⁰ -6 ⁰⁰ (hours)	Day time 6 ⁰⁰ -18 ⁰⁰ (hours)	Evening 18 ⁰⁰ -22 ⁰⁰ (kW)	Midnight 22 ⁰⁰ -6 ⁰⁰ (%)	Day time 6 ⁰⁰ -18 ⁰⁰ (kW)
			4	8	12			
1)	Business [kW/Block]	7.00				9.75	0.44	1.00
	Spread Trade	0.50	4.00	1.00	0.00	0.50	0.06	
	Lodging house	3.00	6.00	0.00	2.00	4.50		0.50
	Restaurants	1.00	6.00	0.00	4.00	1.50		0.33
	Cafeterias	1.00	4.00	0.00	2.00	1.00		0.17
	Bar, Caraoke, Disco etc.	1.50	6.00	2.00	0.00	2.25	0.38	
2)	Industry [kW/Block]	72.90				13.50	0.25	29.65
	Mechanical Work Shop	12.00						
	Electric Welder (Soldador)	7.00	0.00	0.00	5.00			2.92
	Elect. Lathe (Torno)	4.00	0.00	0.00	4.00			1.33
	Illumination & others	1.00	1.00	0.00	8.00	0.25		0.67
	Industrial Work Shop	40.30						
	Water Pump	3.00	0.00	0.00	5.00			1.25
	Peeler of Rice	7.45	0.00	0.00	5.00			3.10
	Mill of Corn	2.24	0.00	0.00	5.00			0.93
	Electric Sierra	1.86	0.00	0.00	5.00			0.78
	Refrigerator	0.75	1.33	2.67	4.00	0.25	0.25	0.25
	Peeler of Coffee	12.00	0.00	0.00	5.00			5.00
	Drying of coffee	8.00	0.00	0.00	5.00			3.33
	Illumination & Others	5.00	2.00	0.00	5.00	2.50		2.08
	Bakeries	2.00	1.00	0.00	3.00	0.50		0.50
	Carpentry	5.00	0.00	0.00	7.00			2.92
	Electric and Electronic Shops	3.00	0.00	0.00	7.00			1.75
	Seam Work Shop	0.50	0.00	0.00	8.00			0.33
	General Commercials/ Water Supply/ Others	10.00	4.00	0.00	3.00	10.00		2.50
3)	Public (Public Facilities) [kW/Block]	11.41				1.47	0.22	7.45
	Clinic							
	Sterilizer	0.50	1.00	0.00	8.00	0.13		0.33
	Refrigerator	0.67	1.33	2.67	4.00	0.22	0.22	0.22
	Illumination	0.24	2.00	0.00	3.00	0.12		0.06
	Others	1.00	0.00	0.00	6.00			0.50
	Branch State Office etc.	8.00	0.00	0.00	9.00			6.00
	Church	1.00	4.00	0.00	4.00	1.00		0.33
	Public (Streetlight) [kW/km/HH]	0.06				0.06	0.06	0.00
	Streetlight (Public illuminations):							
	in Rural Community	800 W/km x 80 m/HH	0.06	4.00	8.00	0.00	0.06	0.06

Source: JICA Study Team

Note: Some unit demand for rural area are referred the urban area community unit values, around 50% of the urban area values.

Tabla 5.7 Estimación de la Demanda Total de Energía en Apolo

Category of Demand	No. of Electrified Communities		No. of Electrified Household		Urban			Rural			Max. Demand Total (kW)
	Urban	Rural	Urban	Rural	Evening	Midnight	Day time	Evening	Midnight	Day time	
					18 ⁰⁰ -22 ⁰⁰	22 ⁰⁰ -6 ⁰⁰	6 ⁰⁰ -18 ⁰⁰	18 ⁰⁰ -22 ⁰⁰	22 ⁰⁰ -6 ⁰⁰	6 ⁰⁰ -18 ⁰⁰	
Block-A (Apolo Central Town)											
1) Domestic	1	0	587	0	156.96	4.11	17.67	0.00	0.00	0.00	
2) Business	1	0	587	0	14.00	0.81	1.33	0.00	0.00	0.00	
3) Industry	1	0	587	0	35.23	0.88	47.74	0.00	0.00	0.00	
4) Public (Public Facilities)	1	0	587	0	37.06	0.27	28.68	0.00	0.00	0.00	
Public (Streetlight)	1	0	587	0	23.48	23.48	0.00	0.00	0.00	0.00	
Total					266.73	29.55	95.42	0.00	0.00	0.00	270
Block-B											
1) Domestic	1	7	587	253	156.96	4.11	17.67	34.18	0.00	2.72	
2) Business	1	7	587	253	14.00	0.81	1.33	9.75	0.44	1.00	
3) Industry	1	7	587	253	35.23	0.88	47.74	13.50	0.25	29.65	
4) Public (Public Facilities)	1	7	587	253	37.06	0.27	28.68	1.47	0.22	7.45	
Public (Streetlight)	1	7	587	253	23.48	23.48	0.00	16.19	16.19	0.00	
Total					266.73	29.55	95.42	75.09	17.10	40.82	340
Block-C											
1) Domestic	0	15	0	338	0.00	0.00	0.00	45.66	0.00	3.63	
2) Business	0	15	0	338	0.00	0.00	0.00	9.75	0.44	1.00	
3) Industry	0	15	0	338	0.00	0.00	0.00	13.50	0.25	29.65	
4) Public (Public Facilities)	0	15	0	338	0.00	0.00	0.00	1.47	0.22	7.45	
Public (Streetlight)	0	15	0	338	0.00	0.00	0.00	21.63	21.63	0.00	
Total					0.00	0.00	0.00	92.01	22.54	41.73	90
Block-D											
1) Domestic	0	7	0	230	0.00	0.00	0.00	31.07	0.00	2.47	
2) Business	0	7	0	230	0.00	0.00	0.00	9.75	0.44	1.00	
3) Industry	0	7	0	230	0.00	0.00	0.00	13.50	0.25	29.65	
4) Public (Public Facilities)	0	7	0	230	0.00	0.00	0.00	1.47	0.22	7.45	
Public (Streetlight)	0	7	0	230	0.00	0.00	0.00	14.72	14.72	0.00	
Total					0.00	0.00	0.00	70.51	15.63	40.57	70
Block-E											
1) Domestic	0	8	0	337	0.00	0.00	0.00	45.53	0.00	3.62	
2) Business	0	8	0	337	0.00	0.00	0.00	9.75	0.44	1.00	
3) Industry	0	8	0	337	0.00	0.00	0.00	13.50	0.25	29.65	
4) Public (Public Facilities)	0	8	0	337	0.00	0.00	0.00	1.47	0.22	7.45	
Public (Streetlight)	0	8	0	337	0.00	0.00	0.00	21.57	21.57	0.00	
Total					0.00	0.00	0.00	91.82	22.48	41.72	90
Block-F											
1) Domestic	0	5	0	216	0.00	0.00	0.00	29.18	0.00	2.32	
2) Business	0	5	0	216	0.00	0.00	0.00	9.75	0.44	1.00	
3) Industry	0	5	0	216	0.00	0.00	0.00	13.50	0.25	29.65	
4) Public (Public Facilities)	0	5	0	216	0.00	0.00	0.00	1.47	0.22	7.45	
Public (Streetlight)	0	5	0	216	0.00	0.00	0.00	13.82	13.82	0.00	
Total					0.00	0.00	0.00	67.72	14.73	40.42	70
Block-G											
1) Domestic	0	2	0	32	0.00	0.00	0.00	4.32	0.00	0.34	
2) Business	0	2	0	32	0.00	0.00	0.00	9.75	0.44	1.00	
3) Industry	0	2	0	32	0.00	0.00	0.00	13.50	0.25	29.65	
4) Public (Public Facilities)	0	2	0	32	0.00	0.00	0.00	1.47	0.22	7.45	
Public (Streetlight)	0	2	0	32	0.00	0.00	0.00	2.05	2.05	0.00	
Total					0.00	0.00	0.00	31.09	2.96	38.44	40
Total (B - G)	1	44	587	1,406	270	30	100	430	100	240	700

Source: JICA Study Team

Tabla 5.8 Costo Preliminar de Construcción de la MCH de Apolo para Casos Alternativos

[Financial Cost (With Tax)]

Unit : US\$

Item	Case1 270kW	Case2 340kW	Case3 410kW	Case4 480kW	Case5 570kW	Case6 660kW	Case7 700kW	Note
1. Preparation Works & Access, etc.	469,100	498,400	537,800	564,200	616,400	654,700	669,800	
1.1 Preparation Works	136,300	165,300	204,100	230,300	275,900	320,000	334,700	(2 + 3) * 10%
1.2 Access Road	325,500	325,500	325,500	325,500	325,500	325,500	325,500	Gravel Pavd. W=4m (Sta. Teresa - Site)
1.3 Mitigation for Environment	7,300	7,600	8,200	8,400	9,000	9,200	9,600	2 * 0.01
2. Civil Works	729,200	755,200	820,200	839,500	894,900	918,500	963,900	
2.1 Intake Weir	57,000	57,000	57,000	57,000	57,000	57,000	57,000	
2.2 Intake	46,200	51,700	57,900	62,000	67,600	73,000	75,100	
2.3 Sand Settling Basin	0	0	0	0	0	0	0	
2.4 Headrace	512,200	512,200	537,500	528,800	554,400	545,800	573,900	
2.5 Head Tank	58,600	69,200	79,100	88,400	100,100	111,100	116,000	
2.6 Penstock	37,700	42,900	49,000	53,600	60,400	65,800	68,700	
2.7 Spillway	7,600	10,400	10,400	13,600	13,600	13,600	17,000	
2.8 Power House	6,800	8,700	26,500	32,400	39,900	48,300	51,900	
2.9 Tailrace	3,100	3,100	3,400	3,700	3,900	3,900	4,300	
2.10 Outlet	0	0	0	0	0	0	0	
3. Electric and Mechanical Works	633,800	897,700	1,221,200	1,463,300	1,862,100	2,281,400	2,383,300	
3.1 Turbine/Generator	310,000	360,000	520,000	580,000	640,000	720,000	740,000	350kW x 2 set, include tax, transportation, installation
3.2 Transmission/Distribution Line	170,400	374,300	517,800	689,900	1,018,700	1,348,000	1,419,900	
3.3 Mechanical Works	153,400	163,400	183,400	193,400	203,400	213,400	223,400	
4. Transportation	52,700	64,600	76,100	86,100	106,000	124,000	130,400	(2 + 3.2 + 3.3) * 5% (La Paz - Apolo - Site)
5. Direct Cost Total	1,884,800	2,215,900	2,635,300	2,953,100	3,475,400	3,978,600	4,147,400	1. + 2. + 3. + 4.
6. Administration and Engineering Service.	179,300	285,700	241,100	265,000	306,600	346,700	364,300	{Admin. : (1. + 2. + 3.) * 6% + D.D. US\$20,000} * 138%
Total Construction Cost	2,064,100	2,421,600	2,896,400	3,218,100	3,782,000	4,325,300	4,507,600	5. + 6.

Note: Access Road Cost = Mountain Area (Rock): 9.1km²/30,000 US\$/km + Flat Area (Standard): 3.1km²/13,000 US\$/km

[Economic Cost (Without Tax)]

Unit : US\$

Item	Case1 270kW	Case2 340kW	Case3 410kW	Case4 480kW	Case5 570kW	Case6 660kW	Case7 700kW	Note
1. Preparation Works & Access, etc.	484,400	429,700	463,600	486,300	526,200	564,400	577,400	
1.1 Preparation Works	117,500	142,500	175,900	198,500	237,800	275,900	288,500	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
1.2 Access Road	280,600	280,600	280,600	280,600	280,600	280,600	280,600	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
1.3 Mitigation for Environment	6,300	6,600	7,100	7,200	7,800	7,900	8,300	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2. Civil Works	628,700	651,200	707,000	723,600	773,200	791,700	830,800	
2.1 Intake Weir	49,100	49,100	49,100	49,100	49,100	49,100	49,100	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.2 Intake	39,800	44,600	49,400	53,400	58,300	62,900	64,700	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.3 Sand Settling Basin	0	0	0	0	0	0	0	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.4 Headrace	441,600	441,600	463,400	455,900	477,900	470,500	494,700	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.5 Head Tank	50,500	59,700	68,200	76,200	86,300	95,800	100,000	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.6 Penstock	32,500	37,000	42,200	46,200	52,100	56,700	59,200	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.7 Spillway	6,800	9,000	9,000	11,700	11,700	11,700	14,700	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.8 Power House	5,900	7,500	22,800	27,900	34,400	41,600	44,700	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.9 Tailrace	2,700	2,700	2,900	3,200	3,400	3,400	3,700	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
2.10 Outlet	0	0	0	0	0	0	0	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
3. Electric and Mechanical Works	539,600	761,000	1,034,800	1,238,200	1,572,200	1,923,800	2,009,900	
3.1 Turbine/Generator	265,400	308,200	445,200	496,600	548,000	616,500	633,600	(cost with tax) / 1.1679
3.2 Transmission/Distribution Line	142,000	311,900	431,500	574,900	848,900	1,123,300	1,183,300	(cost with tax) / 1.2
3.3 Mechanical Works	132,200	140,900	158,100	166,700	175,300	184,000	192,600	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
4. Transportation	45,400	55,700	65,600	74,200	91,400	106,900	112,400	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
5. Direct Cost Total	1,618,100	1,897,600	2,271,000	2,522,300	2,963,800	3,396,900	3,530,100	
6. Administration and Engineering Service.	154,600	177,300	207,900	228,400	264,300	298,900	318,500	(cost with tax) / ((1+IVA.13%+IT.3%)) 1.16
Total Construction Cost	1,772,700	2,074,900	2,478,900	2,750,700	3,227,300	3,695,700	3,848,600	

Note: Access Road Cost = Mountain Area (Rock): 9.1km²/30,000 US\$/km + Flat Area (Standard): 3.1km²/13,000 US\$/km

Tabla 5.9 Costo Preliminar del Proyecto y Beneficio para Casos Alternativos

Item	Unit	Case1	Case2	Case3	Case4	Case5	Case6	Case7
Exchange Rate (as of May 23, 2001)	Bs./US\$	6.53	6.53	6.53	6.53	6.53	6.53	6.53
Install Capacity P	kW	270	340	410	480	570	660	700
Annual Demand Energy (Based on the estimated daily load curve of decm)	kWh/year	869,673	1,187,345	1,426,420	1,802,857	2,152,648	2,484,920	2,680,925

COST

1) Cost of the Micro-hydro:

Micro-hydro:

Preparation Works	US\$	404,400	429,700	463,600	486,300	526,200	564,400	577,400
Civil works (including engineering)	US\$	628,700	651,200	707,000	723,600	773,200	791,700	830,800
Electric Works (Turbine&Generator)	US\$	265,400	308,200	445,200	496,600	548,000	616,500	633,600
Mechanical Works	US\$	132,200	140,900	158,100	166,700	175,300	184,000	192,600
Transportation	US\$	45,400	55,700	65,600	74,200	91,400	106,900	112,400
Administration and Engineering Service.	US\$	154,600	177,300	207,800	228,400	264,300	298,900	310,500
Total initial investment cost of MHP	US\$	1,630,700	1,763,900	2,047,300	2,175,800	2,378,400	2,562,400	2,657,300

2) Cost of the Distribution Lines

Cost of Transmission & Distribution Line	US\$	142,000	311,900	431,500	574,900	848,900	1,123,300	1,183,300
Total costs of Transmission & distribution lines	US\$	142,000	311,900	431,500	574,900	848,900	1,123,300	1,183,300

3) Operation & Maintenance Cost

OM Cost of the Electromechanical Equipment (% of investment)	%	2.0	2.0	2.0	2.0	2.0	2.0	2.0
OM Cost of the Civil Engineering (% of investment)	%	0.5	0.5	0.5	0.5	0.5	0.5	0.5
OM Cost of the Transmission & Distribution Lines (% of investment)	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5
OM cost for the electromechanical equipment	US\$/year	5,308	6,164	8,904	9,932	10,960	12,330	12,672
OM cost for civil engineering	US\$/year	3,144	3,256	3,535	3,618	3,866	3,959	4,154
OM cost of the Transmission & distribution lines	US\$/year	3,550	7,798	10,788	14,373	21,223	28,083	29,583
Total OM cost per annual	US\$/year	12,002	17,218	23,227	27,923	36,049	44,371	46,409

4) Total Cost of the MHP System

Total Investment Cost of MHP	US\$	1,772,700	2,074,900	2,478,800	2,750,700	3,227,300	3,685,700	3,840,600
Total O/M Cost of MHP	US\$/year	12,002	17,218	23,227	27,923	36,049	44,371	46,409

Item	Unit	Case1	Case2	Case3	Case4	Case5	Case6	Case7
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BENEFIT

1) Investment Cost (Diesel Generator Related)

Cost of Diesel Generator	US\$	202,500	255,000	307,500	360,000	427,500	495,000	525,000
Generation Capacity	kW	270	340	410	480	570	660	700
Cost of Generator per kW	US\$/kW	750	750	750	750	750	750	750
Cost of Automatic Transfer Switch	US\$	1,910	1,910	1,910	1,910	1,910	1,910	1,910
Cost of Protection Box	US\$	917	917	917	917	917	917	917
Building	US\$	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total Investment Cost of Diesel Generator	US\$	206,827	259,327	311,827	364,327	431,827	499,327	529,327

2) Cost of the Transmission & Distribution Lines

Cost of Transmission Lines (x 105%)	US\$	0	137,813	220,500	324,625	540,838	757,663	824,425
Length of Total Transmission Line	km	15.00	27.50	41.00	58.00	93.30	128.70	137.60
Length of Transmission Line (only for MHP)	km	15.00	5.00	5.00	5.00	5.00	5.00	3.00
Length of Transmission Line (by Diesel)	km	0.00	22.50	36.00	53.00	88.30	123.70	134.60
Cost of Transmission Line per Kilometer (without Tax)	US\$/km	5,833	5,833	5,833	5,833	5,833	5,833	5,833
Cost of Distribution Lines (without Tax)	US\$	50,157	143,500	180,400	219,692	277,433	335,004	340,471
Length of Distribution Line (by Diesel)	km	14.68	42.00	52.80	64.30	81.20	98.05	99.65
Cost of Distribution Line per Kilometer (without Tax)	US\$/km	3,417	3,417	3,417	3,417	3,417	3,417	3,417
Total Cost of Transmission & Distribution Lines	US\$	50,157	281,313	400,900	544,317	818,271	1,092,667	1,164,896

3) Fuel Cost

Diesel Oil Cost per Liter (including transportation cost, without Tax)	Bs./Liter	3.88	3.88	3.88	3.88	3.88	3.88	3.88
	US\$/Liter	0.59	0.59	0.59	0.59	0.59	0.59	0.59
For Idling Generation								
Fuel Consumption for Idling Generation (0.2 liter/hour/100kW x 7)	Liter/hour	26.30	26.30	26.30	26.30	26.30	26.30	26.30
Idling Operation Hour per day	hour/day	24	24	24	24	24	24	24
Operation days per year	day/Year	365	365	365	365	365	365	365
Annual Fuel Consumption for Idling Generation	Liter/Year	214,620	214,620	214,620	214,620	214,620	214,620	214,620
Annual fuel cost for Idling Generation	US\$/year	127,523	127,523	127,523	127,523	127,523	127,523	127,523
For Load Generation								
Fuel Consumption for Load Generation	Liter/kWh	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	869,673	1,187,345	1,426,420	1,802,857	2,152,648	2,484,920	2,680,925
Annual Fuel Consumption for Load Generation	Liter/Year	173,935	237,469	285,284	360,571	430,530	496,984	536,185
Annual fuel cost for Load Generation	US\$/year	103,549	141,099	169,510	214,245	255,812	295,298	318,591
Total Annual fuel cost	US\$/year	230,872	268,623	297,033	341,768	383,335	422,821	446,114

4) Maintenance Cost of Diesel Generator

OM Cost of Generator (% of the investment costs)	%	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Annual maintenance cost (without Building) =(Total investment costs x %)	US\$/year	10,286	12,891	15,516	18,141	21,516	24,891	26,591

5) OM Cost of Transmission & Distribution Line

OM Cost of Distribution Lines (% of the investment costs)	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Annual OM Cost of the Transmission & Distribution Line	US\$/Year	1,254	7,033	10,023	13,608	20,457	27,317	29,122

6) Total Cost of Diesel Generator & Transmission/Distribution Line

Total Investment Cost of Diesel	US\$	256,984	540,640	712,727	908,644	1,258,098	1,591,994	1,694,223
Total O/M Cost of Diesel	US\$/year	242,392	288,547	322,572	375,517	425,309	475,029	501,628

Source: UMISA and JICA Study Team

Note: All costs are economic cost (not include taxes).

Tabla 5.10 Evaluación Económica de Casos Alternativos (1/4)

Case: 1
 Install Capacity: 270 kW Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)	
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)		
-3	590,900	0	590,900		0	0	-590,900	
-2	590,900	0	590,900		0	0	-590,900	
-1	590,900	0	590,900	256,984	0	256,984	-333,916	
1		12,002	12,002		242,392	242,392	230,390	
2		12,002	12,002		242,392	242,392	230,390	
3		12,002	12,002		242,392	242,392	230,390	
4		12,002	12,002		242,392	242,392	230,390	
5		12,002	12,002		242,392	242,392	230,390	
6		12,002	12,002		242,392	242,392	230,390	
7		12,002	12,002		242,392	242,392	230,390	
8		12,002	12,002		242,392	242,392	230,390	
9		12,002	12,002		242,392	242,392	230,390	
10		12,002	12,002	206,827	242,392	449,219	437,217	
11		12,002	12,002		242,392	242,392	230,390	
12		12,002	12,002		242,392	242,392	230,390	
13		12,002	12,002		242,392	242,392	230,390	
14		12,002	12,002		242,392	242,392	230,390	
15		12,002	12,002		242,392	242,392	230,390	
16		12,002	12,002		242,392	242,392	230,390	
17		12,002	12,002		242,392	242,392	230,390	
18		12,002	12,002		242,392	242,392	230,390	
19		12,002	12,002		242,392	242,392	230,390	
20		12,002	12,002		242,392	242,392	230,390	
Total	1,772,700	240,040	2,012,740	463,811	4,847,839	5,311,650	3,298,910	
N.P.V.	1,469,481	76,769	1,546,250	404,553	1,550,428	1,903,414	257,164	
							EFRR =	13.4%
							B/C =	1.37

Case: 2
 Install Capacity: 340 kW Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)	
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)		
-3	691,633	0	691,633		0	0	-691,633	
-2	691,633	0	691,633		0	0	-691,633	
-1	691,633	0	691,633	540,640	0	540,640	-150,994	
1		17,218	17,218		288,547	288,547	271,329	
2		17,218	17,218		288,547	288,547	271,329	
3		17,218	17,218		288,547	288,547	271,329	
4		17,218	17,218		288,547	288,547	271,329	
5		17,218	17,218		288,547	288,547	271,329	
6		17,218	17,218		288,547	288,547	271,329	
7		17,218	17,218		288,547	288,547	271,329	
8		17,218	17,218		288,547	288,547	271,329	
9		17,218	17,218		288,547	288,547	271,329	
10		17,218	17,218	259,327	288,547	547,874	530,656	
11		17,218	17,218		288,547	288,547	271,329	
12		17,218	17,218		288,547	288,547	271,329	
13		17,218	17,218		288,547	288,547	271,329	
14		17,218	17,218		288,547	288,547	271,329	
15		17,218	17,218		288,547	288,547	271,329	
16		17,218	17,218		288,547	288,547	271,329	
17		17,218	17,218		288,547	288,547	271,329	
18		17,218	17,218		288,547	288,547	271,329	
19		17,218	17,218		288,547	288,547	271,329	
20		17,218	17,218		288,547	288,547	271,329	
Total	2,074,900	344,360	2,419,260	799,967	5,770,934	6,570,901	4,151,641	
N.P.V.	1,719,990	110,133	1,830,122	705,810	1,845,651	2,326,959	496,836	
							EFRR =	14.2%
							B/C =	1.37

Tabla 5.10 Evaluación Económica de Casos Alternativos (2/4)

Case: 3
 Install Capacity: 410 kW Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
-3	826,267	0	826,267		0	0	-826,267
-2	826,267	0	826,267		0	0	-826,267
-1	826,267	0	826,267	712,727	0	712,727	-113,540
1		23,227	23,227		322,572	322,572	299,345
2		23,227	23,227		322,572	322,572	299,345
3		23,227	23,227		322,572	322,572	299,345
4		23,227	23,227		322,572	322,572	299,345
5		23,227	23,227		322,572	322,572	299,345
6		23,227	23,227		322,572	322,572	299,345
7		23,227	23,227		322,572	322,572	299,345
8		23,227	23,227		322,572	322,572	299,345
9		23,227	23,227		322,572	322,572	299,345
10		23,227	23,227	311,827	322,572	634,399	611,172
11		23,227	23,227		322,572	322,572	299,345
12		23,227	23,227		322,572	322,572	299,345
13		23,227	23,227		322,572	322,572	299,345
14		23,227	23,227		322,572	322,572	299,345
15		23,227	23,227		322,572	322,572	299,345
16		23,227	23,227		322,572	322,572	299,345
17		23,227	23,227		322,572	322,572	299,345
18		23,227	23,227		322,572	322,572	299,345
19		23,227	23,227		322,572	322,572	299,345
20		23,227	23,227		322,572	322,572	299,345
Total	2,478,800	464,540	2,943,340	1,024,554	6,451,443	7,475,997	4,532,657
N.P.V.	2,054,803	148,568	2,203,371	905,642	2,063,290	2,669,097	485,726
						EIRR =	13.2%
						B/C =	1.22

Case: 4
 Install Capacity: 480 kW Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
-3	918,900	0	918,900		0	0	-918,900
-2	918,900	0	918,900		0	0	-918,900
-1	918,900	0	918,900	908,644	0	908,644	-8,256
1		27,923	27,923		373,517	373,517	345,594
2		27,923	27,923		373,517	373,517	345,594
3		27,923	27,923		373,517	373,517	345,594
4		27,923	27,923		373,517	373,517	345,594
5		27,923	27,923		373,517	373,517	345,594
6		27,923	27,923		373,517	373,517	345,594
7		27,923	27,923		373,517	373,517	345,594
8		27,923	27,923		373,517	373,517	345,594
9		27,923	27,923		373,517	373,517	345,594
10		27,923	27,923	364,327	373,517	737,844	709,921
11		27,923	27,923		373,517	373,517	345,594
12		27,923	27,923		373,517	373,517	345,594
13		27,923	27,923		373,517	373,517	345,594
14		27,923	27,923		373,517	373,517	345,594
15		27,923	27,923		373,517	373,517	345,594
16		27,923	27,923		373,517	373,517	345,594
17		27,923	27,923		373,517	373,517	345,594
18		27,923	27,923		373,517	373,517	345,594
19		27,923	27,923		373,517	373,517	345,594
20		27,923	27,923		373,517	373,517	345,594
Total	2,750,700	558,460	3,309,160	1,272,971	7,470,337	8,743,308	5,434,148
N.P.V.	2,280,195	178,606	2,458,800	1,127,136	2,389,151	3,177,361	718,560
						EIRR =	14.9%
						B/C =	1.28

Tabla 5.10 Evaluación Económica de Casos Alternativos (3/4)

Case: 5
 Install Capacity: 570 kW Discount Rate = 10%

Year	Cost (MFP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
-3	1,075,767	0	1,075,767		0	0	-1,075,767
-2	1,075,767	0	1,075,767		0	0	-1,075,767
-1	1,075,767	0	1,075,767	1,250,098	0	1,250,098	174,331
1		36,049	36,049		425,309	425,309	389,260
2		36,049	36,049		425,309	425,309	389,260
3		36,049	36,049		425,309	425,309	389,260
4		36,049	36,049		425,309	425,309	389,260
5		36,049	36,049		425,309	425,309	389,260
6		36,049	36,049		425,309	425,309	389,260
7		36,049	36,049		425,309	425,309	389,260
8		36,049	36,049		425,309	425,309	389,260
9		36,049	36,049		425,309	425,309	389,260
10		36,049	36,049	430,327	425,309	855,636	819,587
11		36,049	36,049		425,309	425,309	389,260
12		36,049	36,049		425,309	425,309	389,260
13		36,049	36,049		425,309	425,309	389,260
14		36,049	36,049		425,309	425,309	389,260
15		36,049	36,049		425,309	425,309	389,260
16		36,049	36,049		425,309	425,309	389,260
17		36,049	36,049		425,309	425,309	389,260
18		36,049	36,049		425,309	425,309	389,260
19		36,049	36,049		425,309	425,309	389,260
20		36,049	36,049		425,309	425,309	389,260
Total	3,227,300	720,980	3,948,280	1,680,425	8,506,172	10,186,597	6,238,317
N.P.V.	2,675,272	230,583	2,905,855	1,492,095	2,720,430	3,784,297	878,442
						EIRR =	15.7%
						B/C =	1.38

Case: 6
 Install Capacity: 660 kW Discount Rate = 10%

Year	Cost (MFP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
-3	1,228,567	0	1,228,567		0	0	-1,228,567
-2	1,228,567	0	1,228,567		0	0	-1,228,567
-1	1,228,567	0	1,228,567	1,591,994	0	1,591,994	363,427
1		44,371	44,371		475,029	475,029	430,658
2		44,371	44,371		475,029	475,029	430,658
3		44,371	44,371		475,029	475,029	430,658
4		44,371	44,371		475,029	475,029	430,658
5		44,371	44,371		475,029	475,029	430,658
6		44,371	44,371		475,029	475,029	430,658
7		44,371	44,371		475,029	475,029	430,658
8		44,371	44,371		475,029	475,029	430,658
9		44,371	44,371		475,029	475,029	430,658
10		44,371	44,371	489,327	475,029	974,356	929,985
11		44,371	44,371		475,029	475,029	430,658
12		44,371	44,371		475,029	475,029	430,658
13		44,371	44,371		475,029	475,029	430,658
14		44,371	44,371		475,029	475,029	430,658
15		44,371	44,371		475,029	475,029	430,658
16		44,371	44,371		475,029	475,029	430,658
17		44,371	44,371		475,029	475,029	430,658
18		44,371	44,371		475,029	475,029	430,658
19		44,371	44,371		475,029	475,029	430,658
20		44,371	44,371		475,029	475,029	430,658
Total	3,685,700	887,420	4,573,120	2,091,321	9,500,588	11,591,908	7,018,788
N.P.V.	3,055,263	283,813	3,339,077	1,859,934	3,038,462	4,379,188	1,040,111
						EIRR =	15.7%
						B/C =	1.38

Tabla 5.10 Evaluación Económica de Casos Alternativos (4/4)

Case: 7
 Install Capacity: 700 kW
 Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
-3	1,280,200	0	1,280,200		0	0	-1,280,200
-2	1,280,200	0	1,280,200		0	0	-1,280,200
-1	1,280,200	0	1,280,200	1,694,223	0	1,694,223	414,023
1		46,409	46,409		501,628	501,628	455,219
2		46,409	46,409		501,628	501,628	455,219
3		46,409	46,409		501,628	501,628	455,219
4		46,409	46,409		501,628	501,628	455,219
5		46,409	46,409		501,628	501,628	455,219
6		46,409	46,409		501,628	501,628	455,219
7		46,409	46,409		501,628	501,628	455,219
8		46,409	46,409		501,628	501,628	455,219
9		46,409	46,409		501,628	501,628	455,219
10		46,409	46,409	529,327	501,628	1,030,955	984,546
11		46,409	46,409		501,628	501,628	455,219
12		46,409	46,409		501,628	501,628	455,219
13		46,409	46,409		501,628	501,628	455,219
14		46,409	46,409		501,628	501,628	455,219
15		46,409	46,409		501,628	501,628	455,219
16		46,409	46,409		501,628	501,628	455,219
17		46,409	46,409		501,628	501,628	455,219
18		46,409	46,409		501,628	501,628	455,219
19		46,409	46,409		501,628	501,628	455,219
20		46,409	46,409		501,628	501,628	455,219
Total	3,840,600	928,180	4,768,780	2,223,550	10,032,552	12,256,102	7,487,322
N.P.V.	3,183,668	296,849	3,480,517	1,977,663	3,208,594	4,634,816	1,154,299
						EFRR =	16.1%
						B/C =	1.33

Note) Replacement cost of diesel generator at 10 year is assumed as amount of
 1. new diesel generator, 1. Automatic transfer switch, 1. protection box.

Tabla 5.11 Costo de Construcción de Obras Civiles, Eléctricas y Mecánicas de la MCH de Apolo (Detalles para Pre-F/S) (1/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Case (700kW) Quantity	Amount	Note
Maximum Discharge Qmax			1,815		
Effective Head He			51.70		See Effective Head Calculation
Installed Capacity P			700		$9.8 * Q_{max} * He * hc_{hc} = 0.761$
Turbine Number n (max=2)			2		
Type of Turbine			FR	Fracs	
3. Civil Works					
3.1 Intake Weir					
Height H	m		1.0		Excavation height = 1.5 - 2.5
Length L	m		21.5		
Excavation (Intake part)	m ³	65.00	64.0	4,160	$(L+L2)/2 * H * L = (2.3+4.1)/2 * 2.0 * 10.0$
Excavation (Stop Log part)	m ³	65.00	44.0	2,860	$H * B * L = 0.5 * 6.0 * 11.0$
Concrete (Intake part)	m ³	280	22.0	6,160	$T * (B+H1+H2) * L = 0.5 * (1.6+1.6+1.1) * 10$
Concrete (Stop Log part)	m ³	280	14.0	3,920	(Base): $T * B * L = 0.5 * 2.0 * 11$, (Gate Post): $(H * B * T) * sets = (2 * 0.75 * 0.5) * 4$
Reinforcement Bar	t	1,200	1.8	2,160	0.050 * Vc
Sub Total				19,280	
3.2 Intake					
Length L	m		5.0		
Excavation (rock, with dinamite)	m ³	65.00	44.0	2,860	$(L1+L2)/2 * H * L = (2.0+5)/2 * 2.5 * 5$
Concrete (water way)	m ³	280	17.5	4,900	$(B_{outside} * H_{inside}) * L = ((2.0 * 2.5) - (1.0 * 1.5)) * 5 = 3.5 m^3 / m * 5 m$
Concrete (gate control tower)	m ³	280	9.0	2,520	$(3.5 + 2.5) * 0.5 * 3$
Concrete (flood wall)	m ³	280	22.5	6,300	$1/2 * (9+6) * 3 * 2 * 0.5$
Reinforcement Bar	t	1,200	2.5	3,000	0.050 * Vc
Sub Total				19,580	
3.3 Sand Settling Basin					
Sub Total				0	Sand settling basin is substitute at headtank.
3.4 Headrace					
1) Open Conduit					
Length Loc	m		0.0		Headrace channel (open conduit) is not used.
Sub Total				0	
2) Tunnel (Free Flow)					
Waterdepth (plan)	m		0.5		
Width	m		1.2		
Height	m		1.8		$H1 + H2 = 0.2 + 1.6$
Length Lt	m		143.0		
Excavation (rock, with dinamite)	m ³	600	292.0	175,200	$(B+H1/2+B*H2) * Lt = (1.2 * 0.2/2 + 1.2 * 1.6) * 143$
Concrete	m ³	280	66.0	18,480	(Side: $T * H * 2 = 0.1 * 1.5 * 2 + Bottom: T * B = 0.2 * 0.8) * Lt$
Reinforcement Bar	t	1,200	1.3	1,560	0.020 t/m ³ * Vc
Sub Total				195,240	

Tabla 5.11 Costo de Construcción de Obras Civiles, Eléctricas y Mecánicas de la MCH de Apolo (Detalles para Pre-F/S) (2/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Gase (700kW) Quantity	Amount	Note
3.5 Head Tank					
Excavation (common excavation)	m ³	9.00	600.0	5,400.0	$(B*H)/(2*W) = (14*14)/(2*6.0) + \text{alfa}$
Concrete (Side wall)	m ³	280	173.5	48,580.0	$[(12+16)/2*H] + (20+21)/2*3* T0.5 * 2*set$
Concrete (Downstream side wall)	m ³	280	27.5	7,700.0	$B*H*T = 5.0*1*0.5$
Concrete (Upstream side wall)	m ³	280	21.0	5,880.0	$(10+4)*3*T0.5$
Concrete (Bottom)	m ³	280	145.0	40,600.0	$(1/2*B1*H1*T1) + (1/2*B2*H2*T2) = (1/2*6*3*5) + (1/2*8*5*5)$
Reinforcement Bar	t	1,200	3.7	4,440.0	0.010*Vc
Sub Total				112,600.0	
3.6 Penstock					
Diameter Dp	m		1.11		0.888*Qpmax ^{0.375}
Length Lp	m		74.0		
Excavation (common excavation)	m ³	9.00	243.0	2,187.0	$(1/2*(B1+B2)*H1 + 1/2*B2*H2)*Lp = (1/2*(2.3+3.2)*0.9 + 1/2*(3.2*0.5)*7.4$
Concrete (Invert.)	m ³	280	20.0	5,600.0	$[T*(B1+H)] * L = [0.1*(2.3+0.15)] * 66$
Concrete (Support anchor block)	m ³	280	6.0	1,680.0	$(B*H*W) * set = (1.2*1.1*0.5) * 8$
Concrete (Bottom anchor block) (diverging pipe anchor)	m ³	280	83.0	23,240.0	$(B1-L1)*H1*(B1+2L1)/2 + (B2-L2)*H2*(B2+2L2)/2 + (L1-L2)*H1*(B1+L1+L2)/2 + (L1-L2)*H2*(B2+L2+L1+L2)/2 + (L1-L2)*H1*(B1+L1+L2)/2 + (L1-L2)*H2*(B2+L2+L1+L2)/2$
Reinforcement Bar	t	1,200	2.2	2,640.0	0.020*Vc
Sub Total				35,347.0	
3.7 Spillway					
Average Slope i			10		
Diameter Ds	m		0.8		$0.394*(Qpmax / i^{0.369})^{0.375}$
Length Ls	m		65.0		
Excavation (common excavation)	m ³	9.00	440.0	3,960.0	$9.87*D_s^{2.67} * L_s$
Foundation (mix cement)	m ³	70	124.0	8,680.0	$2.78*D_s^{1.76} * L_s$
Sub Total				12,640.0	
3.8 Power House					
1) Foundation Works					
Excavation (common excavation)	m ³	9.00	690.0	6,210.0	$1/2*(H1+H2)*B1*L = 1/2*(4.5+3.0)*8 * 23$
Foundation (foundation of power hc (mix cement))	m ³	70	315.0	22,050.0	$[1/2*(H1+H2)*B*L] * 2 = [1/2*(2.0+4.0)*7.0*7.5]*2$
Concrete (RC, floorboard)	m ³	280	184.0	51,520.0	$B*L*H = 8.0*23.0*1.0$
Reinforcement Bar	t	1,200	1.0	1,200.0	0.005*Vc
Concrete (RC, partition wall for tailrace from two turbine)	m ³	280	14.0	3,920.0	$H*B*T = 4.0*7.0*0.5$
Concrete (RC, bottom tank)	m ³	280	98.0	27,440.0	Side wall: $(B-L)*2*H*T + \text{Bottom: } B*L*T = (7.5+8.0)*2*4*0.5 + 8.0*9.0*0.5$
Reinforcement Bar	t	1,200	1.2	1,440.0	0.010*Vc

Tabla 5.11 Costo de Construcción de Obras Civiles, Eléctricas y Mecánicas de la MCH de Apolo (Detalles para Pre-F/S) (3/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Case Quantity	Pre-F/S Case Amount (700kW)	Note
2) Power House (Building)	L.S.			39,916	
Wooden Window	m ²	75	100	7500 (B*H) *set = (1.0*1.0) * 10	
Wooden Door	m ²	135	80	10800 (B*H) *set = (2.0*2.0) * 2	
Loof (Calamine Cover)	m ²	23	2400	5220 B*L = 10*24	
Brick Wall	m ²	15	5185	7778 (B-L)*2*(H1+H2)/2 = (7.5*23)*3*(9+8)/2	
Covering Tile	m ²	24	1650	3960 B*L = 7.5*220	
Structural Steel Frame (H-shape)	m	50	1940	9700 H*set + B*set + L*set = 12*6 + 7.5*4 + 23*4	
Crane (chain winch, 20t)	L.S.	7000	1	7000 assumed	
Installation of Sanitary	L.S.	500	1	500	
Others				3,628 10% of Power house cost	
Sub Total				153,696	
3.9 Tailrace					
Length	m		5.0		
Excavation (common excavation)	m ³	9.00	180.0	1,620 1/2*H3*B2*L = 1/2*3.0*5.0 * 23	
Foundation (mix cement)	m ³	70	180.0	12,600 1/2*H3*B2*L = 1/2*3.0*5.0 * 23	
Sub Total				14,220	
4(a) Electrical Works					
4.1 Turbine/Generator					
Type of Turbine			Francis		
Number of Turbine n			2		
Unit Capacity per one Turbine			350		
Unit Cost of Turbine&Generator			370,000		Francis Turbine Made in Sweden (TURAB) (350kW) SEK 2,000,000+40% Tax+\$110,000/unit
Sub Total				740,000	
4.2 Transmission/Distribution Line					
Transmission Line	km	7,000	137.60	1,011,360 plane length [km] * 105% * unit cost	
Benefit. Household	HH		1,993		
Distribution Line	km	4,100	99.65	408,565 50 m/Household * 2000 HH* unit cost	
Sub Total				1,419,925	
4.3 Mechanical Works					
4.3.1 Intake Weir					
Stop Log Gate (steel plate)	m ²	320	6.8	2,160 (B*L) * set = (3*0.75) * 3set	
4.3.2 Intake					
Screen	m ²	500	15.0	7,500 B*L = 1.5*10	
Intake Gate (Electrical Automatic Control)	t	700,000	1.7	170,000 1.27*(Dc/2 * Qmax) ^{0.85}	
4.3.3 Head Tank					
Sand Flushout Gate	pce	3,000	1.0	3,000	
4.3.4 Penstock					
Thickness tp	mm		6.0	tp = [D(mm) + 400] / 800, tp >= 6 mm	
Weight	t		12.2	* * D * t * 7.85 * Lp	
Diameter Dp	m		1.11	0.888 * Qmax ^{0.75}	
Length	m	500	740	37,000	
Sub Total				219,660	

Tabla 5.12 Costo de Construcción de la MCH de Apolo (Pre-F/S)

Financial Cost (With Tax)

Unit : US\$.

Item	Pre-F/S Case (700kW)	Note
1. Preparation Works & Access, etc.	625,500	
1.1 Preparation Works	294,200	(2.+3.).*10%
1.2 Access Road	325,500	Gravel Paved, W=4m (Sta.Teresa - Site)
1.3 Mitigation for Environment	5,600	2.*0.01
2. Civil Works	562,500	
2.1 Intake Weir	19,300	
2.2 Intake	19,600	
2.3 Sand Settling Basin	0	
2.4 Headrace	195,200	
2.5 Head Tank	112,600	
2.6 Penstock	35,300	
2.7 Spillway	12,600	
2.8 Power House	153,700	
2.9 Tailrace	14,200	
2.10 Outlet	0	
3. Electric and Mechanical Works	2,379,600	
3.1 Turbine/Generator	740,000	350kW x 2 set, include tax, transportation, installation
3.2 Transmission/Distribution Line	1,419,900	
3.3 Mechanical Works	219,700	
4. Transportation	110,100	(2.+3.2.+3.3)*5% (La Paz - Apolo - Site)
5.Direct Cost Total	3,677,500	1.+2.+3.+4.
6. Administration and Engineering Service.	323,000	(Admin.: (1.+2.+3.)*6%+D/D: US\$20,000)*138%
Total Construction Cost	4,000,500	4. + 5.

Note: Access Road Cost = Mountain Area (Rock): 9.1km*30,000 US\$/km + Flat Area (Shoulder): 3.5km*15,000US\$/km

Economic Cost (Without Tax)

Unit : US\$.

Item	Pre-F/S Case (700kW)	Note
1. Preparation Works & Access, etc.	539,000	
1.1 Preparation Works	253,600	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
1.2 Access Road	280,600	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
1.3 Mitigation for Environment	4,800	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2. Civil Works	484,900	
2.1 Intake Weir	16,600	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.2 Intake	16,900	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.3 Sand Settling Basin	0	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.4 Headrace	168,300	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.5 Head Tank	97,100	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.6 Penstock	30,400	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.7 Spillway	10,900	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.8 Power House	132,500	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.9 Tailrace	12,200	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.10 Outlet	0	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
3. Electric and Mechanical Works	2,006,300	
3.1 Turbine/Generator	633,600	(cost with tax) / 1.1679
3.2 Transmission/Distribution Line	1,183,300	(cost with tax) / 1.20
3.3 Mechanical Works	189,400	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
4. Transportation	94,900	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
5.Direct Cost Total	3,125,100	
6. Administration and Engineering Service.	278,400	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
Total Construction Cost	3,403,500	

Tabla 5.13 Costo del Proyecto de la MCH de Apolo (Pre-F/S)

(Costo de Construcción + O&M)

Item	Unit	Pre-F/S Case (700kW)
Exchange Rate (as of May 23, 2001)	Bs./US\$	6.53
Install Capacity P	kW	700
Annual Demand Energy (Based on the estimated daily load curve of deemed energy)	kWh/year	2,680,925

COST

1) Cost of the Micro-hydro:

Micro-hydro:

Preparation Works	US\$	539,000
Civil works (including engineering)	US\$	484,900
Electric Works (Turbine&Generator)	US\$	633,600
Mechanical Works	US\$	189,400
Transportation	US\$	94,900
Administration and Engineering Service.	US\$	278,400
Total initial investment cost of MHP	US\$	2,220,200

2) Cost of the Distribution Lines

Cost of Transmission & Distribution Line	US\$	1,183,300
Total costs of Transmission & distribution lines	US\$	1,183,300

3) Operation & Maintenance Cost

OM Cost of the Electromechanical Equipment (% of investment)	%	2.0
OM Cost of the Civil Engineering (% of investment)	%	0.5
OM Cost of the Transmission & Distribution Lines (% of investment)	%	2.5
OM cost for the electromechanical equipment	US\$/year	12,672
OM cost for civil engineering	US\$/year	2,425
OM cost of the Transmission & distribution lines	US\$/year	29,583
Total OM cost per annual	US\$/year	44,679

4) Total Cost of the MHP System

Total Investment Cost of MHP	US\$	3,403,500
Total O/M Cost of MHP	US\$/year	44,679

Tabla 5.14 Costo del Beneficio de la MCH de Apolo (Pre-F/S)
(Costo de Diesel + O&M)

Item	Unit	Pre-F/S Case (700kW)
BENEFIT		
1) Investment Cost (Diesel Generator Related)		
Cost of Diesel Generator	US\$	525,000
Generation Capacity	kW	700
Cost of Generator per kW	US\$/kW	750
Cost of Automatic Transfer Switch	US\$	1,910
Cost of Protection Box	US\$	917
Building	US\$	1,500
Total Investment Cost of Diesel Generator	US\$	529,327
2) Cost of the Transmission & Distribution Lines		
Cost of Transmission Lines (x 105%)	US\$	824,425
Length of Total Transmission Line	km	137.60
Length of Transmission Line (only for MHP)	km	3.00
Length of Transmission Line (by Diesel)	km	134.60
Cost of Transmission Line per Kilometer (without Tax)	US\$/km	5,833
Cost of Distribution Lines (without Tax)	US\$	340,471
Length of Distribution Line (by Diesel)	km	99.65
Cost of Distribution Line per Kilometer (without Tax)	US\$/km	3,417
Total Cost of Transmission & Distribution Lines	US\$	1,164,896
3) Fuel Cost		
Diesel Oil Cost per Litter (including transportation cost, without Tax) Bs. 4.5/Litter /1.16	Bs./Litter	3.88
	US\$/Litter	0.59
For Idling Generation		
Fuel Consumption for Idling Generation (0.2 litter/hour/100kW x 7)	Litter/hour	24.50
Idling Operation Hour per day	hour/day	24
Operation days per year	day/Year	365
Annual Fuel Consumption for Idling Generation	Litter/Year	214,620
Annual fuel cost for Idling Generation	US\$/year	127,523
For Load Generation		
Fuel Consumption for Load Generation	Litter/kWh	0.20
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	2,489,925
Annual Fuel Consumption for Load Generation	Litter/Year	536,185
Annual fuel cost for Load Generation	US\$/year	318,591
Total Annual fuel cost	US\$/year	446,114
4) Maintenance Cost of Diesel Generator		
OM Cost of Generator (% of the investment costs)	%	5.0
Annual maintenance cost (without Building) =(Total investment costs x 0.05)	US\$/year	26,391
5) OM Cost of Transmission & Distribution Line		
OM Cost of Distribution Lines (% of the investment costs)	%	2.5
Annual OM Cost of the Transmission & Distribution Line	US\$/Year	29,122
6) Total Cost of Diesel Generator & Transmission/Distribution Line		
Total Investment Cost of Diesel	US\$	1,694,223
Total O/M Cost of Diesel	US\$/year	501,628

Source: UMSA and JICA Study Team

Note: All costs are economic cost (not include taxes).

Tabla 5.15 TIR (Tasa Economica Interna de Retorno) para Proyecto del Project MCH en Apolo (La Paz) [Unidad: US\$]

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Benefit																							
Investment																							
Diesel Generator			525,000										525,000										
Automatic Transfer Switch			1,910										1,910										
Protection Box			917										917										
Building			1,500										1,500										
Transmission Lines			824,425																				
Distribution Lines			340,471																				
OM Cost																							
OM Cost of the Diesel Generator, etc.				26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391	26,391
OM Cost of the Distribution Lines				29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122	29,122
Final cost				446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114	446,114
Total Benefit			1,694,223	501,628	501,628	501,628	501,628	501,628	501,628	501,628	501,628	501,628	1,000,955	501,628	501,628	501,628	501,628	501,628	501,628	501,628	501,628	501,628	501,628
Cost																							
Investment																							
Preparation Works and Access, etc.			179,667																				
Civil Works			161,633																				
Turbine/Generator			211,200																				
Transmission/Distribution Lines			394,433																				
Mechanical Works			63,133																				
Transportation			31,633																				
Administration and Engineering Service			92,800																				
OM Cost																							
Turbine/Generator				12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672	12,672
Civil Works				2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425	2,425
Transmission/Distribution Lines				29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583	29,583
Total Cost			1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500	1,134,500
Balance			559,723	456,949	456,949	456,949	456,949	456,949	456,949	456,949	456,949	456,949	986,276	456,949	456,949	456,949	456,949	456,949	456,949	456,949	456,949	456,949	456,949
EIRR			19.2%																				

Tabla 6.1 Consumo de electricidad por usuario en Tambo Quemado (Actual)

Category (1)	Category (2)	Items	No. of unit	Potential per Unit (Watt)	Potential per House /Office (Watt)	Fraction Period of connection (% /hour / connect-d)																								
						Day time												Evening												
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Domestic	Residential House (Large) (Office)	60W Light	3	12	36																									
		Radio	2	30	60																									
		TV (25" color)	1	120	120																									
	Residential House (Small)	Hot water Shower	1	5,000	5,000																									
		CF Light	3	12	36																									
		60W Light	2	60	120																									
	Residential House (Small) (Small Café/ Resturante-Small)	Radio	2	30	60																									
		TV (15" color)	1	60	60																									
		Hot water Shower	1	5,000	5,000																									
		SUB-TOTAL			5,316																									
Business	Offices (Large)	CF Light	5	12	60																									
		80W Light	2	60	120																									
		Computer Set	3	125	465																									
	Offices (Small)	Printer/Copy	1	500	500																									
		VCR	1	120	120																									
		Heater	3	1,000	3,000																									
		SUB-TOTAL			4,305																									
	Café / Resturante (Large)	CF Light	3	12	36																									
		60W Light	2	60	120																									
		Computer Set	1	155	155																									
Café / Resturante (Small)	Printer/Copy	1	500	500																										
	Heater	2	1,000	2,000																										
	Radio	1	30	30																										
	SUB-TOTAL			3,831																										
Store (Large)	CF Light	5	12	60																										
	60W Light	2	60	120																										
	Stereo	1	55	55																										
	Radio	1	30	30																										
	SUB-TOTAL			373																										
Public	CF Light	2	12	24																										
	40W Light	1	40	40																										
	Radio	1	20	20																										
	TV (15" color)	1	60	60																										
	SUB-TOTAL			144																										
Industry	Furniture (Sawing, etc.)	CF Light	3	12	36																									
		Sawing Machine	1	75	75																									
	Iron	1	400	400																										
		SUB-TOTAL			511																									
	Public	Equipment of x-ray	1	2,000	2,000																									
	Sterilize	1	500	500																										
	Cement/Bage	1	200	200																										
	CF Light	4	13	48																										
	60W Light	4	60	240																										
	Other	1	800	800																										
	SUB-TOTAL			3,798																										
	Street Light (200m x 100w/lm)	1	320	320																										
	SUB-TOTAL			320																										
	TOTAL			28,206																										

Tabla 6.3 Estimación del Consumo de Electricidad en Tambo Quemado (Futuro)

Category (1)	Category (2)	Means	No. of unit	Potential per Unit /Office (Watt) (KWatt)	Fraction Period of operation (%/hour/segment)																													
					Midnight						Peak Hour						Day time												Evening					
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Domestic	Residential House (Large) (Office)	CF Light	3	12	36	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00					
		60W Light	2	60	120																													
		Radio	2	20	40																													
		TV (25" color)	1	120	120																													
		Hot water Shower	1	5,000	5,000																													
	Residential House (Large) (Large Restaurant)	SUB-TOTAL			5,316																													
		CF Light	3	12	36																													
		60W Light	2	60	120																													
		Radio	2	20	40																													
		TV (25" color)	1	120	120																													
Business	Office (Large)	Hot water Shower	1	5,000	5,000																													
		SUB-TOTAL			5,144																													
		CF Light	5	12	60																													
		60W Light	2	60	120																													
		Computer Set	5	155	465																													
	Office (Small)	Printer/Copy	1	500	500																													
		VCR	1	120	120																													
		Refrigerator	3	1,000	3,000																													
		Radio	2	20	40																													
		SUB-TOTAL			4,208																													
Industry	Cafe/Restaurant (Large)	CF Light	3	12	36																													
		60W Light	2	60	120																													
		Computer Set	1	155	155																													
		Printer/Copy	1	500	500																													
		Refrigerator	2	1,000	2,000																													
	Cafe/Restaurant (Small)	Radio	1	20	20																													
		SUB-TOTAL			2,831																													
		CF Light	3	12	36																													
		60W Light	2	60	120																													
		Stereo	1	55	55																													
Public	Cafe/Restaurant (Small)	Radio	1	20	20																													
		TV (15" color)	1	120	120																													
		SUB-TOTAL			373																													
		CF Light	2	12	24																													
		60W Light	2	60	120																													
	Shore (beach)	Radio	1	20	20																													
		TV (19" color)	1	60	60																													
		SUB-TOTAL			224																													
		CF Light	3	12	36																													
		60W Light	2	60	120																													
TOTAL	Industry	TV (19" color)	1	60	60																													
		SUB-TOTAL			226																													
		CF Light	3	12	36																													
		Sawing Machine	1	75	75																													
		SUB-TOTAL			7,971																													
	Public	Iron	1	400	400																													
		SUB-TOTAL			511																													
		Equipment of key	1	2,000	2,000																													
		Sterilize	1	500	500																													
		SUB-TOTAL			3,778																													
TOTAL	TOTAL	Street Light (200m x 1600w/lamp)	1	320	320																													
		SUB-TOTAL			28,336																													
		CF Light	3	12	36																													
		Sawing Machine	1	75	75																													
		SUB-TOTAL			320																													

Tabla 6.5 Costo Preliminar de Construcción para Casos Alternativos en la MCH de Tambo Quemado
Financial Cost (With Tax)

Item	Case1	Case2	Case3	Case4	Case5	Note
	40kW MHP + Diesel	50kW MHP + Diesel	50kW GHP with Pond + Diesel	62kW MHP + Diesel	62kW MHP with Pond	
1. Preparation Works & Access, etc.	1,600	1,800	2,000	2,000	2,200	
1.1 Preparation Works	800	900	1,000	1,000	1,100	2.1%
1.2 Access Road	0	0	0	0	0	
1.3 Mitigation for Environment	800	900	1,000	1,000	1,100	2.1%
2. Civil Works	84,700	91,100	98,500	100,200	114,800	
2.1 Intake Weir	100	100	100	100	100	
2.2 Intake	100	100	100	100	100	
2.3 Sand Settling Basin	0	0	0	0	0	
2.4 Headrace	66,500	71,300	71,300	77,900	77,900	
2.5 Head Tank	3,200	3,700	11,100	4,500	19,100	
2.6 Penstock	10,900	12,000	12,000	13,700	13,700	
2.7 Spillway	500	500	500	500	500	
2.8 Power House	3,100	3,100	3,100	3,100	3,100	
2.9 Tailrace	300	300	300	300	300	
2.10 Outlet	0	0	0	0	0	
3. Electric and Mechanical Works	79,500	81,400	81,400	92,800	92,800	
3.1 Turbine/Generator	32,300	31,500	31,500	38,700	38,700	Perfor. 62kW x 1 set, include tax, transportation, installation
3.2 Transmission/Distribution Line	26,100	26,100	26,100	26,100	26,100	
3.3 Mechanical Works	21,100	23,800	23,800	28,000	28,000	
4. Transportation	8,200	8,600	9,000	9,700	10,400	(2.+3.)*5%
5. Direct Cost Total	174,000	182,900	190,900	204,700	226,200	1.+2.+3.+4.
6. Administration and Engineering Service.	17,900	18,600	19,200	20,300	21,500	{Admin. (1.+2.+3.)*6%+D/D by(NGO: US\$3,000)*1.38%
Total Construction Cost	191,900	201,500	210,100	225,000	247,700	5.+6.

Note: Access Road Cost = Mountain Area (Rocky) 9.1km*30,000 US\$/km + Flat Area (Standard) 3.3km*15,000 US\$/km

Economic Cost (Without Tax)

Item	Case1	Case2	Case3	Case4	Case5	Note
	40kW MHP + Diesel	50kW MHP + Diesel	50kW GHP with Pond + Diesel	62kW MHP + Diesel	62kW MHP with Pond	
1. Preparation Works & Access, etc.	1,400	1,600	1,800	1,800	1,800	
1.1 Preparation Works	700	800	900	900	900	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
1.2 Access Road	0	0	0	0	0	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
1.3 Mitigation for Environment	700	800	900	900	900	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2. Civil Works	73,100	78,600	85,000	86,500	99,100	
2.1 Intake Weir	100	100	100	100	100	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.2 Intake	100	100	100	100	100	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.3 Sand Settling Basin	0	0	0	0	0	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.4 Headrace	57,300	61,500	61,500	67,200	67,200	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.5 Head Tank	2,800	3,200	9,600	3,900	16,500	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.6 Penstock	9,400	10,300	10,300	11,800	11,800	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.7 Spillway	400	400	400	400	400	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.8 Power House	2,700	2,700	2,700	2,700	2,700	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.9 Tailrace	300	300	300	300	300	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
2.10 Outlet	0	0	0	0	0	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
3. Electric and Mechanical Works	67,700	69,300	69,300	79,000	79,000	
3.1 Turbine/Generator	27,700	27,000	27,000	33,100	33,100	(cost with tax) / 1.1679
3.2 Transmission/Distribution Line	21,800	21,800	21,800	21,800	21,800	(cost with tax) / 1.20
3.3 Mechanical Works	18,200	20,500	20,500	24,100	24,100	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
4. Transportation	7,100	7,400	7,800	8,400	9,000	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
5. Direct Cost Total	149,300	156,900	162,900	175,700	188,900	
6. Administration and Engineering Service.	15,400	16,000	16,600	17,300	18,500	(cost with tax) / (1+IVA 13%+IT 3%) 1.16
Total Construction Cost	164,700	172,900	180,500	193,000	207,400	

Tabla 6.6 Costo Preliminar del Proyecto para Casos Alternativos de la MCH de Tambo Quemado

Item	Unit	Case1	Case2	Case3	Case4	Case5
		MHP +Diesel	MHP +Diesel	MHP with Pond +Diesel	MHP +Diesel	MHP with Pond
Type of Power Generation						
Exchange Rate (as of May 23, 2001)	Bs./US\$	6.53	6.53	6.53	6.53	6.53
Install Capacity P	kW	40	50	50	62	62
Annual Demand Energy (Based on the estimated daily load curve of demand energy)	kWh/year	181,147	181,147	181,147	181,147	181,147
COST						
1) Investment Cost of MHP						
Cost of the Micro-hydro:						
Preparation Works	US\$	1,400	1,600	1,800	1,800	1,800
Civil works	US\$	73,100	78,600	85,000	86,500	99,100
Mechanical Works	US\$	18,200	20,500	20,500	24,100	24,100
Turbine/Generator	US\$	27,700	27,000	27,000	33,100	33,100
Transportation	US\$	7,100	7,400	7,800	8,400	9,000
Administration and Engineering Service	US\$	15,400	16,000	16,600	17,500	18,500
Total initial investment cost of MHP (without Transmission Line)	US\$	142,900	151,100	158,700	171,400	185,600
2) Investment Cost of Diesel Generator						
Cost of the Diesel Generator:						
Cost of Diesel Generator	US\$	16,500	16,500	9,000	18,750	0
Generation Capacity	kW	22	22	12	25	0
Cost of Generator per kW	US\$/kW	750	750	750	750	750
Cost of Automatic Transfer Switch	US\$	1,910	1,910	1,910	1,910	0
Cost of Protection Box	US\$	917	917	917	917	0
Building (Existing, only reinstall at 10 years)	US\$	1,500	1,500	1,500	1,500	0
Total Investment Cost of Diesel Generator	US\$	20,827	20,827	13,327	23,077	0
3) Cost of the Transmission and Distribution Lines						
Cost of Transmission Line per km (cost = unit cost x line length)	US\$/km	16,769	16,769	16,769	16,769	16,769
Cost of Distribution Line per km	US\$/km	16,769	16,769	16,769	16,769	16,769
	km	1.3	1.3	1.3	1.3	1.3
Length of Distribution Line (Tambo Quemado was already exist)	km	0	0	0	0	0
Total costs of Transmission & distribution lines	US\$	21,800	21,800	21,800	21,800	21,800
4) Fuel Cost of Diesel Generator						
Diesel Oil Cost per Litter (including transportation cost, without Tax(6%) Bs.3.8/Litter / 1.16)	Bs./Litter	3.28	3.28	3.28	3.28	3.28
	US\$/Litter	0.50	0.50	0.50	0.50	0.50
For Idling Generation						
Fuel Consumption for Idling Generation	Litter/hour	1.30	1.30	1.30	1.30	1.30
Idling Operation Hour per day	hour/day	24	24	24	24	0
Operation days per year	day/Year	365	365	365	365	0
Annual Fuel Consumption for Idling Generation	Litter/Year	28,908	28,908	28,908	28,908	0
Annual fuel cost for Idling Generation	US\$/year	14,520	14,520	14,520	14,520	0
For Load Generation						
Fuel Consumption for Load Generation	Litter/kWh	0.20	0.20	0.20	0.20	0.20
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	16,247	18,814	8,900	7,800	0
Annual Fuel Consumption for Load Generation	Litter/Year	3,248	2,163	1,794	1,520	0
Annual fuel cost for Load Generation	US\$/year	1,622	1,087	901	764	0
Total Annual fuel cost	US\$/year	16,152	15,607	15,421	15,284	0
5) Operation & Maintenance Cost for MHP						
OM Cost of the Electromechanical Equipment (% of investment)	%	2.0	2.0	2.0	2.0	2.0
OM Cost of the Civil Engineering (% of investment)	%	0.5	0.5	0.5	0.5	0.5
OM Cost of the Transmission & Distribution Lines (% of investment)	%	2.5	2.5	2.5	2.5	2.5
OM cost for the electromechanical equipment	US\$/year	554	540	540	662	662
OM cost for civil engineering	US\$/year	366	393	425	433	496
OM cost of the distribution lines	US\$/year	545	545	545	545	545
Total OM cost per annual	US\$/year	1,465	1,478	1,510	1,640	1,703
6) Maintenance Cost for Diesel Generator						
OM Cost of Generator (% of the investment costs, without building cost)	%	5.0	5.0	5.0	5.0	5.0
Annual maintenance cost for Diesel =(Total investment costs x 0.05)	US\$/year	966	966	591	1,079	0
7) Total Cost of the MHP & Diesel Combined System						
Total Construction Cost of MHP+Transmission/Distribution Line	US\$	164,700	172,900	180,500	193,200	207,400
Total Construction Cost of Diesel System	US\$	20,827	20,827	13,327	23,077	0
Total Investment Cost of MHP & Diesel Combined System	US\$	185,527	193,727	193,827	216,277	207,400
Total O/M Cost of MHP & Diesel Combined System	US\$/year	18,583	18,051	17,523	18,002	1,703

Source: JICA Study Team

Note: All costs are economic cost (without taxes).

Tabla 6.7 Proyecto de Beneficio Preliminar para Casos Alternativos de la MCH de Tambo Quemado

Item	Unit	Case1	Case2	Case3	Case4	Case5
		MHP +Diesel	MHP +Diesel	MHP with Pond +Diesel	MHP +Diesel	MHP with Pond
Type of Power Generation						
BENEFIT						
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	181,147	181,147	181,147	181,147	181,147
1) Investment Cost of Diesel Generator						
Cost of Diesel Generator	US\$	46,500	46,500	46,500	46,500	46,500
Generation Capacity	kW	62	62	62	62	62
Cost of Generator per kW	US\$/kW	750	750	750	750	750
Cost of Automatic Transfer Switch	US\$	1,910	1,910	1,910	1,910	1,910
Cost of Protection Box	US\$	917	917	917	917	917
Building (Existing, only reinstall at 10 years)	US\$	1,500	1,500	1,500	1,500	1,500
Total Investment Cost of Diesel Generator	US\$	50,827	50,827	50,827	50,827	50,827
2) Cost of the Transmission & Distribution Lines for Diesel						
		** Tambo Quemado Diesel Generator System had existing Distribution Line.				
Cost of Transmission Lines (x 105%)	US\$	0	0	0	0	0
Length of Transmission Line (by MHP)	km	1.30	1.30	1.30	1.30	1.30
Length of Transmission Line (only for MHP)	km	1.30	1.30	1.30	1.30	1.30
Length of Transmission Line (by Diesel)	km	0.00	0.00	0.00	0.00	0.00
Cost of Transmission Line per Kilometer	US\$/km	16,769	16,769	16,769	16,769	16,769
Cost of Distribution Lines	US\$	0	0	0	0	0
Length of Distribution Line (by Diesel)	km	0	0	0	0	0
Cost of Distribution Line per Kilometer	US\$/km	16,769	16,769	16,769	16,769	16,769
Total Cost of Transmission & Distribution Lines	US\$	0	0	0	0	0
3) Fuel Cost						
Diesel Oil Cost per Litter (including transportation cost)	Bs./Litter	3.28	3.28	3.28	3.28	3.28
	US\$/Litter	0.50	0.50	0.50	0.50	0.50
For Idling Generation						
Fuel Consumption for Idling Generation	Litter/hour	3.30	3.30	3.30	3.30	3.30
Idling Operation Hour per day	hour/day	24	24	24	24	24
Operation days per year	day/Year	365	365	365	365	365
Annual Fuel Consumption for Idling Generation	Litter/year	28,908	28,908	28,908	28,908	28,908
Annual fuel cost for Idling Generation	US\$/year	14,520	14,520	14,520	14,520	14,520
For Load Generation						
Fuel Consumption for Load Generation	Litter/kWh	0.20	0.20	0.20	0.20	0.20
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	181,147	181,147	181,147	181,147	181,147
Annual Fuel Consumption for Load Generation	Litter/Year	36,229	36,229	36,229	36,229	36,229
Annual fuel cost for Load Generation	US\$/year	18,198	18,198	18,198	18,198	18,198
Total Annual fuel cost	US\$/year	32,718	32,718	32,718	32,718	32,718
4) Maintenance Cost of Diesel Generator						
OM Cost of Generator (% of the investment costs)	%	5.0	5.0	5.0	5.0	5.0
Annual maintenance cost =(Total investment costs (without Buildings) x 0.05)	US\$/year	2,466	2,466	2,466	2,466	2,466
5) OM Cost of Transmission & Distribution Line						
OM Cost of Distribution Lines (% of the investment costs)	%	2.5	2.5	2.5	2.5	2.5
Annual OM Cost of the Transmission & Distribution Line	US\$/Year	0	0	0	0	0
6) Total Cost of Distribution Line						
Total Investment Cost of Diesel	US\$	50,827	50,827	50,827	50,827	50,827
Total O/M Cost of Diesel	US\$/year	35,185	35,185	35,185	35,185	35,185

Source: JICA Study Team

Note: All costs are economic cost (without taxes).

Tabla 6.8 Evaluación Económica de la MCH de Tambo Quemado (1/3)

Case: **1** Install Capacity MHP: **40 kW** Type: **MHP +Diesel**
 Install Capacity of Diesel: **22 kW** Discount Rate = **10%**

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)	
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)		
0	164,700	0	164,700	0	0	0	-164,700	
1		18,583	18,583		35,185	35,185	16,602	
2		18,583	18,583		35,185	35,185	16,602	
3		18,583	18,583		35,185	35,185	16,602	
4		18,583	18,583		35,185	35,185	16,602	
5		18,583	18,583		35,185	35,185	16,602	
6		18,583	18,583		35,185	35,185	16,602	
7		18,583	18,583		35,185	35,185	16,602	
8		18,583	18,583		35,185	35,185	16,602	
9		18,583	18,583		35,185	35,185	16,602	
10	20,827	18,583	39,410	50,827	35,185	86,012	46,602	
11		18,583	18,583		35,185	35,185	16,602	
12		18,583	18,583		35,185	35,185	16,602	
13		18,583	18,583		35,185	35,185	16,602	
14		18,583	18,583		35,185	35,185	16,602	
15		18,583	18,583		35,185	35,185	16,602	
16		18,583	18,583		35,185	35,185	16,602	
17		18,583	18,583		35,185	35,185	16,602	
18		18,583	18,583		35,185	35,185	16,602	
19		18,583	18,583		35,185	35,185	16,602	
20		18,583	18,583		35,185	35,185	16,602	
Total	185,527	371,658	557,185	50,827	703,693	754,520	197,335	
N.P.V.	166,940	143,824	300,851	42,006	272,315	290,130	-10,721	
							EIRR =	9.0%
							B/C =	0.96

Case: **2** Install Capacity MHP: **50 kW** Type: **MHP +Diesel**
 Install Capacity of Diesel: **22 kW** Discount Rate = **10%**

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)	
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)		
0	172,900	0	172,900	0	0	0	-172,900	
1		18,051	18,051		35,185	35,185	17,133	
2		18,051	18,051		35,185	35,185	17,133	
3		18,051	18,051		35,185	35,185	17,133	
4		18,051	18,051		35,185	35,185	17,133	
5		18,051	18,051		35,185	35,185	17,133	
6		18,051	18,051		35,185	35,185	17,133	
7		18,051	18,051		35,185	35,185	17,133	
8		18,051	18,051		35,185	35,185	17,133	
9		18,051	18,051		35,185	35,185	17,133	
10	20,827	18,051	38,878	50,827	35,185	86,012	47,133	
11		18,051	18,051		35,185	35,185	17,133	
12		18,051	18,051		35,185	35,185	17,133	
13		18,051	18,051		35,185	35,185	17,133	
14		18,051	18,051		35,185	35,185	17,133	
15		18,051	18,051		35,185	35,185	17,133	
16		18,051	18,051		35,185	35,185	17,133	
17		18,051	18,051		35,185	35,185	17,133	
18		18,051	18,051		35,185	35,185	17,133	
19		18,051	18,051		35,185	35,185	17,133	
20		18,051	18,051		35,185	35,185	17,133	
Total	193,727	361,027	554,754	50,827	703,693	754,520	199,766	
N.P.V.	174,394	139,710	304,192	42,006	272,315	290,130	-14,062	
							EIRR =	8.7%
							B/C =	0.93

Tabla 6.8 Evaluación Económica de la MCH de Tambo Quemado (2/3)

Case: **3** **Install Capacity MHP: 50 kW** **Type: MHP with Pond +Diesel**
Install Capacity of Diesel: 12 kW **Discount Rate = 10%**

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
0	180,500	0	180,500	0	0	0	-180,500
1		17,523	17,523		35,185	35,185	17,662
2		17,523	17,523		35,185	35,185	17,662
3		17,523	17,523		35,185	35,185	17,662
4		17,523	17,523		35,185	35,185	17,662
5		17,523	17,523		35,185	35,185	17,662
6		17,523	17,523		35,185	35,185	17,662
7		17,523	17,523		35,185	35,185	17,662
8		17,523	17,523		35,185	35,185	17,662
9		17,523	17,523		35,185	35,185	17,662
10	13,327	17,523	30,850	50,827	35,185	86,012	55,162
11		17,523	17,523		35,185	35,185	17,662
12		17,523	17,523		35,185	35,185	17,662
13		17,523	17,523		35,185	35,185	17,662
14		17,523	17,523		35,185	35,185	17,662
15		17,523	17,523		35,185	35,185	17,662
16		17,523	17,523		35,185	35,185	17,662
17		17,523	17,523		35,185	35,185	17,662
18		17,523	17,523		35,185	35,185	17,662
19		17,523	17,523		35,185	35,185	17,662
20		17,523	17,523		35,185	35,185	17,662
Total	193,827	350,453	544,280	50,827	703,693	754,520	210,240
N.P.V.	175,105	135,618	304,380	42,006	272,315	290,130	-14,250
						EIRR =	8.7%
						B/C =	0.95

Case: **4** **Install Capacity MHP: 62 kW** **Type: MHP +Diesel**
Install Capacity of Diesel: 25 kW **Discount Rate = 10%**

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
0	193,200	0	193,200	0	0	0	-193,200
1		18,002	18,002		35,185	35,185	17,182
2		18,002	18,002		35,185	35,185	17,182
3		18,002	18,002		35,185	35,185	17,182
4		18,002	18,002		35,185	35,185	17,182
5		18,002	18,002		35,185	35,185	17,182
6		18,002	18,002		35,185	35,185	17,182
7		18,002	18,002		35,185	35,185	17,182
8		18,002	18,002		35,185	35,185	17,182
9		18,002	18,002		35,185	35,185	17,182
10	23,077	18,002	41,079	50,827	35,185	86,012	44,932
11		18,002	18,002		35,185	35,185	17,182
12		18,002	18,002		35,185	35,185	17,182
13		18,002	18,002		35,185	35,185	17,182
14		18,002	18,002		35,185	35,185	17,182
15		18,002	18,002		35,185	35,185	17,182
16		18,002	18,002		35,185	35,185	17,182
17		18,002	18,002		35,185	35,185	17,182
18		18,002	18,002		35,185	35,185	17,182
19		18,002	18,002		35,185	35,185	17,182
20		18,002	18,002		35,185	35,185	17,182
Total	216,277	360,049	576,326	50,827	703,693	754,520	178,194
N.P.V.	194,708	139,332	323,057	42,006	272,315	290,130	-32,927
						EIRR =	7.3%
						B/C =	0.90

Tabla 6.8 Evaluación Económica de la MCH de Tambo Quemado (3/3)

Case: 5 Install Capacity MHP: 62 kW Type: MHP with Pond
 Install Capacity of Diesel: 0 kW Discount Rate = 10%

Year	Cost (MHP)			Benefit (Diesel)			B-C (US\$)
	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	Investment Cost (US\$)	O & M Cost (US\$)	Total Cost (US\$)	
0	207,400	0	207,400	0	0	0	-207,400
1		1,703	1,703		35,185	35,185	33,482
2		1,703	1,703		35,185	35,185	33,482
3		1,703	1,703		35,185	35,185	33,482
4		1,703	1,703		35,185	35,185	33,482
5		1,703	1,703		35,185	35,185	33,482
6		1,703	1,703		35,185	35,185	33,482
7		1,703	1,703		35,185	35,185	33,482
8		1,703	1,703		35,185	35,185	33,482
9		1,703	1,703		35,185	35,185	33,482
10	0	1,703	1,703	50,827	35,185	86,012	84,309
11		1,703	1,703		35,185	35,185	33,482
12		1,703	1,703		35,185	35,185	33,482
13		1,703	1,703		35,185	35,185	33,482
14		1,703	1,703		35,185	35,185	33,482
15		1,703	1,703		35,185	35,185	33,482
16		1,703	1,703		35,185	35,185	33,482
17		1,703	1,703		35,185	35,185	33,482
18		1,703	1,703		35,185	35,185	33,482
19		1,703	1,703		35,185	35,185	33,482
20		1,703	1,703		35,185	35,185	33,482
Total	207,400	34,050	241,450	50,827	703,693	754,520	513,070
N.P.V.	188,545	13,177	201,722	42,006	272,315	290,130	88,408
						EIRR =	16.2%
						B/C =	1.44

Note) The diesel generator was not planned investment at 0 year, since generator exist in Tambo Quemado in 2000.

Replacement cost of diesel generator at 10 year is assumed as amount of

- 1. new diesel generator, 1. Automatic transfer switch, 1. protection box, 1. Power House

Tabla 6.9 Costo de Construcción de Obras Cíviles, Eléctricas y Mecánicas de la MCH de Tambo Quemado (Pre-F/S) (1/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S (62kW)		Note
			Quantity	Amount	
Maximum Discharge Qmax			0.0879		
Effective Head He			99.10		See Effective Head Calculation
Installed Capacity P			62		$9.8 * Q_{max} * He * \eta_e \cdot \eta_g = 0.731$
Turbine Number n			1		
1. Preparation Works					
1.1 Access Roads	m	0	100	0	
3. Civil Works					
3.1 Intake Weir					
1) Upstream					
Height H	m		0.5		
Length L	m		1.5		
Excavation	m ³	7	6.3	44	$8.69 * (H * L)^{1.34}$
Concrete	m ³	10	5.5	55	$11.8 * (H * L)^{0.781}$
Foundations					
Sub Total				99	
2) Down Stream					
Height H	m		0.3		
Length L	m		1.0		
Excavation	m ³	7	2.2	15	$8.69 * (H * L)^{1.34}$
Concrete	m ³	10	1.8	18	$11.8 * (H * L)^{0.781}$
Foundations					
Sub Total				33	
3.2 Intake					
1) Upstream					
Excavation	m ³	7	1.200	8	$3 * D_{pv} * 1.0$
Concrete	m ³	60	0.800	48	$\{ (3 * D_{pv})^2 * (2 * D_{pv}) - D_{pv}^2 \} * 1.0$
Foundations					
Sub Total				56	
2) Downstream					
Excavation	m ³	7	1.200	8	$3 * D_{pv} * 1.0$
Concrete	m ³	60	0.800	48	$\{ (3 * D_{pv})^2 * (2 * D_{pv}) - D_{pv}^2 \} * 1.0$
Foundations					
Sub Total				56	
3.4 Headrace (FVC[Rib-Loc] Pipe)					
Length Lpv	m		2,310		
Diameter Dpv	m		0.40		
Diameter Dpv	m		0.40		
Water Area A			0.079		$0.492 * D_{pv}^2$, water depth / Dpv = 0.6
Hydraulic Radius R			0.111		$0.2776 * D_{pv}$, water depth / Dpv = 0.6
n value n			0.010		
Slope			0.002		

Tabla 6.9 Costo de Construcción de Obras Civiles, Eléctricas y Mecánicas de la MCH de Tambo Quemado (Pre-F/S) (2/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S (62kW)		Note
			Quantity	Amount	
Discharge			0.0813		
Check			-0.0066	OK	$A/n * R^{2n} / u^5$
PVC (Rib-Loc) Unit Cost Cpv	m		23.7		$(D-600: 0.0527 * D - 0.1179 - 0.0855 * D - 0.0217) * 1.13 \text{Tax}$
PVC Pipe Setup Cost	m	6	2,310	68,607	$Lpv * (Cp + 6\$/m)$
Excavation	m ³	7	1,247	8,732	$L * B * H = Lpv * (Dpv + 0.1 + 0.1) * (Dpv + 0.2 + 0.3)$
Concrete	m ³	60	8.9	534	$2 * Dpv * 0.3 * 0.4 * Lpv / 25$
Foundations					
Sub Total				77,873	
3.5 Head Tank					
Storage Volume			225		
Storage Wall Thickness			0.30		
Storage Slab Thickness			0.50		
Excavation	m ³	7	511.2	3,578	$142m^2 * 6.0m * 60\%$
Concrete	m ³	60	268.5	16,110	$142m^2 * 0.5m^2 + 25.3m^2 * 5m$
Reinforcemnt Bar	t	732	13.7	10,028	0.051 * Vc
Sub Total				29,717	
3.6 Penstock					
Diameter Dp	m		0.36		$0.876 * Qpmax^{0.687}$
Length Lp	m		300		
Excavation	m ³	7	21.2	148	$L * B * H = Lp * (Dp + 0.1 + 0.1) * (Dp + 0.15 + 0.2)$
Concrete	m ³	60	10.8	648	$3.1m^2 * 1.36m + 3.5m^2 * 1.0m + 2.3m^2 * 1.36$
Reinforcemnt Bar	t	732	0.2	146	0.018 * Vc
Sub Total				943	
3.7 Spillway					
L	m		20		
B	m		0.5		
H	m		0.5		
Excavation	m ³	7	11.2	78	$(B + 0.15m^2) * (H + 0.2m) * L$
Concrete	m ³	60	6.2	372	$\{(B + 0.15m^2) * (H + 0.2m) - (B * H)\} * L$
Sub Total				450	
3.8 Power House					
Excavation	m ³	7	27	189	$4.2m^2 * 6.5m$
Concrete	m ³	13	55	715	$9.7m^2 * 6.5m - (3.1m^2 * 2.0m + 0.7m^2 * 1.3)$
Reinforcemnt Bar	t	732	0.0	0	Mass concrete
Building	L.S.	1,000	1	1,000	
Sub Total				1,904	

Tabla 6.9 Costo de Construcción de Obras Civiles, Eléctricas y Mecánicas de la MCH de Tambo Quemado (Pre-F/S) (3/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S (62kW)		Note
			Quantity	Amount	
3.9 Tailrace					
Length	m		5		
Excavation	m ³		0		
Concrete	m ³		6.2	62	$1.0m^2 * (3m + 4m) / 2 + 0.25m^2 * 1.0m^2 + 0.55m^2 * 4m$
Reinforcement Bar	t		0.0	0	Mass Concrete
Sub Total				62	
4. Mechanical Works					
4.1 Head Tank					
Sand Flushout Gate	pce	2,000	1	2,000	$0.910 * Od^{0.613}$, $Qd = 0.05m^3/s$
4.2 Penstock					
Diameter Dp	m		0.36		$0.876 * Qpmax^{0.387}$
Length Lp	m		300.0		
PVC Unit Cost	m		91.9		$(0.001528231 * D^2 - 0.04373631 * D + 1.387783) / 2$
PVC Pipe setup cost	m		300.0	27,870	
Sub Total				29,870	
5. Electrical Works					
Unit Cost of Turbine/Generator			600		$<10kW: 1000\$/kW, <50kW: 770, <100kW: 600, <200: 500, <300: 300$
Turbine/Generator	kW		62	37,200	$US\$47,000 / 70kW$
Installation and Equipment Test	LS	1,500		1,500	
Sub Total				38,700	
Transmission Line	LS	19,088	1.3	26,056	1.3km of Transmission line only.

Tabla 6.10 Costo de Construcción de la MCH de Tambo Quemado (Pre-F/S)
Financial Cost (With Tax)

Unit : US\$.

Item	Pre-F/S 62kW MHP with Pond	Note
1. Preparation Works & Access, etc.	2,224	
1.1 Preparation Works	1,112	2.*1%
1.2 Access Road	0	
1.3 Mitigation for Environment	1,112	2.*1%
2. Civil Works	111,194	
2.1 Intake Weir	133	
2.2 Intake	113	
2.3 Sand Settling Basin	0	
2.4 Headrace	77,873	
2.5 Head Tank	29,717	
2.6 Penstock	943	
2.7 Spillway	450	
2.8 Power House	1,904	
2.9 Tailrace	62	
2.10 Outlet	0	
3. Electric and Mechanical Works	94,626	
3.1 Turbine/Generator	38,700	Perton, 62kW x 1 set, include tax, transportation, installation
3.2 Transmission/Distribution Line	26,056	
3.3 Mechanical Works	29,870	
4. Transportation	10,291	(2.+3.)*5%
5. Direct Cost Total	218,334	1.+2.+3.+4.
6. Administration and Engineering Service.	21,366	(Admin: (1.+2.+3.)*6%+D/D by NGO: US\$3,000)*138%
Total Construction Cost	239,700	5.+6.

Economic Cost (Without Tax)

Unit : US\$.

Item	Pre-F/S 62kW MHP with Pond	Note
1. Preparation Works & Access, etc.	2,000	
1.1 Preparation Works	1,000	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
1.2 Access Road	0	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
1.3 Mitigation for Environment	1,000	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2. Civil Works	95,800	
2.1 Intake Weir	100	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.2 Intake	100	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.3 Sand Settling Basin	0	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.4 Headrace	67,100	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.5 Head Tank	25,600	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.6 Penstock	800	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.7 Spillway	400	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.8 Power House	1,600	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.9 Tailrace	100	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
2.10 Outlet	0	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
3. Electric and Mechanical Works	88,600	
3.1 Turbine/Generator	33,100	(cost with tax) / 1.1679
3.2 Transmission/Distribution Line	21,700	(cost with tax) / 1.20
3.3 Mechanical Works	25,800	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
4. Transportation	8,900	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
5. Direct Cost Total	187,300	
6. Administration and Engineering Service.	18,400	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
Total Construction Cost	205,700	

Tabla 6.11 Costo del Proyecto y Beneficio de la MCH de Tambo Quemado (Pre-F/S)

Item	Unit	Pre-F/S
Exchange Rate (as of May 23, 2001)	Bs./US\$	6.53
Install Capacity P	kW	62
Annual Demand Energy (Based on the estimated daily load curve of demand energy)	kWh/year	181,147
COST		
1) Investment Cost of MHP		
Cost of the Micro-hydro:		
Preparation Works	US\$	2,000
Civil works	US\$	95,800
Mechanical Works	US\$	25,800
Turbine/Generator	US\$	33,100
Transportation	US\$	8,900
Administration and Engineering Service	US\$	18,400
Total initial investment cost of MHP (without Transmission Line)	US\$	184,000
2) Cost of the Transmission and Distribution Lines		
Cost of Transmission Line per km (cost = unit cost x line length)	US\$/km	16,692
Cost of Distribution Line per km	US\$/km	16,692
	km	1.3
<u>Length of Distribution Line (Tambo Quemado was already exist)</u>	km	0
Total costs of Transmission & distribution lines	US\$	21,700
3) Operation & Maintenance Cost for MHP		
OM Cost of the Electromechanical Equipment (% of investment)	%	2.0
OM Cost of the Civil Engineering (% of investment)	%	0.3
OM Cost of the Transmission & Distribution Lines (% of investment)	%	2.3
OM cost for the electromechanical equipment	US\$/year	662
OM cost for civil engineering	US\$/year	479
<u>OM cost of the distribution lines</u>	<u>US\$/year</u>	<u>543</u>
Total OM cost per annual	US\$/year	1,684
4) Total Cost of the MHP System		
Total Investment Cost of MHP System	US\$	205,700
Total O/M Cost of MHP System	US\$/year	1,684
BENEFIT		
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	181,147
1) Investment Cost of Diesel Generator		
Cost of Diesel Generator	US\$	46,500
Generation Capacity	kW	62
Cost of Generator per kW	US\$/kW	750
Cost of Automatic Transfer Switch	US\$	1,910
Cost of Protection Box	US\$	917
Building	US\$	1,500
Total Investment Cost of Diesel Generator	US\$	49,910
2) Cost of the Transmission & Distribution Lines for Diesel		
Cost of Transmission Lines (x 105%)	US\$	0
Length of Transmission Line (by MHP)	km	1.30
Length of Transmission Line (only for MHP)	km	1.20
Length of Transmission Line (by Diesel)	km	0.00
Cost of Transmission Line per Kilometer	US\$/km	16,692
Cost of Distribution Lines	US\$	0
Length of Distribution Line (by Diesel)	km	0
<u>Cost of Distribution Line per Kilometer</u>	<u>US\$/km</u>	<u>16,692</u>
Total Cost of Transmission & Distribution Lines	US\$	0
3) Fuel Cost		
Diesel Oil Cost per Litter (including transportation cost)	Bs./Litter	3.28
	US\$/Litter	0.50
For Idling Generation		
Fuel Consumption for Idling Generation	Litter/hour	3.30
Idling Operation Hour per day	hour/day	24
Operation days per year	day/Year	300
Annual Fuel Consumption for Idling Generation	Litter/Year	28,908
Annual fuel cost for Idling Generation	US\$/year	14,520
For Load Generation		
Fuel Consumption for Load Generation	Litter/kWh	0.20
Annual Generated Energy (Diesel) (= Annual Energy Demand by User)	kWh/Year	181,147
Annual Fuel Consumption for Load Generation	Litter/Year	36,229
Annual fuel cost for Load Generation	US\$/year	18,198
Total Annual fuel cost	US\$/year	32,718
4) Maintenance Cost of Diesel Generator		
OM Cost of Generator (% of the investment cost)	%	5.0
Annual maintenance cost = (Total investment costs (without Buildings) x 0.05)	US\$/year	2,466
5) OM Cost of Transmission & Distribution Line		
OM Cost of Distribution Lines (% of the investment costs)	%	2.3
Annual OM Cost of the Transmission & Distribution Line	US\$/Year	0
6) Total Cost of Distribution Line		
Total Investment Cost of Diesel	US\$	49,910
Total O/M Cost of Diesel	US\$/year	35,185

Source: URMSA and JICA Study Team
 Note: All costs are economic cost (without taxes).

Tabla 6.12 TIR (Tasa Economica Interna de Retorno) para Proyecto del Project MCH en Tambo Quemado (Oruro) [Unidad: US\$]

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Benefit																						
Investment																						
Diesel Generator									46,500													
Automatic Transfer Switch									1,910													
Protection Box									917													
Building									1,500													
Transmission Lines																						
Distribution Lines																						
OM Cost																						
OM Cost of the Diesel Generator, etc.		2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466	2,466
OM Cost of the Distribution Lines		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feed cost		32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718	32,718
Total Benefit	0	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184	86,011	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184	35,184
Cost																						
Investment																						
Preparation Works and Access, etc.	2,000																					
Civil Works	95,800																					
Turbine/Generator	33,100																					
Transmission/Distribution Lines	21,700																					
Mechanical Works	25,800																					
Transportation	8,900																					
Administration and Engineering Service	18,400																					
OM Cost																						
Turbine/Generator		662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662	662
Civil Works		479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479	479
Transmission/Distribution Lines		543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543	543
Total Cost	205,700	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684	1,684
Balance	-205,700	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	84,928	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501
EIRR																						16.4%

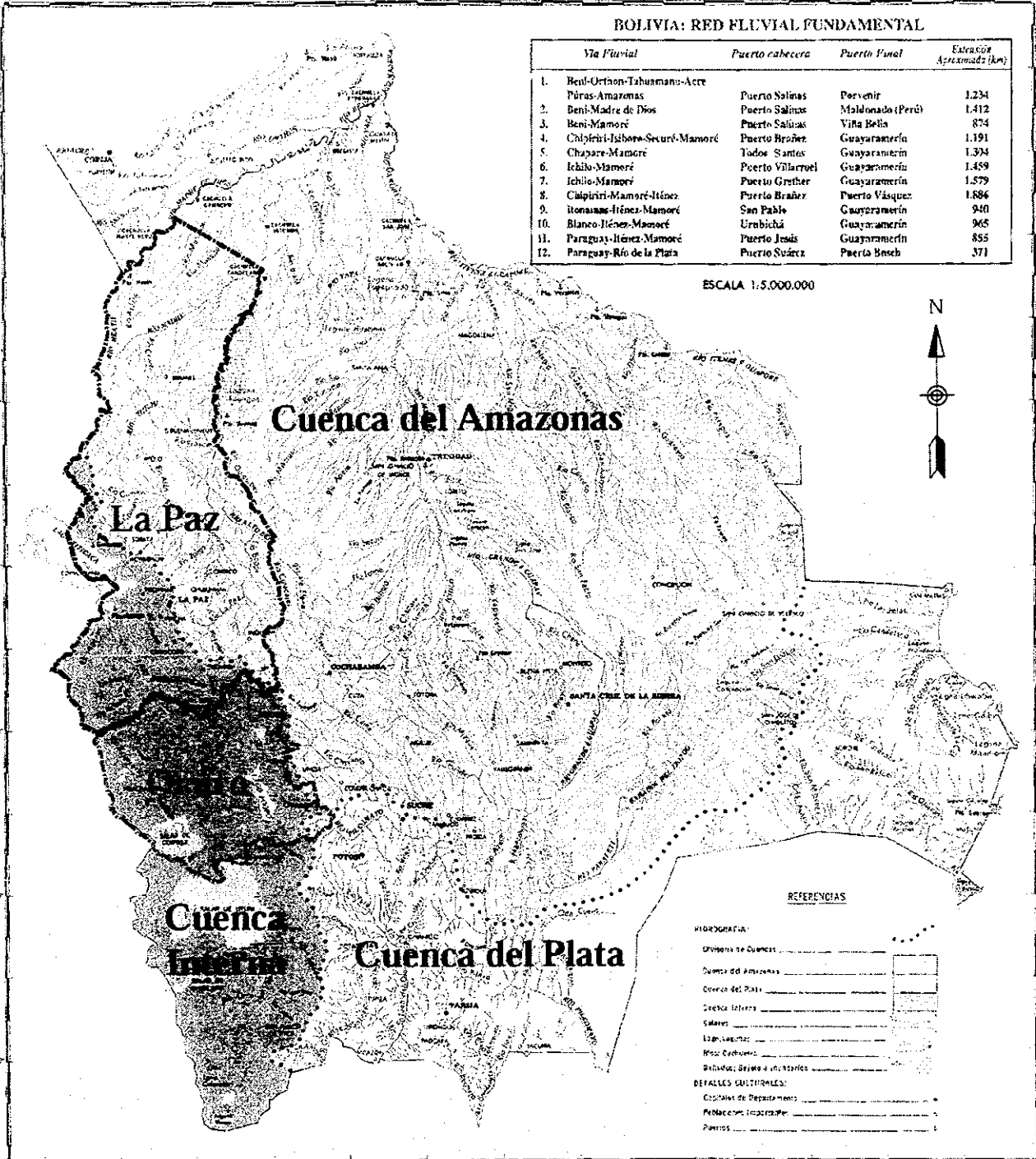
FIGURAS

MAPA HIDROGRAFICO DE BOLIVIA

BOLIVIA: RED FLUVIAL FUNDAMENTAL

Vía Fluvial	Puerto cabecera	Puerto Final	Extensión Aproximada (km)
1. Beni-Ortón-Tabusmano-Acre	Puerto Salinas	Porvenir	1.234
2. Beni-Madre de Dios	Puerto Salinas	Maldonado (Perú)	1.412
3. Beni-Mamoré	Puerto Salinas	Villa Bella	874
4. Chispiri-Isiboro-Securá-Mamoré	Puerto Brañer	Guayaramerín	1.391
5. Chapare-Mamoré	Tados Santos	Guayaramerín	1.374
6. Ichilo-Mamoré	Puerto Villaruel	Guayaramerín	1.459
7. Ichilo-Mamoré	Puerto Grether	Guayaramerín	1.579
8. Chispiri-Mamoré-Iténez	Puerto Brañer	Puerto Visquez	1.884
9. Itonasas-Iténez-Mamoré	San Pablo	Guayaramerín	940
10. Blanco-Iténez-Mamoré	Urubichá	Guayaramerín	965
11. Paraguay-Iténez-Mamoré	Puerto Jesús	Guayaramerín	855
12. Paraguay-Río de la Plata	Puerto Suárez	Puerto Beseh	371

ESCALA 1:5.000.000



REFERENCIAS

HIDROGRAFIA:

- límites de Cuencas
- Cuenca del Amazonas
- Cuenca del Plata
- Cuenca Interior
- Salares
- Lago Lagunas
- Riós Cochabambas
- Detalles: Sejales e hidrografía

DETALLES CULTURALES:

- Capitales de Departamento
- Periferias de Departamentos
- Puebros

SUPERFICIE DE CUENCAS Y SUB CUENCAS HIDROGRAFICAS

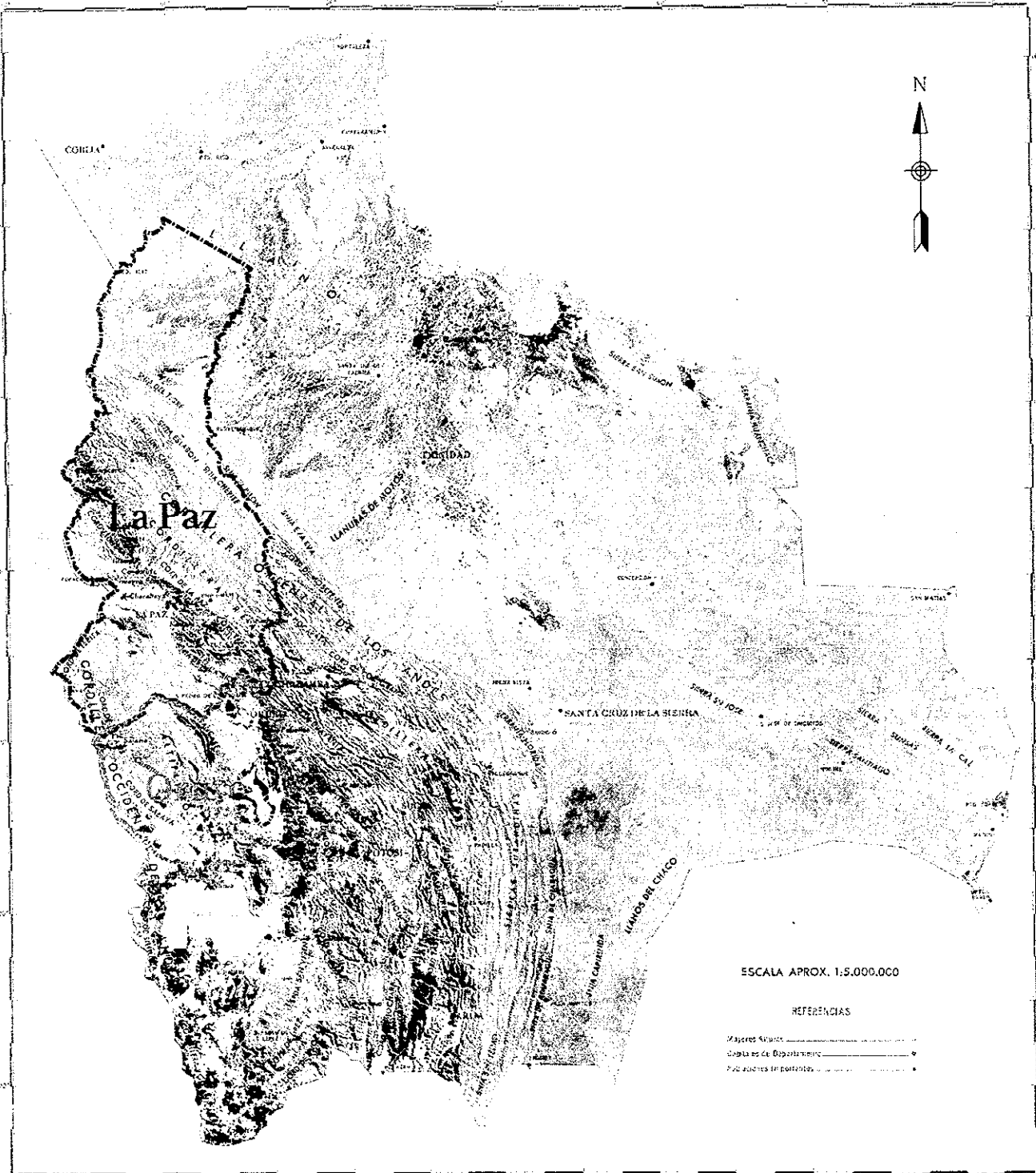
CUENCA DEL AMAZONAS			CUENCA CENTRAL			CUENCA DEL PLATA		
SUB CUENCAS	SUP. Km ²	%	SUB CUENCAS	SUP. Km ²	%	SUB CUENCAS	SUP. Km ²	%
SUB CUENCA ACRE	2680	0,7	SUB CUENCA FITIGACA	1567	1,3	SUB CUENCA PILCOMAYO	11280	2,7
SUB CUENCA ARLUNA	24713	2,2	SUB CUENCA DESAGUADERO POZCO	3182	4,7	SUB CUENCA BERMUDEO	12350	1,1
SUB CUENCA ORTÓN	10516	1,5	SUB CUENCA COPASA	23718	2,2	SUB CUENCA PARAGUAY	3048	0,1
SUB CUENCA MADRE DE DIOS	28506	2,6	SUB CUENCA UYUNI	61975	5,6			
SUB CUENCA BENI	124369	11,3						
SUB CUENCA MAMORÉ	267375	24,3						
SUB CUENCA ITENÉZ	207891	18,9						
SUB CUENCA PARAGUAY-ITENÉZ	15312	1,4						
TOTAL	922137	95,2	TOTAL	151526	12,8	TOTAL	224817	20,3

Source: "Atlas Geográfico de la República de Bolivia". Instituto Geográfico Militar Bolivia

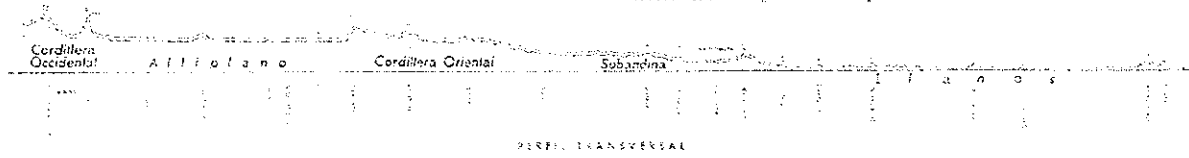
THE STUDY ON RURAL ELECTRIFICATION
IMPLEMENTATION PLAN BY RENEWABLE ENERGY
IN THE REPUBLIC OF BOLIVIA
JAPAN INTERNATIONAL COOPERATION AGENCY

Figura 2.1
Cuenca Hidrografica de Bolivia

MAPA OROGRAFICO DE BOLIVIA



Source: "Atlas Geográfico de la República de Bolivia". Instituto Geográfico Militar Bolivia

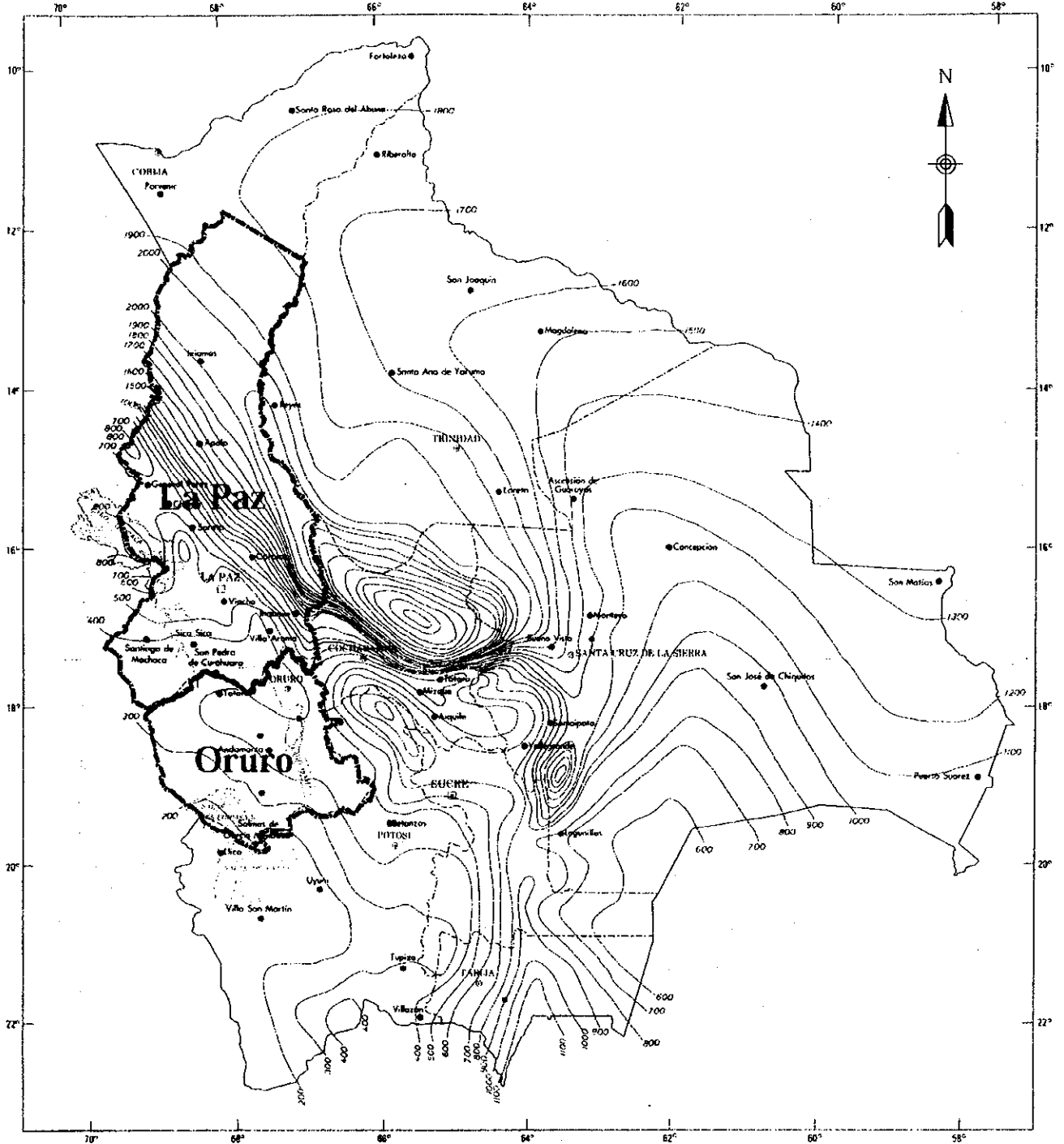


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Figura 2.2

Imagen Satelital de Bolivia

PRECIPITACIONES ANUALES PERIODO 1961-1990



REFERENCIAS

- LIMITE INTERNACIONAL - - - - -
- LIMITE DEPARTAMENTAL - - - - -
- CAPITAL DE REPUBLICA (C)
- SEDE DE GOBIERNO □
- CAPITAL DE DEPARTAMENTO (D)
- CAPITAL DE PROVINCIA (P)

ESCALA APROXIMADA 1:5,300,000

SERVICIO NACIONAL DE
METEOROLOGIA E HIDROLOGIA

ELABORADO POR: Sr. REYNALDO MALDONADO

Source: "Atlas Geográfico de la Republic de Bolivia", Instituto Geográfico Militar Bolivia

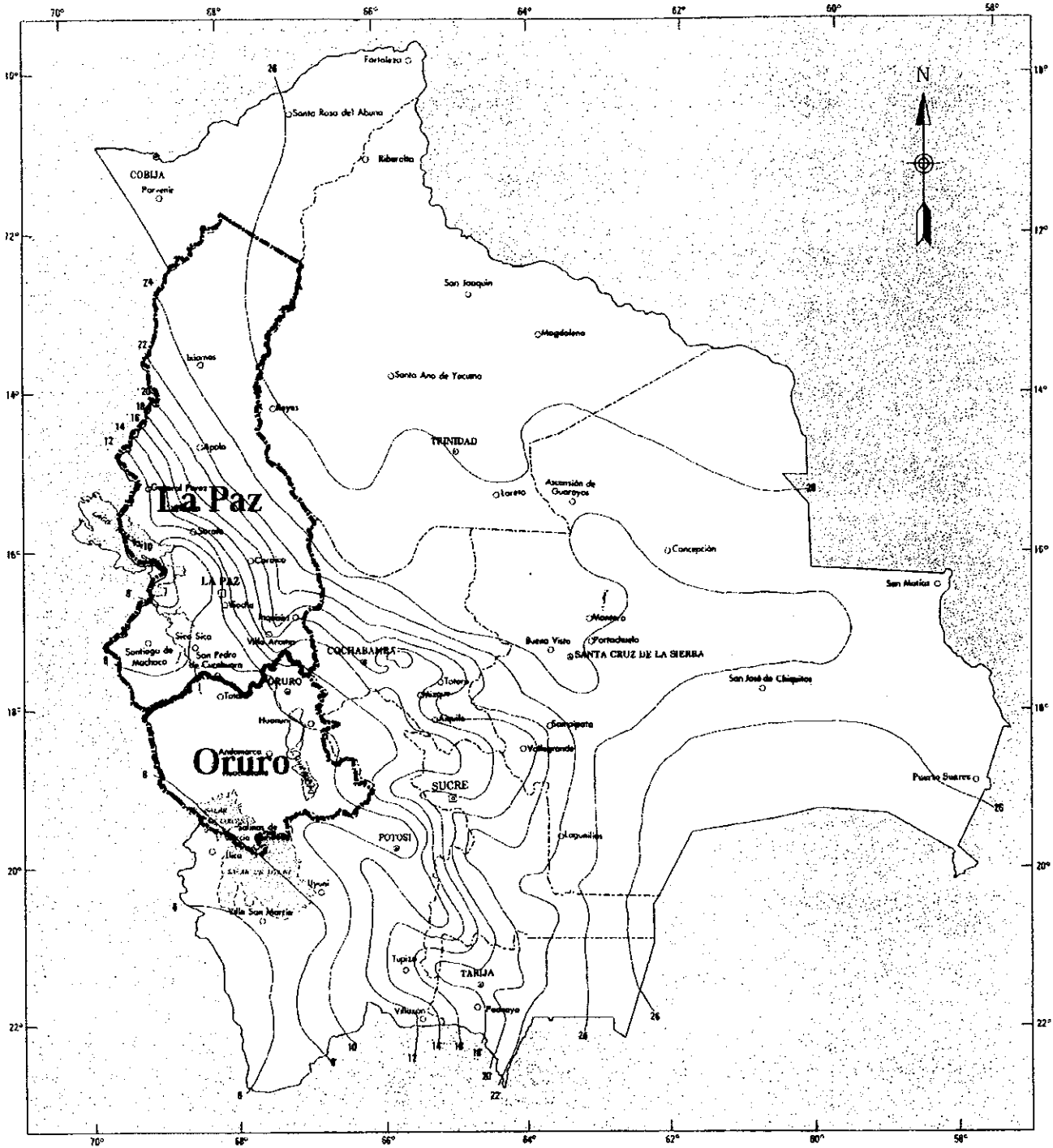
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Figura 2.3

Mapa Isohyetal (Precipitación Pluvial Anual)
de Bolivia (1961-1990)



MAPA DE TEMPERATURA MEDIA ANUAL PERIODO 1961-1990



REFERENCIAS

- LIMITE INTERNACIONAL _____
- LIMITE DEPARTAMENTAL _____
- CAPITAL DE REPUBLICA [Symbol]
- SEDE DE GOBIERNO [Symbol]
- CAPITAL DE DEPARTAMENTO [Symbol]
- CAPITAL DE PROVINCIA [Symbol]

ESCALA APROXIMADA 1:5,300,000

SERVICIO NACIONAL DE
METEOROLOGIA E HIDROLOGIA

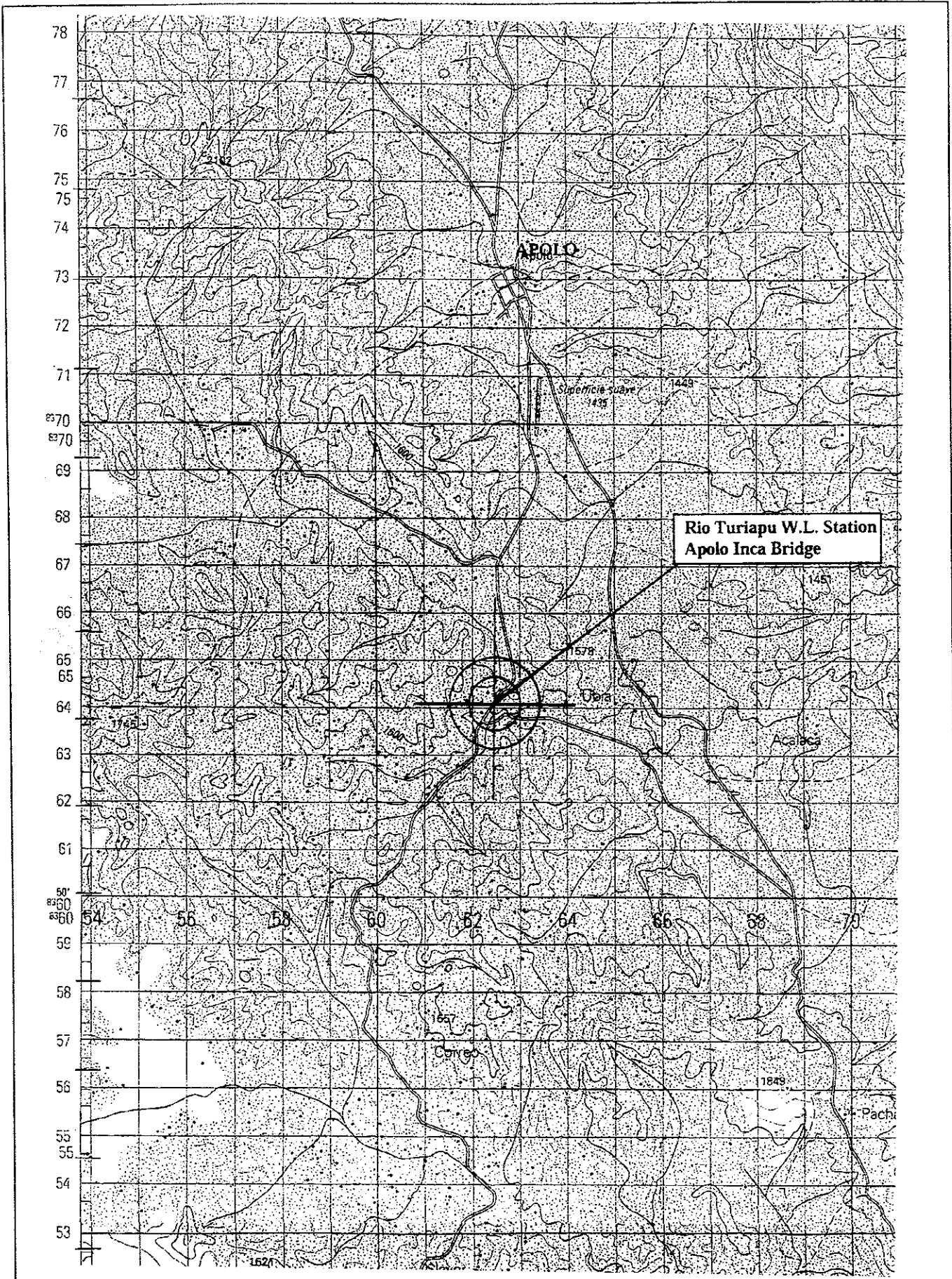
ELABORADO POR S. RETNALDO MATEGNAGH

Source: "Atlas Geografico de la Republic de Bolivia", Instituto Geografico Militar Bolivia

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Figura 2.4

Temperatura Anual de Bolivia (1961-1990)



THE STUDY ON RURAL ELECTRIFICATION
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 IN THE REPUBLIC OF BOLIVIA
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Figura 2.6
 Ubicacion de la Estacion W.L. Rio Turiapu
 (Apolo/ F.Tamayo/ La Paz)

SECCION TRANSVERSAL RIO TURIAPU (APOLO)
Escola. H: 1:100
V: 1:50

