

附表

表 2.1 気象観測所一覧(ラパス県) (SENAMHI)

(1/2)

Code No.	DEPARTMENT LA PAZ								
	Station Name	Province	Type	Install	Altitude	Latitude	Longitude	State	Record
300	Achachicala	Murillo	Pluviometrica	1975	3 700	16 ° 28 '	68 ° 09 '	Bueno	17
301	Achiri	Pacajes	Pluviometrica	1975	3 940	17 ° 13 '	69 ° 00 '	Bueno	17
303	Achumani	Murillo	Pluviometrica	1991	3 200	16 ° 33 '	68 ° 09 '	Bueno	2
305	Alto Seguencoma	Murillo	Pluviometrica	1979	3 640	16 ° 31 '	68 ° 07 '	Bueno	13
306	Alto Lima	Murillo	Pluviometrica	1987	4 070	16 ° 29 '	68 ° 29 '	Bueno	6
308	Alto Achachicala	Murillo	Pluviometrica	1991	3 700	16 ° 28 '	68 ° 09 '	Bueno	2
309	Ancorairmes	Omasayos	Pluviometrica	1975	3 870	15 ° 54 '	68 ° 54 '	Bueno	17
310	Ancoma	Larecaja	Pluviometrica	1969	3 000	15 ° 44 '	68 ° 30 '	Bueno	13
311	Antaquilla	Franz Tamayo	Pluviometrica	1975	4 500	14 ° 52 '	69 ° 18 '	Bueno	17
312	Apolo	Franz Tamayo	Termopluviometrica	1943	1 383	14 ° 43 '	68 ° 31 '	Bueno	47
313	Apolo (AASANA)	Franz Tamayo	Sinoptica	1973	1 383	14 ° 43 '	68 ° 34 '	Bueno	48
314	Araca	Loayza	Pluviometrica	1975	3 580	16 ° 49 '	67 ° 33 '	Bueno	17
315	Asunta	Sud Yungas	Termopluviometrica	1973	600	16 ° 02 '	67 ° 13 '	Bueno	19
318	Ayo Ayo	Aroma	Termopluviometrica	1953	3 880	17 ° 05 '	68 ° 00 '	Bueno	39
319	Batallas	Los Andes	Pluviometrica	1985	3 825	16 ° 25 '	68 ° 29 '	Bueno	7
321	Belen	Omasuyos	Climatologica Ordinaria	1949	3 820	16 ° 01 '	68 ° 42 '	Bueno	42
322	Berenguela	Pacajes	Pluviometrica	1976	4 100	17 ° 08 '	69 ° 13 '	Fieglar	16
323	Bolsa Negra	Sud Yungas	Pluviometrica	1975	3 800	16 ° 33 '	67 ° 48 '	Bueno	17
324	Calamarca	Aroma	Pluviometrica	1958	4 030	16 ° 54 '	68 ° 07 '	Bueno	16
325	Calacoto	Pacajes	Termopluviometrica	1943	3 805	17 ° 17 '	68 ° 38 '	Bueno	39
326	Camata	Munecas	Termopluviometrica	1977	2 250	15 ° 10 '	68 ° 46 '	Bueno	15
327	Carabuco	Camacho	Climatologica Principal	1991	3 815	15 ° 45 '	69 ° 10 '	Bueno	2
329	Caracato	Loayza	Pluviometrica	1975	2 580	17 ° 00 '	67 ° 48 '	Bueno	17
330	Capinata	Inquisivi	Pluviometrica	1976	2 976	17 ° 10 '	66 ° 58 '	Bueno	16
331	Caquiaviri	Pacajes	Termopluviometrica	1976	3 940	17 ° 01 '	68 ° 36 '	Bueno	16
334	Circuata	Inquisivi	Termopluviometrica	1968	2 012	16 ° 38 '	67 ° 15 '	Bueno	23
335	Collana	Aroma	Termopluviometrica	1973	3 940	16 ° 54 '	68 ° 17 '	Bueno	19
338	Conchamarca	Aroma	Pluviometrica	1969	3 950	17 ° 23 '	67 ° 28 '	Bueno	23
340	Copacabana	Manco Kapac	Termopluviometrica	1943	3 850	16 ° 10 '	69 ° 05 '	Bueno	47
340	Copacabana	Manco Kapac	Sinoptica Automatica	1991	3 850	16 ° 10 '	69 ° 05 '	Bueno	1
344	Coromata	Omasuyos	Termopluviometrica	1968	1 760	18 ° 19 '	67 ° 36 '	Bueno	9
345	Corpaputo	Omasuyos	Pluviometrica	1973	4 080	16 ° 04 '	68 ° 32 '	Bueno	19
350	Chicani	Murillo	Pluviometrica	1977	3 500	16 ° 29 '	68 ° 05 '	Bueno	9
352	Chorocona	Ingavi	Termopluviometrica	1972	2 800	16 ° 58 '	67 ° 12 '	Bueno	20
353	Chuma	Munecas	Pluviometrica	1969	3 000	15 ° 24 '	68 ° 56 '	Bueno	19
354	Chunavi Alto	Los Andes	Pluviometrica	1976	4 000	16 ° 19 '	68 ° 20 '	Bueno	16
355	Chulumani	Sud Yungas	Termopluviometrica	1943	1 740	16 ° 24 '	67 ° 32 '	Bueno	40
356	Chuquiaguillo	Murillo	Pluviometrica	1997	4 000	16 ° 27 '	68 ° 06 '	Bueno	17
358	El Alto (AASANA)	Murillo	Sinoptica	1943	4 071	16 ° 31 '	68 ° 13 '	Bueno	48
358	El Alto	Murillo	Sinoptica Automatica	1975	4 071	16 ° 31 '	68 ° 13 '	Bueno	10
359	El Tejar	Murillo	Pluviometrica	1982	3 700	16 ° 29 '	68 ° 09 '	Bueno	10
361	Guanay	Larecaja	Termopluviometrica	1969	420	15 ° 27 '	67 ° 51 '	Bueno	21
363	Huatajata	Omasuyos	Pluviometrica	1946	3 824	16 ° 13 '	68 ° 42 '	Bueno	21
364	Huarina	Omasuyos	Termopluviometrica	1991	3 825	16 ° 11 '	68 ° 38 '	Bueno	2
365	Huarina Cota Cota	Omasuyos	Climatologica Principal	1973	3 825	16 ° 12 '	68 ° 38 '	Bueno	19
365	Huarina Cota Cota	Omasuyos	Sinoptica Automatica	1991	3 825	16 ° 12 '	68 ° 38 '	Bueno	2
368	Huayrocondo	Los Andes	Climatologica Ordinaria	1991	3 840	16 ° 21 '	68 ° 39 '	Bueno	2
369	Hichucota	Los Andes	Termopluviometrica	1974	4 460	16 ° 10 '	68 ° 22 '	Bueno	
370	Italaque	Camacho	Pluviometrica	1967	3 500	15 ° 28 '	69 ° 03 '	Bueno	18
371	Isla del Sol	Manco Kapac	Termopluviometrica	1975	4 000	16 ° 02 '	69 ° 09 '	Bueno	13
372	Irupana	Sud Yungas	Termopluviometrica	1945	1 848	16 ° 26 '	67 ° 29 '	Bueno	35
373	Irpa Chico	Ingavi	Pluviometrica	1975	3 880	16 ° 44 '	68 ° 13 '	Bueno	18
374	Inquisivi	Inquisivi	Pluviometrica	1968	2 900	16 ° 58 '	67 ° 10 '	Bueno	24
382	Luribay	Loayza	Termopluviometrica	1943	2 580	17 ° 04 '	67 ° 40 '	Bueno	24
384	Mecapaca	Murillo	Pluviometrica	1976	2 840	16 ° 40 '	68 ° 01 '	Bueno	19
385	Miguillas	Inquisivi	Pluviometrica	1975	1 100	16 ° 27 '	68 ° 10 '	Bueno	17
386	Mulluni	Murillo	Pluviometrica	1976	4 580	16 ° 19 '	68 ° 09 '	Bueno	13
387	Minachi	Nor Yungas	Termopluviometrica	1983	1 600	16 ° 12 '	67 ° 42 '	Bueno	9
389	Ovejuyo	Murillo	Termopluviometrica	1959	3 580	16 ° 32 '	68 ° 03 '	Bueno	12
391	Panpahasi	Murillo	Pluviometrica	1975	3 600	16 ° 35 '	68 ° 08 '	Bueno	3
393	Patacamaya	Aroma	Climatologica Ordinaria	1973	3 789	17 ° 15 '	67 ° 57 '	Bueno	48
394	Penas	Los Andes	Pluviometrica	1948	3 986	16 ° 14 '	68 ° 30 '	Bueno	44
396	Pinaya	Murillo	Pluviometrica	1975	3 840	16 ° 38 '	67 ° 52 '	Bueno	17
398	Poroma	Loayza	Pluviometrica	1976	3 100	17 ° 10 '	67 ° 32 '	Bueno	16
399	Pucarani	Los Andes	Pluviometrica	1984	4 120	16 ° 24 '	68 ° 29 '	Bueno	8
400	Puchini	Loayza	Pluviometrica	1969	4 112	17 ° 16 '	67 ° 20 '	Bueno	23
402	Puente Negro	Murillo	Pluviometrica	1975	3 680	16 ° 30 '	68 ° 08 '	Bueno	17

表 2.2 気象観測所一覧(オルロ県) (SENAMHI)

Code No.	DEPARTMENT URURO								
	Station Name	Province	Type	Install	Altitude	Latitude	Longitude	State	Record
500	Andamarca	Carangas	Climatologica	1975	3 740	18 ° 46 '	67 ° 30 '	Bueno	12
501	Caracollo	Cercado	Climatologica	1973	3 770	17 ° 39 '	67 ° 12 '	Fiegiular	11
502	Challapata	Avaroa	Climatologica	1987	3 715	18 ° 43 '	66 ° 45 '	Bueno	2
503	Chillca	Cercado	Termopluiometrica	1987	4 000	17 ° 50 '	66 ° 48 '	Fiegiular	2
504	Choquekota	Carangas	Climatologica	1991	4 586	18 ° 10 '	68 ° 43 '	Bueno	
505	Chuquina	Cercado	Climatologica	1943	3 710	17 ° 51 '	67 ° 25 '	Fiegiular	36
506	Coipasa	Atahuallpa	Climatologica	1975	3 680	19 ° 17 '	68 ° 16 '	Fiegiular	13
507	Corque	Carangas	Climatologica	1976	3 929	18 ° 20 '	67 ° 41 '	Malo	10
508	Cosapa	Sajama	Climatologica	1975	3 890	18 ° 10 '	68 ° 43 '	Bueno	14
510	Eucalip tus		Pluiometrica	1975	3 728	17 ° 30 '	67 ° 31 '	Fiegiular	32
511	Huachacalla	Litoral	Termopluiometrica	1975	3 740	18 ° 46 '	68 ° 16 '	Fiegiular	15
512	Huayllamarca	Carangas	Termopluiometrica	1990	3 880	17 ° 50 '	67 ° 56 '	Bueno	1
515	Orinoca	Carangas	Sinoptica Automatica	1975	3 780	18 ° 58 '	67 ° 15 '	Bueno	
515	Orinoca	Carangas	Sinoptica	1991	3 780	18 ° 58 '	67 ° 15 '	Bueno	2
516	Oruro (AASANA)	Cercado	Climatologica	1943	3 702	17 ° 58 '	67 ° 07 '	Piegiular	
517	Cabana Forestal	Cercado	Climatologica	1988	3 710	17 ° 58 '	67 ° 40 '	Malo	5
518	Pazna	Poopo	Climatologica	1949	3 740	18 ° 36 '	66 ° 56 '	Fiegiular	27
519	Quillacas	Avaroa	Climatologica	1975	3 749	19 ° 14 '	66 ° 56 '	Bueno	11
520	Sacabaya	Atahuallpa	Climatologica	1975	3 829	18 ° 34 '	68 ° 47 '	Fiegiular	13
521	Sajama	Sajama	Termopluiometrica	1975	4 220	18 ° 07 '	68 ° 58 '	Bueno	
522	Salinas de G. Mendoza	L. Cabrera	Climatologica	1947	3 680	19 ° 38 '	67 ° 41 '	Malo	38
523	San Jose de Kala	Carangas	Pluiometrica	1975	3 850	19 ° 36 '	67 ° 53 '	Fiegiular	11
524	San Maitin	L. Cabrera	Climatologica	1975	3 747	19 ° 16 '	67 ° 35 '	Fiegiular	11
526	Todos Santos	Atahuallpa	Climatologica	1975	3 920	19 ° 01 '	68 ° 44 '	Malo	14
527	Puente Toledo	Saucari	Pluiometrica	1975	3 711	18 ° 11 '	67 ° 21 '	Cambiada	14
528	Turco	Sajama	Climatologica	1975	3 860	18 ° 10 '	68 ° 12 '	Fiegiular	10
529	Ucumasi	L. Cabrera	Pluiometrica	1975	3 768	19 ° 09 '	67 ° 25 '	Fiegiular	14

Source : "Mejoramiento y Ampliacion de La Red Hidrometeorologica Nacional, Inventario de las Estaciones Existentes", SENAMHI, Aug.1993

表 2.1 気象観測所一覧(ラパス県) (SENAMHI)

(2/2)

Code No.	DEPARTMENT LA PAZ								
	Station Name	Province	Type	Install	Altitude	Latitude	Longitude	State	Record
403	Puerto Acosta	Camacho	Pluviometrica	1945	3 835	15 ° 32 '	69 ° 15 '	Bueno	23
405	Quiabaya	Larecaja	Pluviometrica	1969	3 470	15 ° 39 '	68 ° 46 '	Bueno	18
406	Quime	Inquisivi	Pluviometrica	1969	3 190	16 ° 59 '	67 ° 13 '	Bueno	20
409	Rio seco	Murillo	Pluviometrica	1986	4 070	18 ° 29 '	68 ° 09 '	Bueno	6
411	Sapahaqui	Loayza	Pluviometrica	1973	3 140	16 ° 53 '	67 ° 57 '	Bueno	17
412	Sapecho	Sud Yungas	Pluviometrica	1964	3 395	15 ° 32 '	67 ° 23 '	Bueno	28
413	San A. de Machaca	Ingavi	Pluviometrica	1976	3 913	16 ° 58 '	68 ° 58 '	Bueno	16
414	San Jose Alto	G. Villarroel	Pluviometrica	1974	3 823	17 ° 43 '	67 ° 45 '	Bueno	18
416	San P. de la Loma	Nor Yungas	Termopluviometrica		1 640	16 ° 15 '	67 ° 43 '	Bueno	
417	Santiago de Huata	Omasuyos	Termopluviometrica	1974	3 840	16 ° 03 '	68 ° 49 '	Bueno	15
418	Santiago de Machaca	Pacajes	Termopluviometrica	1976	3 871	17 ° 04 '	69 ° 12 '	Bueno	16
420	Sica Sica	Aroma	Pluviometrica	1943	3 917	17 ° 20 '	67 ° 44 '	Bueno	48
421	Suchez	Franz Tarmayo	Pluviometrica	1975	4 540	14 ° 47 '	69 ° 21 '	Bueno	17
422	Suri	Inquisivi	Pluviometrica	1975	2 500	16 ° 51 '	67 ° 14 '	Bueno	17
423	Taraco	Ingavi	Pluviometrica	1975	3 870	16 ° 27 '	68 ° 51 '	Bueno	17
424	Tiahuanacu	Ingavi	Pluviometrica	1973	3 838	16 ° 33 '	68 ° 41 '	Bueno	19
425	Viacha	Ingavi	Climatologica Ordinaria	1962	3 850	16 ° 39 '	68 ° 18 '	Bueno	30
427	Viloco	Loayza	Pluviometrica	1982	3 900	16 ° 53 '	67 ° 28 '	Bueno	10
428	Villa Adela	Murillo	Pluviometrica	1982	3 800	16 ° 29 '	68 ° 09 '	Bueno	10
429	Villa Copacabana	Murillo	Pluviometrica	1977	3 640	16 ° 29 '	68 ° 07 '	Bueno	15
431	Vino Tinto	Murillo	Pluviometrica	1975	3 840	16 ° 29 '	68 ° 03 '	Bueno	17
433	Yanamuyo	Ingavi	Pluviometrica	1973	3 940	16 ° 38 '	68 ° 29 '	Bueno	19
434	Alcoche	Nor Yungas	Sinoptioca Automatica	1991	660	15 ° 44 '	67 ° 40 '	Bueno	1
435	Laykakota	Murillo	Sinoptioca Automatica	1991		16 ° 30 '	68 ° 10 '	Bueno	2
436	Ixiamas	Iturrealde	Climatologica Ordinaria	1977	254	13 ° 46 '	68 ° 08 '	Bueno	6
436	Ixiamas	Iturrealde	Sinoptioca Automatica	1991	254	13 ° 46 '	68 ° 08 '	Bueno	2
437	Turnupasa	Iturrealde	Termopluviometrica	1991	2 540	14 ° 07 '	67 ° 48 '	Bueno	2
438	Charana (AASANA)	Pacajes	Sinoptica	1945	4 057	17 ° 35 '	69 ° 27 '	Bueno	46
439	Puente Villa	Sud Yungas	Pluviometrica	1970	1 282	16 ° 23 '	67 ° 38 '	Bueno	18
440	Sorata	Larecaja	Termopluviometrica	1943	2 697	15 ° 45 '	68 ° 41 '	Bueno	34

Source : "Mejoramiento y Ampliacion de La Red Hidrometeorologica Nacional, Inventario de las Estaciones Existentes", SENAMHI, Aug.1993

表 2.3 水文観測所一覧(ラパス県・オルロ県) (SENAMHI)

(1/2)

Code No.	DEPARTMENT LA PAZ							
	Station Name	Province	River	RIVER BASIN	Latitude (S)	Longitude (W)	Altitude (m)	Period of Data
300	ABAROA	PACAJES	MAURI	CERRADA	17° 31' 13"	69° 14' 53"	3 930	1972/1993
301	ABAROA	PACAJES	CAQUENA	CERRADA	17° 31' 28"	69° 14' 53"	3 950	1972/1993
302	ACHACACHI	OMASUYOS	KEKA	CERRADA	16° 02' 28"	68° 40' 00"	3 820	1972/1993
303	ACHACHICALA	MURILLO	KALUYO	AMAZONICA	16° 27' 47"	68° 10' 40"	3 960	1977/1992
304	ACHUMANI	MURILLO	JILLUSAYA	AMAZONICA	16° 31' 53"	68° 04' 31"	3 325	1977/1980
305	ACHUMANI ALTO	MURILLO	JILLUSAYA	AMAZONICA	16° 31' 53"	68° 04' 31"	3 325	1982/1983
306	ACHUMANI VIBERO	MURILLO	ACHUMANI	AMAZONICA	16° 31' 47"	68° 04' 36"	3 340	1977/1981
307	ACHUMANI VIBERO	MURILLO	ACHUMANI	AMAZONICA	16° 31' 47"	68° 04' 36"	3 440	1977/1981
308	AGUALLAMAYA	INGAVI	DESAGUADERO	CERRADA	16° 40' 54"	68° 54' 00"	3 805	1973/1984
309	ALIRCAYA	LOS ANDES	CATARI	CERRADA	16° 33' 27"	68° 27' 40"	3 825	1973
310	ANGOSTO ESPERANZA	LARECAJA	ATEN	AMAZONICA	15° 18' 00"	68° 31' 00"	610	1974/1982
311	ANGOSTO INICUA	SUD YUNGAS	ALTO BENI	AMAZONICA	15° 18' 00"	67° 33' 00"	4 000	
312	ANGOSTO INICUA	SUD YUNGAS	ALTO BENI	AMAZONICA	15° 18' 00"	68° 31' 00"	420	1974/1984/1988/1993
313	ANGOSTO QUERCANO	LARECAJA	MAPIRI	AMAZONICA	15° 23' 00"	27° 58' 00"	600	1975/1985/1989/1993
314	ARANJUEZ	MURILLO	LA PAZ	AMAZONICA	16° 33' 18"	68° 05' 29"	3 170	1974/1992
315	BAROMPAMPA	LARECAJA	CHALLANA	AMAZONICA	15° 28' 00"	67° 20' 00"	4 200	1973/1981
316	BELEN	OMASUYOS	KEKA	CERRADA	16° 00' 36"	68° 42' 53"	3 812	1973/1981
317	CAHUA	MURILLO	ZONGO	AMAZONICA	16° 03' 01"	68° 00' 35"	1 230	1977/1992
318	CAJETILLAS	SUD YUNGAS	LA PAZ	AMAZONICA	15° 26' 00"	67° 17' 00"	762	1974/1984/1990
319	CALACHACA	INQUISIVI	CALACHACA	AMAZONICA	16° 48' 25"	67° 23' 05"	3 420	1971/1983/1986
320	CALACOTO	PACAJES	MAURI	CERRADA	17° 17' 43"	68° 38' 52"	3 792	1976/1993
321	CALACOTO	PACAJES	DESAGUADERO	CERRADA	17° 16' 51"	68° 36' 42"	3 790	1971/1983/1985/1992
322	CANAL GUAQUI	INGAVI	LAGO TITICACA	CERRADA	16° 35' 00"	68° 51' 00"	3 810	1973/1989
323	CARABUCO	INQUISIVI	MIGUILLAS	AMAZONICA	16° 48' 38"	67° 19' 25"	2 830	1972/1988
324	CARANAVI	NOR YUNGAS	YARA	AMAZONICA	15° 45' 00"	67° 36' 00"	476	1962/1973
325	CHACAJAHUIRA	INQUISIVI	CALACHACA	AMAZONICA	16° 47' 00"	67° 22' 00"	3 080	1961/1983/1987/1992
326	CHICANI	MURILLO	KALLAPA	AMAZONICA	16° 28' 38"	68° 04' 28"	3 580	1978/1985/1987/1993
327	CHILCARA	SUD CINTI	PILAYA	DEL PLATA	21° 02' 00"	61° 57' 00"	1 829	1975/1985/1992/1993
328	CHORO	NOR YUNGAS	CHORO	AMAZONICA	16° 01' 47"	67° 37' 53"	970	1971/1973/1977/1982
329	CHOROCONA	INQUISIVI	KATU	AMAZONICA	16° 53' 06"	67° 09' 06"	2 075	1973/1993
330	CIELO JAHUIRA	MURILLO	CIELO JAHUIRA	AMAZONICA	16° 00' 53"	67° 55' 13"	830	1978/1982/1984/1992
331	CONDOR KHALA	INQUISIVI	CONDOR KHALA	AMAZONICA	16° 47' 51"	67° 23' 04"	3 350	1971/1983/1986/1992
332	CONSATA	LARECAJA	LLICA	AMAZONICA	15° 18' 00"	68° 34' 00"	1 300	1974/1979/1981
333	DESAGUADERO	INGAVI	DESAGUADERO	CERRADA				1986/1991
334	ESCOMA	CAMACHO	SUCHEZ	CERRADA	15° 39' 00"	69° 07' 00"	3 817	1972/1993
335	GUANAY	LARECAJA	TIPUANI	AMAZONICA	15° 28' 00"	67° 50' 00"	418	1973/1978/1984/1992
336	HICHUCOTA	LOS ANDES	HICHUCOTA	CERRADA	16° 11' 02"	68° 23' 08"	4 335	1973/1983/1990/1992
337	HOLGUIN	MURILLO	ORKOJAHURA	AMAZONICA	16° 31' 02"	68° 06' 46"	3 380	1981/1993
338	HUAJI	MURILLO	HUAJI	AMAZONICA	16° 03' 09"	67° 58' 34"	1 695	1977/1984/1987/1992
339	HUATAIATA	OMASUYOS	LAGO TITICACA	CERRADA	16° 12' 00"	68° 12' 00"	3 810	1974/1992
340	HUMAPALCA	INQUISIVI	MIGUILLAS	AMAZONICA	16° 44' 05"	67° 22' 02"	1 980	1972/1984/1986
341	HUMAPALCA	INQUISIVI	MIGUILLAS	AMAZONICA	16° 44' 05"	67° 22' 02"	1 980	1972/1985/1987/1993
342	ISLA DEL SOL	MANCO KAPAC	LAGO TITICACA	CERRADA	16° 01' 00"	69° 08' 00"	3 810	1976/1993
343	JALANCHA	INQUISIVI	JALANCHA	AMAZONICA	16° 47' 02"	67° 26' 13"	3 410	1967/1993/1986/1992
344	KOLLUCACHI	LOS ANDES	KOLLUCACHI	CERRADA	16° 18' 00"	68° 23' 00"	3 902	1976/1992
345	LLIPI	LARECAJA	TIPUANI	AMAZONICA	15° 38' 00"	68° 10' 00"	1 047	1969/1972
346	NAZACARA	PACAJES	DESAGUADERO	CERRADA	16° 56' 17"	68° 46' 01"	3 805	1976/1992
347	NUBE	LARECAJA	KAKA	AMAZONICA	15° 24' 00"	67° 41' 00"	3 840	1968/1984
348	OBRAJES	MURILLO	CHOQUEYAPU	AMAZONICA	16° 31' 40"	68° 05' 50"	3 260	1983/1993
349	PUENTE CANATIA	LOS ANDES	TUNI	CERRADA	16° 16' 00"	68° 17' 00"	4 335	1973/1993
350	PUENTE UYUNENSE	NOR YUNGAS	COROICO	AMAZONICA	15° 45' 00"	67° 36' 00"	635	1976/1984/1986/1992
351	PUENTE VILLA	SUD YUNGAS	TAMAMPAYA	AMAZONICA	16° 23' 32"	67° 37' 55"	1 185	1974/1986/1987/1993
352	PUENTE VILLA	SUD YUNGAS	UNDUAVI	AMAZONICA	16° 23' 58"	67° 39' 04"	1 190	1977/1988/1991/1992
353	PUENTE VILLA	SUD YUNGAS	TAQUESI	AMAZONICA	16° 24' 03"	67° 38' 34"	1 201	1970/1992
354	PUERTO ACOSTA	CAMACHO	YANARICO	CERRADA	15° 31' 38"	69° 14' 56"	3 875	1972/1980/1983/1992
355	PUERTO LEON	NOR YUNGAS	QUITA CALZON	AMAZONICA	15° 58' 00"	67° 31' 00"	800	1976/1977
356	PUERTO LINARES	NOR YUNGAS	ALTO BENI	AMAZONICA	15° 28' 00"	67° 36' 00"	420	1974/1978/1982/1989
357	QUERQUETA	INGAVI	GUAQUIRA	CERRADA	16° 36' 33"	68° 32' 16"	3 873	1973/1977/1992
358	SAN PEDRO	NOR YUNGAS	COROICO	AMAZONICA				1983
359	SANTAFE	NOR YUNGAS	BRONCINI	AMAZONICA	15° 47' 00"	67° 12' 00"	570	1966/1967/1980/1981
360	SANTARITA DE BUENOS	LARECAJA	COROICO	AMAZONICA	15° 43' 00"	67° 63' 00"	435	1973/1991
361	SARARIA	F. TAMAYO	ALTO BENI	AMAZONICA				1967/1970
362	SIPE SIPE	OMASUYOS	JAPA JAHUIRA	CERRADA	16° 08' 11"	68° 36' 53"	3 880	1973/1985
363	SIRUPAYA	SUD YUNGAS	UNDUAVI	AMAZONICA	16° 21' 20"	67° 46' 21"	1 640	1979/1993
364	SORATA	LARECAJA	CHALLASUYO	AMAZONICA	15° 44' 00"	68° 42' 00"		1980/1988
365	SORATA	LARECAJA	SAN CRISTOBAL	AMAZONICA	15° 44' 00"	68° 42' 00"		1973/1975
366	TAIPICHACA	LOS ANDES	HUAJHUATANI	CERRADA	16° 12' 38"	68° 21' 07"	4 290	1974/1985
367	TAMBILLO	LOS ANDES	CATARI	CERRADA	16° 31' 05"	68° 29' 46"	3 835	1973/1993
368	TIAHUANACU	INGAVI	TIAHUANACU	CERRADA	16° 32' 40"	68° 40' 53"	3 830	1973/1992
369	TORA	LARECAJA	TORA	AMAZONICA	15° 38' 00"	68° 10' 00"		1969/1974
370	TORA	LARECAJA	LLIPI	AMAZONICA	15° 38' 00"	68° 10' 00"	1 047	1972/1974
371	TORA	LARECAJA	TIPUANI	AMAZONICA	15° 38' 00"	68° 10' 00"	1 047	1969/1976
372	ULLOMA	PACAJES	DESAGUADERO	CERRADA	17° 24' 32"	68° 27' 24"	3 775	1974/1992
373	ULLOMA	PACAJES	DESAGUADERO	CERRADA	17° 24' 32"	68° 27' 24"	3 775	1975/1992
374	VERTEDERO	INQUISIVI	CHACAJAHUIRA	AMAZONICA	16° 47' 00"	67° 22' 00"	3 080	1968/1972/1974/1979
375	VILAQUE	LARECAJA	CHALLANA	AMAZONICA	17° 39' 00"	67° 59' 00"	600	1970/1990
376	VILLA BARRIENTOS	SUD YUNGAS	TAMAMPAYA	AMAZONICA	16° 18' 00"	67° 27' 00"	1 050	1974/1984/1989/1993

表 2.3 水文観測所一覧(ラパス県・オルロ県) (SENAMHI)

(2/2)

Code No.	DEPARTMENT LA PAZ							
	Station Name	Province	River	RIVER BASIN	Latitude (S)	Longitude (W)	Altitude (m)	Period of Data
377	VILLA BARRIENTOS	SUD YUNGAS	SOLACAMA	AMAZONICA	16 ° 18 ' 00 "	67 ° 27 ' 00 "	1 050	1975/1983
378	VILLA FLOR	NOR YUNGAS	CHALLHUANI	AMAZONICA	15 ° 42 ' 00 "	67 ° 36 ' 00 "	636	1973/1992
379	VILLA IQUACA	LOS ANDES	SEHUENCA	CERRADA	16 ° 24 ' 05 "	68 ° 32 ' 59 "	3 850	1973/1981
380	YACO	LOAYZA	YACO	AMAZONICA	17 ° 09 ' 21 "	67 ° 24 ' 26 "	3 560	1979/1993
381	YANAPIRI	PACAJES	YANAPIRI	CERRADA				
382	YOLOSA	NOR YUNGAS	YOLOSA	AMAZONICA			1 185	1984
383	YOLOSANI	MURILLO	YOLOSANI	AMAZONICA				1982

Code No.	DEPARTMENT ORURO							
	Station Name	Province	River	RIVER BASIN	Latitude (S)	Longitude (W)	Altitude (m)	Period of Data
500	CHUQUINA	CERCADO	DESAGUADERO	CERRADA	17 ° 41 ' 26 "	67 ° 27 ' 39 "	3 710	
501	COSAPA	SAJAMA	COSAPA	CERRADA				1983/1991
502	EUCALIPTUS	CERCADO	DESAGUADERO	CERRADA	17 ° 35 ' 49 "	67 ° 31 ' 32 "	3 715	1973/1654/1987/1993
503	HUACHACALLA	LITORAL	TURCO	CERRADA	18 ° 40 ' 13 "	68 ° 14 ' 40 "	3 713	1974/1982/1984
504	HUACHACALLA	LITORAL	LAUCA	CERRADA	18 ° 40 ' 29 "	68 ° 14 ' 55 "	3 712	1972/1984/1988/1992
505	LAGO ORURO	CERCADO	LAGO ORURO	CERRADA				1988/1989
506	PUENTE CAIHUASI	CERCADO	CAIHUASI	CERRADA	17 ° 39 ' 49 "	67 ° 03 ' 08 "	3 815	1972/1975
507	PUENTE TOLEDO	CERCADO	DESAGUADERO	CERRADA	18 ° 05 ' 35 "	67 ° 16 ' 03 "	3 698	1973/1985/1992
508	SACABAYA	ATAHUALLPA	LAUCA	CERRADA	18 ° 33 ' 56 "	68 ° 47 ' 11 "	3 825	1973/1985/1991/1992
509	SACABAYA	SAJAMA	SAJAMA	CERRADA	18 ° 31 ' 03 "	68 ° 44 ' 34 "	3 800	1973/1985/1991/1992
510	THOLA PALCA	CERCADO	THOLA PAL. CHICO	CERRADA	17 ° 52 ' 00 "	66 ° 48 ' 57 "	3 950	1973/1984
511	TODOS SANTOS	ATAHUALLPA	TODOS SANTOS	CERRADA	19 ° 00 ' 28 "	68 ° 42 ' 55 "	1 239	1976/1984/1988/1992
512	UCUMASI	CARANGAS	LAKAJAHUIRA	CERRADA				1991/1992

Source : "Mejoramiento y Ampliacion de La Red Hidrometeorologica Nacional, Inventario de las Estaciones Existentes", SENAMHI, Aug.1993

表 2.5 水文資料入手可能期間(オルロ県) (SENAMHI)

No.	Station	River	Data	Information of Recorded (from 1960)																																								
				60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	
1	Kori Kollo	Desaguadero	L.E.																																									
			AFORO																																									
2	Chuquina	Desaguadero	L.E.																																									
			AFORO																																									
3	Eucaliptus	Dasaguadero	L.E.																																									
			AFORO																																									
4	Pte. Burguillos	Aflente Desaguadero	L.E.																																									
			AFORO																																									
5	Pte. Caihuasi	Caihuasi	L.E.																																									
			AFORO																																									
6	Thoia Palcs	Tholapaca chico	L.E.																																									
			AFORO																																									
7	Huachacalla	Lauca	L.E.																																									
			AFORO																																									
8	Huachacalla	Turca	L.E.																																									
			AFORO																																									
9	Lago Oruno	Lago Oruro	L.E.																																									
			AFORO																																									
10	Pte. Toledo	Desaguadero	L.E.																																									
			AFORO																																									
11	Todos Santos	Todos Santos	L.E.																																									
			AFORO																																									
12	Pte. Espafiol	Desaguadero	L.E.																																									
			AFORO																																									
13	Sacabaya	Lauca	L.E.																																									
			AFORO																																									
14	Sacabaya	Sajama	L.E.																																									
			AFORO																																									
15	Ucumasi	Lakajahuira	L.E.																																									
			AFORO																																									
16	Cosapa	Cosapa	L.E.																																									
			AFORO																																									
17	Pazna	Poopo	L.E.																																									
			AFORO																																									
18	Pampa Aullagas	Lakajahuira	L.E.																																									
			AFORO																																									

Source : MINISTERIO DE DESARROLLO SOSTENIBLE Y MEDIO AMBIENTE, SERVICIO NACIONAL DE METEOROLOGIA E HIDROLOGIA, DEPARTAMENT DE HIDROLOGIA

表 2.6 流量観測結果 (1999年9月 ~ 2001年4月)

< La Paz >										Discharge Observation								
No	Selected Site	Area (direction)	Name	Department	Province	Municipal	Canton	River (Cuenca)	Site	Obs. Discharge (m3/s)	Observed date (by JICA Study Team)							
1	1	LaPaz-SE	Yanamayu Rio Yanamayu	La Paz	S. Yundas	La Asunta	Yanamayu (&Chamaca,Charobamba,Palmar)	Rio Yanamayu	10m D/S of lower road bridge	0.67	29/08/1999							
2	2	LaPaz-W	Culva & Canlaya Rio Opinuwaya	La Paz	B. Saavedra	Curva	Calaya	Rio Opinuwaya	Canlaya	0.32	03/09/1999							
3		LaPaz-W	Amarete Rio Amarete	La Paz	B. Saavedra	G. J. J. Pérez	Amarete	Rio Amarete	455m down from Amarete town	0.41	03/09/1999							
4		LaPaz-W	Camata (A) Rio Quillarwaya	La Paz	Munecas	Ayata	Camata	Rio Quillarwaya	Rio Camata (300m U/S from confluence point with Rio Charazani)	4.67	02/09/1999							
5		LaPaz-W	Camata (B) Camata Canal	La Paz	Munecas	Ayata	Camata	Camata village canal	access to Camata village road	0.03	02/09/1999							
6	3	LaPaz-N	Apolo	La Paz	F. Tamayo	Apolo	Apolo	Rio Turiapu	U/S of Road Bridge	1.99	14/10/1999							
										24.16	21/01/2000							
										4.97	03/06/2000							
										3.32	24/07/2000							
										1.75	15/09/2000							
								11.20	23/04/2001									
															Rio Machariapu	Proposed MHP Site	3.59	23/07/2000
																2.67	14/09/2000	
								6.67	24/04/2001									
							Rio Vilipiza	Road across	0.10	12/09/2000								
7	4	LaPaz-N	Ixiamas	La Paz	Iturralde	San Buenaventura	Ixiamas	Rio Tequeje	U/S of Under-Construction Road Bridge	2.68	23/10/1999							
										16.70	12/01/2000							
										26.24	16/06/2000							
														Rio Tudarai	Confluence point Rio Tequeje	0.13	16/06/2000	
8	5	LaPaz-E	Covendo	La Paz	S. Yundas	Palos Blancos	Palos Blancos	Rio Covendo	Covendo Village Church	2.42	18/06/2000							
< Oruro >																		
1		Oruro-NW	Tomarapi	Oruro	Sajama	Curahuara de Carangas	Sajama / Caripe	Rio Tomarapi	Tomarapi village	0.10	07/09/1999							
2		Oruro-NW	Sajama (A)	Oruro	Sajama	Curahuara de Carangas	Comunidades de S.P.Tomarapi y Sajama	Rio Sajama	Sajama village	0.39	08/09/1999							
3		Oruro-NW	Sajama (B)	Oruro	Sajama	Curahuara de Carangas	Comunidades de S.P.Tomarapi y Sajama	Rio Milluni	Ecia Kasilla	0.05	08/09/1999							
4	1	Oruro-W	Chachacomani (A) Rio Jaruma	Oruro	Sajama	Turco	Chachacomani	Rio Jaruma	4.5km SW from Quimsa Jakka town	0.040	09/09/1999							
										0.056	06/11/1999							
										0.072	30/01/2000							
										0.027	10/06/2000							
										0.008	09/09/2000							
										0.073	20/01/2001							
5		Oruro-W	Chachacomani (B) Rio Chohojho	Oruro	Sajama	Turco	Chachacomani	Rio Chohojho	4.0km SW from Chachacomani village	0.03	09/09/1999							
6	2	Oruro-W	Chachacomani (C) Rio Sajama	Oruro	Sajama	Turco	Ecia Centro Morgachi	Rio Sajama	11 km SE from Chachacomani village	2.14	09/09/1999							
										2.23	06/11/1999							
										5.86	30/01/2000							
										2.40	10/06/2000							
									0.072	09/06/2000								
										0.056	09/09/2000							
										0.092	20/01/2001							
8		Oruro-W	Rio Lauca	Oruro	Sajama	Sacabaya	Macaya	Rio Lauca	8 km SW from Macaya village	1.62	10/09/1999							
9		Oruro-SW	Juro	Oruro	Atahualpa	Co. Puquintia	Juro (Ecia Villyo)	Rio Pacokhaua	15 km SE from Jule town	0.04	10/09/1999							
10	4	Oruro-SE	Sevaruyo Rio Mallka	Oruro	Avaroa	Santuario de Quillacas	Soraga / Est. Torko (Sevaruyo)	Rio Mallka	5km from Est. Torko	0.17	08/06/2000							

Source: JICA Study Team

表 3.1 既設小水力発電所一覧(ラパス県・オルロ県)
(Completed and Under Construction)

La Paz

No.	Name of Project	Departamento	Province	Municipality	Canton	River Name	MHP										Conducted by			
							No.of Benef.	No.of Benef.	Year Completed	Plant Discharge	Effective Head (Net)	Installed Capacity	Investment Cost (MHP)	kW Cost (MHP)	Anneal Energy	Annualized Investment + OM Cost per kWh (MHP)		Investment Cost per Household (MHP)		
							(HH)	(Population)		(l/s)	(m)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)	(US\$/kWh)		(US\$/HH)		
a	-	-	b	c	d	e	f =e/d	g =(d*8*365*0.95)	h =CRF + OM 1.8% *e / g	i =e / a										
1	La Asunta	La Paz	S. Yungas	La Asunta	La Asunta		200		1996	750	34	150	385 000	2 567	394 200	0.18	1 925	Munc. La Asunta, Prefectura La Paz		
2	Chamaca	La Paz	S. Yungas	La Asunta	Chamaca		355			500	26	70	147 000	2 100	183 960	0.15	414	Munc. Asunta, Comunidad, UMSA-IHH		
3	Yarija-Chajro	La Paz	S. Yungas	Chulumani	Yarija Chajru		52			180	25	20	125 000	6 250	52 560	0.45	2 404	Munc. De Chulumani, Prefectura La Paz		
4	Velo novia	La Paz	S. Yungas	Yanacachi	Villa Aspiasu		10					0.5	1 500	3 000	1 314	0.21	150	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura		
5	Chimpa	La Paz	S. Yungas	Chulumani			1 028					20	64 000	3 200	55 480	0.16	62	Munc. De Chulumani, Prefectura La Paz		
6	Covendo	La Paz	S. Yungas	Palos Blancos	Covendo	Rio Covendo	1		1948		16	2.7	8 100	3 000	7 096	0.21	8 100	Church of Covendo		
7	La Cascada	La Paz	S. Yungas	Palos Blancos	La Cascada		80	400	2000	80	68.7	35	94 711	2 706	91 980	0.19	1 184	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura		
8	Flor de Mayo	La Paz	S. Yungas	Irupana	Irupana		200		2001	40	58	15	30 000	2 000	39 420	0.14	150	UNDP, UMSA-IHH, Prefectura Alcaldia		
9	Unduavi	La Paz	Nor Yungas	Coroico	Unduavi	Rio Unduavi	35			150	15	15	25 000	1 667	39 420	0.12	714	UMSA-IHH		
10	Quenallata	La Paz	Nor Yungas	Coroico	Quenallata		15					0.3	900	3 000	788	0.21	60	UMSA-IHH		
11	Santa Rosa de Quilo Quilo	La Paz	Nor Yungas	Coroico	Mururata		80			80	70	40	72 600	1 815	105 120	0.13	908	Munc. De Coroico, Proy. Ecotecnologico, UMSA-IHH		
12	Challa	La Paz	Nor Yungas	Coroico	Challa		119	600	2001	100	80	51	83 850	1 644	134 028	0.12	705	NF-Alisei (Italia), EU, Alcaldia, Munc., Prefectura		
13	San Pedro	La Paz	Caranavi	Caranavi	Choro	Rio San Pedro	50		1998	33	150	16	43 164	2 698	42 048	0.19	863	Comunidad de San Pedro, PROPER, UMSA-IHH		
14	Choro	La Paz	Caranavi	Caranavi	Choro		66			10		24	72 000	3 000	63 072	0.21	1 091	UMSA-IHH		
15	Chojña	La Paz	Caranavi	Caranavi	Chojña		60		2000	60		15	86 000	5 733	39 420	0.41	1 433	Munc. De Caranavi, UMSA-IHH		
16	Colonia 18 de Mayo	La Paz	Caranavi	Caranavi	Colonia 18 de Mayo		50		2000	30		12	54 000	4 500	31 536	0.32	1 080	Munc. De Caranavi, UMSA-IHH		
17	Taypiplaya	La Paz	Caranavi	Caranavi	Taypiplaya		200		2001			200	280 000	1 400	525 600	0.10	1 400	Munc. De Caranavi, Prefectura La Paz		
18	San Isidro Uyunense	La Paz	Caranavi	Caranavi	Uyunense		140	720	2001	100	71	40	63 300	1 583	105 120	0.11	452	NF-Alisei (Italia), EU, Alcaldia, Munc., Prefectura		
19	San Pablo	La Paz	Caranavi	Caranavi	San Palblo		120	750	2001	80	96	40	59 250	1 481	105 120	0.11	494	NF-Alisei (Italia), EU, Alcaldia, Munc., Prefectura		
20	Pongo I, II, III	La Paz	Murillo	La Paz	Zongo		20			8	50	10	30 000	3 000	26 280	0.21	1 500	UMSA-IHH, GTZ		
21	Charazani	La Paz	B.Saavedra	Charazani	Charazani		100		1988			70	183 000	2 614	183 960	0.19	1 830	Munc. De Charazani, Prefectura La Paz		
22	Tipuani	La Paz	Larecaja	Tipuani	Tipuani		4000					200	420 000	2 100	525 600	0.15	105			
23	Tumupasa	La Paz	Iturralde	San Buenaventura	Tumupasa	Rio Tumupasa	180			80	80	37	82 427	2 228	97 236	0.16	458	Munc. De S.Buenaventura, PROPER, UMSA-IHH		
TOTAL							7 161						#####	2 410 802						

Oruro

No.	Name of Project	Departamento	Province	Municipality	Canton	River Name	MHP										Conducted by			
							No.of Benef.	No.of Benef.	Year Completed	Plant Discharge	Effective Head (Net)	Installed Capacity	Investment Cost (MHP)	kW Cost (MHP)	Anneal Energy	Annualized Investment + OM Cost per kWh (MHP)		Investment Cost per Household (MHP)		
							(HH)	(Population)		(l/s)	(m)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)	(US\$/kWh)		(US\$/HH)		
a	-	-	b	c	d	e	f =e/d	g =(d*8*365*0.95)	h =CRF + OM 1.8% *e / g	i =e / a										
1	Todos Santos	Oruro	Mejillones	Todos Santos	Todos Santos	Rio Todos Santos	100			40	50	135	2 500 000	18 519	354 780	1.32	25 000	Prefectura de Oruro		
2	Condo	Oruro	Sebastian Pagado	Santiago de Hua	San Pedro de Condo		70			125	62	65	50 000	769	170 820	0.05	714	Prefectura de Oruro, PROPER		
TOTAL							170						200	2 550 000						

表 3.2 小水力発電計画一覧 (1/2) (ラパス県)

No.	Name of Project (Name of Community)	Province	Canton	MHP						Study Conducted by	Stage of Project (1:Profile, 2:Pre-F/S, or F/S, 3:Final)
				No.of Benef.	Installed Capacity	Investment Cost (MHP)	kW Cost (MHP)	Annual Energy	Annualized Investment + OM Cost per kWh (MHP)		
				(HH)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)	(US\$/kWh)		
a	d	e	f=e/d	g=(d*8*365*0.95)	h=(CRF+OM 1.8%)*e/g	j					
1	Padilla -Thiyumayo	Nor Yungas	Coroico	220	20	39 450	1 973	55 480	0.10	EU, Prefectura, Alcaldia	1
2	Huarinillas-Coroico [Rehabilitation]	Nor Yungas	Coroico	978	205	279 000	1 361	568 670	0.07	UMSA-IHH	1
3	Chairo	Nor Yungas	Pacollo	100	40	56 170	1 404	110 960	0.07	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
4	Mocori	Nor Yungas	Milluhuaya	22	8.8	29 600	3 364	24 411	0.16	UMSA-IHH	1
5	Ikiko	S. Yungas	Lambate	65	50	175 000	3 500	138 700	0.17	Munc. De Irupana, Prefectura La Paz	1
6	San Isidro	S. Yungas	Villa Asunta (Cutusuma)	67	40	87 600	2 190	110 960	0.11	Munc. Chulumani, UMSA-IHH, Proy. Ecotecnologico	1
7	Piguaya-Ilumaya	S. Yungas	Villa Aspiazu	90	24	76 027	3 168	66 576	0.15	UMSA-IHH	1
8	Villa Barrientos	S. Yungas	Villa Barrientos	100	23	50 000	2 174	63 802	0.11	ECOTEC	1
9	Colopampa-Santa Rosa	S. Yungas	Colopampa Grande	580	160	270 512	1 691	443 840	0.08	UMSA-IHH	3
10	Yanamayu	S. Yungas	Yanamayu	230	88	183 561	2 086	244 112	0.10	UMSA-IHH	3
11	Palmar	S. Yungas	Chamaca	150	40	70 000	1 750	110 960	0.09	ECOTEC	1
12	Calisaya	S. Yungas	Calisaya	80	25	34 300	1 372	69 350	0.07	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
13	Charia	S. Yungas	Charia	200	50	80 000	1 600	138 700	0.08	ECOTEC	1
14	Pichari	S. Yungas	San Jose	162	48	100 000	2 083	133 152	0.10	ECOTEC	1
15	San Miguel de Huachi	S. Yungas	Palos Blancos	55	40	140 000	3 500	110 960	0.17	Munc. De Palos Blancos, Prefectura La Paz	2
16	Remolinos	S. Yungas	Palos Blancos	60	25	61 968	2 479	69 350	0.12	Khana Wayra, Energética y PROPER	1
17	Tucupi	S. Yungas	Palos Blancos	120	28	67 273	2 403	77 672	0.12	Khana Wayra, Energética y PROPER	1
18	Covendo [Rehabilitation]	S. Yungas	Palos Blancos	137	25	116 655	4 666	69 350	0.23	Khana Wayra, Energética	1
19	Inicua-Delicias	S. Yungas	Palos Blancos	84	60	141 140	2 352	166 440	0.11	VMEH/PNUD/Solsticio SRL.	1
20	Centro Tocoroni	S. Yungas	Villa Barrientos	828	60	174 773	3 000	166 440	0.14	UNDP	3
21	Calama	Caranavi	Calama	170	50	175 204	3 504	138 700	0.17	UMSA-IHH	3
22	Oro verde	Caranavi	Suapi Alto Beni	60	25	52 000	2 080	69 350	0.10	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
23	Incahuara	Caranavi	Incahuara de Ckullu Kuchij	70	30	150 000	5 000	83 220	0.24	Munc. De Caranavi, UMSA-IHH	1
24	Nueva Esperanza	Caranavi	Nueva Esperanza	65	30	78 000	2 600	83 220	0.13	Munc. De Caranavi, UMSA-IHH	1
25	Illimani	Caranavi	Alto Illimani	60	20	58 000	2 900	55 480	0.14	Munc. De Caranavi, UMSA-IHH	1
26	Villa el Carmen	Caranavi	Rosario Entre Rios	90	40	68 100	1 703	110 960	0.08	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
27	Cañisaya	Caranavi		33	10	25 000	2 500	27 740	0.12	EU-NF, Prefectura, Alcaldia	1
28	Miguillas-Circuata	Inquisivi	Circuata	978	350	759 000	2 169	970 900	0.11	UMSA-IHH	1
29	Poroma	Larecaja	Santa Rosa de Challana	350	300	300 000	1 000	832 200	0.05	ECOTEC	1
30	Camata	Munecas	Camata	200	20	140 000	7 000	55 480	0.34	UMSA-IHH	1
31	Chajlaya	Munecas	Chajlaya	100	50	150 000	3 000	138 700	0.15		1
32	Pocomayo (Pocomayo, Vilaque, Choquepata)	Munecas	Timusi	102	25	53 842	2 154	69 350	0.11	Comunidad de Pocomayo, UMSA-IHH	1
33	Amarete	B.Saavedra	Amarete	200	200	505 000	2 525	554 800	0.12	Munc Charazani, Prefectura La Paz	3
34	Curva - Canlaya (Río Opinuwaya)	B.Saavedra	Curva	170	45	112 500	2 500	124 830	0.12	JICA Study Team	1
35	Ulla Ulla	F.Tamayo	Ulla Ulla	60	20	50 000	2 500	55 480	0.12		1
36	Suches	F.Tamayo	Suches	140	100	200 000	2 000	277 400	0.10		1
37	Apolo (Río Turiapu)	F. Tamayo	Apolo	600	200	628 000	3 140	554 800	0.15	CORDEPAZ	2
38	Apolo (Río Machariapu) [Phase - I	F. Tamayo	Apolo, Santa Cruz del Valle Ameno & Aten	1 100	350	2 000 000	5 714	970 900	0.28	JICA Study Team	2
38	Apolo (Río Machariapu) [Phase - II	F. Tamayo	Apolo, Santa Cruz del Valle Ameno & Aten	900	350	2 000 000	5 714	970 900	0.28	JICA Study Team	2
39	Quillihuyo y Tirajahua - Huamanata	Camacho	Humanata	700	10	27 398	2 740	27 740	0.13	ORPA, Khana Wayra y PROPER	1
40	Cotosi - Queñi	Camacho	Mocomoco	137	5	20 550	4 110	13 870	0.20	ORPA, Khana Wayra y PROPER	1
41	Llallagua	J. Manuel Pando	Santiago de Machaca	10	8	8 485	1 061	22 192	0.05	PROPER, Misión Alianza Noruega (MAN)	1
42	25 de Mayo	Iturrealde	San Buena Ventura	350	25	65 000	2 600	69 350	0.13	EU-NF, Prefectura, Alcaldia	1
43	San Miguel	Iturrealde	San Buena Ventura	80	25	66 900	2 676	69 350	0.13	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
44	San José de Chupiamonas	Iturrealde	San José de Chupiamonas	80	40	70 200	1 755	110 960	0.09	NF-Alisei (Italia), EU, Alcaldia., Munc., Prefectura	2
45	Ixiamas	Iturrealde	Ixiamas	650	400	2 600 000	6500	1 109 600	0.32	JICA Study Team	1
TOTAL				321 W/HH	11 783	3 788	12 596 207	2 728			

表 3.2 小水力発電計画一覧 (2/2) (オルロ県)

No.	Name of Project	Province	Canton	MHP						Study Conducted by	Stage of Project (1:Profile, 2:Pre-F/S, or F/S, 3:Final Design)
				No.of Benef.	Installed Capacity	Investment Cost (MHP)	kW Cost (MHP)	Annual Energy	Annualized Investment + OM Cost per kWh (MHP)		
				(HH)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)	(US\$/kWh)		
a	d	e	f=e/d	g=(d*8*365*0.95)	h=(CRF+OM 1.8%)*e/g	j					
1	Tomarapi - Caripe	Sajama	Sajama / Caripe	40	10	39 312	3 931	27 740	0.19	Prefectura de Oruro, JICA Study Team	1
2	Sajama (Rio Jachcha Huancollo)	Sajama	Sajama	60	25	75 000	3 000	69 350	0.15	ECOTEC, JICA Study Team	1
3	Tambo Quemado	Sajama	Chachacomani	69	62	202 000	3 258	171 988	0.16	JICA Study Team, ECOTEC	2
4	Chachacomani (Rio Jaruma)	Sajama	Chachacomani	70	14	49 000	3 500	38 836	0.17	JICA Study Team	1
5	MHP & WIND Hybrid System	Sajama	Chachacomani	1 100	340	2 040 000	6 000	943 160	0.29	JICA Study Team	1
6	Chachacomani (Rio Sajama)	Sajama	Chachacomani	226	53	54 000	1 019	147 022	0.05	Prefectura de Oruro, China	1
7	Todos Santos [Rehabilitation]	Mejillones	Todos Santos	20	10	37 100	3 710	27 740	0.18		1
8	Juro - Viluyo (Rio Pacokhaua, Est. Viluyo)	Atahualpa	Negrillos / Juro	80	15	52 500	3 500	41 610	0.17	JICA Study Team	1
9	Cruce Culta	Spagador	Culta	200	70	210 000	3 000	194 180	0.15	JICA Study Team	1
10	Mallka (Sevaruyo)	Avaroa	Soraga	200	50	180 000	3 600	138 700	0.18	Prefectura de Oruro, PROPER	2
TOTAL				318 W/HH	2 065	649	2 938 912				

Source : JICA Study Team

Note: *1) Column 'e', 'f', 'g': Italic numbers are assumed.

*2) Column 'g' & 'h': For the estimation of annual energy of the MHP, following parameter are used.

Effective Operation Hour (Demand) per Day for Estimation of kWh [hour/day] = 8
Plant Factor for MHP = 0.95
n : Life Time of the System [Years] = 20
R: Discount Rate [%] = 10%
CRF (Capital Recovery Factor) = $(R(1+R)^n)/((1+R)^n-1)$ = 0.1175
OM Cost for MHP (% of total investment) [%] = 1.8%

表 4.2 小水力発電計画プロジェクトの選定(オルロ県)
(Plan 2002 - 2011)

No.	Proposed Implementation Schedule (Term of Year)	Name of Project	Province	Canton	MHP					Study Conducted by	Stage of Project (1:Profile, 2:Pre-F/S, or F/S, 3:Final Design)	Grid Extension Case					Priority Evaluation					Priority Scheme (Justified by kWh Cost)															
					No. of Benef. (Families)	Installed Capacity (kW)	Investment Cost (MHP) (US\$)	kW Cost (MHP) (US\$/kW)	Annual Energy (kWh/Year)			Annualized Investment + OM Cost per kWh (MHP) (US\$/kWh)	Length of Transmission Line from Exist. Grid (km)	Factor of Topographic Condition	Modified No. of Benef. Families by Grid (HH)	Length of Distribution Line (230 V) (km)	Investment Cost (if by Grid) (US\$)	Annual Energy (kWh/Year)	Annualized Marginal Cost per kWh (Grid) (US\$/kWh)	Investment Cost per Household (Grid) (US\$/HH)	Cost(Grid) / Cost(MHP) (x times)	Priority Scheme (Justified by kWh Cost)	Priority Scheme (Justified by Invest. Cost)	Distance from Exist. Grid (km)		Cost(Grid) / Cost(MHP)		Benefit Household Size		Stage of Project (1:Profile, 2:Pre-F/S, or F/S, 3:Final Design)		Overall Priority		MHP Investment Cost		Proposed Implementation Schedule (Term of Year)	
					(HH)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)			(US\$/kWh)												(3-F)	(3-F)	(1-F)	(1-F)	(3-F)	(kWh/Year)	(US\$/kWh)	(US\$/HH)	(x times)	(HH)	(HH)	(km)		(Rank 1)
1	-	Tomarapi - Caripe	Sajama	Sajama / Caripe	40	10	39 312	3 931	27 740	0.19	Prefectura de Oruro, JICA Study Team	1	53	1.00	580	11.6	496 900	508 080	0.18	857	12.6	Grid	MHP	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2007 - 2011	Sajama (Rio Jachcha Huancollo)	Sajama	Sajama	60	25	75 000	3 000	69 350	0.15	ECOTEC, JICA Study Team	1	70	1.00	690	13.8	650 200	604 440	0.20	942	8.7	MHP	MHP	70	2	8.7	2	60	3	1	2	11.0	3	75 000	367 200	2007 - 2011	
3	2002 - 2006	Tambo Quemado	Sajama	Chachacomani	69	62	239 700	3 866	171 988	0.19	JICA Study Team, ECOTEC	2	85	1.00	760	15.2	783 300	665 760	0.21	1 031	3.3	MHP	MHP	85	1	3.3	3	69	2	2	1	8.0	1	239 700	239 700	2002 - 2006	
4	-	Chachacomani (Rio Jaruma) MHP & WIND Hybrid System	Sajama	Chachacomani	70	14	49 000	3 500	38 836	0.17	JICA Study Team	1	95	1.00	840	16.8	874 700	735 840	0.21	1 041	17.9	Wind	MHP	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	-	Chachacomani (Rio Sajama)	Sajama	Chachacomani	1 100	340	2 040 000	6 000	943 160	0.29	JICA Study Team	1	135	1.00	1 070	21.4	1 233 100	937 320	0.23	1 152	0.6	Grid	Grid	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	-	Todos Santos [Rehabilitation]	Mejillones	Todos Santos	226	53	54 000	1 019	147 022	0.05	Prefectura de Oruro, China	1	x	1.00	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
7	-	Cahuana	Atahuallpa	Cahuana	20	10	37 100	3 710	27 740	0.18		1	x	1.00	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
8	2007 - 2011	Juro - Viluyo (Rio Pacokhuau, Est. Viluyo)	Atahuallpa	Negrillos / Juro	80	15	52 500	3 500	41 610	0.17	JICA Study Team	1	60	1.00	400	8.0	542 000	350 400	0.27	1 355	10.3	MHP	MHP	60	3	10.3	1	80	1	1	2	9.0	2	52 500	292 200	2007 - 2011	
9	-	Cruce Culta	Spagador	Culta	200	70	210 000	3 000	194 180	0.15	JICA Study Team	1	x	1.00	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
10	-	Mallka (Sevaruyo)	Avaroa	Soraga	200	50	180 000	3 600	138 700	0.18	Prefectura de Oruro, PROPER	2	x	1.00	-	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		

Note: "Chachacomani (Rio Jaruma) MHP" is selected but explain as WIND POWER PROJECT for chachacomani town.

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.

Number of MHP = 3 5

3 367 200

1
2
3

Average Installed Capacity per Household in the Selected MHP Projects (Oruro) = 488 W/HH
Source : JICA Study Team

Note: *1) Column 'e', 'f', 'g': Italic numbers are assumed.

*2) Column 'g' & 'h': For the estimation of annual energy of the MHP, following parameter are used.

Effective Operation Hour (Demand) per Day for Estimation of kWh [hour/day] = 8
Plant Factor for MHP = 0.95
n : Life Time of the System [Years] = 20
R: Discount Rate [%] = 10%
CRF (Capital Recovery Factor) = $(R(1+R)^n)/((1+R)^n - 1) = 0.1175$
OM Cost for MHP (% of total investment) [%] = 1.8%

*3) Column 'k' - 'o': Length of transmission line from existing grid to target village are measured by using "Grid Map, La Paz - A&B, Oruro", (1:50,000, VMEH, updated by JICA Study Team)

*4) The unit costs of grid extension per kilometer for each voltage capacity in the line (exp. 34.5kV, 24.9kV, etc.) are used averaged investment cost of the grid extension investment cost in the La Paz prefecture.

This cost including materials, manpower, supervision, instances, Tax, company benefit (9.5%), extra expense (3%), sundry expenses (5%).

34.5kV: Yungas / Amazonia Area, 24.9kV: Altiplano Area, 19.2kV: Yungas and Amazonia Area, 14.4kV: Altiplano Area, 6.9kV: Altiplano Area, 380/230V: Yungas and Amazonia Area in the La Paz prefecture

*5) Column 'p': "Factors of topographic condition" for the above "unit costs of grid extension per kilometer for each voltage capacity" are assumed by using topographic map.

*6) Column 'q': Beneficial household number by grid extenuation are accumulated of assumed electrified household on the route of additional grid line.

*7) Column 'r', 's', 'al' & 'an': For the estimation of investment cost and annual energy of the GRID, following parameter are used Conton-wise Rural Electrification "DATA BASE" (VMEH, 1999).

Effective Operation Hour (Demand) per Day for Estimation of kWh [hour/day] = 8
CRF (Capital Recovery Factor) = $(R(1+R)^n)/((1+R)^n - 1) = 0.1175$
Maintenance Cost for Grid Line (% of investment) [%] = 2.5%
LRMC (Long Run Marginal Cost) of Grid per kWh [US\$/kWh] = 0.0452
Power Demand per Household [W/House] = 300
Length of Distribution Line to Each Household [m/HH] = 20
Distribution Line Connecting Cost per Household [US\$/HH] = 100
Max. Cost per HH for Grid [US\$/HH] = 1 200

*8) Column 'x' & 'y': IF Cost(MHP) <= Cost(Grid) then "MHP", IF Cost(MHP) > Cost(Grid) and Cost/HH(Grid) <= US\$1,200 then "Grid", IF Cost(MHP) > Cost(Grid) and Cost/HH(Grid) > US\$1,200 then "Grid **"

*9): Column 'aa', 'ac' & 'ae': Ranking number in the selected MHP projects. If distance from existing grid (km, column 'z') is long, the rank will be high.

*10): Column 'ah': Overall point = (Rank-1 x 1) + (Rank-2 x 1) + (Rank-3 x 1) + (Rank-4 x 2)

表 4.3 選定した優先小水力プロジェクト(ラパス県・オルロ県)
(Plan 2002 - 2011)

La Paz

Priority Ranking No.	Proposed Implementation Schedule (Term of Year)	Name of Project	Province	Canton	MHP						Study Conducted by	Stage of Project
					No. of Benef. Families by MHP	Installed Capacity	Investment Cost (MHP)	kW Cost (MHP)	Annual Energy	Annualized Investment + OM Cost per kWh (MHP)		
					(HH)	(kW)	(US\$)	(US\$/kW)	(kWh/Year)	(US\$/kWh)		
a	d	e	f=e/d	g =(d*8760/0.95)	h=(CRF+OM 1.8%)*e/g		j					
* 1	2002 - 2006	Apolo (Rio Machariapu) [Phase - I]	F. Tamayo	Apolo, Santa Cruz del Valle Ameno & Aten	1 100	350	2 000 000	5 714	970 900	0.28	JICA Study Team	2
2	2002 - 2006	San José de Chupiamonas	Iturralde	San José de Chupiamonas	80	40	70 200	1 755	110 960	0.09	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
3	2002 - 2006	San Miguel	Iturralde	San Buena Ventura	80	25	66 900	2 676	69 350	0.13	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
4	2002 - 2006	25 de Mayo	Iturralde	San Buena Ventura	350	25	65 000	2 600	69 350	0.13	EU-NF, Prefectura, Alcaldia	1
5	2002 - 2006	Yanamayu	S. Yungas	Yanamayu	230	88	183 561	2 086	244 112	0.10	UMSA-IHH	3
6	2002 - 2006	Colopampa-Santa Rosa	S. Yungas	Colopampa Grande	580	160	270 512	1 691	443 840	0.08	UMSA-IHH	3
7	2002 - 2006	Calisaya	S. Yungas	Calisaya	80	25	34 300	1 372	69 350	0.07	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
8	2002 - 2006	Charia	S. Yungas	Charia	200	50	80 000	1 600	138 700	0.08	ECOTEC	1
9	2002 - 2006	Pichari	S. Yungas	San Jose	162	48	100 000	2 083	133 152	0.10	ECOTEC	1
9	2002 - 2006	Centro Tocoroni	S. Yungas	Villa Barrientos	828	60	174 773	3 000	166 440	0.14	UNDP	3
11	2002 - 2006	Suches	F. Tamayo	Suches	140	100	200 000	2 000	277 400	0.10		1
12	2002 - 2006	Curva - Canlaya (Rio Opinuwaya)	B. Saavedra	Curva	170	45	112 500	2 500	124 830	0.12	JICA Study Team	1
13	2002 - 2006	Palmar	S. Yungas	Chamaca	150	40	70 000	1 750	110 960	0.09	ECOTEC	1
13	2002 - 2006	Villa el Carmen	Caranavi	Rosario Entre Rios	90	40	68 100	1 703	110 960	0.08	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
15	2007 - 2011	Calama	Caranavi	Calama	170	50	175 204	3 504	138 700	0.17	UMSA-IHH	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	Nor Yungas	Pacollo	100	40	56 170	1 404	110 960	0.07	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
18	2007 - 2011	Pocomayo (Pocomayo, Vilaque, Choquepata)	Munecas	Timusi	102	25	53 842	2 154	69 350	0.11	Comunidad de Pocomayo, UMSA-IHH	1
19	2007 - 2011	Inicua-Delicias	S. Yungas	Palos Blancos	84	60	141 140	2 352	166 440	0.11	VMEH/PNUD/Solsticio SRL.	1
20	2007 - 2011	Llallagua	J. Manuel Pando	Santiago de Machaca	10	8	8 485	1 061	22 192	0.05	PROPER, Misión Alianza Noruega (MAN)	1
21	2007 - 2011	Incahuara	Caranavi	Incahuara de Ckullu Kuchij	70	30	150 000	5 000	83 220	0.24	Munc. De Caranavi, UMSA-IHH	1
21	2007 - 2011	Poroma	Larecaja	Santa Rosa de Challana	350	300	300 000	1 000	832 200	0.05	ECOTEC	1
23	2007 - 2011	Padilla -Thiyumayo	Nor Yungas	Coroico	220	20	39 450	1 973	55 480	0.10	EU, Prefectura, Alcaldia	1
24	2007 - 2011	Villa Barrientos	S. Yungas	Villa Barrientos	100	23	50 000	2 174	63 802	0.11	ECOTEC	1
25	2007 - 2011	Huarinillas-Coroico [Rehabilitation]	Nor Yungas	Coroico	978	205	279 000	1 361	568 670	0.07	UMSA-IHH	1
26	2007 - 2011	Oro verde	Caranavi	Suapi Alto Beni	60	25	52 000	2 080	69 350	0.10	NF-Alisei (Italia), EU, Alcaldia., Munic., Prefectura	2
26	2007 - 2011	Cotosi - Queñi	Camacho	Mocomoco	137	5	20 550	4 110	13 870	0.20	ORPA, Khana Wayra y PROPER	1
28	2007 - 2011	Nueva Esperanza	Caranavi	Nueva Esperanza	65	30	78 000	2 600	83 220	0.13	Munc. De Caranavi, UMSA-IHH	1
29	2007 - 2011	Mocori	Nor Yungas	Milluhuya	22	8.8	29 600	3 364	24 411	0.16	UMSA-IHH	1
30	2007 - 2011	Ilimani	Caranavi	Alto Ilimani	60	20	58 000	2 900	55 480	0.14	Munc. De Caranavi, UMSA-IHH	1
* -	2007 - 2011	Apolo (Rio Machariapu) [Phase - II]	F. Tamayo	Apolo, Santa Cruz del Valle Ameno & Aten	900	350	2 000 000	5 714	970 900	0.28	JICA Study Team	2

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
 Average Installed Capacity per Household in the Selected MHP Projects (La Paz) = 300 W/HH 910 [US\$/HH]

Oruro

1	2002 - 2006	Tambo Quemado	Sajama	Chachacomani	69	62	239 700	3 866	171 988	0.19	JICA Study Team, ECOTEC	2
2	2007 - 2011	Juro - Viluyo (Rio Pacokhaua, Est. Viluyo)	Atahuallpa	Negrillos / Juro	80	15	52 500	3 500	41 610	0.17	JICA Study Team	1
3	2007 - 2011	Sajama (Rio Jachcha Huancollo)	Sajama	Sajama	60	25	75 000	3 000	69 350	0.15	ECOTEC, JICA Study Team	1

Sub-Total 2002 - 2006 69 62 240 000
 Sub-Total 2007 - 2011 140 40 128 000
 TOTAL (2002 - 2011) 209 102 368 000
 Average Installed Capacity per Household in the Selected MHP Projects (Oruro) = 488 W/HH 1 761 [US\$/HH]

Source : JICA Study Team

Note: *1) Column 'e', 'f', 'g': Italic numbers are assumed.

*2) Column 'g' & 'h': For the estimation of annual energy of the MHP, following parameter are use

Effective Operation Hour (Demand) per Day for Estimation of kWh (hour/day)	8
Plant Factor for MHP	0.95
n : Life Time of the System [Years]	20
R : Discount Rate [%]	10%
CRF (Capital Recovery Factor) = (R(1+R) ⁿ)/((1+R) ⁿ -1)	0.1175
OM Cost for MHP (% of total investment) [%]	1.8%

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

表 5.1 アポロ市月平均気温・湿度

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

表 5.2 アポロ市月降水量記録 (1966 年 - 2000 年)

ESTACION : APOLO (AEROPUERTO)
 PROVINCIA : F. TAMAYO
 DEPTO. : LA PAZ

LATITUD S : 14°44'
 LONGITUD W : 68°32'
 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	266.0	246.0	196.0	17.0	19.0	3.0	5.0	31.0	86.0	309.0	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.

表 5.3 需要対象地域の村落人口および世帯数（アポロ, 1999 年）

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	Liucamayo, San José, Ubía, 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)

表 5.4 計画村落世帯数 (アポロ, 1999 年および 2005 年)

Block A (only Apolo Central Town Case)

No.	Canton	Area	Community	1999 (Actual)			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	Iltasawa	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	Yalihua	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	Muruagua	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	Ubía	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.

表 5.5 一世帯当たりの家庭用単位電力消費量（アポロ）

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

表 5.6 非家庭用单位電力消費量 (アポロ) (1/2)

[for Urban Area, 2005]

No.	Category	Potintial 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	1.00 ₁	0.00	0.50 ₁	0.06 ₁	
	Lodging house	3.00	6.00 ₁	0.00 ₁	2.00	4.50 ₁		0.50
	Restaurants	1.00	6.00 ₁	0.00 ₁	4.00	1.50 ₁		0.33
	Cafeterias	1.00	4.00 ₁	0.00 ₁	2.00	1.00 ₁		0.17
	Bar, Caraoke, Disco etc.	3.00	6.00 ₁	2.00 ₁	0.00	4.50 ₁	0.75 ₁	
	Video theater	2.00	4.00 ₁	0.00 ₁	2.00	2.00 ₁		0.33
2)	Industrialy [kW/Block]	107.00				35.23	0.88	47.74
	Mechanical Work Shop							
	Electric Welder (Soldador)	12.00	7.00	0.00 ₁	0.00 ₁	5.00		2.92
	Elect. Lathe (Torno)		4.00	0.00 ₁	0.00 ₁	4.00		1.33
	Illumination & others		1.00	1.00 ₁	0.00 ₁	8.00	0.25 ₁	0.67
	Religious house (Orden Franciscana)							
	Circulate (Sierra Circular)	17.50	2.50	0.00 ₁	0.00 ₁	5.00		1.04
	Water Pump		3.00	0.00 ₁	0.00 ₁	5.00		1.25
	Illumination & Others		12.00	2.00 ₁	0.00 ₁	8.00	6.00 ₁	8.00
	Religious house (Orden Cisterciense)							
	Peeler of Rice	45.00	7.45	0.00 ₁	0.00 ₁	5.00		3.10
	Mill of Corn		2.24	0.00 ₁	0.00 ₁	5.00		0.93
	Electric Sierra		1.86	0.00 ₁	0.00 ₁	5.00		0.78
	Toast factory (Torrefactora)		1.12	0.00 ₁	0.00 ₁	5.00		0.47
	Refrigerator		0.75	1.33 ₁	2.67 ₁	4.00	0.25 ₁	0.25
	Illumination & Others		5.46	2.00 ₁	0.00 ₁	8.00	2.73 ₁	3.64
	Congeladoras		1.12	0.00 ₁	0.00 ₁	3.00		0.28
	Industrial Work Shop							
	Peeler of Coffee		12.00	0.00 ₁	0.00 ₁	5.00		5.00
	Drying of coffee		8.00	0.00 ₁	0.00 ₁	5.00		3.33
	Illumination & Others		5.00	2.00 ₁	0.00 ₁	5.00	2.50 ₁	2.08
	Bakeries		2.00	1.00 ₁	0.00 ₁	3.00	0.50 ₁	0.50
	Carpentry		5.00	0.00 ₁	0.00 ₁	7.00		2.92
	Electric and Electronic Shops		3.00	0.00 ₁	0.00 ₁	7.00		1.75
	Seam Work Shop		0.50	0.00 ₁	0.00 ₁	8.00		0.33
	Radiate Radio Station		2.00	6.00 ₁	2.50 ₁	13.00	3.00 ₁	0.63
	General Commercials/ Water Supply/ Others		20.00	4.00 ₁	0.00 ₁	3.00	20.00 ₁	5.00
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 ₁	0.00 ₁	1.00		0.17
	Sterilizer		0.50	1.00 ₁	0.00 ₁	8.00	0.13 ₁	0.33
	Centrifuge		0.20	0.00 ₁	0.00 ₁	0.50		0.01
	Refrigerator		0.80	1.33 ₁	2.67 ₁	4.00	0.27 ₁	0.27
	Illumination		3.20	2.00 ₁	0.00 ₁	3.00	1.60 ₁	0.80
	Others		3.00	0.00 ₁	0.00 ₁	6.00		1.50
	State Offices		8.00	0.00 ₁	0.00 ₁	9.00		6.00
	Military (Battalion Murillo)		21.82	4.00 ₁	0.00 ₁	4.00	21.82 ₁	7.27
	Church (Lutheran church)		2.00	4.00 ₁	0.00 ₁	4.00	2.00 ₁	0.67
	AASANA (Airport)		10.00	4.00 ₁	0.00 ₁	12.00	10.00 ₁	10.00
	DITER		2.50	2.00 ₁	0.00 ₁	8.00	1.25 ₁	1.67
	Public (Streetlight) [kW/km/HH]	0.04				0.04	0.04	0.00
	Streetlight (Public illuminations):							
	in Urban Town		0.04	4.00 ₁	8.00 ₁	0.00	0.04 ₁	0.04 ₁

Source: JICA Study Team

Note: reference source: "Minicentral Hidroelectrica en Apolo (Rio Turiapu)", Regionalizacion Energetica de Bolivia, Programa de la OEA. (1987)

表 5.6 非家庭用単位電力消費量 (アポロ) (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]	72.80				13.50	0.25	29.65
	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
	Industrial Work Shop							
	Water Pump	40.30	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
	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
	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		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.

表 5.7 総電力需要量推定結果（アポロ）

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 ₁	4.11 ₁	17.67	0.00 ₁	0.00 ₁	0.00	
2) Business	1	0	587	0	14.00 ₁	0.81 ₁	1.33	0.00 ₁	0.00 ₁	0.00	
3) Industry	1	0	587	0	35.23 ₁	0.88 ₁	47.74	0.00 ₁	0.00 ₁	0.00	
4) Public (Public Facilities)	1	0	587	0	37.06 ₁	0.27 ₁	28.68	0.00 ₁	0.00 ₁	0.00	
Public (Streetlight)	1	0	587	0	23.48 ₁	23.48 ₁	0.00	0.00 ₁	0.00 ₁	0.00	
Total					266.73₁	29.55₁	95.42	0.00₁	0.00₁	0.00	270
Block-B											
1) Domestic	1	7	587	253	156.96 ₁	4.11 ₁	17.67	34.18 ₁	0.00 ₁	2.72	
2) Business	1	7	587	253	14.00 ₁	0.81 ₁	1.33	9.75 ₁	0.44 ₁	1.00	
3) Industry	1	7	587	253	35.23 ₁	0.88 ₁	47.74	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	1	7	587	253	37.06 ₁	0.27 ₁	28.68	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	1	7	587	253	23.48 ₁	23.48 ₁	0.00	16.19 ₁	16.19 ₁	0.00	
Total					266.73₁	29.55₁	95.42	75.09₁	17.10₁	40.82	340
Block-C											
1) Domestic	0	15	0	338	0.00 ₁	0.00 ₁	0.00	45.66 ₁	0.00 ₁	3.63	
2) Business	0	15	0	338	0.00 ₁	0.00 ₁	0.00	9.75 ₁	0.44 ₁	1.00	
3) Industry	0	15	0	338	0.00 ₁	0.00 ₁	0.00	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	0	15	0	338	0.00 ₁	0.00 ₁	0.00	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	0	15	0	338	0.00 ₁	0.00 ₁	0.00	21.63 ₁	21.63 ₁	0.00	
Total					0.00₁	0.00₁	0.00	92.01₁	22.54₁	41.73	90
Block-D											
1) Domestic	0	7	0	230	0.00 ₁	0.00 ₁	0.00	31.07 ₁	0.00 ₁	2.47	
2) Business	0	7	0	230	0.00 ₁	0.00 ₁	0.00	9.75 ₁	0.44 ₁	1.00	
3) Industry	0	7	0	230	0.00 ₁	0.00 ₁	0.00	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	0	7	0	230	0.00 ₁	0.00 ₁	0.00	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	0	7	0	230	0.00 ₁	0.00 ₁	0.00	14.72 ₁	14.72 ₁	0.00	
Total					0.00₁	0.00₁	0.00	70.51₁	15.63₁	40.57	70
Block-E											
1) Domestic	0	8	0	337	0.00 ₁	0.00 ₁	0.00	45.53 ₁	0.00 ₁	3.62	
2) Business	0	8	0	337	0.00 ₁	0.00 ₁	0.00	9.75 ₁	0.44 ₁	1.00	
3) Industry	0	8	0	337	0.00 ₁	0.00 ₁	0.00	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	0	8	0	337	0.00 ₁	0.00 ₁	0.00	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	0	8	0	337	0.00 ₁	0.00 ₁	0.00	21.57 ₁	21.57 ₁	0.00	
Total					0.00₁	0.00₁	0.00	91.82₁	22.48₁	41.72	90
Block-F											
1) Domestic	0	5	0	216	0.00 ₁	0.00 ₁	0.00	29.18 ₁	0.00 ₁	2.32	
2) Business	0	5	0	216	0.00 ₁	0.00 ₁	0.00	9.75 ₁	0.44 ₁	1.00	
3) Industry	0	5	0	216	0.00 ₁	0.00 ₁	0.00	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	0	5	0	216	0.00 ₁	0.00 ₁	0.00	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	0	5	0	216	0.00 ₁	0.00 ₁	0.00	13.82 ₁	13.82 ₁	0.00	
Total					0.00₁	0.00₁	0.00	67.72₁	14.73₁	40.42	70
Block-G											
1) Domestic	0	2	0	32	0.00 ₁	0.00 ₁	0.00	4.32 ₁	0.00 ₁	0.34	
2) Business	0	2	0	32	0.00 ₁	0.00 ₁	0.00	9.75 ₁	0.44 ₁	1.00	
3) Industry	0	2	0	32	0.00 ₁	0.00 ₁	0.00	13.50 ₁	0.25 ₁	29.65	
4) Public (Public Facilities)	0	2	0	32	0.00 ₁	0.00 ₁	0.00	1.47 ₁	0.22 ₁	7.45	
Public (Streetlight)	0	2	0	32	0.00 ₁	0.00 ₁	0.00	2.05 ₁	2.05 ₁	0.00	
Total					0.00₁	0.00₁	0.00	31.09₁	2.96₁	38.44	40
Total (B ~ G)	1	44	587	1,406	270₁	30₁	100	430₁	100₁	240	700

Source: JICA Study Team

表 5.8 概略工事費（アポロ小水力発電計画・比較検討用）

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	610,400	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 Paved, 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	896,900	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	57,300	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 Woks	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	2,655,300	2,953,100	3,475,400	3,978,600	4,147,400	1.+2.+3.+4.
6. Administration and Engineering Service.	179,300	205,700	241,100	265,000	306,600	346,700	360,200	[Admin. (1.+2.+3.)*6%+D/D: US\$20,000]*1.38%
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): 9.1km*30,000 US\$/km + Flat Area (Standard): 3.5km*15,000US\$/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.	404,400	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	6,600	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 Woks	539,600	761,000	1,034,800	1,238,200	1,572,200	1,923,800	2,009,500	
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	2,963,000	3,386,800	3,530,100	
6. Administration and Engineering Service.	154,600	177,300	207,800	228,400	264,300	298,900	310,500	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
Total Construction Cost	1,772,700	2,074,900	2,478,800	2,750,700	3,227,300	3,685,700	3,840,600	

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

表 5.9 概略事業費および便益（アポロ小水力発電計画・比較検討用）

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 deen)	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 Woks	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	1,763,000	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 Litter (including transportation cost, without Tax) Bs. 4.5	Bs./Litter	3.88	3.88	3.88	3.88	3.88	3.88	3.88
	US\$/Litter	0.59	0.59	0.59	0.59	0.59	0.59	0.59
For Idling Generation								
Fuel Consumption for Idling Generation (0.2 litter/hour/100kW x 7)	Litter/hour	24.50	24.50	24.50	24.50	24.50	24.50	24.50
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	Litter/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	Litter/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	Litter/Year	173,935	237,469	285,284	360,571	430,530	496,984	536,185
Annual fuel cost for Load Generation	US\$/year	103,349	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 0.	US\$/year	10,266	12,891	15,516	18,141	21,516	24,891	26,391

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	1,250,098	1,591,994	1,694,223
Total O/M Cost of Diesel	US\$/year	242,392	288,547	322,572	373,517	425,309	475,029	501,628

Source: UMSA and JICA Study Team
Note: All costs are economic cost (not include taxes).

表 5.10 経済性評価（アポロ小水力発電計画・比較検討用）(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	1,803,414	257,164	
							EIRR =	12.4%
							B/C =	1.17

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	
							EIRR =	14.2%
							B/C =	1.27

表 5.10 経済性評価 (アポロ小水力発電計画・比較検討用) (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	2,689,097	485,726	
							EIRR =	13.6%
							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	916,900	0	916,900		0	0	-916,900	
-2	916,900	0	916,900		0	0	-916,900	
-1	916,900	0	916,900	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 =	1.29

表 5.10 経済性評価 (アポロ小水力発電計画・比較検討用) (3/4)

Case: 5
 Install Capacity: 570 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	1,075,767	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 =	15.3%
							B/C =	1.30

Case: 6
 Install Capacity: 660 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	1,228,567	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	499,327	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 =	1.31

表 5.10 経済性評価 (アポロ小水力発電計画・比較検討用) (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
						EIRR =	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.

表 5.11 工事費内訳 (土木工事、水力機器・電器機器) (アポロ小水力発電計画・プレ F/S) (1/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Case (700kW)		Note
			Quantity	Amount	
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	Francis	
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) (rock, with dinamite)	m ³	65.00	64.0	4,160	$(L1+L2)/2 * H * L = (2.3+4.1)/2 * 2.0 * 10.0$
Excavation (Stop Log part) (rock, with dinamite)	m ³	65.00	44.0	2,860	$H * B * L = 0.5 * 8.0 * 11.0$
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): $(H * B * T) * sets = (2 * 0.75 * 0.5) * 4$
Reiforcemnt Bar	t	1,200	1.8	2,160	$0.050 * Vc$
Sub Total				19,260	
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	$\left(\left(B_{outside} * H_{outside} \right) - \left(B_{inside} * H_{inside} \right) \right) * L = \left((2.0 * 2.5) - (1.0 * 1.5) \right) * 5 = 3.5 m^3 / m * 5m$
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	$1/2 * (9+6) * 3 * 2 * 0.5$
Reiforcemnt Bar	t	1,200	2.5	3,000	$0.050 * Vc$
Sub Total				19,580	
3.3 Sand Settling Baisn					
Sub Total				0	Sand settling basin is substitute at headtank.
3.4 Headrace					
1) Open Conduit					
Length Loc	m		0.0		
Sub Total				0	
2) Tunnnel (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	$(B * H * 1/2 + B * H2) * Lt = (1.2 * 0.2/2 + 1.2 * 1.6) * 143$
Concrete	m ³	280	66.0	18,480	(Side: $T * H * 2 = 0.1 * 1.5 * 2 +$ Bottom: $T * B = 0.2 * 0.8) * Lt$
Reiforcemnt Bar	t	1,200	1.3	1,560	$0.020 t/m^3 * Vc$
Sub Total				195,240	

表 5.11 工事費内訳 (土木工事、水力機器・電器機器) (アポロ小水力発電計画・プレ F/S) (2/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Case (700kW)		Note
			Quantity	Amount	
3.5 Head Tank					
Excavation (common excavation)	m ³	9.00	600.0	5,400	$(B*H)/2*W = (14*14)/2*6.0 + \text{alfa}$
Concrete (Side wall)	m ³	280	173.5	48,580	$\{((12+16)/2*8 + (20+21)/2*3)* T0.5 * 2\text{set}$
Concrete (Downstream side wall)	m ³	280	27.5	7,700	$B*H*T = 5.0*11*0.5$
Concrete (Upstream side wall)	m ³	280	21.0	5,880	$(10+4)*3*T0.5$
Concrete(Bottom)	m ³	280	145.0	40,600	$(1/2*B1*H1*T1)+(1/2*B2*H2*T2) = (1/2*6*3*5) + (1/2*8*5*5)$
Reforcemnt Bar	t	1,200	3.7	4,440	$0.010*Vc$
Sub Total				112,600	
3.6 Penstock					
Diameter Dp	m		1.11		$0.888*Qpmax^{0.370}$
Length Lp	m		74.0		
Excavation (common excavation)	m ³	9.00	243.0	2,187	$\{1/2*(B1+B2)*H1 + 1/2*B2*H2\}*Lp = \{1/2*(2.3+3.2)*0.9 + 1/2*3.2*0.5\}*74$
Concrete (Invert.)	m ³	280	20.0	5,600	$\{T*(B1+H)\} * L = \{0.1*(2.3+0.15)\} * 66$
Concrete (Support anchor block)	m ³	280	6.0	1,680	$(B*H*W) * \text{set} = (1.2*1.1*0.5) * 8$
Concrete (Bottom anchor block) (diverging pipe anchor)	m ³	280	83.0	23,240	$\{B1+L1+H1\}*\{(B1+B2)/2*L2*H2\}+(B2*L2*H3) = (2.0*1.5*1.35*1.5) + \{(2+11)/2*4.5*1.35*1.5\} + (11*1*1.35)$
Reforcemnt Bar	t	1,200	2.2	2,640	$0.020*Vc$
Sub Total				35,347	
3.7 Spillway					
Average Slope i			10		
Diameter Ds	m		0.8		$0.394*(Qpmax / i^{0.500})^{0.375}$
Length Ls	m		65.0		
Excavation (common excavation)	m ³	9.00	440.0	3,960	$9.87*Ds^{1.69}*Ls$
Foundation (mix cement)	m ³	70	124.0	8,680	$2.78*Ds^{1.70}*Ls$
Sub Total				12,640	
3.8 Power House					
1) Foundation Works				113,780	
Excavation (common excavation)	m ³	9.00	690.0	6,210	$1/2*(H1+H2)*B1*L = 1/2*(4.5+3.0)*8 * 23$
Foundation (foundation of power hc(mix cement))	m ³	70	315.0	22,050	$\{1/2*(H1+H2)* B*L\}*2 = \{1/2*(2.0+4.0)*7.0*7.5\}*2$
Concrete (RC, floorboard)	m ³	280	184.0	51,520	$B*L*H = 8.0*23.0*1.0$
Reforcemnt Bar	t	1,200	1.0	1,200	$0.005*Vc$
Concrete (RC, partition wall for tailrace from two turbine)	m ³	280	14.0	3,920	$H*B*T = 4.0*7.0*0.5$
Concrete (RC, bottom tank)	m ³	280	98.0	27,440	Side wall: $(B+L)*2*H*T$ + Bottom: $B*L*T = (7.5+8.0)*2*4*0.5 + 8.0*9.0*0.5$
Reforcemnt Bar	t	1,200	1.2	1,440	$0.010*Vc$

表 5.11 工事費内訳 (土木工事、水力機器・電器機器) (アポロ小水力発電計画・プレ F/S) (3/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S Case (700kW)		Note
			Quantity	Amount	
2) Power House (Building)	L.S.			39,916	
Wooden Window	m ²	75	10.0	750	(B*H) *set = (1.0*1.0) * 10
Wooden Door	m ²	135	8.0	1,080	(B*H) *set = (2.0*2.0) * 2
Loof (Calamine Cover)	m ²	23	240.0	5,520	B*L = 10*24
Brick Wall	m ²	15	518.5	7,778	(B+L)*2*(H1+H2)/2 = (7.5+23)*3*(9+8)/2
Covering Tile	m ²	24	165.0	3,960	B*L = 7.5*22.0
Structural Steel Frame (H-shape)	m	50	194.0	9,700	H*set + B*set + L*set = 12*6 + 7.5*4 + 23*4
Crane (chain winch, 20t)	L.S.	7,000	1	7,000	assumed
Installation of Sanitary	L.S.	500	1	500	
Others	L.S.			3,629	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	
Sub Total				740,000	Francis Turbine Made in Sweeden (TURAB) (350kW: SEK 2,000,000+40%Tax+\$110,000)/unit
4.2 Transmission/Distribution Line					
Transmission Line	km	7,000	1.37.60	1,011,360	plane length [km] * 105% * unit cost
Benefit. Household	HH		1,993		
Disrtibution 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	100,000	1.7	170,000	1.27*(Dt/2 * Qpmax) ^{0.533}
4.3.3 Head Tank					
Sand Flushout Gate	pce	3,000	1.0	3,000	
4.3.4 Penstock					
Tickness tp	mm		6.0		tp = { D(mm) + 400 } / 800, tp >= 6 mm
Weight	t		12.2		$\pi * D * t * 7.85 * Lp$,
Diameter Dp	m		1.11		0.888*Qpmax ^{0.370}
Length	m	500	74.0	37,000	
Sub Total				219,660	

表 5.12 工事費総括表 (アポロ小水力発電計画・プレ F/S)

Financial Cost (With Tax)

Unit : US\$.

Item	Pre-F/S Case (700kW)	Note
1. Preparation Works & Access, etc.	625,300	
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 Woks	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): 9.1km²30,000 US\$/km + Flat Area (Standard): 3.5km²15,000US\$/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 Woks	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	

表 5.13 事業費（工事費 + 維持管理費）（アポロ小水力発電計画・プレ F/S）

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 Woks	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

表 5.14 事業便益 (アポロ小水力発電計画・プレF/S)

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/Little /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	2,680,925
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).

表5.15 経済的内部収益率(EIRR)算定表 (アポロ小水力発電計画・プレ F/S) [単位: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
Fuel 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	1 030 955	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	179 667	179 667																				
Civil Works	161 633	161 633	161 633																				
Turbine/Generator	211 200	211 200	211 200																				
Transmission/Distribution Lines	394 433	394 433	394 433																				
Mechanical Works	63 133	63 133	63 133																				
Transportation	31 633	31 633	31 633																				
Administration and Engineering Service	92 800	92 800	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	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679	44 679
Balance	-1 134 500	-1 134 500	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%
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表 6.2 電力需要量推定結果(タンボ・ケマード) [現在]

Category (1)	Category (2)	Items	Number of Houses / Offices	Electric Power Demand [kW]																							Midnight	Peak (kW)=		Evening	Daily Energy Demand [kWh/day]			
				Midnight					Peak Hour			Day time										23:00	42	17										
				1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19		20	21	22	23		24	23:00			Peak Hour (8:00)	Office Hour (9:00)	Evening Hour (17:00 ~ 23:00)
Domestic	Residential House (Large) (Office)	CF Light	10	0.00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	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	06:00	09:00	17:00 ~ 23:00	41.7			
		60W Light		0.18	0.36																													
		Radio		0.06	0.06																													
	Residential House (Large) (Large Café/Large Restaurant)	TV (25" color)	5	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~							
		Hot water Shower		0.08	0.08																													
		SUB-TOTAL		0.12	0.36																													
	Residential House (Small)	CF Light	40	0.48	0.96					0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.48	0.96	0.96	0.96	0.48	0.10								
		40W Light		0.08	0.16																0.08	0.08	0.08	0.16	0.08	0.08								
		Radio		0.40	0.64				0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.16	0.40	0.40	0.40	0.24	0.04								
	Residential House (Small) (Small Café/Restaurant+Store)	TV (19" color)	4	0.10	0.20					0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.10	0.20	0.20	0.20	0.40	0.40								
Hot water Shower		0.08		0.16																0.16	0.40	0.40	0.40	0.24	0.04									
SUB-TOTAL		0.08		0.16				0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16									
SUB-TOTAL (DOMESTIC)			55						1.62	4.18				1.38	2.73	1.44	1.52	0.80	0.22	0.48	1.18	0.1	1.5	19.9	40.2	0.1	16.7	82.4						
Business	Office (Large)	CF Light	4	0.02	0.02				0.12	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24																
		60W Light		0.02	0.02				0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02														
		Computer Set		0.37	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86															
	Office (Small)	Printer/Copy	6	0.40	0.40	0.40	0.20	0.20	0.40	0.40	0.40	0.40	0.40	0.20	0.20	0.40	0.40	0.40	0.40	0.40														
		VCR		0.10	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48														
		Heater		0.08	9.60	9.60	9.60	8.40	8.40	9.60	9.60	8.40	8.40	9.60	9.60	9.60	9.60	9.60	9.60	9.60														
	Café / Restaurant (Large)	Radio	5	0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12															
		TV (25" color)		0.39	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01															
		SUB-TOTAL		0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12															
	Café / Restaurant (Small)	CF Light	2	0.02	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05														
40W Light		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																
Radio		0.02		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03																
Store (large)	TV (19" color)	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01														
	CF Light		0.05	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11																
	Radio		0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04																
SUB-TOTAL (BUSINESS)			20						1.59	4.18				1.38	2.73	1.44	1.52	0.80	0.22	0.48	1.18	0.1	1.5	19.9	40.2	0.1	16.7	82.4						
Industry	Handcraf (Sawing, etc.)	CF Light																																
Public	Clinic	Sawing Machine	1																															
		Iron																																
		SUB-TOTAL																																
Public	Street Light (200m x 1600w/km)	Equipment of x-ray	1						0.10	0.10	0.10				0.10	0.10	0.10																	
		Sterilize		0.03	0.03	0.03				0.03	0.03	0.03				0.03	0.03	0.03																
		Centrifuge		0.01	0.01	0.01				0.01	0.01	0.01				0.01	0.01	0.01																
SUB-TOTAL									0.23	0.23	0.23	0.08	0.08	0.23	0.08	0.23	0.23																	
SUB-TOTAL																																		
TOTAL									1.6	41.8		25.6	25.6	25.0	23.4	23.4	23.8	25.6	25.6	1.4	2.7	16.1	16.7	2.1	0.5									

表 6.4 電力需要量推定結果(タンボ・ケマード)[将来]

		Peak (kW)=																																
		Electric Power Demand [kW]																																
Category (1)	Category (2)	Items	Number of Houses / Offices	Midnight						Peak Hour						Day time						Evening						Midnight	Peak Hour	Office Hour	Evening Hour	Daily Energy Demand		
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						23:00	06:00
				01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	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	00:00	06:00	09:00	17:00	23:00			
Domestic	Residential House (Large) (Office)	CF Light	14						0.25	0.50	0.50											0.25	0.50	0.50	0.50	0.25	0.05							
		60W Light		0.08	0.59	0.59																	0.08	0.08	0.34	0.34	0.08	0.08						
		Radio		0.11	0.11	0.11																		0.11	0.11	0.11	0.11	0.06	0.03					
		TV (25" color)		0.17	0.84	0.84																		0.17	0.50	0.84	1.34	0.84	0.08					
	Hot water Shower									24.50	24.50																							
	Hot water Shower									24.50	24.50																							
	Hot water Shower									24.50	24.50																							
	Hot water Shower									24.50	24.50																							
	Hot water Shower									24.50	24.50																							
	Hot water Shower									24.50	24.50																							
									0.62	26.54	26.54										0.62	1.20	13.69	14.20	1.23	0.25								
Residential House (Large)	CF Light	10							0.18	0.36	0.36																							
60W Light	0.06		0.42	0.42																		0.06	0.06	0.24	0.24	0.06	0.06							
Radio	0.08		0.08	0.08																		0.08	0.08	0.08	0.08	0.04	0.02							
TV (25" color)	0.12		0.60	0.60																		0.12	0.36	0.60	0.96	0.60	0.06							
Hot water Shower									17.50	17.50																								
Hot water Shower									17.50	17.50																								
Hot water Shower									17.50	17.50																								
Hot water Shower									17.50	17.50																								
Hot water Shower									17.50	17.50																								
									0.44	18.96	18.96										0.44	0.86	9.78	10.14	0.88	0.18								
Residential House (Small)	CF Light	45					0.38		0.54	1.08	1.08		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05														
60W Light	0.14		0.14	0.14						0.14	0.27	0.27										0.14	0.14	0.14	0.14	0.14								
Radio	0.32		0.32	0.32						0.32	0.72	0.72		0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09													
TV (19" color)																																		
Hot water Shower																																		
Hot water Shower																																		
Hot water Shower																																		
Hot water Shower																																		
Hot water Shower																																		
									0.83	1.13	13.32	13.32	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.86	1.67	1.67	1.80	0.95	0.29	0.8						
									0.83	2.18	58.82	58.82	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.86	1.67	1.67	1.80	0.95	0.29	0.8							
									0.83	2.18	58.82	58.82	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.86	1.67	1.67	1.80	0.95	0.29	0.8							
Business	Office (Large)	CF Light	8																															
60W Light																																		
Computer Set																																		
Printer/Copy																																		
VCR																																		
Heater																																		
Radio																																		
Radio																																		
									1.38	25.53	25.53	25.53	22.73	22.73	23.13	25.53	25.53	25.53	25.53	25.53	25.53	1.91	3.73	25.14	26.14	3.06	0.71	0.8						
Office (Small)	CF Light	6							0.11	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22														
60W Light										0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04														
Computer Set										0.19	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93														
Printer/Copy										0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30													
Heater										9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60													
Radio										0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12													
									0.39	11.20	11.20	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	10.60	1.91	3.73	25.14	26.14	3.06	0.71	0.8						
Café / Restaurant (Large)	CF Light	10							0.30	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60														
60W Light										0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06														
Stereo										0.28	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55														
Radio										0.10	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20													
TV (25" color)										0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60													
									0.74	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	1.91	3.73	25.14	26.14	3.06	0.71	0.8						
Café / Restaurant (Small)	CF Light	5							0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12														
60W Light										0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03														
Radio										0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07														
TV (19" color)										0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07													

表 6.5 概略工事費 (タンボ・ケマード小水力発電計画・比較検討用)

Financial Cost (With Tax)

Unit : US\$.

Item	Case1	Case2	Case3	Case4	Case5	Note
	40kW MHP +Diesel	50kW MHP +Diesel	50kW HP 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	Per-ton, 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	220 200	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 byNGO: US\$3,000}*138%
Total Construction Cost	191 900	201 500	210 100	225 000	241 700	5.+6.

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

Economic Cost (Without Tax)

Unit : US\$.

Item	Case1	Case2	Case3	Case4	Case5	Note
	40kW MHP +Diesel	50kW MHP +Diesel	50kW HP 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	163 900	175 700	188 900	
6. Administration and Engineering Service.	15 400	16 000	16 600	17 500	18 500	(cost with tax) / (1+IVA.13%+IT.3%) 1.16
Total Construction Cost	164 700	172 900	180 500	193 200	207 400	

表 6.6 概略事業費(タンボ・ケマード小水力発電計画・比較検討用)

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 deemed 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 Woks	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 Tax16%) 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	3.30	3.30	3.30	3.30	3.30
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	16 242	10 816	8 968	7 602	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	1 632	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).

表 6.7 事業便益(タンボ・ケマード小水力発電計画・比較検討用)

Item	Unit	Case1	Case2	Case3	Case4	Case5
Type of Power Generation		MHP +Diesel	MHP +Diesel	MHP with Pond +Diesel	MHP +Diesel	MHP with Pond
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						
Cost of TransmissionLines (x 105%)	US\$	0	0	0	0	0
Length of TransmissionLine (by MHP)	km	1.30	1.30	1.30	1.30	1.30
Length of TransmissionLine (only for MHP)	km	1.30	1.30	1.30	1.30	1.30
Length of TransmissionLine (by Diesel)	km	0.00	0.00	0.00	0.00	0.00
Cost of TransmissionLine 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).

表 6.8 経済性評価(タンボ・ケマード小水力発電計画・比較検討用) (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 =	0.95

表 6.8 経済性評価(タンボ・ケマード小水力発電計画・比較検討用) (2/3)

Case: 3		Install Capacity MHP: 50 kW		Type: MHP with Pond +Diesel		Discount Rate = 10%		
		Install Capacity of Diesel: 12 kW						
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		Discount Rate = 10%		
		Install Capacity of Diesel: 25 kW						
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 =	7.2%
							B/C =	0.90

表 6.8 経済性評価(タンボ・ケマード小水力発電計画・比較検討用) (3/3)

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

表 6.9 工事費内訳(土木工事、水力機器・電器機器)(タンボ・ケマード小水力発電計画・プレ 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*Qmax* He * ηc , ηc = 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) ^{1.14}
Concrete Foundations	m ³	10	5.5	55	11.8*(H ² *L) ^{0.781}
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) ^{1.14}
Concrete Foundations	m ³	10	1.8	18	11.8*(H ² *L) ^{0.781}
Sub Total				33	
3.2 Intake					
1) Upstream					
Excavation	m ³	7	1.200	8	3*Dpv * 1.0
Concrete Foundations	m ³	60	0.800	48	{ (3*Dpv)*(2*Dpv) - Dpv ² } * 1.0
Sub Total				56	
2) Downstream					
Excavation	m ³	7	1.200	8	3*Dpv * 1.0
Concrete Foundations	m ³	60	0.800	48	{ (3*Dpv)*(2*Dpv) - Dpv ² } * 1.0
Sub Total				56	
3.4 Headrace (PVC[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 *Dpv ² , water depth / Dpv = 0.6
Hydraulic Radius R			0.111		0.2776 *Dpv, water depth / Dpv = 0.6
n_value n			0.010		
Slope			0.002		

表 6.9 工事費内訳(土木工事、水力機器・電器機器)(タンボ・ケマード小水力発電計画・プレ F/S) (2/3)

Item	Unit	Unit Rate (US\$)	Pre-F/S (62kW)		Note
			Quantity	Amount	
Discharge			0.0813		$A/n * R^{2/3} I^{0.5}$
Check			-0.0066	OK	
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 Foundations	m ³	60	8.9	534	$2 * Dpv * 0.3 * 0.4 * Lpv / 25$
Sub Total				77 873	
3.5 Head Tank					
Storage Volume			225		
Storage Wall Tickness			0.30		
Storage Slab Tickness			0.50		
Excavation	m ³	7	511.2	3 578	$142m^2 * 6.0m * 60\%$
Concrete RC(w/o R.bar)	m ³	60	268.5	16 110	$142m^2 * 0.5m * 2 + 25.3m^2 * 5m$
Reiforcemnt Bar	t	732	13.7	10 028	$0.051 * Vc$
Sub Total				29 717	
3.6 Penstock					
Diameter Dp	m		0.36		$0.876 * Qpmax^{0.367}$
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	$3.1m^2 * 1.36m + 3.5m^2 * 1.0m + 2.3m^2 * 1.36$
Reiforcemnt 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	$9.7m^2 * 6.5m - (3.1m^2 * 2.0m + 0.7m^2 * 1.3)$
Reiforcemnt Bar	t	732	0.0	0	Mass concrete
Building	L.S.	1 000	1	1 000	
Sub Total				1 904	

表 6.9 工事費内訳(土木工事、水力機器・電器機器)(タンボ・ケマード小水力発電計画・プレ 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	7	0	0	
Concrete	m ³	10	6.2	62	$1.0m^2*(3m+4m)/2 + 0.25m^2 * 1.0m * 2 + 0.55m^2 * 4m$
Reinforcemnt Bar	t	732	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		$0.876*Qpmax^{0.367}$
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	1	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.

表 6.10 工事費総括表(タンボ・ケマード小水力発電計画・プレ 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 byNGO: 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	80 600	
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	

表6.11 事業費および便益(タンボ・ケマード小水力発電計画・プレ 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 deemed 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
Length of Distribution Line (Tambo Quemado was already exist)	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)	%	0.5
OM Cost of the Transmission & Distribution Lines (% of investment)	%	2.5
OM cost for the electromechanical equipment	US\$/year	662
OM cost for civil engineering	US\$/year	479
OM cost of the distribution lines	US\$/year	543
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	1.30
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
Cost of Distribution Line per Kilometer	US\$/km	16 692
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	365
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 costs)	%	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)	%	2.5
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: UMSA and JICA Study Team

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

表6.12 経済的内部収益率(EIRR)算定表 (タンボ・ケマード小水力発電計画・プレF/S) [単位: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	
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	
Fuel 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	
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	
Civil Works		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	
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	
Balance	-205,700	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	84,328	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	33,501	
EIRR		16.4%																				