CHAPTER 5 ELECTRIFICATION PLAN

5.1 Basic Strategy

The electrification plan under the Study aims to formulate the optimum approach to energizing the Study villages, based on field reconnaissance and questionnaire survey to determine the socio-economic and natural (topography, hydro-meteorological, etc.) conditions prevailing in the 120 target villages of Haouz Province as contained in the original Study request. Basic electrification strategy in this regard is as follows:

(1) To establish sustainable project facilities from the standpoint of operation and maintenance by eliciting the active participation of the beneficiary population.

(2) To select power supply facilities which impose minimal financial burden on the beneficiary population.

(3) To adopt renewable energy sources to the extent possible.

(4) To establish compatibility with PERG and other rural electrification planning in Morocco.

(5) Power demand in the Study villages is assumed as follows in line with criteria (for household power use) applied in the case of PV generation under PERG: i.e., maximum power per household of 65 W, and maximum daily consumption per household of 240 Wh/day.

(6) Villages which are to be covered under projects by ONE to extend existing transmission line are eliminated from planning under the Study. Even in cases where redundancy does not occur with regard to electrification under the ONE program, villages which can be energized by grid extension at a cost of under DH 10,000 per household are so designated under the Study for this category of electrification.

(7) In the case of micro-hydropower, target villages for electrification are determined based on economic comparison of micro-hydropower alone, and a power source composition including both micro-hydropower and PV generation.

(8) In the case of PV generation, the optimum system is to be selected on the basis of comparing the 3 candidate methods of battery charging station, central distribution system, and solar home system.

(9) Diesel generation is often adopted for rural electrification due to inexpensive facility cost. However, this must be predicated on a constant, easily delivered fuel supply, as well as the availability of technical and economic resources sufficient to operate and maintain the diesel plant. As a result, diesel generation is to be adopted under the Study only in such cases where (i) village

size is above a pre-determined scale, (ii) the village is located at great distance from the existing grid, (iii) fuel supply can be effected easily, and (iv) sufficient O&M capability is present.

5.2 Preliminary Selection of Micro-hydropower Scheme Villages

(1) Strategy in Formulating the Micro-hydropower Plan

Hydropower is an appropriate mode of decentralized electrification in light of the fact that operating costs are low, and off-peak generation is possible. Hydropower was accordingly given a major priority for adoption under the Study.

Micro-hydropower is greatly influenced by a number of natural factors including available discharge, head, etc. In selecting the source of power supply for each village under the Study, it is first necessary to preliminarily determine those scheme sites and villages where potential for micro-hydropower development exists. In addition to the list of 120 villages contained in the Study request, CDER compiled jointly with Haouz Province a list of 28 villages targeted for service by micro-hydropower schemes.

Under the Study, scheme sites and villages for micro-hydropower development were selected according to the following strategy:

1) To carry out field reconnaissance of the 28 listed villages to select those sites with development potential.

2) To examine the feasibility of conveying power from the viable micro-hydropower sites to nearby villages, and on this basis make a preliminary selection of villages which are candidates for electrification by micro-hydropower.

3) To comparatively study power supply cost for micro-hydropower and other electrification options for the preliminarily selected villages.

4) To compare variable cost only for micro-hydropower with other methods of electrification.

5) To determine appropriate development scale given forecast demand, formulate a power supply plan, and carry out economic and financial evaluation of the said plan.

In light of the fact that implementation of micro-hydropower schemes requires more detailed study than other modes of decentralized electrification, pre-feasibility study was carried out for the micro-hydropower scheme sites deemed to have high development maturity.

(2) Selection of Micro-hydropower Sites

1) Strategy for Selection of Micro-hydropower Sites

① Confirmation of villages requested for electrification by micro-hydropower (total of 28)

② Survey of possible competition for discharge with, and impact on, irrigation schemes in the area.

③ Schemes are to be run-of-river type with active use of springs where possible.

④ In the cases where site hydropower potential is small, power supply will be to a single nearby village. However, where generation potential is ample, sites will be selected to provide power to multiple villages where appropriate.

2) Selection of Micro-hydropower Sites

Of the 120 villages requested for electrification by CDER, 28 villages were selected by Haouz Province for electrification by micro-hydropower. (see Table 5-3)

The 28 candidate sites for micro-hydropower schemes to provide electricity to the said villages are largely located in hill areas of over 1,000 m elevation. Water sources for these originate in the Haut Atlas and comprise tributaries of the Tensift river, i.e. Nfis, Rheraya, Ourika and Zat rivers, and mountain torrents branching off of these tributaries, with catchment areas at the sites ranging 10~100 km^2.

River discharge varies greatly between rainy season (October~March) and the dry season (April~September). Particular during July~August in the dry season, discharge dwindles to several liters per second for some rivers. Furthermore, many of these rivers also serve as a precious source, especially during the dry season, for irrigation and domestic water. On the other hand, the mountain torrents experience flash flooding in the rainy season causing damage to adjacent villages. Discharge was analyzed on the basis of existing records at downstream gauging stations, and discharge estimated on the basis of specific discharge calculation and rainfall data in order to upgrade the precision of micro-hydropower development.

In determining generation discharge at each candidate site, low water discharge (Q275) and drought discharge (Q355) were computed for each river from existing data, and the optimum discharge estimated with consideration to water use for irrigation and domestic purposes.

Under the study, a map-top investigation using 1/50,000 scale topomapping was done with regard to access roads to each site, river conditions, location and elevation of targeted villages for electrification, etc. On the basis of the foregoing, site reconnaissance was carried out for those sites determined to have favorable access (motorable road or footpath), and in-situ investigation was done of intake weir and intake structure site, headrace route, river conditions at the power station site, topography, geology, river gradient, springs, discharge diversion for irrigation, village size, vegetation in and around the scheme sites, etc.

As a result, 7 promising micro-hydropower sites were selected. The sites so identified are indicated in Table 5-1.

Table 5-1 Scheme Features of Candidate Sites for Micro-hydropower

No. Site	River (Basin)	Catchment area (km2)	Elevation of intake (El. m)	Cercle	C.Rurale	Nearest village
46 Adardour	Anougal (Amizmiz)	23	1,769	Amizmiz	Anougal	46 Adardour
	- Access road : L=20km mountain road from Amizmiz (motorable) - River discharge : drought discharge (Q355)=20-50 lit./s - Irrigation : discharge diversion from river					
38 Inzaine	Anougal (Amizmiz)	79	1,300	Amizmiz	Anougal	38-Inzaine
	- Access road : L=10km mountain road from Amizmiz (motorable) - River discharge : drought discharge (Q355)=70-100 lit./s - Irrigation : discharge diversion from river and spring					
11 Arg	Imenane (Rhenaya)	48	1,574	Asni	Asni	11-Arg
	- Access road : L=12km mountain road from Asni (motorable) - River discharge : drought discharge (Q355)=20-50 lit./s - Irrigation : discharge diversion from river					
6 Alla Oumzri	Ougardis (N'fis)	8 (spring)	1,500	Asni	Talat N @ Yacoub	6-Alla Oumzri
	- Access road : L=2km footpath from T-N-yacob - River discharge : spring Q=50 lit./s - Irrigation : discharge diversion from river and spring					
7 Id Ssiar	Spring (N'fis)	7 (spring)	1,700	Asni	Ijoukak	7- Id Ssiar
	- Access road : L=6km footpath from Ijoukak - River discharge : spring Q=50 lit./s - Irrigation : discharge diversion from river					
21 Anfli	Ourika (Ourika)	134	1,750	Ourika	Tahanaout	21-Anfli
	- Access road : L=6km footpath from Seti-Fatma - River discharge : drought discharge (Q355)=100 lit./s - Irrigation : discharge diversion from river					
118 Tidsi	Afoughal (Zat)	24	1,725	Ait Ouril	Tighdouine	118-Tidsi
	- Access road : L=7km mountain road from Tadert (motorable) - River discharge : drought discharge (Q355)=10-20 lit./s - Irrigation : discharge diversion from river					

(3) Preliminary Selection of Villages for Micro-hydropower Electrification

1) Study on Composition of Power Supply Source

Micro-hydropower schemes will comprise mini-grids supplying a village network. In cases where ample development scale is available at a particular site, it will be possible to provide power from a single scheme to multiple villages. Accordingly, in the case where multiple villages are to be supplied from a single scheme, a comparative study of was done for cases of (i) supply only by micro-hydropower, and (ii) supply by a combination of micro-hydropower and PV generation.

Case studies were also done with regard to initial investment cost (construction cost) and variable cost (O&M cost).

As a result, in cases where multiple villages can be supplied with power from a single micro-hydropower site, it has been determined under the Study that the most effective power source composition would not include PV generation, and instead in all cases would comprise solely a micro-hydropower mini-grid.

2) Study on Development Potential of Micro-hydropower Sites

From among the micro-hydropower sites preliminarily identified in the previous section, site survey was carried out with priority consideration to the following items. In cases where power supply is possible to multiple villages from a single site, development potential was examined assuming electrification by mini-grid.

1) River discharge (measurements by local consultant and analysis of data)
2) Spring conditions
3) River gradient
4) Water levels and discharge in the drought and rainy seasons
5) Site topography and geology
6) Conditions of discharge use for irrigation
7) Access road conditions

3) Selection of Villages for Micro-hydropower Electrification

On the basis of the above results, confirmation of the following items was done.

① Development potential of the 7 scheme sites (see Table 5-2)
② Supply potential to multiple villages from a single site
③ Supplemental power supply to Afra village (not on the original request list)

Based on the foregoing, seven promising micro-hydropower sites where selected based on the list prepared by CDER (28 villages), and 18 villages were preliminarily selected for electrification by micro-hydropower (see Table 5-2 and Table 5-3).

Table 5-2 Scheme-wise (Micro-hydropower) Target Villages

Micro-hydropower sites		Target villages					Administrative division		P Max
No.	Sites	No. of Douar	No.	Village	No. of household	Population	C. Rural	Cercle	(kW)
46	*Adardour*	*1*		*total*	*160*	*700*			*26*
			46	Adardour	160	700	Anougal	Amizmiz	
38	*Inzaine*	*8*		*total*	*407*	*2,406*			*62*
			35	Imin Tala	70	460	Anougal	Amizmiz	
			36	Addouz	50	300	-ditto-	-ditto-	
			37	Ain Ghad	43	206	-ditto-	-ditto-	
			38	Inzaine	70	420	-ditto-	-ditto-	
			39	Imi N'sli	86	450	-ditto-	-ditto-	
			40	Dou Anammer	35	220	-ditto-	-ditto-	
			41	Igoundem	13	100	-ditto-	-ditto-	
			42	Toug Lkeif	40	250	-ditto-	-ditto-	
11	*Arg*	*3*		*total*	*195*	*1,940*			*30*
			10	Amsakrou	55	420	Asni	Asni	
			11	Arg	75	1,020	-ditto-	-ditto-	
			15	Ikiss	65	500	-ditto-	-ditto-	
6	*Alla Oumzri*	*1*		*total*	*40*	*280*			*10*
			6	Alla Oumzri	40	280	Talat N'Yacoub	Asni	
7	*Id Ssiar*	*1*		*total*	*66*	*500*			*16*
			7	Id Ssiar	66	500			
21	*Anfli*	*2*		*total*	*123*	*748*			*20*
			21	Anfli	63	378	Ourika	Tahanaout	
			22	Timichi	60	370	-ditto-	-ditto-	
118	*Tidsi*	*2*		*total*	*105*	*916*			*15*
			118	Tidsi	40	316	Tighouine	Ait Ouir	
			---	Afra	65	600	Zerkten	-ditto-	
Grand total		*18*			*1,096*	*7,490*			*179*

* No. of households and population indicates present condition

Table 5-3 Preliminarily Selected Villages for Electrification by Micro-hydropower

No.	Target Villages		Water Source		Commune Rurale	Cerecle	No. of Household (present)	Population (present)
	Requested by CDER	Pleliminarily Selected by JICA team	River	Basin				
4	Igrem	---	Imigdal	N'fis	Imigdal	Asni	27	130
6	---	Alla Oumzri	Ougandis	N'fis	Talat N'Yacoub	Asni	40	280
7	---	Id Ssiar	(Spring)	N'fis	Ijoukak	Asni	66	500
10	Amsakrou	Amsakrou	Imenane	Rhenaya	Asni	Asni	55	420
11	Arg	Arg	Imenane	Rhenaya	Asni	Asni	75	1020
12	Tincrhouhrine	---	Imenane	Rhenaya	Asni	Asni	30	250
13-1	El Bour	---	Imenane	Rhenaya	Asni	Asni	65	250
13-2	Imskar	---	Imenane	Rhenaya	Asni	Asni	40	510
15	Ikiss	Ikiss	Imenane	Rhenaya	Asni	Asni	65	280
17	Tacheddirt	---	Imenane	Rhenaya	Asni	Asni	60	500
18	Squour	---	Ourika	Ourika	Ourika	Tahanaout	45	360
19	Amagdour	---	Ourika	Ourika	Ourika	Tahanaout	22	150
20	Tamatcrte	---	Ourika	Ourika	Settifadma	Tahanaout	40	240
21	Anfli	Anfli	Ourika	Ourika	Settifadma	Tahanaout	63	378
22	Timichi	Timichi	Ourika	Ourika	Settifadma	Tahanaout	60	370
23	Agouns	---	Ourika	Ourika	Settifadma	Tahanaout	105	630
35	Imin Tala	Imin Tala	Anougal	Amizmiz	Anougal	Amizmiz	70	460
36	Addouz	Addouz	Anougal	Amizmiz	Anougal	Amizmiz	50	300
37	Ain Ghad	Ain Ghad	Anougal	Amizmiz	Anougal	Amizmiz	43	206
38	Inzaine	Inzaine	Anougal	Amizmiz	Anougal	Amizmiz	70	420
39	Imi N'isly	Imi N'isly	Anougal	Amizmiz	Anougal	Amizmiz	86	450
40	Dou Anammer	Dou Anammer	Anougal	Amizmiz	Anougal	Amizmiz	35	220
41	Igoundem	Igoundem	Anougal	Amizmiz	Anougal	Amizmiz	13	100
42	Toug Lkheif	Toug Lkheif	Anougal	Amizmiz	Anougal	Amizmiz	40	250
46	Adardour	Adardour	Anougal	Amizmiz	Anougal	Amizmiz	160	700
51	Talat Ait Ihla	---	Eldouz	Amizmiz	Anougal	Amizmiz	70	210
117	Ansa	---	Ansa	Amizmiz	Tighdouine	Ait Ourir	59	300
118	Tidsi	Tidsi	Afoughal	Zat	Tighdouine	Ait Ourir	40	316
119	Ait Atmane	---	Tighadwine	Zat	Tighdouine	Ait Ourir	104	900
120	Ezzaouite	---	Yagour	Zat	Tighdouine	Ait Ourir	16	121
---	---	Afla	Afoughal	Zat	Zerkten	Ait Ourir	65	600
Total	(28)	(18)						

* : mycro-hydropwer site is selected in/around the village

5.3 Selection of Village-wise Power Source

(1) Method of Power Source Selection

Selection of power source was made from among PV generation, diesel generation, micro-hydropower and extension of existing transmission line in accordance with the following sequence:

- Cost comparison among the candidate electrification methods (both fixed and variable cost)
- Study of special characteristics of each type of power supply
- Selection of power source
- Comparison of variable cost (micro-hydropower versus grid extension)
- Modification to meet specific local conditions (nature of household distribution, etc.)
- Correlation with ONE electrification criteria (electrification by grid extension)

(2) Comparison of Cost of Power Supply under Each Electrification Method

1) Pre-assumed Criteria in Comparison

The questionnaire survey indicated that the target villages range in size from 20~200 households. On this basis, village sizes of 20, 40, 60, 80, 100, 150 and 200 households were selected as a representative base for calculation and comparison of power supply cost for each electrification method.

The above comparison was done according to the following design criteria.

Power demand was calculated assuming per household demand of 65 W and daily consumption of 240 Wh/day as per standard criteria adopted in Morocco for decentralized electrification. Power demand outside the home (public and commercial) was eliminated from consideration.

Power supply cost was computed by converting the total for fixed cost (construction cost) and variable cost during the utility life of the facilities (O&M cost) into current prices. Although actual utility life of generating facilities depends on the type of electrification, for the purposes of comparison here the utility life of the PV generating module (20 years) was applied across the board. Also, three cases of discount rate, i.e. 0%, 6% and 12%, were applied in computing current prices in consideration of diversity funding source.

2) Power Supply Cost Calculation Criteria

Power supply cost applied to selection of power source was computed on the basis of recent similar projects in Morocco. Also, power supply cost targeted fixed and variable costs.

3) Results of Calculation of Power Supply Cost

On the basis of the above assumptions, overall cost required to supply electricity for a 20 year period was computed. Specifically, calculation was done for cases of uniform consideration (discount rate of 0%) of prices to result from future generated cost for villages with respective size of 20, 40, 60, 80, 100, 150 and 200 households for each type of electrification method, and cases applying discount rates of 6% and 12%.

Results of calculation applying a discount rate of 0% are shown in Tables 5-4 (1)~5-4 (3).

Table 5-4 (1) First Year Investment Cost (Fixed Cost)

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	21,000	16,960	295,200	38,200	53,200	68,200
40	42,000	24,160	335,400	54,400	69,400	84,400
60	63,000	34,260	370,600	70,600	85,600	100,600
80	84,000	46,640	408,800	86,800	101,800	116,800
100	105,000	57,160	461,000	103,000	118,000	133,000
150	157,500	75,710	534,000	143,500	158,500	173,500
200	210,000	100,060	592,000	184,000	199,000	214,000

Table 5-4 (2) 20 Year Variable Cost with No Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	15,600	65,011	24,800	3,504	4,880	6,256
40	31,200	72,720	27,000	7,008	8,940	10,873
60	46,800	82,126	28,250	10,512	12,745	14,979
80	62,400	92,794	29,600	14,016	16,438	18,860
100	78,000	99,040	30,000	17,520	20,071	22,623
150	117,000	117,660	32,000	26,280	29,027	31,774
200	156,000	130,872	33,000	35,040	37,897	40,753

Table 5-4 (3) 20 Year Overall Cost with No Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	36,600	81,971	320,000	41,704	58,080	74,456
40	73,200	96,880	362,400	61,408	78,340	95,273
60	109,800	116,386	398,850	81,112	98,345	115,579
80	146,400	139,434	438,400	100,816	118,238	135,660
100	183,000	156,200	491,000	120,520	138,071	155,623
150	274,500	193,370	566,000	169,780	187,527	205,274
200	366,000	230,932	625,000	219,040	236,897	254,753

(3) Characteristics and Special Features of Power Supply Sources

In the previous section, cost effective ranking was carried out for power supply sources for the target villages. However, there exists a large variation in characteristics and special features of power supply sources. This fact requires that selection of the most appropriate power source be made not solely on the basis of economic factors, but rather take into consideration specific features of power supply sources as well.

In other words, the nature of PV generation is that it is both an inexhaustible energy source and well suited to decentralized electrification, and adoption of the same should therefore be aggressively pursued. Although diesel generation is also an advantageous method of decentralized electrification, it relies on imported fuel resulting in outflow of foreign reserves. A steady fuel supply structure becomes necessary, and diesel generation is constrained by the need for operation during times of high load. In addition, there are environmental concerns. In contrast, since micro-hydropower is based on a renewable energy source, development of the same should be aggressively pursued. Although fixed cost for the same is higher than that for other methods of electrification, variable cost is less. Also, a combination of higher funding ratio under advantageous financial terms, and lesser discount rate results in a marked improvement in cost-effectiveness. On the other hand, extension of existing transmission line represents the optimum method of electrification from the standpoint of the targeted village households. In this regard, ONE is actively pursuing various options, and it is assumed that villages closest to the existing grid will be connected to the same in the very near future.

(4) Results of Power Source Selection

Based on the results of comparison of supply cost for each method of electrification and special features and characteristics of each power supply source, basic criteria for selection of power source based on comparison of overall power supply cost (direct cost and variable cost) is indicated in Table 5-5.

Table 5-5 Basic Criteria for Power Source Selection (comparison of direct and variable costs)

No. of village households	Distance from existing transmission line	Electrification method to be adopted in principle
Under 25	n/a	PV generation
25~45	Under 1 km	Transmission line extension
	Over 1 km	PV generation
45~70	Under 2 km	Transmission line extension
	Over 2 km	PV generation
70~100	Under 3 km	Transmission line extension
	Over 3 km	Diesel generation
	Under 4 km	PV generation
Over 100	Over 3 km	Diesel generation
Over 175	Over 2 km	Diesel generation

As indicated in Table 5-4(1), micro-hydropower construction involves increased cost making it less attractive than other modes of electrification. On this basis only, a breakdown by electrification method is as shown in Table 5-7. However, as the ratio of funding under advantageous financial terms increases, with subsequent preclusion or significant reduction in the need to recover fixed cost, micro-hydropower becomes advantageous in terms of variable cost. Variable cost in the case of micro-hydropower and extension of the existing grid is less than that for other modes of electrification, with cost-effectiveness being determined by the number of households serviced and the transmission line distance.

On the basis of analysis of this relationship, selection with regards to micro-hydropower was done on the basis of variable cost comparison (see Table 5-4(2)), adopting the criteria set out in Table 5-6. Results of this are summarized in Table 5-8.

Table 5-6 Basic Criteria for Power Source Selection (comparison of variable cost only)

No. of village households	Distance from existing transmission line	Electrification method to be adopted in principle
Under 40	Under 10 km	Transmission line extension
	Over 10 km	To be examined case by case
Under 60	Under 9 km	Transmission line extension
	Over 9 km	Micro-hydropower
Under 80	Under 7.5 km	Transmission line extension
	Over 7.5 km	Micro-hydropower
Under 100	Under 6 km	Transmission line extension
	Over 6 km	Micro-hydropower
Under 150	Under 3 km	Transmission line extension
	Over 3 km	Micro-hydropower
Under 200	Under 1 km	Transmission line extension
	Over 1 km	Micro-hydropower
Over 200	n/a	Micro-hydropower

Table 5-7 Selection of Power Source (comparison of overall cost)

Power supply source	No. of villages	No. of households
PV generation	90	*4,441
Diesel generation	13	2,283
Transmission line extension	3	214
Total	106	6,938

* No. of households in 2000

Table 5-8 Selection of Power Source (comparison of variable cost)

Power supply source	No. of villages	No. of households
PV generation	74	*3,266
Diesel generation	13	2,283
Micro-hydropower	16	1,175
Transmission line extension	3	214
Total	106	6,938

* No. of households in 2000

Although five villages fall outside the scope of the basic electrification criteria, given observed conditions in the villages it would be realistic to apply a corrected interpretation of the said criteria. Accordingly, the ultimate result of selection of power source is tabulated in Table 5-9. And the selection by villages are indicated in Table 5-10 ~5.13.

Table 5-9 Final Results of Power Source Selection

Power supply source	No. of villages	No. of households
PV generation	71	*3,213
Diesel generation	12	2,136
Micro-hydropower	18	1,301
Transmission line extension	5	288
Total	106	6,938

* No. of households in 2000

Table 5-10 (1/2) Villages to be Electrified by PV Generation (comparison of construction cost with transmission line extension)

No.	Douars	HH (2000)	PV Generation Construction cost (DH)	PV Generation Construction cost / HH (DH)	Grid extension Distance from exsisting grid line (km)	Grid extension Construction cost (US$)	Grid extension Construction cost / HH (DH)
1	Tizi Oussem	76	160,373	19,616	10.5	225,748	27,654
2	Id Aissa	46	102,607	20,767	8.5	172,810	34,975
3	Tassa Ouirgane	58	120,010	19,264	5.0	127,084	20,399
4	Igrem	28	62,922	20,922	more than 10	---	---
8	Aghella	67	136,595	18,981	more than 10	---	---
9	Ikiss	71	143,415	18,806	more than 10	---	---
12	Tinerhouhrine	31	68,952	20,708	10.1	179,338	53,859
17	Tacheddirt	63	137,904	20,379	13.9	265,074	39,172
18	Sqour	47	78,715	15,592	4.5	109,706	21,731
19	Amagdour	23	38,151	15,443	5.5	103,154	41,755
20	Tamaterte	42	94,738	21,000	5.0	112,716	24,985
26-1	Awin Mazouz	70	116,673	15,518	6.3	157,360	20,929
26-2	Bouchiha Bon Om	69	116,339	15,697	4.5	129,462	17,468
30	Bel Abbas	147	242,779	15,376	4.0	192,006	12,160
32	Derb Chem's	63	104,908	15,503	2.2	89,574	13,237
43	Ait Ouzkri	42	68,614	15,216	4.5	105,216	23,323
44	Ait Hmad	52	85,542	15,315	6.0	136,696	24,474
45	Tizgui	63	103,827	15,343	5.5	139,074	20,552
49	Anermi	94	198,838	19,693	4.0	144,412	14,303
51	Talat Ait Ihla	73	146,444	18,677	5.5	148,054	18,882
53	Adghouss	52	107,611	19,267	6.0	136,696	24,474
56	Tagadirt	52	102,996	18,440	more than 10	---	---
57	Tifirt	94	191,929	19,009	more than 10	---	---
58	Anfrioune	63	128,528	18,994	8.0	176,574	26,094
60	Tifratine	84	171,948	19,058	7.5	187,932	20,829
61	Aguenze	21	35,654	15,807	8.5	146,358	64,885
62	Ifit Baragha	37	60,487	15,220	5.5	115,726	29,119
63	Agadir Baragha	42	68,614	15,216	3.0	82,716	18,335
65	Adar Baragha	12	19,866	15,413	5.5	93,276	72,367
66	Tadchert	31	51,219	15,382	4.0	87,838	26,380
67	Tamsoult	5	7,908	14,725	3.5	56,990	106,115
68	Dar Jamaa Ait Ali	63	106,046	15,671	6.5	154,074	22,769
69	Agadir Ait Brahim	29	47,169	15,143	7.0	131,042	42,069
70	Iouraghan	19	31,603	15,485	7.0	122,062	59,810
71	Imiki	52	85,292	15,271	8.0	166,696	29,845
72	Ifit Ait Alla	23	39,233	15,881	9.5	163,154	66,042
73	Boukhelf	89	149,301	15,618	9.0	214,922	22,482
74	Addar Ait Ali	23	40,564	16,420	7.5	133,154	53,898
77	Ait M' Barek	31	51,219	15,382	9.5	170,338	51,156
78	Agadir Ait Bourd	63	101,414	14,987	11.9	221,574	32,744
79	Afella Ouassif	26	40,899	14,645	10.7	183,848	65,832
81	Afella Ighil	10	17,147	15,961	1.0	23,980	22,325
83-1	Anfeg	16	26,414	15,370	1.2	32,368	18,834
83-2	Aguersouak	21	35,654	15,807	1.0	33,858	15,010
85-1	Oumast	37	60,737	15,283	1.8	60,226	15,154
85--2	Ait Zitoun	37	58,074	14,613	1.5	55,726	14,022
86	Tagadirt	29	46,087	14,796	7.1	132,542	42,551
87-1	Zaouit	9	15,787	16,331	3.0	53,082	54,910
87-2	Izalaghan	13	22,336	15,996	3.2	59,674	42,736
88	Tigouder	25	24,202	9,013	4.0	82,450	30,704
89	Amezi	38	63,206	15,485	2.6	73,124	17,915
90	Agouni	31	51,469	15,457	2.0	57,838	17,370
91	Chaabat Tarik	56	94,503	15,711	5.3	129,788	21,577
92	Ighil Sdidene	15	25,055	15,551	3.5	65,970	40,945

Table 5-10 (2/2) Villages to be Electrified by PV Generation (comparison of construction cost with transmission line extension)

No.	Douars	HH (2000)	PV Generation: Construction cost (DH)	PV Generation: Construction cost / HH (DH)	Grid extension: Distance from exsisting grid line (km)	Grid extension: Construction cost (US$)	Grid extension: Construction cost / HH (DH)
93	Tizi	62	101,357	15,220	3.0	100,676	15,118
94	Aghbalou	94	155,046	15,356	4.6	153,412	15,194
95	Ait Hsain	14	24,777	16,477	3.4	63,572	42,275
96	Ait Boubker	15	26,386	16,377	3.9	71,970	44,669
97	Tazatourt	35	58,849	15,654	4.7	101,930	27,113
98	Tamsoulte	35	58,017	15,433	2.9	74,930	19,931
99	Tizgui	52	85,542	15,315	3.1	93,196	16,686
100	Ait Tirghit	52	84,460	15,122	4.9	120,196	21,520
101	Tachbibt Kabli	31	53,632	16,107	3.0	72,838	21,875
102	Tachbibt Echatoui	31	53,632	16,107	2.5	65,338	19,622
103	Asgoune	31	52,301	15,707	3.5	80,338	24,127
104	Ait Aamara Loued	84	140,312	15,551	4.5	142,932	15,842
106	Lakaama	31	50,138	15,058	1.0	42,838	12,865
113-1	Tarast	47	82,323	16,307	17.0	297,206	58,872
113-2	Assaka	47	80,629	15,971	20.0	342,206	67,786
117	Ansa	62	129,747	19,483	5.0	130,676	19,622
120	Ezzaouite	17	43,279	23,702	8.0	135,266	74,078

Table 5-11 Villages to be Electrified by Diesel Generation (comparison of construction cost with transmission line extension)

No.	Douars	HH (2010)	Diesel Generation: Construction cost (DH)	Diesel Generation: Construction cost / HH (DH)	Grid extension: Distance from exsisting grid line (km)	Grid extension: Construction cost (US$)	Grid extension: Construction cost / HH (DH)
23	Agouns	125	78,865	5,760	6.0	202,250	15,061
47	Lemdinat	190	116,280	5,588	6.5	268,120	13,138
48	Tnirt	273	162,173	5,424	4.0	305,154	10,407
50	Ansmrou	190	115,639	5,557	8.0	290,620	14,240
52	Toulkine	226	135,709	5,482	3.0	247,948	10,214
54	Douzrou	261	155,298	5,432	8.5	361,878	12,908
55	Ait Ourmane	178	109,899	5,637	9.6	303,844	15,892
59	Ait Smil	178	111,423	5,715	4.0	219,844	11,499
76	Ait Bourd	119	76,620	5,878	10.0	256,862	20,096
84	Ait Bouzid	141	87,336	5,655	3.2	174,618	11,530
114	Abadou	131	84,206	5,869	6.0	207,638	14,757
119	Ait Armene	124	80,117	5,899	8.0	231,352	17,370

Table 5-12 Villages to be Electrified by Micro-hydropower Generation (comparison of construction cost with transmission line extension)

No.	Douars	HH (2010)	Micro-hydropower Generation		Grid extension		
			Construction cost (DH)	Construction cost / HH (DH)	Distance from exsisting grid line (km)	Construction cost (US$)	Construction cost / HH (DH)
6	Alla Oumzri	48	482,560	93,597	3.0	88,104	17,089
7	Id Ssior	78	510,560	60,940	6.0	160,044	19,103
10	Amsakrou	65			7.5	170,870	24,474
11	Arg	89			5.0	154,922	16,206
15	Ikiss	77			8.8	201,146	24,320
estimation by scheme		231	956,980	38,569	(*) 5.0	341,438	13,761
21	Anfli	75			8.0	187,350	23,256
22	Timichi	71			8.6	192,758	25,276
estimation by scheme		146	731,160	46,624	(*) 8.0	295,108	18,818
35	Imin Tala	83			10.0	224,534	25,186
36	Addouz	59			10.0	202,982	32,030
37	Ain Ghad	51			10.0	195,798	35,743
38	Inzaine	83			10.0	224,534	25,186
39	Imi N'isly	102			9.0	226,596	20,682
40	Dou Anamer	42			9.0	172,716	38,285
41	Igoundem	15			8.0	133,470	82,840
42	Toug Lkheif	48			7.0	148,104	28,726
estimation by scheme		483	1,563,570	30,138	(*) 7.0	623,734	12,023
46	Adardour	190	869,030		10.0	320,620	15,710
118	Tidsi	48			5.0	118,104	22,907
-	Afra	77			2.0	99,146	11,988
estimation by scheme		125	677,210	50,439	(*) 2.0	177,250	13,202

(*) Distance from exsisting grid line / construction cost including mini-grid sysytem of mucro-hydropower schem

Table 5-13 Villages to be Electrified by Transmission Line Extension (comparison of construction cost with transmission line extension)

No.	Douars	HH (2010)			Grid extension		
					Distance from exsisting grid line (km)	Construction cost (US$)	Construction cost / HH (DH)
13-2	Imskar	40			2.0	65,920	15,343
24	Oulad Mansour	70			1.5	85,360	11,353
34	Hat Tedrara	80			1.0	86,840	10,106
112	Lamhamid	30			0.3	31,440	9,757
115	Quriz	22			0.2	22,756	9,630

5.4 Power Demand Forecast

(1) Demand Forecast Method

Power demand forecasting was done by the following methodology:

① 2010 was chosen as the target date for power demand calculation taking into consideration the fact that the subject villages are scattered and remotely distanced from the existing transmission grid, and compatibility with target year planning under PERG. However, in the case of PV generation, target year is set at the year 2000, with additional modules to be added to meet subsequent demand.

② Using population and number of households in 1996 as a base, the number of future households by the time of the target forecast date was calculated applying an average annual increase in households of 1.24% on the basis of the results of questionnaire survey.

③ As discussed in section 5.3, household power demand was forecast according to the following 2 categories based on the specific characteristics of power source.

- <u>PV generation, diesel generation and extension of the existing grid</u>

Demand forecast assumes criteria adopted under PERG for other PV generation schemes (i.e. 240 Wh/day, maximum power of 65 W per household)

- <u>Micro-hydropower</u>

In the case of micro-hydropower, it is appropriate to match demand and supply on the basis of approximating as closely as possible user side demand with the optimum supply side scale of development. Accordingly, demand is assumed at a supply capacity of 518 Wh/day with maximum power of 87 W per household.

④ Base data was applied in calculating facility quantity vis a vis the demand category for each village.

(2) Demand in the Case of PV Generation, Diesel Generation and Transmission Line Extension

Using the number of households as of 1996 from the results of the questionnaire survey as a base, an average annual increase in household number by a factor of 1.24% (regional) was applied to calculate the number of households in the year 2000.

Demand for street lighting assumes 1 light per 5 households (in line with forecast increase in the number of households by the target year). Other public and commercial power demand was based on facility numbers as of 1996.

(3) Micro-hydropower Demand

Using the number of households as of 1996 from the results of the questionnaire survey as a base, an average annual increase in household number by a factor of 1.24% (regional) was applied to calculate the number of households in the year 2010. Use for categories of home, public and commercial purposes was assumed on the large side at 6 hours per day. Maximum power for lighting demand, given the relationship between demand and supply, is assumed with a margin at 63 W in contrast to the 40 W for PV generation.

(4) Results of Power Demand Forecast

The results of maximum load and power demand forecast according to the above methodology and criteria with regard to PV generation, diesel generation, micro-hydropower generation and transmission line extension are summarized below.

	No. of villages	Maximum power (kW)	Power demand (kWh/d)
PV generation	71	233.19	875.97
Diesel generation	12	120.66	572.73
Extension of transmission li	5	21.07	78.74
Micro-hydropower generatio	18 [1]	150.10	1,233.84 [2]
Total	106	525.02	2,761.28

Note: 1) Number of schemes are 7.

5.5 Power Supply Plan

(1) Basic Strategy for Power Supply Planning

Power supply planning was studied on a village-wise and electrification method wise basis from the standpoint of the basic strategy described below:

1) PV Generation (SHS: solar home system)

In adopting the solar home system (SHS) the most important point is avoidance of use of facilities at excess load as this will shorten system life.

Also, facility capacity will be increased (expanded numbers of PV modules and batteries) in response to growth in power demand.

2) Diesel Generation

Although diesel generation can be said to be technically at a high level of maturity and reliability, it requires a stable fuel supply and an operating structure facilitating procurement of spare parts for maintenance. Also, diesel engine equipment is subject to malfunction due to incomplete combustion as a result of poor quality fuel. In addition, operation at a high load rate is desirable given the fact that operational efficiency of equipment tends to drop dramatically when load rate dips below 40%.

3) Micro-hydropower

Since the same amount of power generation is possible both during the day time and at night in the case of a micro-hydropower scheme given a set available discharge, it is crucial that off-peak demand during the daytime be exploited to the extent possible in order to maximize scheme utilization and improve cost effectiveness. In comparison of scheme scale and power demand in the relevant adjacent villages, it is clear that a generating scale well above that applied in power source selection is available, and a power demand so commensurate is assumed.

4) Extension of Existing Transmission Line

In the case of electrification by extension of the existing grid, it becomes necessary to install switch gear to distribute power to each user household. Since transmission line voltage is 22 kV and the voltage at the village level is 380/220 V, it is required that step-down transformer equipment be installed. In the case where multiple villages are located relatively close together it is more cost effective to establish a single step-down transformer facility at one location to commonly service the subject villages.

(2) Power Supply Plan

1) Generation Scale

On the basis of the fundamental strategy described in the previous section, appropriate generation scale was examined. Generation scale was accordingly determined on the in line with the following criteria vis a vis maximum load.

① PV generation: As indicated below, power supply scale is to be by 2 types of PV module, i.e. 75 Wp and 55 Wp, depending on power demand category (Wh/d).

User	Power demand (Wh/d)	PV module (Wp)	
		Plain	Mountain
Home	240	*75 (75 × 1)	110 (55 × 2)
School	180	60 (75 × 1)	90 (55 × 2)
Street light	120	40 (55 × 1)	60 (75 × 1)
Mosque	160	55 (75 × 1)	83 (55 × 2)
Clinic	150	47 (55 × 1)	71 (75 × 1)
Commercial	50	15 (55 × 1)	23 (55 × 1)

* Necessary PV module capacity to meet demand based on available sunlight hours and system efficiency (power demand / sunlight hours · system efficiency).
( ) indicates the actual PV module capacity installed.

Villages targeted for PV electrification are scattered in plain and mountain areas. Since a reduced sunshine intensity is anticipated in mountain area, PV modules for such sites are of 50% increased capacity.

② Diesel generation: A 10% reserve capacity vis a vis maximum load is assumed in consideration of capacity of diesel generators commonly available on the market. As a result, an average 30% reserve capacity results under the diesel generation schemes.

③ Micro-hydropower generation: With due consideration of the unique features of each scheme site, generating scale was determined with an average reserve capacity of 23% (16~29%) vis a vis maximum load.

④ Existing transmission line extension: A reserve capacity of 10% is assumed vis a vis maximum load.

As a result of the above, facility output by power source category is summarized as follows:

	No. of villages	Facility output (kW)
PV generation	71 [1]	333.6 [3]
Diesel generation	12	156.8
Micro-hydropower	18 [2]	179
Extension of existing gri	5	23.2 [4]
Total	106	692.6

Note:
1) No. of systems is 4,094
2) Scheme total is 7. The Tidsi scheme will provide supplemental power to Afa (not on the original request list)
3) Indicates PV module capacity (kWp)
4) Indicates grid load

2) Power Supply Method

① Solar Home System

PV panels (modules) are to be installed in each target home. Generated power is to be battery stored via a charge/discharge controller. Power is then supplied from the battery to the electrical appliances in use in the home.

② Diesel Generation

Diesel generators are to be installed in each of the target villages. The said generating equipment is to be operated for the designated hours to supply power to each user household via 220 V distribution line.

③ Micro-hydropower

Discharge is to be conveyed by headrace to the optimum location for power house (turbine and generator equipment). Power is then supplied by 220 V distribution line to user homes.

④ Extension of Existing Transmission Line

Branch transmission lines (22 kV) are to be run from the nearest existing transmission line to the target villages. Medium voltage / low voltage transformers are to be installed in the said villages. Power is then to be supplied by 380/220 kV distribution line to the user homes.

(3) Optimum Scale for Micro-hydropower Generation

The power generation scale applied in the selection of village-wise power source was based on forecast of "ordinary demand", and assumed an identical scale for each category of electrification method. However, there is considerable surplus power generating potential in the case of micro-hydropower depending on site conditions. With regard to decentralized electrification, since the scale of power generation within the mini-grid is to be equivalent to power demand, a comparative analysis was done for "expanded demand" with consideration to future increase in power demand.

Under the said comparative examination, "ordinary demand" was designated as Case-A (maximum output of 65 W / household) and "expanded demand" as Case-B (maximum output of 87 W / household). Results of study of scale in the Case-A are indicated in Table 5-14 and the results of comparative study of cost effectiveness for optimum generating scale are indicated in Table 5-15. On the basis of the foregoing, Case-B is advantageous over Case-A in terms of per kW and per kWh construction cost, and thus is the optimum generation scale. However, these values are considerably high in comparison to the envisioned electricity tariff. This is a result of the unique features of micro-hydropower schemes in the Study area and is considered unavoidable.

Table 5-14 Facility Output for Ordinary Demand (Case-A)

Scheme	Maximum Output (kW)			Installed Capacity (kW)	Generated Energy (kWh)		
	Household	Others	Total		Rainy months	Dry months	Year
Adardour	16.53	1.54	18.07	19	15,040	5,357	20,397
Inzaine	42.02	3.40	45.42	46	40,910	11,629	52,539
Arg	20.10	1.80	21.90	22	20,562	5,031	25,593
Alla Oumzri	4.18	0.27	4.45	5	4,066	1,593	5,659
Id Ssiar	6.79	0.52	7.31	8	6,607	2,485	9,092
Anfli	12.70	1.21	13.91	14	12,366	4,460	16,826
Tidsi	10.88	1.11	11.99	12	7,623	4,789	12,412
Total	113.20	9.85	123.05	126	107,174	35,344	142,518

Table 5-15 Comparison of Cost Effectiveness for Optimum Generating Scale

Scheme	No. of Douar	Nos of Households	by Moderate Demand Forecast (Case A)					by Sufficient Demand Forecast (Case B)				
			Capacity (kW)	Generated Energy (kWh)	Construction Cost (10^3 US$)	Cost / kW (10^3 US$)	Cost / kWh (US$)	Capacity (kW)	Generated Energy (kWh)	Construction Cost (10^3 US$)	Cost / kW (10^3 US$)	Cost / kWh (US$)
Adardour	1	190	19	20,397	512.00	26.95	25.10	26	56,914	631.00	27.27	11.09
Inzaine	8	483	46	52,539	967.60	21.03	18.42	62	148,900	1,137.00	18.34	7.64
Arg	3	231	22	25,593	578.40	26.29	22.60	30	73,648	698.00	23.27	9.48
Afla Oumzri	1	48	5	5,659	210.50	42.10	37.20	10	42,561	353.00	35.30	8.29
Id Ssior	1	78	8	9,092	224.00	28.00	24.64	16	54,034	371.00	23.19	6.87
Anfli	2	146	14	16,826	426.60	30.47	25.35	20	52,092	536.00	26.80	10.29
Tidsi	2	125	12	12,412	436.80	36.40	35.19	15	22,203	501.00	33.80	22.56
Total	18	1,301	126	142,518	3,355.90	average 26.63	average 23.55	179	450,352	4,227.00	average 23.61	average 9.39

(4) Candidate Sites for Pre-feasibility Study

From among the 7 project sites selected for the Master Plan, a further winnowing down of sites which warrant consideration under the Pre-feasibility Study was done in close consultation with CDER. Criteria for priority ranking of sites for development are as follows:

① Access road conditions (road length, width, gradient, etc.)
② Need for coordination of irrigation discharge use and power generation discharge use between or among villages
③ Numbers and population of villages to be electrified
④ Whether or not spring is uses as a water source
⑤ Geographical distribution of priority sites
⑥ Development aspirations of the local government entities (Cercle and Commune Rurale)

On the basis of study and discussion based on the above criteria, the following 3 sites were selected as meeting the conditions for consideration under the Pre-feasibility Study.

Site	Area	River	Catchment area (km^2)	Output (kW)
46 Adardour	Anougal	Anougal	23	26
11 Arg	Asni	Inemane	48	30
118 Tidsi	Tighdouine	Afoughal	24	15

5.6 Operation and Management Plan

(1) Start Up

1) Plan at Start up of Project

① Creation of Users' Association

At present when CDER embarks on an electrification program, it begins by establishing users' associations in the target villages. The association comprises all the system users, from among which generally 7 officers area elected, i.e. the association representative, deputy representative, secretary, accountant, village leader, etc. However, since more detailed operational care is essential in the case of home solar systems, it is recommended that the users' association not be formed on a single village unit basis, but rather that a separate association be established for each sub-hamlet within the village. However, in the case of these smaller sized associations, 3 elected officers would suffice, i.e. an association representative, secretary and accountant.

② Establishment of Coordinating Committee

If each users' association were to liaise directly and independently with CDER and the other related government agencies, communication channels would become immensely complex and inefficient. Accordingly, it is necessary to establish coordinating committee which integrate for multiple villages the linkage requirements between the said villages and the concerned government agencies. These meetings would comprise representatives from the users' associations and the appropriate officials from the related government and other entities. Specifically, this would include the representatives of the respective users' associations, representatives from CDER, the Kaidat (the sub-agency of the Ministry of Interior), ONE and the private contractors performing O&M services. The meetings would provide a forum for discussion and coordination on issues of facility improvement, operation and maintenance of the systems, etc., as well as serve to make transparent the process of collection and disposal of monthly payments by users.

2) Implementation of Installation Works

Installation works would be performed by private contractors. In selecting contractors, it will be important to select those which clearly have the capacity to respond to the anticipated future needs for maintenance, rehabilitation and repair works. Toward this end, contractors would be evaluated at the time of tendering and only those contractors nominated which fulfill the foregoing criteria.

3) Equipment Development

In the case of PV generation, controller and battery quality is a key factor. In Morocco, it is a common practice that the battery used for home energy purposes is originally a car battery. Use of a car battery under a PV generating system results in an estimated battery life of 3 years. However, given the nature of the car battery, there is no guarantee that this will necessarily be the optimum for fluorescent light and TV operation in the home. During the Study, the Study Team discussed with battery manufacturers in Casablanca (Tudor, etc.) the possibility of manufacturing a battery with superior electric current characteristics. In this regard, the said manufacturers are directing efforts at development of improved PV generating equipment including batteries. PV system batteries under development with the generally used capacity of 85~105 Ah capacity can be marketed for a price of DH 1,000 which is comparable to the cost of the commonly available car battery. In this regard, it is desirable that efforts in development of related equipment continue in the future.

(2) Operation and Maintenance

1) Maintenance Structure

In the case of PV generation, a single self contained system from solar panel to battery has been designed. In order to effect sustained, safe use of the envisioned PV systems in the early stages, the user would be expected to carry out only simple maintenance such as cleaning of the solar panel with a professional technician to make periodic visits to check the equipment. Accordingly, even delegating responsibility for what on the surface appear to be very simple tasks such as battery re-watering to professional technicians enables the most overall effective O&M of the systems and prolonging of the PV generating system life. This ultimately in the best interest of the user. Considering the current situation in the environs of Marrakech, it is judged that employment of a number of private contractors based in Marrakech to periodically inspect the equipment under this Project would yield the most satisfactory results.

2) Cost Payment and Equipment Ownership

① Examples of Cost Payment by Users

Payment method of initial cost varies depending on the system; however 4 actual examples are set out below (3 systems actually in operation and the payment method established under PERG).

(a) DH 2,000 levied per household

This comprises a one time levy of DH 2,000 per household, with no other required payment outside of electricity tariffs. This was originally to be basically a single lump sum payment; however, due to the inability to pay of some households, payment by installment was allowed. As of the present, 80% payment recovery rate from the subject households has been achieved. (GTZ micro-hydropower project)

(b) Payment of DH 320 when a new user joins the users' association under the solar home system

Following payment of the join-up fee of DH 320, the user is assessed a monthly payment of DH 85 for a 6 year period. This represents a total payment by each user over the said 6 year period of DH 6,440. The monthly payment includes O&M costs and repayment for the PV kit (including panel and battery). (PPER solar home system project)

(c) No initial payment cost in the case of the centralized type PV generation system (PPER solar home system project)

(d) Initial payment of DH 1,440 by each user household

This comprises one part of the purchase cost of the PV kit. Subsequent to this, each user pays a monthly fee of DH 60 for 84 months (7 years). This represents a total payment by each user over the said 7 year period of DH 6,480.The monthly payment includes O&M costs and repayment for the PV kit (including panel and other equipment, but not battery). (PERG solar home system project)

② Cost and Equipment Ownership

In the case of the PPER home solar system and the GTZ micro-hydropower projects, initial cost is recouped in the form of join-up fees levied on new members of the users' associations. In the case of the French PPER project, original equipment ownership rights are shared among the French government, CDER and the regional government entity under the Ministry of Interior. After 6 years, ownership of the systems is turned over to the users' associations. The project, incidentally, is loan based. The GTZ project on the other hand is grant-aid; however, in this case as well ownership of the schemes is handed over to the users' associations after 7 years.

3) Collection Method and Management of Operating Costs

① O&M Cost

O&M costs to go to the private contractors would be covered under the monthly payments to be made by the users. However, due to the fact that accumulated money in this regard would be small for about the first 3 years of the Project operation, it is anticipated that such would not be sufficient to cover all O&M costs. To offset this, CDER would carry out during the Project implementation period sufficient training of users' associations, private contractors and the general village population in system operation and maintenance technology in order to make possible a joint maintenance effort by the associations, contractors and villagers. This will serve to reduce the amount of money which would need to be paid to the contractors for O&M works. It is recommended that the said training program in this regard be within a framework of funding under advantageous financial terms.

② Electricity Tariffs and Users' Association Costs

Collection of user monthly payments by the users' associations is the same method under similar projects in the country financed by the various donors, and is consequently considered the most feasible under this Project as well. It would at first appear appropriate that CDER make the rounds of the villages, collect the relevant monies from the users' associations and allow this fund pool to build up to a point where payment to the private contractors would begin after the 3rd year. However, the present capability of CDER is such that it lacks personnel to collect and manage payments.

③ Transparency of Payment Collection and Management

Under the Project, the users' associations will collect the monthly payments from the user households, and then use these to make the allocated payments to the private contractors and CDER. However, the amount to paid is relatively higher in the case of solar home systems. Accordingly, assuming some situations where payments would be in arrears for some households, it is necessary that the status of payments be readily transparent from a third party standpoint.

④ Bank Account Management

The users' association accountant would open and bank account and deposit funds at interest. Since the associations will collect the electricity tariff and the O&M cost (including battery cost) in a single lump sum, they will be guided in the opening of two separate bank accounts and the separate management of these funds.

⑤ Management of Association Join-up Fees

The join-up fees to be collected by members will serve as the operating fund base for the users' associations, and it is intended that these funds would be set aside and left untouched for the initial period following Project start up. These fees would be banked together in the same account along with the users' association cost portion of the monthly payment by user households. The said fund base would have applications for O&M purposes, as well as for possible future facility expansion if necessary with increase in number of new system users.

5) Capability Strengthening of CDER

The Project will entail the installation of a large amount of facilities and equipment in a relatively short period of time. Simultaneous to this, it will also be necessary to set up an operational and maintenance structure which effectively incorporates the services of private contractors. If the said system installation was merely at the pilot project level, it might be feasible to delegate all responsibility for Project implementation to CDER; however, in actuality CDER lacks sufficient personnel to execute the Project solely on its own within the limited implementation period. Although CDER has good technological expertise in electrification projects, it is considered necessary that the agency's capability be strengthened in the area of project management. This need would have to be responded to at the time of Project implementation within the framework of appropriate measures to upgrade CDER's operational and management capacity.

5.7 Implementation Schedule

(1) Overall Schedule

It is assumed that CDER will be the prime executing agency for the Project. The overall project implementation schedule would comprise ① internal preparations on the Moroccan government side, ② funding procurement, ③ basic design study and establishment of implementation procedures, ④ detailed design, tender document preparation, and selection of contractors, and ⑤ project construction works.

Breakdown of total villages and total numbers of households by electrification category under the Project is as follows:

Electrification method	Villages to be electrified	Households to be electrified
PV generation	71	3,213
Diesel generation	12	2,136
Micro-hydropower generation	18	1,301
Extension of existing transmission line	5	288
Total	106	6,938

Of the above, extension of existing transmission line would be performed by ONE, and as such would not be included in the implementation schedule for this Project.

It is recommended that the Project implementation period comprise 2 phases in light of the time anticipated to establish an effective management structure for execution and the conditions discussed below.

1) PV Generating Facilities

In carrying out the pv generation portion of the project, it will be necessary to install a large quantity of equipment. Taking into consideration requirements of procurement, quality control and construction supervision, it is recommended that implementation of the pv generation portion be divided into 2 phases. Of particular note is the fact that the critical data on sunshine intensity in mountainous areas is lacking in accuracy. Accordingly, level terrain electrification would be commenced first, and during this implementation period sunshine intensity observations would be carried out in mountainous areas in order to maximize the accuracy of system capacity for the latter.

2) Diesel Generating Facilities

As the number of households are large in the case of villages to be electrified by diesel generation, it is necessary to coordinate this portion of the Project with the ongoing efforts by ONE to extend the existing grid. Under the Study, the criterion for considering extension of the existing grid as the electrification method for a subject village is that the said village lies within 3 km of existing transmission line. Since the numbers of households are large for the villages to be electrified by diesel generation under the Project, it is considered a high likelihood that those such villages which are closer to existing transmission line (3~6 km) will eventually be electrified under the ONE program to extend the grid. In this light, the 6 villages located more than 6 km from existing transmission line would comprise phase I of the diesel generation portion of the Project, during which period specific measures for electrifying the remaining 6 villages would be re-confirmed with ONE and the candidate remaining villages electrified under phase II.

3) Micro-hydropower Generating Facilities

Adoption of this method of electrification is based on the potential at the hydropower sites. However, in some cases candidate sites do not have access roads. Micro-hydropower schemes included relatively heavy pieces of equipment including turbine and generator for which it is essential that adequate access roads exist for transport of the same to the sites. In this regard, the 3 schemes where existing access roads are available for equipment transport are to be implemented under phase I, during which period access roads would be constructed for the remaining 4 schemes to be implemented under the subsequent phase II.

On the basis of examination of overall construction schedule with consideration to the above criteria, Phase I of the overall Project would be completed in March 2001 (FY 2000) and Phase II in March 2003 (FY 2002). (see Figure 5-1)

(2) Construction Schedule

1) PV Generating Facilities

In the case of PV module installation, the critical path in overall implementation would be the fabrication of mounting frames and system assembly in-situ. Required quantities of PV modules are as follows:

	Phase I	Phase II
Target villages	54	17
Target no. of homes	2,318	895
PV modules:		
75 Wp (set)	2,310	245
55 Wp (set)	501	2,068

Under Phase I above, the module sets would be procured and installed in a 16 month period. Procurement would be possible within 10~12 months; however, since installation would require time, 12 system assembly teams would be deployed to effect system installation in a 10 month period. Phase II as well would bed completed within a 16 month period.

2) Diesel Generating Facilities

Procurement and installation of diesel engines and generators comprise the critical path in overall construction works under this portion of the Project. Required equipment are as follows:

	Phase I	Phase II
Target villages	6	6
Target no. of homes	1,318	818
Diesel generating equipment		
21.6 kW (set)	2	--
14.0 kW (set)	4	--
11.2 kW (set)	--	2
9.6 kW (set)	--	2
8.0 kW (set)	--	2

Six sets each of diesel generating facilities will be installed in Phase I and Phase II, respectively. For each phase, an 8 month procurement period and 8 month installation period are assumed, which will make possible completion of the envisioned works within the allotted time period.

Since distribution line construction works can be carried out parallel to the generator facility assembly and installation works, a 16 month time period for each phase is considered ample to effect all the required works for the said schemes.

3) Micro-hydropower Generating Facilities

Civil works construction, particularly that for headrace, comprises the critical path under the implementation schedule for this portion of the Project. In cases where headrace is long, the entire alignment would be divided into several work segments for which construction would be implemented in parallel.

Parallel construction would be carried out as well for intake weir, penstock, and power house structures.

Headrace construction would be carried out by a work group comprising an excavation sub-work group and canal structure sub-work group, which would carry out their work tasks in parallel. However, since Phase I under the project is just 16 months, this construction would pose a very tight schedule for only one work group. Accordingly, canal alignment would be divided into 2 segments, and 2 work groups formed to carry out construction works in parallel. This will allow for ample completion of the envisioned works within the allotted period.

Since generator equipment installation and distribution line construction can be carried out parallel to the above civil works construction, formation of the required construction work groups for these tasks would enable overall scheme completion within the scheduled implementation period.

Micro-hydropower schemes with shorter headrace canal lengths are foreseen to pose no problems for completion within the allotted time period of 16 months.

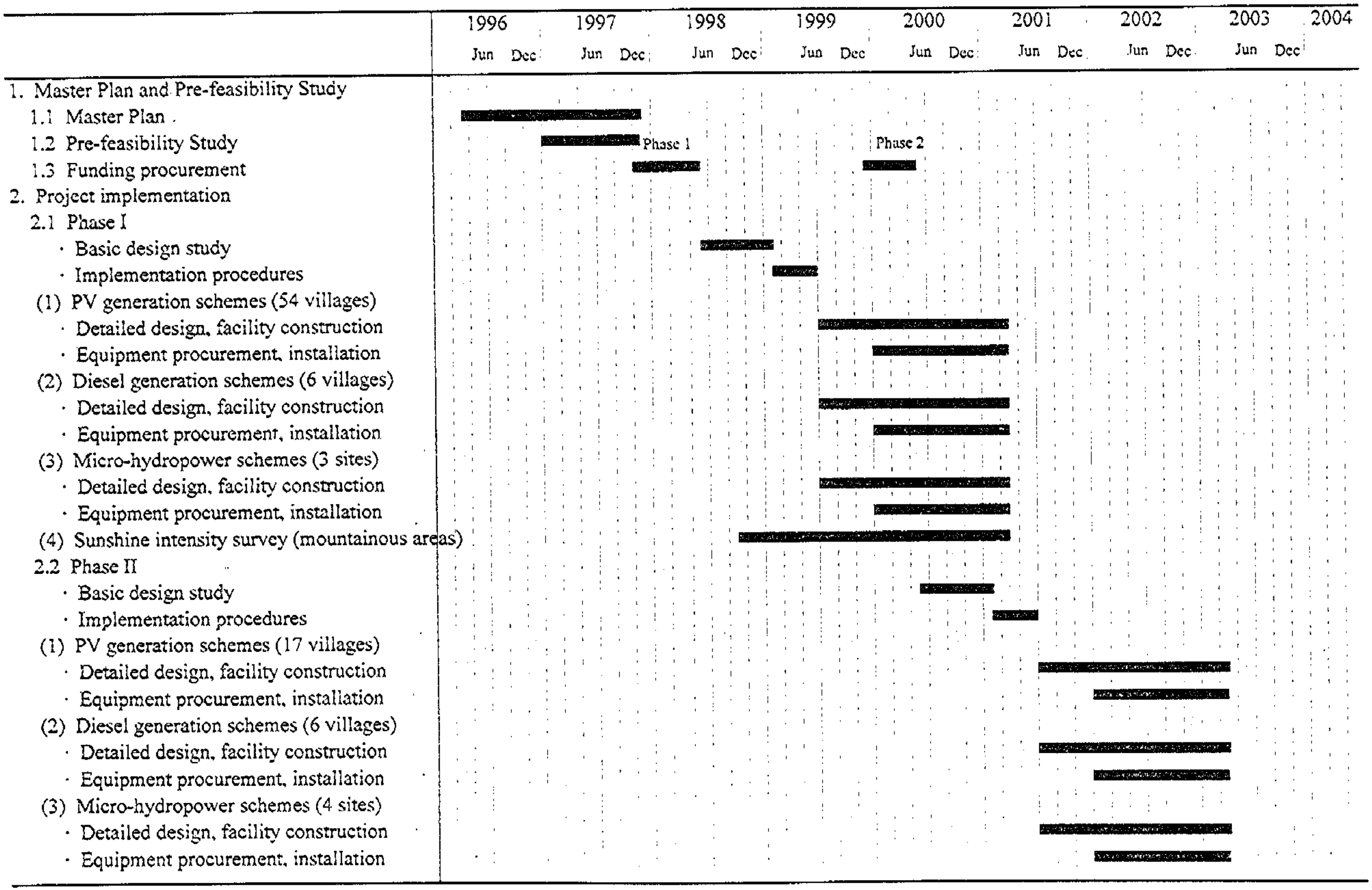


Figure 5-1 Project Implementation Schedule

CHAPTER 6 PRELIMINARY PROJECT COST ESTIMATE

Table 6-1 indicates preliminary project cost estimate including civil construction, equipment cost, packing and transportation, installation works, tax, engineering fee and physical contingency.

Table 6-1 Preliminary Estimate of Overall Project Cost

(10^3 US$)

	PV generation			Diesel generation			Micro-hydropower generation			Transmission line extension			Project Cost		
	Phase I	Phase II	Total	Phase I	Phase II	Total	Phase I	Phase II	Total	Phase I	Phase II	Total	Phase I	Phase II	Grand Total
1 Construction Cost															
1-1 Civil Works				15	15	30	1,036	1,417	2,453				1,051	1,432	2,483
1-2 Equipment															
(1) Generating equipment	1,874	1,114	2,988	49	49	98	295	296	591				2,218	1,459	3,677
(2) Transmission facilities							119	151	270	110		110	229	151	380
(3) Distribution facilities				394	398	792	229	356	585	209		209	832	754	1,586
(4) Packin g and transport	272	176	448	10	10	20	59	60	119				341	246	587
(5) Installation works	731	333	1,064	4	4	8	92	117	209				827	454	1,281
Total	2,877	1,623	4,500	457	461	918	794	980	1,774	319		319	4,447	3,064	7,511
Grand Total	2,877	1,623	4,500	472	476	948	1,830	2,397	4,227	319		319	5,498	4,496	9,994
2 Tax (VAT)	252	114	366	83	83	166	272	377	649	64		64	671	574	1,245
[Civil works (1-1) + Generating equipment (1) + Transmission facilities (2) + Distribution facilities (3) + Installation works (5)+(Packing & trans (4)×0.05)] × 20%															
3 Engineering fee	288	162	450	47	48	95	184	240	424	32		32	551	450	1,001
[Construction cost (1) × 10%															
4 Physical contingency	316	179	495	52	52	104	202	264	466	35		35	605	495	1,100
[Construction cost (1) + engineering fee (3) × 10%															
5 Preliminary project cost estimate	3,733	2,078	5,811	654	659	1,313	2,488	3,278	5,766	450		450	7,325	6,015	13,340

(2) Cost Estimate Criteria

Criteria applied in preliminary project cost estimate are as follows:

(1) Prices are as of the end of May 1997.

(2) Exchange rate:

US$ 1.0 = DH 9.31 (Dirhams)
US$ 1.0 = ¥ 115.0

(3) Costs for imported equipment were computed based on market price survey (FOB prices), assuming an additional 20% cost (of FOB) for packing and transportation. Inland transportation component is assumed at 5% of the overall packing and transport cost.

(4) Engineering fee is assumed at 10% of equipment cost, transport and installation cost and civil works cost.

(5) Physical contingency cost is assumed at 10% of equipment cost, transport and installation cost, civil works cost and engineering fee.

(6) Interest and price increases during the project construction period have not been taken into consideration.

CHAPTER 7 FINANCIAL AND ECONOMIC EVALUATION

7.1 Financial Evaluation

7.1.1 Evaluation Methodology

① Financial evaluation was done first on a village wise basis (with the exception of micro-hydropower, for which evaluation was done on a scheme-wise basis), then collated for each electrification category.

② Monthly payment to be made by each user was computed. In this case, computation was done for cases of initial investment recovery rate of 100%, 75%, 25% and 0% (corresponding at the same ratio to the financial burden to be borne by the user). At the same time, discount rates of 0, 3, 6 and 9% were applied to each case.

③ Project life is assumed at 30 years for micro-hydropower, 20 years for PV generation, and 10 years for diesel generation.

④ Fixed cost includes all costs computed in this regard under preliminary project cost estimate.

⑤ Variable cost assumes in addition to system facility O&M cost, a levy of US$ 1/month/household each for CDER and users' association operating costs, respectively.

⑥ Cost for electricity use at public facilities is assumed to be borne equally by the relevant users in the villages.

7.1.2 Power Supply Cost Calculation

The household monthly payment which makes possible a sustainable project implies the cost to be borne by the users which effectively covers over the long term variable cost (O&M cost, fuel cost, etc.) as well as the operational costs required by CDER (overall responsibility for project operation) and users' associations (responsible for daily system management) in the case where no outside subsidy is applied to the Project.

Table 7-1 sets out the household monthly payment (collected amount) which would result if a US$ 1/month surcharge is applied to cover operational costs of CDER and the users' associations, respectively.

Table 7-1 Monthly Cost to be Paid per Household (including operation cost)

(US$ / mo. / home)

Electrification method		PV generation	Diesel generation	Micro-hydropower
No. of villages		71	12	18 (7)
No. of households (year 2000)		3,213	1,890	1,158
Return on initial investment	Discount rate	20 year life	10 year life	30 year life
100%	0%	14.1	10.4	14.8
	3%	15.7	11.4	219.4
	6%	18.2	12.4	29.7
	9%	20.9	13.5	39.5
75%	0%	12.2	9.1	11.9
	3%	13.3	9.8	16.8
	6%	15.2	10.6	23.1
	9%	17.1	11.4	30.4
50%	0%	10.3	7.7	9.0
	3%	11.0	8.2	12.3
	6%	12.2	8.7	16.5
	9%	13.4	9.3	21.4
25%	0%	8.4	6.4	6.1
	3%	8.6	6.6	7.8
	6%	9.1	6.9	9.9
	9%	9.7	7.2	12.3
0%	0%	6.5	5.0	3.2
	3%	6.2	5.0	3.2
	6%	6.1	5.0	3.2
	9%	6.0	5.1	3.3

7.1.3 Balance of Payments Calculation

(1) Estimated Payment by Users

On the basis of questionnaire survey, present household expenditure on illumination fuel (butane gas, candles) is estimated at DH 786 per year (DH 66/month). In addition, expenditure for battery to power TV, radio and other electrical appliances comes to an average DH 97/month. Analysis of this expenditure on a household basis in terms of income bracket and geographic location indicates, with the exception of the more economically advantageous class, an expenditure of DH 60~70 /month for illumination fuel and DH 70~100 for power to energize electrical appliances. On this basis, although some difference is evident depending on income bracket, there is no major variation in expenditure geographically with the exception of one affluent sector of the Tahanout consumer population.

On the other hand, demand was forecast on the basis of general rural electrification planning as a result of consultations with CDER. However, judging from the status of utilization of lighting, TVs and radios by each household and the findings of questionnaire survey, it is anticipated that numbers of light fixtures per household as well as hours of TV and radio will increase in the future beyond this basic demand forecast. In addition, it can be expected that some insufficiency of power supply may occur at times in the case of PV generation (due excessive cloudy weather) or micro-hydropower (due to drought discharge). As a result, it is necessary to assume some continued expenditure by households for illumination fuel and radio dry cell battery, etc.

Under the envisioned Project, electricity tariff level which can be afforded by the user (each household) is assumed on average for all households at the above described DH 163/month (DH 66 + 97/month). However, also as discussed above, it becomes necessary to assume a separate expenditure by each household of DH 20/month for illumination fuel (butane gas) and DH 20/month for radio dry cell batteries.

Accordingly, an appropriate amount which the beneficiary user will be able to afford for electricity tariffs is assumed at around DH 100~120/month (present expenditure for lighting fuel and batteries minus the above separate expenditure to offset times of insufficient power under the schemes). Also, the willing-to-pay amount indicated by the target beneficiaries of DH 50~75 accounts for some 80% of the total, with households indicating DH 50/month being in the largest group. Overall average willing-to-pay amount is DH 71.

It is necessary here to understand that the foregoing gap between willing-to-pay (DH 71/month) and afford-to-pay amounts (DH 100~120/month) is the natural result of the target households desiring maximum electricity service at minimum cost burden.

With consideration to the above criteria, an electricity tariff level which beneficiaries are capable of paying for the power to be supplied under the Project is estimated as follows:

1) Under the PERG electrification program currently under way in Morocco, it is planned to collect tariffs from users of DH 40/month in the case of extension of the grid, and DH 60/month in the case of PV generation (battery replacement cost to be borne by the user).

2) Under the questionnaire survey carried out in the course of this Study, responses were obtained from each village with regards to affordability to pay for electricity tariffs. In this regard, the general villager indicated an average DH 71/month for the same.

3) The questionnaire survey likewise revealed that at present villagers pay per household an average DH 163/month for energy for illumination purposes, including DH 97/month for battery purchase and recharging, plus additional cost for kerosene and candles. After subtracting the above supplemental cost (DH 20 + 20/month) from the present outlay of DH 163/month for illumination fuel and battery purchase, the result is DH 123/month. However, due to the fact that in actuality the said supplemental cost varies depending on

the village and the household, the affordable cost burden by users is assumed at DH 123~163/month for electricity tariffs.

On the basis of the above data, assuming household outlay per month at a minimum of DH 40/month and a maximum of DH 163/month, balance of payment under each category of electrification was computed for household monthly payments of US$ 4, 7, 10, 14 and 17, respectively (DH 1 = US$ 1.0).

(2) Results of Balance of Payment Calculation

Results of balance of payment calculation for each category of electrification are shown in Table 7-2.

Table 7-2 ***Overall Balance of Payment Calculation***

1) PV generation

(US$ 1,000)

Return on initial investment	Discount rate	Monthly payment (US$ / household)				
		4	7	10	14	17
100%	0%	-7,975	-5,662	-3,348	-264	2,050
	3%	-7,235	-5,398	-3,562	-1,113	723
	6%	-6,845	-5,403	-3,960	-2,037	-595
	9%	-6,578	-5,406	-4,235	-2,673	-1,501
75%	0%	-6,523	-4,210	-1,896	1,188	3,501
	3%	-5,783	-3,946	-2,110	339	2,175
	6%	-5,393	-3,951	-2,508	-585	857
	9%	-5,126	-3,955	-2,783	-1,221	-50
50%	0%	5,071	-2,758	-445	2,640	4,953
	3%	-4,331	-2,495	-658	1,790	3,627
	6%	-3,941	-2,499	-1,057	867	2,309
	9%	-3,674	-2,503	-1,331	231	1,402
25%	0%	-3,620	-1,306	1,007	4,092	6,405
	3%	-2,880	-1,043	794	3,242	5,079
	6%	-2,490	-1,047	395	2,318	3,761
	9%	-2,223	-1,051	120	1,682	2,854
0%	0%	-2,168	145	2,459	5,543	7,857
	3%	-1,428	409	2,245	4,694	6,530
	6%	-1,038	404	1,847	3,770	5,212
	9%	-771	401	1,572	3,134	4,306

*note: indicates balance of payment in the black

2) Diesel Generation

(US$ 1,000)

Return on initial investment	Discount rate	Monthly payment (US$ / household) 4	7	10	14	17
100%	0%	-1,566	-837	-107	865	1,594
	3%	-1,529	-909	-289	538	1,159
	6%	-1,500	-966	-432	279	813
	9%	-1,476	-1012	-548	71	535
75%	0%	-1,237	-508	221	1,193	1,922
	3%	-1,201	-580	40	867	1,487
	6%	-1,171	-638	-104	608	1,141
	9%	-1,148	-684	-219	399	863
50%	0%	-909	-180	549	1,522	2,251
	3%	-872	-252	368	1,195	1,815
	6%	-843	-309	224	936	1,470
	9%	-819	-355	109	728	1,192
25%	0%	-581	149	878	1,850	2,579
	3%	-544	76	697	1,524	2,144
	6%	-514	19	553	1,264	1,798
	9%	-491	-27	437	1,056	1,520
0%	0%	-252	477	1,206	2,178	2,908
	3%	-215	405	1,025	1,852	2,472
	6%	-186	348	881	1,593	2,126
	9%	-162	302	766	1,384	1,849

*note indicates balance of payment in the black

3) Micro-hydropower

(US$ 1,000)

Return on initial investment	Discount rate	Monthly payment (US$ / household) 4	7	10	14	17
100%	0%	-5,372	-3870	-2,368	-365	1,137
	3%	-5,532	-4576	-3,620	-2346	-1,390
	6%	-5,618	-4963	-4,308	-3434	-2,779
	9%	-5,668	-5189	-4,710	-4071	-3,592
75%	0%	-3,924	-2422	-920	1,082	2,584
	3%	-4,084	-3128	-2,173	-898	58
	6%	-4,171	-3515	-2,860	-1986	-1,331
	9%	-4,220	-3741	-3,262	-2623	-2,144
50%	0%	-2,476	-974	528	2,530	4,032
	3%	-2,636	-1681	-725	550	1,506
	6%	-2,723	-2068	-1,412	-538	117
	9%	-2,773	-2293	-1,814	-1176	-696
25%	0%	-1,029	473	1,975	3,978	5,480
	3%	-1,189	-233	723	1,998	2,953
	6%	-1,275	-620	36	909	1,565
	9%	-1,325	-846	-367	272	751
0%	0%	419	1,921	3,423	5,426	6,928
	3%	259	1,215	2,171	3,445	4,401
	6%	173	828	1,483	2,357	3,012
	9%	123	602	1,081	1,720	2,199

*note: indicates balance of payment in the black

(3) Example of Results of Balance of Payment Calculation

1) Case of Monthly Payment of US$ 4

PV generation:	No profit occurs for any of the cases of initial investment recovery rate or discount rate.
Diesel generation:	No profit occurs for any of the cases of initial investment recovery rate or discount rate.
Micro-hydropower:	Profit occurs for an initial investment recovery rate of 0%. Since variable cost and operating cost are borne by the users, facility O&M is possible.

2) Case of Monthly Payment of US$ 7

PV generation:	Profit occurs for an initial investment recovery rate of 0%. Since variable cost and operating cost are borne by the users, facility O&M is possible.
Diesel generation:	Profit occurs for an initial investment recovery rate of 25% and discount rate of 6%. In other words, users can bear responsibility of 25% of initial investment.
Micro-hydropower:	Profit occurs for an initial investment recovery rate of 25% and discount rate of 0%. In other words, users can bear responsibility of 25% of initial investment.

In other words, all 3 modes of electrification are sustainable. In the case of diesel generation and micro-hydropower, 25% of initial investment can be borne by the users.

(4) Envisioned Monthly Payment

1) Under the results of questionnaire survey, outlays for lighting purposes and to operated electrical appliances (TV, radio) in the home average a total DH 163/month, comprising DH 66/month for candle and butane gas, and DH 97/month for battery purchase and recharge. If this outlay becomes available for monthly payment after implementation of the schemes, affordability to pay would be DH 163/month = US$ 17.5 /month (DH 9.3 = US$ 1).

   Calculation of FIRR in Table 7-2 assuming the foregoing US$ 17.5 as the monthly payment by users yields a 6% FIRR at 100% recovery rate for PV generation, an FIRR over 10% at 100% recovery rate for diesel generation, and a 1% FIRR at 100% recovery rate for micro-hydropower.

2) If the envisioned monthly payment is intended to correspond only to the DH 97/month current outlay per household for battery purchase and recharge, then the said monthly payment would be around US$ 10/month. Calculation of FIRR in Table 7-2 assuming the foregoing US$ 10 as the monthly payment by users yields a 10% FIRR at 25% recovery rate for PV generation, a 3% FIRR

at 75% recovery rate for diesel generation, and a 6% FIRR at 25% recovery rate for micro-hydropower. Resulting in the user assuming responsibility for approximately 25% of overall initial investment. This is roughly equivalent to conditions under the PERG program. A US$ 10/month payment under conditions of the foregoing initial investment burden by the users achieves an internal rate of return (including interest) of over 6% overall.

3) A monthly payment of US$ 14, corresponding to a midway point between 1) and 2) above, yields a 4% FIRR at 75% recovery rate for PV generation, a 10% FIRR at 100% recovery rate for diesel generation, and a 1% FIRR at 75% recovery rate for micro-hydropower.

(5) Collection, Use and Management of Monthly Payments

Implementation of the Project does not merely imply a redirection of the present household outlay for lighting and electricity purposes, but also the establishment of cleaner and safer energy source, elimination of the laborious task of battery recharging at charging stations, and the inconvenience of not having electricity during the period of battery recharge.

Full collection of the envisioned household monthly payment would result in an approximate monthly income for CDER of US$ 6,000. This capital could then be used, in addition to Project operation and management, for related purposes including research and personnel training in renewable energy exploitation, training and awareness programs for users, and public relations campaigning throughout Morocco with regard to the advantages of renewable energy development.

Also as discussed earlier, analysis for each electrification category was done on an overall basis for the entire Project area. In actuality, however, a considerable fluctuation in cost is seen from village to village.

Accordingly, collection of an overall uniform monthly payment (or a fixed monthly payment by mode of electrification) from the system users would result in a profit for some villages and a deficit for others. To rectify this, it will be necessary to manage collected funds such that the surplus at one village is effectively rerouted to cover the insufficiency at another village, thereby ensuring the long term stability and sustainability of project operation. For this purpose, it is necessary that CDER secure the personnel and operational resources to make such management of funds possible.

(6) Collection in the Form of Electricity Tariff

In comparing the power cost for each mode of electrification, comparison of per kWh is the most readily understandable yardstick. For this purpose, the monthly payment amounts calculated in Table 7-1 have been divided by the monthly electricity consumption of 7.2 kWh to give the per kWh cost. However, in the case of micro-hydropower generated energy is high at an available 15.5 kWh/month, and this has been reflected in the calculated unit prices.

Table 7-3 Cost per kWh of Consumed Power (including operation cost)

(US$ / kWh)

Electrification method		PV generation	Diesel generation	Micro-hydropower	
No. of villages		71	12	18 (7)	
No. of households (year 2000)		3,213	1,890	1,158	
Generated energy by hydropower				7.2 kWh	15.5 kWh
Return on initial investment	Discount rate	20 year life	10 year life	30 year life	
100%	0%	1.96	1.44	2.06	1.03
	3%	2.18	1.58	2.97	1.48
	6%	2.39	1.72	4.12	2.06
	9%	2.9	1.87	5.49	2.75
75%	0%	1.69	1.26	1.65	0.82
	3%	1.85	1.36	2.33	1.16
	6%	2.11	1.47	3.21	1.61
	9%	2.37	1.58	4.22	2.11
50%	0%	1.43	1.07	1.25	0.62
	3%	1.53	1.14	1.71	0.85
	6%	1.69	1.21	2.29	1.14
	9%	1.86	1.29	2.97	1.48
25%	0%	1.17	0.89	0.85	0.43
	3%	1.19	0.92	1.08	0.54
	6%	1.26	0.96	1.37	0.68
	9%	1.35	1	1.71	0.86
0%	0%	0.9	0.69	0.44	0.22
	3%	0.86	0.69	0.44	0.22
	6%	0.85	0.69	0.44	0.22
	9%	0.83	0.71	0.46	0.22

1) Electricity tariffs for home power use in Morocco are reported nation-wide at DH 1/kWh (US$ 0.1/kWh). At this rate under the envisioned schemes of this Project, all villages would operate in the red even with a recovery rate on initial investment of 0%. In other words, power supply under these conditions would not be sustainable without some kind of subsidization.

2) Under ERD (decentralized rural electrification) of PERG, users serviced by grid extension are subject to a steady base fee of DH 15/month and DH 40/month to cover construction cost (this ranges from a minimum of DH 0.842/kWh to a maximum of DH 4/kWh. Under the envisioned Project, users of 7.2 kWh/month will be subject to a payment of DH 61/month over the first 7 years (DH 84/month in the case of higher electricity tariffs). After this, it is assumed that payment would drop to DH 21/month (DH 44/month in the case of higher electricity tariffs). Converted into an average payment over a 20 year period, the result is as follows depending on the applied discount rate:

At a discount rate of 3%: DH 40.5/month
At a discount rate of 6%: DH 43.1/month

At a discount rate of 9%: DH 45.5/month

In the case of higher electricity tariff:

At a discount rate of 3%: DH 63.5/month
At a discount rate of 6%: DH 66.1/month
At a discount rate of 9%: DH 68.4/month

Since a 6% discount rate is applied under PERG, electricity tariffs to be collected in line with the PERG framework would be DH 43/month (US$ 4.6/month at an exchange rate of DH 9.3 = US$ 1) and DH 66/month (US$ 7.1/month).

Monthly household payment calculated under the Project is an average US$ 5.3 (PV, diesel and micro-hydropower) at an initial investment recovery of 0% and discount rate of 6%. Application of the minimum tariff of US$ 0.7/month would result in inadequate funding base for system operation and maintenance; however, application of the high tariff would bring in US$ 7.1/month per household which generates sufficient funding for O&M.

On the other hand, due to the fact that a monthly payment of DH 60/month for 7 years only is indicated for beneficiaries of PV generation in the case of PERG, costing under the Project assumes an outlay by the user from the eighth year for battery replacement of US$ 2.4/month. In such case, payments become DH 43.5/month for a discount rate of 3%, DH 45.6/month for a discount rate of 6% and DH 47.5/month for a discount rate of 9%. Adoption of DH 45.6/month for a discount rate of 6% is equivalent to US$ 4.9/month which represent a deficiency in O&M cost of US$ 0.4; however, system operation is considered to be viable given this limited degree of insufficiency.

7.1.4 Initial Investment Structure

From Table 7-2, calculation was done for monthly payment based on varying ratios of (i) portion of initial investment funding which must be repaid, and (ii) portion of initial investment funding which need not be repaid. (Interest on portion of initial investment funding which must be repaid was assumed in this case at 6%.) Monthly payments (preliminary estimate) by users under each electrification category are as follows for varying ratios of portion of initial investment funding which must be repaid, and portion of initial investment funding which need not be repaid.

(US$/month/household)

Portion of funding to be repaid	Portion of funding that need not be repaid	PV generation	Diesel generation	Micro-hydropower	Overall average (reference value)
100%	0%	17	13	30	18.2
75%	25%	15	11	22	15.1
50%	50%	12	8	16	11.5
25%	75%	10	7	10	9.1
0%	100%	7	6	4	6.1

Overall average was computed on the basis of household number as of the year 2000 and does not include subsequent future increase in number of households.

In the case where portion of funding to be repaid is 100%, necessary monthly household payment is US$ 17 for PV generation, US$ 13 for diesel generation, and US$ 30 for micro-hydropower generation, with an average reference value for all modes of electrification at US$ 18.2. In the case where the portion of funding to be repaid is 25%, necessary monthly household payment is US$ 10 for PV generation, US$ 7 for diesel generation, and US$ 10 for micro-hydropower generation, with an average reference value for all modes of electrification at US$ 9.1.

As reference, the funding plan would be as follows in the case of a recovery rate of 25% on initial investment.

(US$ 10^3)

Electrification method	Preliminary project cost estimate	Portion which must be repaid	Portion which need not be repaid
PV generation	5,766	1,442	4,324
Diesel generation	1,713	328	985
Micro-hydropower	5,766	1,442	4,324
Total	12,845	3,212	9,633

7.2 Economic Evaluation

Economic evaluation is carried out by comparing the total cost during the project life for the designated electrification method (cost) with that over the same period for the alternative method (benefit). In this case the economic evaluation cost (shadow cost) is applied.

Calculation was performed on a village-wise basis for each method of electrification. Diesel generation was adopted as the alternative electrification method for the purposes of comparison, with the exception of villages where diesel generation is to be adopted from the outset, in which case PV generation was used as the alternative method for comparison (see Table 7-4).

Calculation assumes that initial investment would occur in the 1st year of the Project, with actual power generation to commence from the 2nd year. In all cases a 20 year supply of power was assumed, with costs incurred each year calculated in terms of shadow prices. NPV were computed by applying an annual factor corresponding to the determined discount rate.

In the case of benefit under PV generation, micro-hydropower and extension of the existing grid, the cost for comparable scale power supply by diesel generation has been factored in.

On the other hand, in the case of villages to be electrified by diesel generation, the cost for comparable scale power supply by PV generation has been factored in.

Table 7-4 Benefit-Cost Comparison
(Total Villages under Each Category of Electrification Method)

Benefit/cost	Discount rate	PV generation	Diesel generation	Micro-hydropower
Benefit (US$ 1,000)	0%	5,490	3,381	962
	3%	4,553	2,991	854
	6%	3,929	2,729	782
	9%	3,501	2,549	732
Cost (US$ 1,000)	0%	6,679	2,563	3,360
	3%	5,952	2,235	3,243
	6%	5,465	2,016	3,179
	9%	5,129	1,866	3,141
Benefit/cost	0%	0.82	1.32	0.33
	3%	0.77	1.34	0.30
	6%	0.72	1.35	0.27
	9%	0.68	1.37	0.26

In cases where the benefit/cost ratio exceeds 1, the selected method of electrification is advantageous compared to the alternative. In this regard the subject calculations indicate that PV generation for 31 villages is advantageous over diesel generation. In the cases where benefit/cost ratio exceeds 1, the EIRR (Economic Internal Rate of Return) can be computed, and the EIRR for PV generation for 31 villages is 0 ~ over 100%. On the other hand, for villages targeted for adoption of diesel generation, this method of electrification is advantageous over PV generation in all the subject cases.

7.3 Evaluation of Socio-economic Impacts to Result from Village Electrification

(1) Electrification of Public Facilities and Homes

Project implementation will result in the electrification of the households and facilities indicated in the table below by means of clean, safe and readily accessible energy (based on survey of socio-economic conditions).

	Village no.	General households	Street lighting	Schools	Mosques	Shops	Beneficiary population
2000	106	6,512	1,303	112	132	281	41,380
2010	106	6,938	1,389	112	132	281	44,663

(2) Improved Educational Levels

Increased hours of illumination will expand opportunity for TV and radio use in schools and the home, and thereby promote the dissemination of information and contribute upgraded educational levels.

(3) Better Access to Information

Improved access to TV, radio and other telecommunication sources will significantly expand the information horizon of the Project area population. Likewise, increased leisure opportunities will become possible both in the home and at public gathers through availability of TV, radio, karaoke, etc.

(4) Contribution to Global Environmental Improvement

At present, butane gas is a common means of energy for illumination in the mountainous regions of Morocco. With illumination possible by electrification, this butane gas use can be directed at cooking purposes, thereby reducing the consumption of fuel wood for the same.

Electrification by means of PV and micro-hydropower schemes, which are the primary focus of the subject Project, results in zero emissions of sulfur oxides and nitrogen oxides which occur in the case of fossil fired power generation. The subject power sources are both clean and renewable and have major positive significance from the standpoint of improved global environment.

(5) Reduced Work Load for Women

Fuel wood and water fetching are primarily performed by women in the Project area. Electrification of the target villages will reduce the need for fuel wood, and make possible domestic water via pump. This will greatly reduce the labor load in this regard, and free women for more productive educational and work pursuits.

(6) Improved Productivity

In the areas electrified by diesel generation and micro-hydropower, power will become available in the off-peak hours to operate threshing, milling and grinding (pottery) equipment. Also, nighttime work as a result of electric lighting is facilitated, and a power source for operation of simple electrical machinery becomes available.

(7) Regional Economic Development · Prevention of Population Influx to Urban Centers

During the project implementation period, installation and civil construction works will increase employment opportunities for local labor. After completion of construction as well, maintenance works, an operational material/equipment procurement and transport will result in movement of capital into the Project area, which can be expected to have a stimulating effect on general economic activity in the region.

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusions Drawn from Study

(1) Decentralized Electrification Approach is Advantageous for the Study Area

The Study has shown that many of the target villages are small, and located with poor access. In the case of the majority of the Study area villages, extension of the existing grid as a means of electrification shows poor cost performance in terms of required initial investment and resultant power consumption. It was accordingly confirmed that power supply by decentralized systems is the recommended approach to Study area electrification.

(2) Formulation of Power Supply Plan for Each Power Source Category

The power supply plan for the 106 Study villages by power source category is as follows:

	No. of villages	No. of households	Facility output (kW)
PV generation	71	3,213	333.6
Diesel generation	12	2,136	156.8
Micro-hydropower	18	1,301	179
Extension of existing gri	5	288	23.2
Total	106	6,938	692.6

(3) Project Plan

The envisioned Project will be carried out under a phase 1 works and a phase 2 works. Phase 1 works comprise PV electrification of 54 villages, diesel electrification of 6 villages, and 3 micro-hydropower schemes (pre-feasibility study schemes), and phase 2 works comprise PV electrification of 17 villages, diesel electrification of 6 villages, and 4 micro-hydropower schemes. Phase 1 works are scheduled to begin in June 1998 and finish in March 2001. Phase 2 works are scheduled to begin in June 2000 and finish in March 2003.

Since extension of existing transmission lines is under the jurisdiction of ONE, this has been eliminated from the scope of the Project; however, it is anticipated that this work will be accomplished in the near future by ONE as a part of PERG.

(4) Preliminary Project Cost Estimate

Preliminary cost estimate for the Project is US$ 13,340 × 10^3.

(unit US$ 10^3)

Electrification method:	Phase 1		Phase 2		Grand total
	No. of villages	Project cost	No. of villages	Project cost	
PV generation	54	3733	17	2078	5811
Diesel generation	6	654	6	659	1313
Micro-hydropower	3	2488	4	3278	5766
Total		6875		6015	12890
Extension of existing gri	--	450	--	--	450
Grand total		7325		6015	13340

(5) Setting of Electricity Tariffs

Overall balance of payment calculation was carried out for the cases ①~⑤ of household payment indicated below, and this data is proposed as base data for electrification planning in Morocco (case ② is close to that being applied under PERG).

Monthly household payment	Tariff criteria
① US$ 4.0	Monthly payment corresponding to electricity tariffs of DH 40/month in the case of extension of the existing grid and DH 60/month in the case of PV generation under the PERG program (battery replacement cost borne by the user)
② US$ 7.0	Monthly payment corresponding to the affordability to pay of DH 70/month in the case of the general villager, as indicated by the results of questionnaire survey
③ US$ 10.0	Monthly payment corresponding to the affordability to pay of DH 70/month in the case of the general villager, as indicated by the results of questionnaire survey.
④ US$ 14.0	Monthly payment corresponding to the average affordability-to-pay amount of DH 140/month as indicated by village leaders during the questionnaire survey
⑤ US$ 17.5	Monthly payment corresponding to expenditure by household per month for illumination purposes and battery purchase and recharge as indicated by questionnaire survey.

8.2 Recommendations on Implementation

(1) Implementation Structure

- It is necessary for CDER to assume a leading role in the establishment of user's associations at the village level.

- It is necessary that steps be taken to strengthen the management capabilities of CDER with regard to electrification projects.

- With regard to the aspects of scheme maintenance in the case of micro-hydropower and diesel generation which are currently beyond the capability of the target villagers, as well as O&M of the PV systems, it is necessary that CDER provide guidance to the said villagers as well as technical and financial support towards delegation of O&M activities in this regard to private contractors where appropriate.

- In order to optimize service under the schemes, it is recommended that committees be officially established for the purpose of eliciting the views of the users, as well as to maintain close linkage between the public and the private sector.

(2) Operation and Maintenance

- Accumulation of O&M costs to go to the private contractors would be limited for around the first 3 years of the Project. To offset this, CDER would carry out during the Project implementation period sufficient training of users' associations, private contractors and the general village population in system O&M technology in order to make possible a joint maintenance effort by all concerned parties.

- At the time of coordinating meetings, CDER would collect the electricity tariff portion (monthly set fee) of the monthly payment by user households. During the first 3 years of Project operation, O&M fees would be banked by the users' associations themselves and function as operating funds for the associations. After the third year, it is proposed that the users' associations would begin direct payment of O&M costs to the private contractors.

- Users' associations would be obliged to issue receipts and keep appropriate accounting records, and these would be submitted to CDER at the time of coordinating meetings for management by CDER and ensure transparency of tariff collection.

(3) Selection of Target Villages for Electrification, and Electrification Method

As of this report, electrification approach has been planned for 106 target villages. However, a full confirmation for all villages has as yet not been accomplished with regard to villager aspirations concerning electrification. Toward this end, it is anticipated that in the course of subsequent stages of actual Project implementation in the future that villager aspirations continue to be reflected in planning by the National Rural Electrification Committee in line with stipulated procedure under PERG.

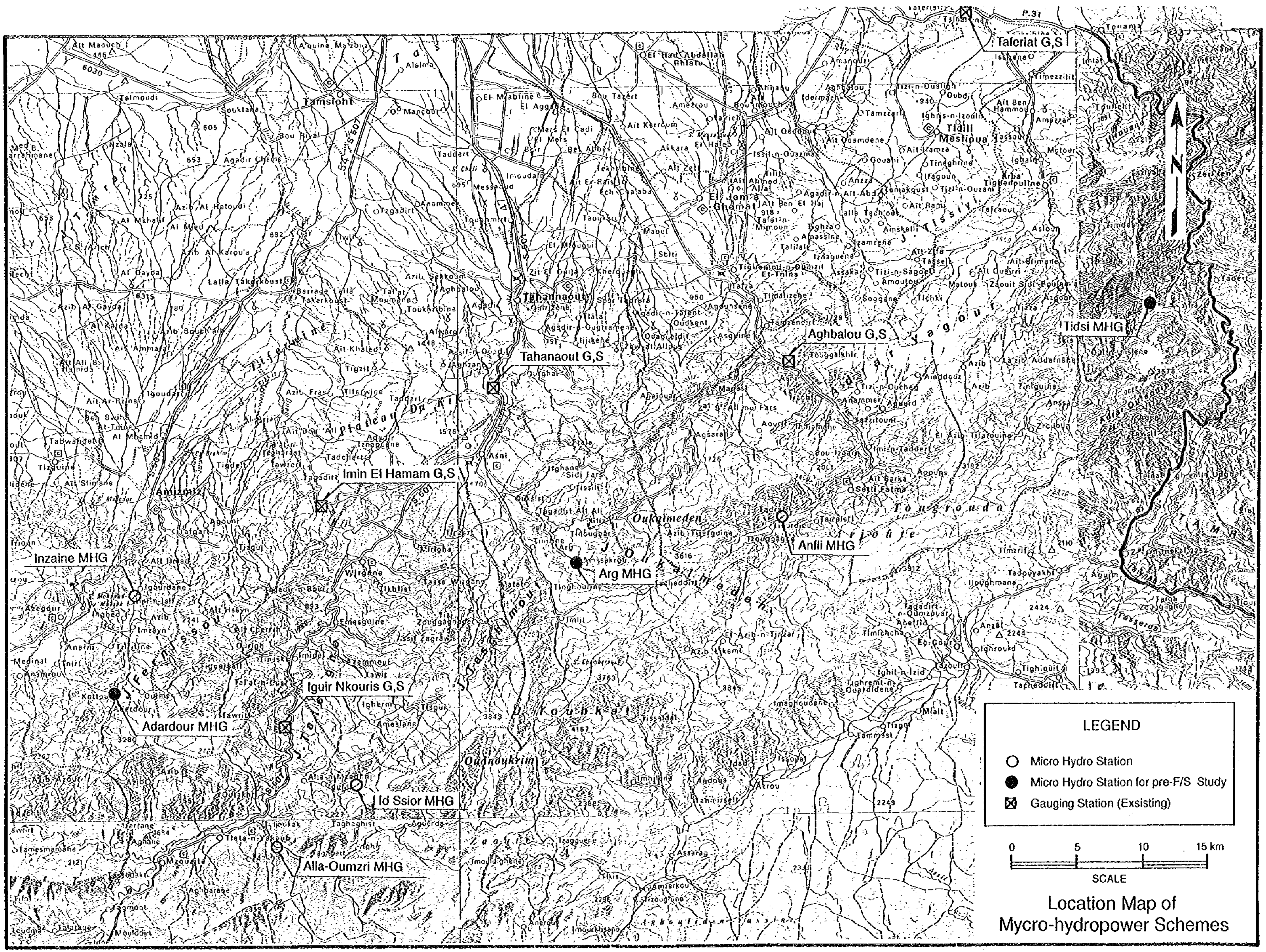
(4) Future Study Plan

It is recommended that the following studies be carried out in order to move smoothly to the next phase of the envisioned Project.

① Sunshine intensity observations in mountainous region of the Project area
② Water level and discharge observations at newly installed gauging stations

VOLUME II MICRO-HYDROPOWER PREFEASIBILITY STUDY

Volume II embodies the results of Prefeasibility Study carried out for three of the most promising schemes out of the seven micro-hydropower schemes which were selected as one portion of the electrification program under the Master Plan. These three schemes are Adardour, Arg and Tidsi.



Location Map of
Mycro-hydropower Schemes

CHAPTER 1 FIELD SURVEY

Under the Prefeasibility Study, the field surveys described below were carried out, and the findings of the same used as base data for scheme design.

1.1 Topographical Survey

Survey in this regard comprised toposurvey (total of 45,900 m^3) of intake weir, canal alignments and power station sites, as well as river cross-section survey including the upstream and downstream of each intake and power station site. Survey range for each scheme is shown in Table 1.1. The results of the said toposurvey were applied to subsequent geological survey and prefeasibility level design. Topomapping was also prepared on A-1 size paper at 1:500 scale, with 1 m contour line intervals.

Table 1.1 Range of Toposurvey

Category of survey	Adardour	Arg	Tidsi
Toposurvey:			
Target area (total)	14,600 m^2	17,000 m^2	14,300 m^2
Intake weir sites	2,100 m^2 (30 m × 70 m)	3,000 m^2 (30 m × 100 m)	1,800 m^2 (30 m × 60 m)
Canal alignments	8,000 m^2 (10 m × 800 m)	8,000 m^2 (10 m × 800 m)	8,000 m^2 (10 m × 800 m)
Pensock alignment and power station	4,500 m^2 (30 m × 150 m)	6,000 m^2 (30 m × 200 m)	4,500 m^2 (30 m × 150 m)
River cross-section survey			
No. of cross-sections	Total of 8 sections	Total of 10 sections	Total of 8 sections

1.2 Geological Survey

Of the 7 micro-hydropower sites selected under the Master Plan Study, geological reconnaissance was carried out for the 3 sites targeted for prefeasibilty study, and 1:500 scale geological mapping prepared. An abbreviated geological survey was carried out for the remaining 4 sites as well to facilitate further survey of these schemes in the future.

Adardour:	Prefeasibility Study	→ geological reconnaissance	→ preparation of 1:500 geological mapping
Arg:	Prefeasibility Study	→ geological reconnaissance	→ preparation of 1:500 geological mapping
Tidsi:	Prefeasibility Study	→ geological reconnaissance	→ preparation of 1:500 geological mapping
Alla Oumzri:	Master Plan Study	→ abbreviated geological survey	
Inzaine:	Master Plan Study	→ abbreviated geological survey	
Id Ssior:	Master Plan Study	→ use of existing data only	
Anfli:	Master Plan Study	→ use of existing data only	

The 7 promising micro-hydropower sites selected under the Master Plan Study are all located on the northwestern slopes of the Haut Atlas range. Geologically, the two sites at Arg and Anfli are located in granitic zone, while the other 5 are situated in metamorphic rock zone. These formations are generally hard, well consolidated rock; however, surface strata in many cases exhibit heavy weathering as a result of (i) steep slope topography which precludes vegetal growth and exposes rock to intense sunlight during the dry season (summer), and (ii) ice crystal action during the low temperature rainy season (winter). This results in a weak surface layer.

Although some care most be given to the foregoing when considering scheme construction and maintenance, results of survey overall indicate no serious geological issues in implementing the schemes.

1.3 Meteorological and Hydrological Survey

There are 5 existing gauging stations within the catchments of the Study area rivers. However, the subject micro-hydropower sites are all located at the upper basins of river tributaries, at considerable distance from these existing stations. Catchments also vary greatly in terms of area size. As a result, 3 new gauging stations were established in the course of reconnaissance survey in the vicinity of the promising sites. Water level and discharge observations were carried out and this data was used to cross-check the discharge records at the existing stations.

However, it must be noted that the said water level and discharge observations were carried out only over a very short period (10 times over 10 months from August 1996 to May 1997), and therefore does not represent a thorough observation program.

As a result, there were marked differences in the specific discharges calculated from discharge data at the existing stations, and the discharge values observed at the newly installed gauging stations. Specifically, discharge values at the new stations were considerably higher than values indicated by records at the said existing stations. Since no other data was available (rainfall data as well was sparse), existing station discharge values were adopted to be on the safe side.

The newly established gauging stations are summarized in Table 1.2.

Table 1.2 Summary of New Gauging Stations

Gauging station	Infag	Arg	Tidsi
River	Anougal	Imenane	Afoughal
Catchment area (km²)	79	48	24
Latitude (° - ' - " N)	31-04-31	31-11-17	31-20-33
Longitude (° - ' - " N)	8-16-50	7-55-19	7-26-29
Elevation (m)	1,250	1,480	1,750

Monthly mean and annual mean discharges adopted for the scheme sites under the Study are indicated in Table 1.3, while discharge characteristics at the sites are indicated in Table 1.4.

Table 1.3 Monthly Mean and Annual Mean Discharges Adopted for the Scheme Sites (averages for the most recent 10 year period)(m³/s)

Scheme Catchment area (km²) Gauging station	Adardour 23 Tahanaout	Imzaine 79 Tahanaout	Arg 48 Tahanaout	Anfli 134 Aghbalou	Tidsi 24 Aghbalou
Sep	0.05	0.17	0.11	0.5	0.69
Oct	0.14	0.46	0.3	0.42	0.07
Nov	0.15	0.52	0.34	0.78	0.14
Dec	0.18	0.61	0.4	1.81	0.32
Jan	0.15	0.51	0.34	0.81	0.14
Feb	0.21	0.69	0.46	1.46	0.26
Mar	0.38	1.28	0.84	5.68	1.00
Apr	0.63	2.13	1.41	7.3	1.29
May	0.73	2.47	1.63	4.95	0.87
Jun	0.34	1.13	0.75	1.05	0.19
Jul	0.10	0.34	0.23	0.75	0.13
Aug	0.05	0.17	0.11	0.57	0.10
Total	0.26	0.87	0.58	2.17	0.38

Table 1.4 Discharge Characteristics at the Sites (averages for the most recent 10 year period)(m^3/s)

River discharge	Adardour	Inzaine	Arg	Anfli	Tidsi
Q_1	0.987	3.315	2.186	9.679	1.708
Q_{35}	0.654	2.195	1.448	6.529	1.152
Q_{95}	0.397	1.331	0.878	2.809	0.496
Q_{185}	0.156	0.524	0.346	0.934	0.165
Q_{275}	0.100	0.337	0.222	0.468	0.083
Q_{329}	0.044	0.147	0.097	0.248	0.044
Q_{355}	0.031	0.103	0.068	0.177	0.021
Q_{365}	0.027	0.089	0.059	0.099	0.017

1.4 Environmental Impact Assessment

(1) Evaluation Items

Evaluation was made on the potential impacts which construction of the envisioned schemes may have on the environment. Study including consideration of both direct and indirect impacts to be effected on the immediate scheme area as well as surrounding region.

1) Direct Impacts on the Environment

- Land wildlife
- River wildlife
- Groundwater
- Geology
- River bed modification
- Communicable diseases
- Potable water availability
- Agriculture
- Air pollution
- Water and ground pollution
- Micro-climate

2) Indirect Impacts on the Environment

- Culture
- Economic development

(2) Results of Assessment

1) Adardour Scheme

Immediate environmental impact of the project in Adardour is considered likely since the construction activity will require a certain amount of blasting of foundation along the canal route. However, the environmental impact from this is not perceived as significant due to the short construction period. In the long term, the environmental impact may be significant due to change in village life style and economic development. Nevertheless, it is anticipated that this potential impact will be favorable.

2) Arg Scheme

The immediate environmental impact of the project in Arg is likely to be the smallest since the construction activity will be the least intrusive with only hand labor involved and the percentage of stream flow required for the operation of the plant will probably be the least of the three. In the long term, the environmental impact may be significant due to changes in village life style and economic development. Nevertheless, it is anticipated that this potential impact will be favorable.

3) Tidsi Scheme

Immediate environmental impact of the project in Tidsi is considered to be minimal provided care is taken to minimize blasting during the construction process. In the long term, the environmental impact may be significant due to changes in village life style and economic development. Nevertheless, it is anticipated that this potential impact will be favorable.

CHAPTER 2 FORMULATION OF OPTIMUM DEVELOPMENT PLAN

2.1 Selection of Canal Route and Location of Major Facilities

In the case of the 3 scheme sites selected for prefeasibility study, catchment areas and annual average discharge are small at 23~48 km² and 0.25~0.57 m³/s, respectively. In addition, well established irrigation canal systems in the areas make it unavoidable that scheme generation scale is small in the range of 15~30 kW.

Generation is to be run-of-river type. Selection of canal route for hydropower is constrained by the inter-relationship with irrigation requirements. The most cost effective approach in this regard is to expand the capacity of existing canal to function for the dual purposes of hydropower and irrigation.

In the same way, the location of major facilities is limited, and it is necessary to select sites where diversion and tailrace discharge from the micro-hydropower schemes do not impact on water use for irrigation. In this case, every effort is made to achieve maximum head with the shortest possible headrace canal alignment, taking into consideration topographical and geological conditions at each scheme site.

2.2 Transmission and Distribution Plan

The maximum distance from the power station site to the target villages is 5 km. Since low voltage transmission would result in a large transmission loss, generator voltage of 440 V is to be stepped up to 22 kV for conveyance to the villages at which point voltage would then be stepped down to 400 V / 220 V by pole mounted transformers in the villages for power supply to each household.

Transmission power poles are to be wood with the exception of villages with extremely poor access, where in such cases out of consideration of transport weight, assembly type, galvanized steel transmission poles will be adopted.

Standard power pole interval is to be 35~50 m, with this standard to be modified where necessary in light of actual in-situ topographical and meteorological conditions. Standard power pole height is to be 9 m (standard height prevailing in Morocco at present is 8~10.5 m).

In the case of distribution poles, the standard adopted is 1 pole per 5 homes, and these are to be laid out with consideration to power utilization by schools, mosques, etc. as well. As these poles will be mounted with transformers to step down voltage from 22 kV to 400 V / 220 V, it is recommended that they have a strength of 300 kg/cm².

Standard for transmission line cable is to be 34 mm² diameter, with unit resistance under 0.899 Ω/km. However, in cases where a high transmission loss may be anticipated, cable diameter will be selected from among the ONE standard of 75 mm² and 148 mm². It is recommended that cable material be either aluminum or steel, with strength of 1,140 kg/cm².

Transformer equipment to be mounted on distribution line poles is to feature manual switch gear, with 22 kV primary side and 400 V / 220 V secondary side for power delivery to the individual home.

CHAPTER 3 PREFEASIBILITY DESIGN

3.1 Civil Facilities

- Intake weirs are to be reverse "T", reinforced concrete type structures. Although weir foundation will not rest on basement rock, design is such that the downstream side will be reinforced with masonry and the upstream side with boulder rip-rap.

- In the case of the Adardour and Arg schemes, canal capacity is designed to convey discharge for both hydropower and irrigation purposes. Canal is to be open, with mortar finished masonry lining.

- Head tanks are designed with a capacity allowing for regulation of roughly 2 minutes worth of generating discharge.

- Penstock is to be steel pipeline, and is to be buried to the extent possible to prevent damage from rock slide.

- It would be considered practical that power house structures be fabricated from concrete block produced in-situ. A stilling basin would be constructed below the turbine to function as well for dummy load discharge.

3.2 Generating Equipment

Under the subject schemes, effective head is 15~37 m and generating discharge is 0.11~0.18 m^3/s. Specific speed for rpms of 1,000 will be 60~110 (rpm/kW/m). On the basis of this criteria, the cross flow type turbine is to be adopted.

Given the generating scheme type, fluctuation in head will be small; however, in light of the fact that scheme operation will be required during months of low river discharge as well in the course of the annual power supply plan, there will be a dramatic fluctuation in generating discharge. In the case of the conventional cross flow turbine, guide vanes are generally separated and generation is performed by one guide vane side in order to upgrade operational efficiency when generating discharge is low. Since maximum generating discharge is small to begin with under the subject Project, however, with narrow turbine runner and short guide vanes, the adoption of separate guide vanes is considered impractical.

Generally, in the case where separate guide vanes cannot be adopted in the case of the cross flow turbine, turbine efficiency radically drops when actual generating discharge drops below 30% of the maximum design discharge. In order to compensate for this, and with consideration to cost effectiveness, a small discharge reverse pump up turbine is to be installed separately for power generation during the low water season.

In selection of generator, the synchronous type and induction type were considered. The induction type is more economical, as inexpensive, small motor equipment commonly available on the market can be utilized, particularly in the case of micro-hydropower generating schemes. However, an important difference between the induction type and synchronous type generator is that in the case of the former power factor adjustment is not possible. In the case of the latter, independent operation is facilitated by the fact that it is equipped with and independent excitation system. In light of the foregoing and the fact that power utilization is almost entirely for illumination load, the synchronous type generator has been selected despite higher cost due to the fact that power factor adjustment is possible.

The control system for hydropower generating facilities comprises turbine · generator start up, shut down and other protective devices. It is also a standard procedure to install a governor to maintain stable turbine · generator rpms and frequency. However, in the case of the subject Project where power output is small, generation frequency is to be stabilized by adjusting surplus power via resistance capacity. This is referred to as the "dummy load governor method".

3.3 Design Features

Prefeasibility study level design was carried out based on the above described criteria. A summary of the results of the same is given in Table 3.1.

Table 3.1 Summary of Design Criteria for the Micro-hydropower Schemes

Salient features	Unit	Adardour	Arg	Tidsi
River		Amizmiz	Rhenaya	Zat
Catchment area	km^2	23	48	24
Max. output	kW	26	30	15
Max. generating discharge	m^3/s	0.11	0.18	0.15
Effective head	m	37	25	15
Intake weir				
Type		reverse T	reverse T	reverse T
Height	m	1.65	1.85	2.15
Crest length	m	16	15	14
Headrace				
Type		open	open	open
Length	m	685	1,175	750
Penstock				
Type		buried	buried	buried
Length	m	76	84	33
No. 1 turbine	kW	26 (cross flow)	30 (cross flow)	15 (cross flow)
generator	kW	32.5 (3 phase synchronous)	37.5 (3 phase synchronous)	18.8 (3 phase synchronous)
No. 2 turbine	kW	10.1 (reverse pump up)	--	5.0 (reverse pump up)
generator	kW	12.6 (3 phase synchronous)	--	6.3 (3 phase synchronous)
Transmission line voltage	V	22,000	22,000	22,000
Length	m	1,550	4,400	2,500

CHAPTER 4 IMPLEMENTATION PLAN

As indicated in Volume 1, the overall implementation schedule for the Master Plan is to be carried out in 2 phases. Within this framework, the 3 priority micro-hydropower schemes are to implemented during Phase I, with construction to start in July 1999 and end in March 2001 (implementation period of 1 year and 9 months).

The controlling factor in the construction process for the schemes will be headrace canal construction. All headraces are to be open canal structures made of masonry and concrete. As this work is to be performed manually, headrace canal construction constitutes the critical path for the overall implementation of the schemes. Accordingly, headrace construction is to be commenced at the same time for all 3 schemes, and a work execution setup devised to ensure completion within the designated implementation period for the schemes. In the case of structures other than headrace canal, i.e. intake structures, head tanks, penstocks, and power houses, these are to be constructed simultaneous to the aforementioned headrace canal construction, with careful attention to safety measures required in mountainous areas (prevention of rockfall) and elicitation of the cooperation of residents in the construction areas. Transport of construction material and equipment into the site areas will be via the existing access roads. However, since final approach to the sites from the main highways will be via mountain roads (piste) which are single lane and unsurfaced, a thorough program of access road maintenance and repair must be in effect throughout the construction period. The envisioned implementation schedule for the micro-hydropower schemes, based on the above criteria, is indicated in Figure 4.1.

Procurement of construction material and equipment is planned as follows based on the Study findings:

- Construction equipment and facilities are to be procured in Morocco.
- Construction materials including cement, steel, lumber, etc. are to be procured in principle in Morocco. However, penstock pipe would be imported material procured locally.
- Lubricants and fuel can be procured from merchants in or near the site areas.

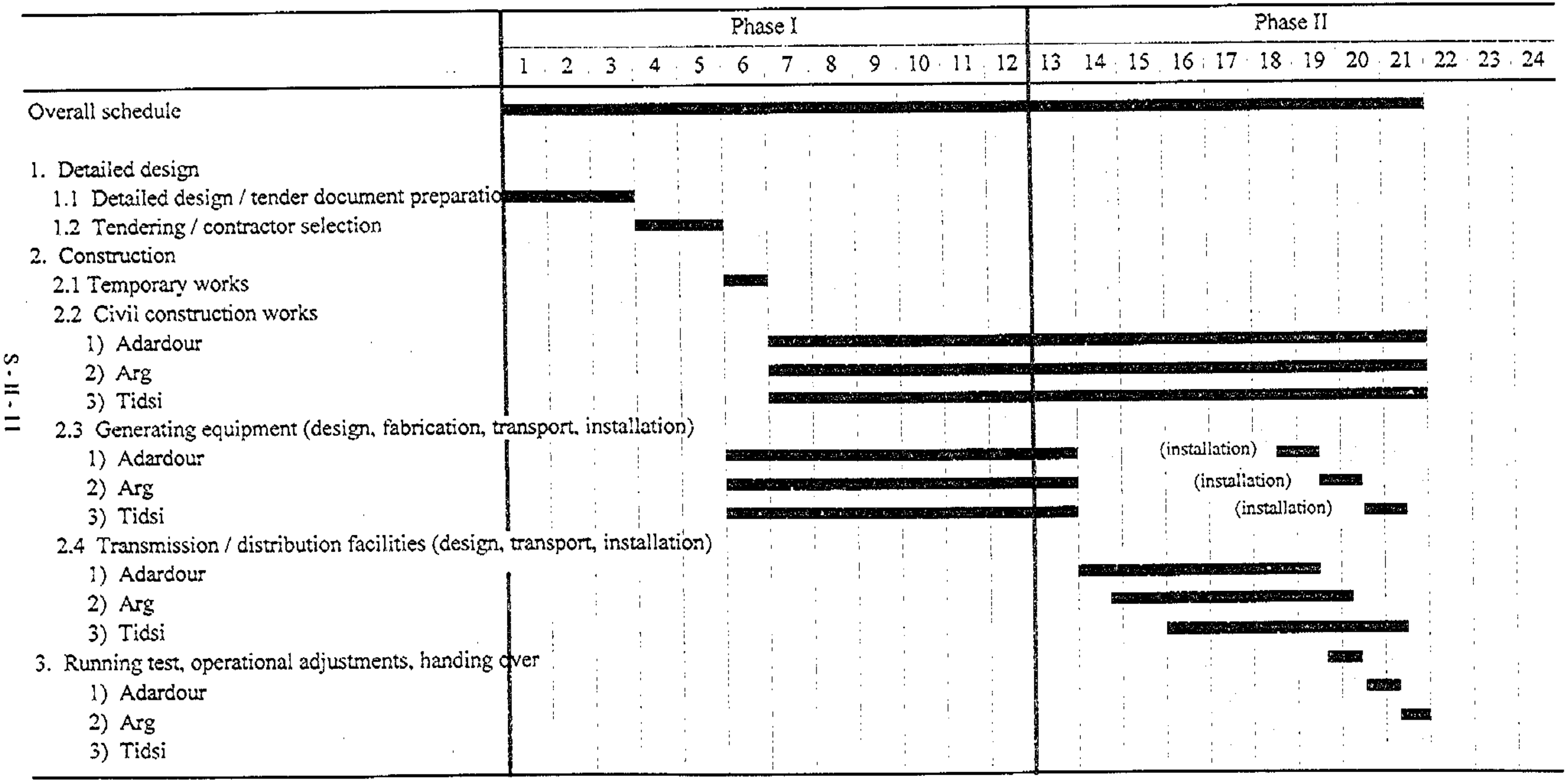


Figure 4.1 *Micro-hydropower Scheme Implementation Schedule*

Chapter 5 Project Cost

Calculation criteria for project cost are the same as those adopted in Volume 1. Construction unit cost has been calculated separately for each category of work, on the basis of labor cost, engineer remuneration, transport cost, main materials cost and equipment cost.

Overall Project cost US$ 2,488,000 is as indicated in Table 5.1 (including civil works cost, equipment cost, installation cost, packing and transport cost, tax, engineering fee and physical contingency).

Table 5.1 Overall Project Cost for Micro-hydropower Schemes

Rate US$ 1.0 / DH 9.31 / ¥ 115 (unit US$ 10^3)

	Adardour (26 kW)			Arg (30 kW)			Tidsi (15 kW)			Project total (71 kW)		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Construction item												
1. Construction cost												
1-1 Civil works												
(1) Direct cost		214	214		264	264		170	170		648	648
(2) Indirect cost	38	90	128	47	111	158	31	71	102	116	272	388
Sub total	38	304	342	47	375	422	31	241	272	116	920	1,036
1-2 Equipment												
(3) Generating facilities												
a. Turbine / generator	70		70	42		42	50		50	162		162
b. Appurtenant facilities	55		55	32		32	46		46	133		133
Subtotal	125		125	74		74	96		96	295		295
(4) Transmission / distribution facilities												
a. Transmission facilities		25	25		59	59		35	35		119	119
b. Distribution facilities		79	79		102	102		48	48		229	229
Subtotal		104	104		161	161		83	83		348	348
(5) Installation		35	35		26	26		31	31		92	92
(6) Packing / transport (FC x 20%)	24	1	25	14	1	15	18		18	56	2	58
Total: (3)~(6)	149	140	289	88	188	276	114	114	228	351	442	793
Total: (1)~(6)	187	444	631	135	563	698	145	355	500	467	1,362	1,829
2. Tax (VAT) ((1) + (2) + (4) + (5) + (6) x 0.05) x 20%		89	89		113	113		71	71		272	272
3. Engineering fee (1)~(6) x 10%	19	44	63	14	56	70	15	36	51	48	136	184
4. Physical contingency (1) + (3) x 10%	21	49	70	15	62	77	16	39	55	52	150	202
5. Total Project cost	227	626	853	164	794	958	176	502	678	570	1,918	2,488

Chapter 6 Financial Evaluation

Calculation of monthly household payments on a scheme wise basis is as shown in Table 6.1. In the case of an initial investment recovery rate of 0%, monthly payments are US$ 1.4/month/household for the Adardour scheme, US$ 1.0/month/household for the Arg scheme and US$ 1.8/month/household for the Tidsi scheme. These tend overall to be somewhat higher than the average US$ 1.2/month/household indicated in Volume I.

Table 6.1 Monthly Household Payments on a Scheme Wise Basis

Adardour

Initial investment recovery rate	Discount rate			
	0%	3%	6%	9%
100%	13.0	19.7	28.1	38.0
75%	10.1	15.1	21.5	28.9
50%	7.2	10.6	14.8	19.7
25%	4.3	6.0	8.1	10.8
0%	1.4	1.4	1.4	1.4

Arg

Initial investment recovery rate	Discount rate			
	0%	3%	6%	9%
100%	11.7	17.9	25.6	34.7
75%	9.0	13.6	19.5	26.3
50%	6.3	9.4	13.3	17.8
25%	3.6	5.2	7.1	9.4
0%	1.0	1.0	1.0	1.0

Tidsi

Initial investment recovery rate	Discount rate			
	0%	3%	6%	9%
100%	15.8	23.9	34.2	46.1
75%	12.3	18.4	26.1	35.0
50%	8.8	12.9	18.0	24.0
25%	5.3	7.3	9.9	12.9
0%	1.7	1.8	1.8	1.8

CHAPTER 7 CONCLUSIONS

(1) The Adardour, Arg and Tidsi schemes which were targeted for prefeasibility study are considered to be the highest priority candidates out of the 7 schemes selected under the Master Plan Study, feature relatively good access, and are judged to be of high development maturity.

(2) Each scheme represents a minimized, run-of-river generating plan. Maximum outputs are 26 kW for Adardour, 30 kW for Arg and 15 kW for Tidsi. Available discharge during the low water season is small, resulting in small maximum generating discharges for the schemes of 0.11~0.18 m^3/s. Effective head as well is small at 15~30 m as a result of river gradient features. Nevertheless, the schemes are planned to supply as many villages as possible making maximum use of site potential.

(3) In order to minimize scheme construction cost, existing irrigation canals are to be used to the extent possible with appropriate widening of the same. Construction planning also calls for maximum utilization of local/domestic materials and equipment. Only turbine and generator equipment is to be procured from off-shore.

(4) The cross flow type turbine has been adopted for the schemes. However, due to extremely low discharge during the dry season in the case of Adardour and Tidsi, which results in a turbine efficiency rate making operation impossible, generating equipment is to be augmented by a separate pump reversal turbine.

(5) In order to minimize transmission loss in the conveyance of power from the power house to the user households, generator voltage of 440 V is to be stepped up to 22 kV, and then stepped down by pole mounted transformers at the villages to 400 V / 22 kV for final distribution to the user households.

(6) It is concluded that no impacts would occur to the natural or social environment of a magnitude so as to preclude construction of the schemes. However, due to the close interlinkage with existing irrigation canals, the schemes must be implemented under thorough consultation with villagers with regard to water use.

(7) On the basis of the results of financial analysis, monthly household payments in the case of an initial investment recovery rate of 0% are US$ 1.4/month/household for the Adardour scheme, US$ 1.0/month/household for the Arg scheme and US$ 1.8/month/household for the Tidsi scheme. The average for the total 7 schemes under financial analysis in Volume 1 is US$ 1.2/month.

(8) Implementation schedule calls for 5 months for detailed design and contractor selection, and 16 months for actual construction (21 months overall). Total construction cost is estimated at US$ 2.5 million.

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