VOL.I CHAPTER 5
ELECTRIFICATION PLAN

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. (see section 5.6)

(2) To select power supply facilities which impose minimal financial burden on the beneficiary population. (see section 5.3)

(3) To adopt renewable energy sources to the extent possible. (se section 5.3)

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

In selecting the electrification method for each village, the approach which imposes the minimal financial burden on the beneficiary households is to be selected as discussed above. As a result, a comparative study is first made of the fixed cost (construction cost) and variable cost (O&M cost) for each category of electrification (extension of existing transmission line, micro-hydropower, diesel generation, and PV generation) over a 20 year period for each village. Following this, study was made of cases for reduction in the ratio of fixed cost as a result of government electrification policy.

The above also takes into consideration the ceiling cost for electrification by extending the existing grid (i.e. under DH 10,000 per household). (see sectioin 5.3)

(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. (see section 5.4)

(6) Villages which are to be covered under projects by ONE to extend existing transmission line are eliminated from planning under the Study. (see section 3.6)

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. Also, although adoption of electrification by means of grid extension is examined under the Study, actual implementation of such electrification works would be performed by ONE. (see section 5.3)

(7) In the case of micro-hydropower, development is possible only under conditions of a available of a set amount of discharge and head. In cases where natural conditions offer particularly good hydropower potential, it becomes possible to electrify more than one nearby village. In this regard, target villages for electrification are determined based on economic comparison of both (i) micro-hydropower alone, and (ii) a power source composition including micro-hydropower and PV generation (see section 5.2). Also, optimum micro-hydropower generating scale is determined on the bases of comparative study (see section 5.5).

Although 28 villages were listed for micro-hydropower electrification in the original request, it was determined under the Study to first survey natural conditions at the requested village sites, and on this basis finally select viable micro-hydropower scheme locations and the scale of village electrification to be achieved under each scheme (see section 5.2).

(8) In the case of PV generation, the optimum system is to be selected on the basis of comparing the 3 candidate methods indicated below. In the case of the battery charging station, users are faced with the rather laborious task of transporting batteries for recharge. O&M is also relatively more difficult. In the case of the centralized distribution system, construction cost is somewhat higher, as well as the fact that unresolved technical issues remain (see section 3.5).

- Solar home system (SHS)
- Battery charging station (BCS)
- Centralized distribution system (CDS)

(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 (see section 5.3).

5.2 Preliminary Selection of Micro-hydropower Scheme Villages

5.2.1 Strategy in Formulating the Micro-hydropower Plan

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

Also, larger facility scale within a reasonable range incurs only minimal extra construction cost, and is therefore an appropriate method of electrification in terms of a maximum, cost-effective scale taking into consideration future power demand increase.

However, 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, preliminary selection survey was first carried out centering on the 28 villages targeted in the original list for micro-hydropower generation as indicated in section 5.5.2. This comprised field reconnaissance to select those sites with development potential. Next, as indicated in section 5.2.3, the feasibility of conveying power from the viable micro-hydropower sites to nearby villages was examined, and on this basis a preliminary selection of villages which are candidates for electrification by micro-hydropower was made.

Following this, comparative study was made of power supply cost for micro-hydropower and other electrification options for the preliminarily selected villages. In the case of micro-hydropower, however, overall scheme construction cost is anticipated to be higher than that for other modes of electrification. On the other hand, financing under advantageous conditions either precluding recovery of initial investment or greatly reducing the need for the same markedly improves the cost-effectiveness of micro-hydropower. As a result, appropriateness of micro-hydropower was done on the basis of comparison of variable cost only.

Finally, in light of the scale-merit of micro-hydropower, optimum generating scale vis a vis demand forecast as set out in section 5.4 was examined and a supply plan formulated as described in section 5.5. Ultimate appropriateness of power supply source was then made on the basis of financial evaluation as set out in Chapter 7.

On the candidate modes of decentralized electrification, micro-hydropower requires a more detailed study for implementation in terms of meteo-hydrological conditions (particularly river discharge), topographical conditions (effective head, etc.) and facility structures (headrace, penstock, power house facilities, etc.). Accordingly, pre-feasibility study was carried out for those micro-hydropower schemes deemed to have the most mature development potential in order to upgrade planning precision and contribute to the earliest possible scheme exploitation in the future. Selection procedure for the micro-hydropower schemes subject to pre-feasibility study is as set out in section 5.4.4.

5.2.2 Selection of Micro-hydropower Sites

(1) Strategy for Selection of Micro-hydropower Sites

1) Confirmation of scheme sites for villages (total of 28)requested for electrification by micro-hydropower. The request list indicated no specific sites for electrification of the said villages.

2) The design scheme sites are located in the upper basins of rivers, with small catchment area resulting in unavoidably small schemes. In addition, there are many cases where the envisioned hydropower scheme will compete with existing irrigation schemes for river discharge. It is therefore necessary to plan the said micro-hydropower schemes so as to have no impact on irrigation practices in the scheme areas.

3) Hydropower schemes are to be run-of-river type given the fact that no suitable reservoir sites were identified. To the extent possible, springs are to be used as water sources.

4) Comparison of hydropower is made with other modes of electrification assuming response to power demand in nearby village(s) as per the results of study indicated in section 5.2.3 (1) In other words, in the cases where site hydropower potential is small, power supply will be to a single nearby village. However, where generation potential is ample, a site 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 5.2-5)

The 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 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 km².

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 characteristic flash flooding in the rainy season causing damage to adjacent villages. As a result of this large difference in discharge between seasons, as well as a relatively large fluctuation from year to year, it is extremely difficult to quantitatively identify discharge volume over the long term. Accordingly, discharge is analyzed on the basis of existing records at downstream gauging stations, and discharge estimated on the basis of specific discharge calculation and rainfall data.

Existing data comprises observations being carried out by the Department of Water Use (Ministry of Public Works) at the middle reaches of rivers, and data in this regard for the past 10 years was applied to calculation of discharge at the candidate sites. Existing gauging stations, and the results of data analysis are as presented in Chapter 4. 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.

The basins at the candidate sites for the most part comprise V-shaped gorges, with nearby villages located on small patches of flat terrain. Dwellings are mostly on hill slopes located at high elevation from the river bed in order to escape damage from flooding during the rainy season and to maximize access to daylight. Access roads connecting villages are for the most part located at high elevation as well, and comprise dirt paths traversed on foot or by donkey / mule. Accordingly, establishing adequate access roads for scheme construction at the candidate sites will be an issue that must be resolved in developing the sites.

The geology of the candidate sites comprises crystalline schist, mica schist, siliceous rock, limestone and other metamorphic rock which forms the basement of the Haut Atlas. Overlying this is a layer of marine deposits rich in calcareous content and made up of dolomite, limestone, maar, shale, etc. Under these geological conditions, although there is some detachment and fall of small rock fragments from outcrops, there is no danger of large scale slope collapse. Excavation of the surface layer would be expected to expose good quality rock foundation.

Structures under micro-hydropower schemes are smaller than conventional hydropower schemes, and the ground bearing capacity at the sites given the above geology is considered ample to support the lighter load of the envisioned facilities. Nevertheless, limestone erosion over the long-term is a concern, requiring a more detailed geological survey at each site to ensure the safety and stability of structures.

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, seven micro-hydropower sites were selected under the Study as indicated in Table 5.2-1. In the case of the two villages of No. 6 Alla Oumzri and No. 7 Id Ssior, these had not been included in the list submitted by CDER of villages slated for electrification by micro-hydropower. However, results of field reconnaissance by the Study Team confirmed ample spring discharge with effective head available near the two villages. It was identified that micro-hydropower schemes could be developed at these two sites which would not impact on current discharge use for irrigation and domestic purposes, and as such these schemes have been included under the Project.

Table 5.2-1 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
16 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					

5.2.3 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 potential 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 overall project cost was done for cases of (i) supply only by micro-hydropower, and (ii) supply by a combination of micro-hydropower and other power source (in this case PV generation is considered the most advantageous).

In carrying out the said study, it is assumed that all nearby villages which can be effectively supplied with power from a particular site (as discussed in the next section (2) Study on Development Potential of Micro-hydropower Sites) will be target villages for electrification under the subject scheme.

Case studies were also done with regard to initial investment cost (construction cost) and variable cost (O&M cost) as indicated in Table 5.2-2. For initial investment, computation results indicated in Table 6.2-2 and Table 6.2-4 were applied. In the case of variable cost, computation results in Table 5.2-2 were applied (20 year variable cost assuming no discount rate). Calculation method in the case of PV generation computed project cost in linkage with number of beneficiary households, while that for micro-hydropower calculated the same in terms of facility capacity (kW) including civil construction cost and equipment cost (generating facilities) as well as in terms of distance(transmission line length) from the point of power generation.

As a result of calculation according to the above criteria, micro-hydropower exhibits higher initial investment as facility capacity becomes larger; however, it is cheaper than other modes of electrification in terms of variable cost. In other words, in the case of financing under advantageous terms which either precludes or greatly reduces the need for recovery of initial investment, micro-hydropower becomes the optimum method of electrification given less O&M cost (cost burden falling on the beneficiary users). Accordingly, in the case where multiple villages can be supplied with the potential from a single site, all of the said villages have been designated under the Study as subject to energizing by micro-hydropower.

Table 5.2.2 Cost Comparison by Composition of Power Source

(Unit: 10³US$)

Case / Project site	Case 1						Case 2						Case 3						Case 4					
	MHG		PV		Total		MHG		PV		Total		MHG		PV		Total		MHG		PV		Total	
	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost	Initial investment	Variable cost
(1) Arg																								
1) Target villages																								
- Arg (79)	353	30	-	-	353	30			-	-					-	-								
- Amsakrou (58)	-	-	61	45	61	45	474	32	-	-	474	32	698	34	-	-	698	34						
- Ikiss (68)	-	-	72	53	72	53	-	-	72	53	72	53			-	-								
2) Cost total	353	30	133	98	486	128	474	32	72	53	546	85	698	34	-	-	698	34						
3) Overall cost	383		231		614		506		125		631		732		-		732							
(2) Inzaine																								
1) Target villages																								
- Imi-Nisly (90)	-	-	78	58	78	58			-	-					-	-					-	-		
- Dou-Anamer (37)	-	-	55	41	55	41			-	-					-	-					-	-		
- Igoudem (14)			-	-			529	34	-	-	529	34			-	-					-	-		
- Toug Lkheif (42)	181	31	-	-	181	31			-	-			823	36	-	-	823	36			-	-		
- Ainghad (74)	-	-	95	70	95	70	-	-	95	70	95	70			-	-					-	-		
- Inzaine(45)	-	-	39	29	39	29	-	-	39	29	39	29			-	-			1,137	38	-	-	1,137	38
- Imin-tala (74)	-	-	15	11	15	11	-	-	15	11	15	11	-	-	15	11	15	11			-	-		
- Addouz (53)	-	-	44	33	44	33	-	-	44	33	44	33	-	-	44	33	44	33			-	-		
2) Cost total	181	31	326	242	507	273	529	34	193	143	722	177	823	36	59	44	882	80	1,137	38	-	-	1,137	38
3) Overall cost	212		568		780		563		336		899		859		103		962		1,175		-		1,175	
(3) Tidsi																								
1) Target villages																								
- Tidsi (42)	211	27	-	-	211	27			-	-														
- Afra (63)	-	-	66	49	66	49	501	30	-	-	501	30												
2) Cost total	211	27	66	49	277	76	501	30	-	-	501	30												
3) Overall cost	238		115		353		531		-		531													
(4) Anfli																								
1) Target villages																								
- Anfli (66)	279	29			279	29			-	-														
- Timichi (63)			66	49	66	49	536	29	-	-	536	29												
2) Cost total	279	29	66	49	345	78	536	29	-	-	536	29												
3) Overall cost	308		115		423		565		-		565													

-MHG: micro-hydropower generation
-PV: photovoltaic generation
( ): no. of households

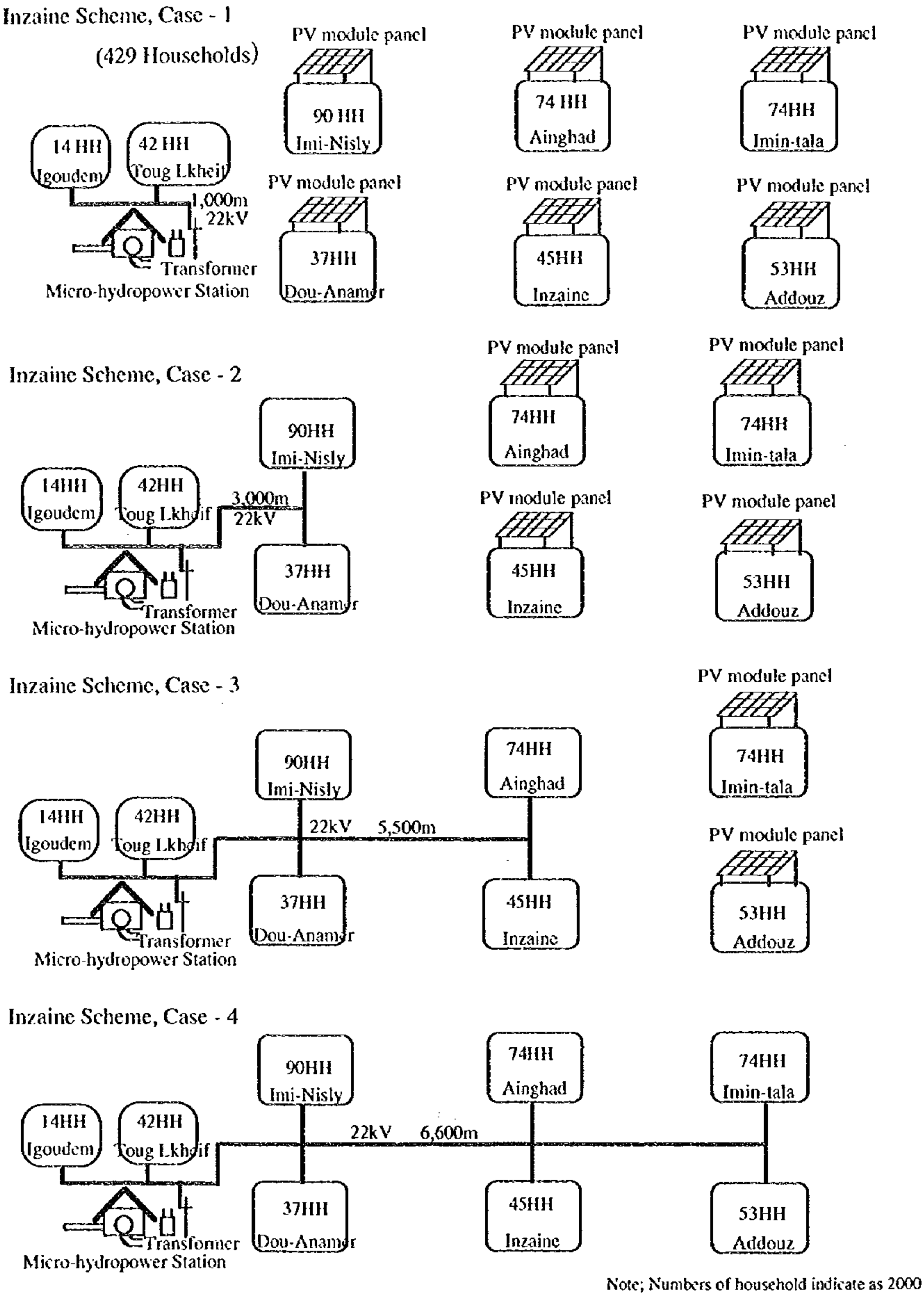
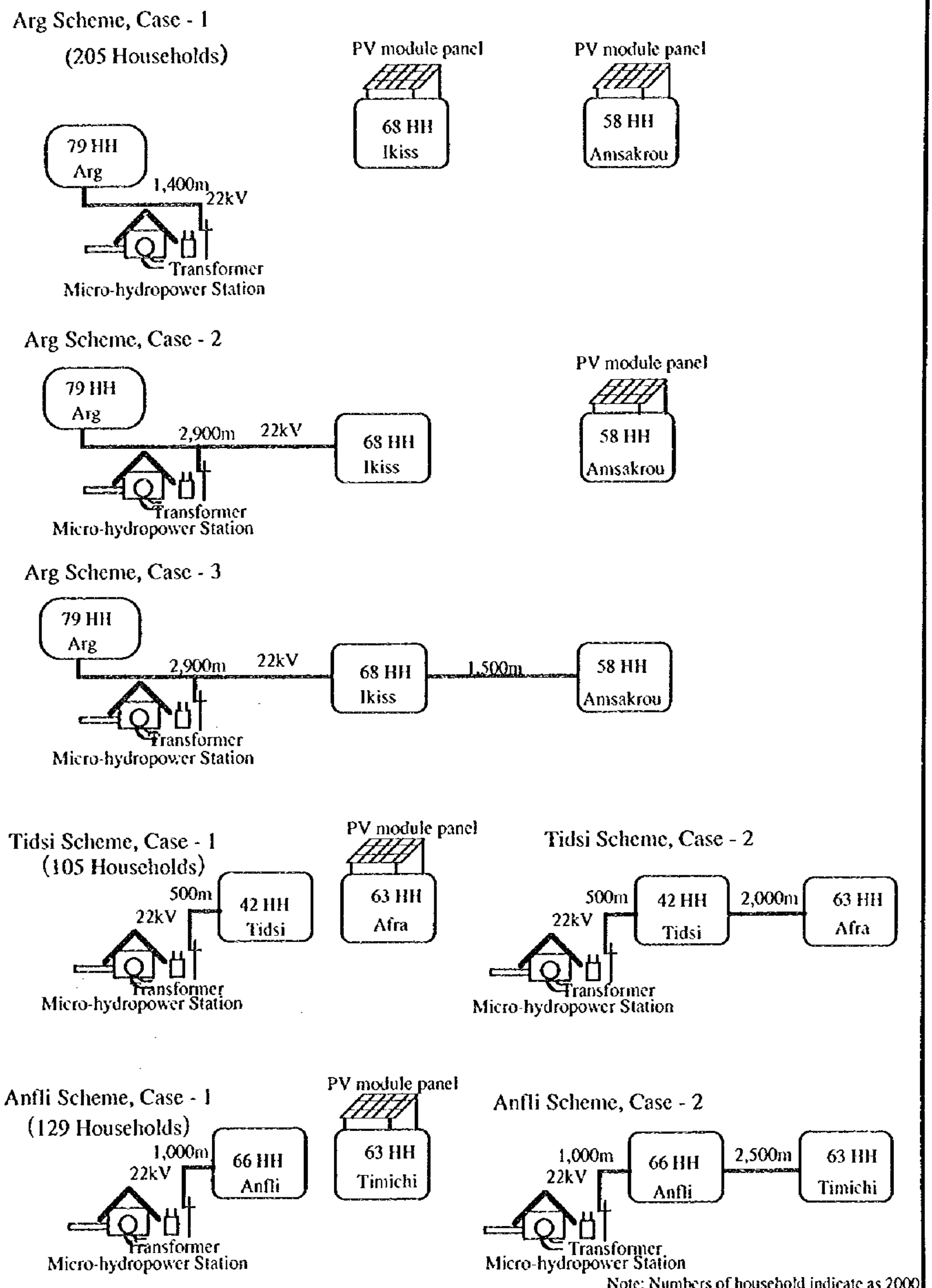


Figure 5.2-1 (1/2) Conceptual Diagram for Composition of Micro-hydropower and PV generation



Note; Numbers of household indicate as 2000

Figure 5.2-1 (2/2) Conceptual Diagram for Composition of Micro-hydropower and PV generation

(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

With regards to the hydropower potential at each site, the results of the above survey and existing data were analyzed, generation discharge determined, and canal length and head identified in order to calculate power output (P_{max}) by the following formula.

$$P_{max} = Q_{max} \times H_e \times g \times \eta$$

Where,

P_{max}	:	maximum installed capacity (kW)
Q_{max}	:	maximum generation discharge (m^3/s)
H_e	:	effective head (m)
g	:	gravity acceleration (m/s^2) (9.8)
η	:	composite efficiency of turbine and generator (0.7)

In general, the generating discharge at a project site is calculated on the basis of specific discharge determined from existing discharge data for the same river. However, with regard to discharge for mountain torrents with small catchment area, there are cases where it is necessary to apply discharge data for another basin with similar rainfall and discharge characteristics. For this Study, data from the existing gauging stations indicated below which exhibit similar rainfall patterns were used as basis for calculating Q275 and Q355. In the case of the Alla-Oumzri and Id Ssiar sites for which springs are the water source for power generation, actual spring discharge was measured and applied as the generation discharge.

Micro-hydropower site	Catchment area (km²)	Existing gauging station and catchment area (km²)		River discharge Q275	(m³/s) Q355
46 Adardour	23	(4) Tahanaout	(226)	0.31	0.09
38 Inzaine	79	(4) Tahanaout	(226)	0.31	0.09
11 Arg	48	(4) Tahanaout	(226)	0.31	0.09
6 Alla Oumzri	8	(3) Aghbalow	(503)	0.28	0.06
7 Id Ssiar	7	(3) Aghbalow	(503)	0.28	0.06
21 Anfli	134	(3) Aghbalow	(503)	0.28	0.06
118 Tidsi	24	(3) Aghbalow	(503)	0.28	0.06

With regard to effective head at each site, a preliminary survey of river gradient was done in order to estimate the effective head existing between the intake and power station sites.

Also, generating scale at each site was determined on the basis of the above generation discharge and head, and the necessary installed capacity which would exceed the estimated demand at the targeted villages for electrification by each respective scheme. As a result, maximum generation discharge at each site was set at a value higher than Q275 (low water discharge) which will make necessary the consideration of measures to either limit power use or adopt supplemental power sources (battery, etc.) during the drought season (March~April). Also, villager aspirations were confirmed with regard to divided use of available discharge for irrigation purposes and power generation during the drought season. Specifically, power generation at each project site (each village) would be 3~4 hours at night, with discharge to be utilized outside this time frame for irrigation and domestic purposes. Generation discharge and effective head were re-examined on the basis of results of water level and discharge observations, and topographical survey (sub-contracted works), and the optimum power generating scale determined. Scheme descriptions for each of the project sites are given in Table 5.2-4.

Table 5.2-3 Scheme Features of Project Sites under Master Plan

Scheme	River (basin)	Elevation of intake (m)	Channel		Head		Discharge			Pmax (kW)
			L (m)	S	H_g (m)	H_e (m)	Q_{355} (m^3/s)	Q_{275} (m^3/s)	Q_{max} (m^3/s)	
Adardour	Anougal (Amizmiz)	1,769	685	1:300	38.0	37.0	0.07	0.10	0.11	26
Inzaine	Anougal (Amizmiz)	1,300	1,200	1:300	28.0	27.0	0.07	0.33	0.33	62
Arg.	Imenane (Rhenaya)	1,574	1,175	1:300	26.5	25.0	0.15	0.22	0.18	30
Alla-Oumzri	Ougardis (Nfis)	1,500	600	1:300	18.0	17.0	0.10	0.10 (spring water)	0.10	14
Id Ssiar	Spring (N'fis)	1,700	600	1:300	28.0	26.0	0.10	0.10 (spring water)	0.10	16
Anfli	Ourika (Ourika)	1,750	800	1:300	13.5	12.5	0.10	0.46	0.25	20
Tidsi	Afoughal (Zat)	1,724.5	850	1:400	16.0	15.0	0.01	0.08	0.15	15

(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

The 7 scheme sites selected in the previous section all exhibit good hydropower potential, with favorable topographical and geographical conditions.

② Supply potential to multiple villages from a single site

Of the 7 schemes, it was identified that 4 have the potential for power supply to multiple villages. As a result, the number of villages to be supplied by the 7 schemes is 18, as indicated in Table 5.2-4.

③ Supplemental power supply to Afra village (not on the original request list)

The Tidsi site has potential in excess of the demand at the single village of Tidsi. However, there are no other villages proximate to the scheme site which are included in the request list by CDER of candidate villages for electrification under the Project. However, the village of Afra (Zerkten Commune Rurale) located 2 km from the generating site as been including under the power supply plan through extension of the scheme mini-grid.

Based on the foregoing, and as indicated in Table 5.2-4, 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. An accordance with section 5.3 of this report, these candidate villages for micro-power electrification were subsequently examined in terms of comparative cost-effectiveness of other modes of electrification as a basis for ultimate selection of the optimum power source.

Furthermore, in the case of the other villages contained in the request list by CDER, it was decided to exclude these from electrification by micro-hydropower due to factors of insufficient river discharge for hydropower development, poor access, etc. Instead, these villages are to be energized by other power sources (PV generation, diesel generation, transmission line extension).

Those micro-hydropower sites are shown in Figure 5.2-2, and site locations of each microhydro generation are shown in Attachment - 1A ~ 1G.

Table 5.2-4 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 5.2-5 Preliminarily Selected Villages for Electrification by Micro-hydropower

No.	Target Villages		Water Source		Commune Rurale	Cercle	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	101	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

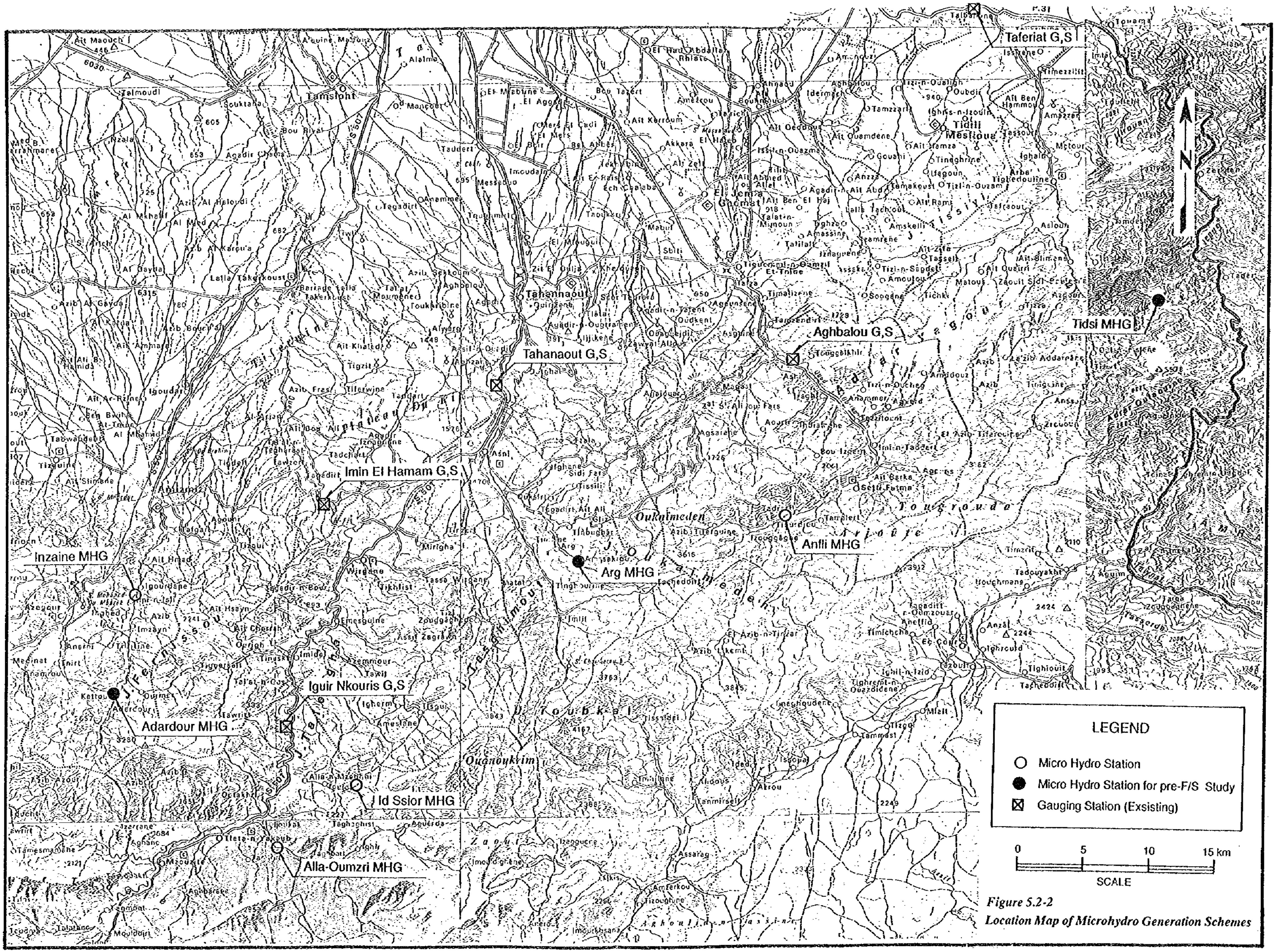


Figure 5.2-2
Location Map of Microhydro Generation Schemes

5.3 Village-wise Selection of Power Source

5.3.1 Selection Method for Power Source

In formulating the electrification plan for the Project area, it is first necessary to select the type of power source for each village. Next, appropriate generating scale is determined from the power demand at each village, and finally financial and economic evaluation is carried out for each power supply scheme. Types of candidate power source are be PV generation, diesel generation, micro-hydropower, and extension of existing transmission line in line with the discussion in section 3.4.

Selection of power source was made 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 and grid extension)
- Modification to meet specific local conditions (nature of household distribution, etc.)
- Correlation with ONE electrification criteria (electrification by grid extension)

Section 5.3.2 presents a comparison of supply cost for each mode of electrification, while section 5.3.3 describes the special features of each mode of electrification. As a result of comparison of supply cost (fixed and variable costs), selection criteria for power supply source have been established, correction for special site conditions made, and a list of villages by mode of electrification prepared (section 5.3.4). Also, result of power source selection have been compared with ONE criteria, and comparison of per household fixed cost for the selected mode of electrification and extension of existing transmission line for each village presented in Tables 5.3-17~5.3-20. Ultimate determination of power source, however, will be made by the National Rural Electrification Committee (COSPER) with adjustments to take into account electrification method as desired by the target villagers.

5.3.2 Comparison of Cost of Power Supply under Each Electrification Method

(1) Pre-assumed Criteria in Comparison

When assessing the advantage of a power project in terms of cost effectiveness, it is a general practice to apply the cost-benefit method. In the case of the subject study, it was assumed that number of village households to be supplied, and amount of power consumption per household would be constant for all types of electrification considered. In other words, benefit would be the same for all methods of power. Accordingly, ranking of methods of electrification in principal centered on comparison of cost required for power supply.

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 ranking of electrification method. Here, number of households implies the scale of generation facility.

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 (see section 5.4). 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 of 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, there are instances where for some items under power cost breakdown an average value was applied depending on the type of electrification method (power cost for financial evaluation was computed on a village-wise basis). Power supply cost targeted fixed and variable costs. For transport cost in the case of micro-hydropower, it was assumed that only turbine and generator equipment would be imported from off-shore, and in this regard CIF prices were applied. Inland transport cost was eliminated from consideration due to only very slight variation depending on the type of power source. This applied as well to engineering fee, added value tax. Calculated prices are as of May 1997 (US$ 1 = DH 9.31 = ¥ 115).

Calculation criteria for each power source are set out below:

1) Solar Home System

	Item	Unit	Price	Criteria
Fixed cost:	PV system - 1 set (75 Wp / 100 Ah / home)	US$ / Wp	14	PV module: US$ 8/Wp Battery: US$ 1/Ah Controller: US$ 90 Installation: US$ 260 (including house wiring)
Variable cost:	Battery replacement	US$/Ah	0.3	3 year life
	Controller replacement	US$	90	10 year life (replacement in the 10th year)
	Maintenance personnel	US$/mo./home	1	1 maintenance personnel / 100 households (US$ 100/mo./person)

Calculation method:

Fixed cost:	System installation	:	unit cost × module size
Variable cost:	Battery replacement	:	unit cost × battery size (calculated year-wise)
	Controller replacement	:	unit cost × 1 (in the 10th year only)
	Maintenance	:	unit cost × 12

2) Diesel Generation

	Item	Unit	Price	Criteria
Fixed cost:	Installation	US$ / village	3,160	according to market survey
	Diesel generator	US$ / kW	1,200~ 450	according to facility capacity
	Intra-village wiring	US$ / home	250~ 175	according to facility capacity
			The above are based on past ONE performance and market survey	
Variable cost:	Fuel	US$/kWh	0.28~ 0.18	past performance locally
	Overhaul	% / 5 years	50	estimated
	Maintenance	%/year	5	estimated
	Maintenance personnel	US$/mo./village	200	estimated based on past performance locally

Calculation method:

Fixed cost:	Installation	:	unit cost × 1
	Diesel generator	:	unit cost × installed capacity (kW)
	Intra-village wiring	:	unit cost × no. of homes
Variable cost:	Fuel	:	unit cost × engine combustion efficiency
	Overhaul	:	0.5 × generator cost (every 5 years)
	Maintenance	:	0.05 × generator cost (yearly)
	Maintenance personnel	:	maintenance personnel × unit cost

3) Micro-hydropower Generation

	Item	Unit	Price	Criteria
Fixed cost:	Facility construction	US$ / scheme	12,000 - 22,000	based on facility capacity
	Turbine / generator	US$ / kW	3,500~ 8,000	based on facility capacity
	Transmission/distribution line	US$ / scheme	50,000~ 70,000	based on no. of households
	House connection wiring	US$ / home	260	past ONE performance and market survey
Variable cost:	Maintenance	%/year	1	estimated
	Maintenance personnel	US$ / scheme	200	estimated based on past performance locally

Calculation method:

Fixed cost:	Facility construction	:	unit cost × kW
	Turbine / generator	:	unit cost × generator capacity (kW)
	Transmission / distribution line	:	unit cost × scheme
	House connection/wiring	:	unit cost × no. of homes
Variable cost:	Maintenance	:	0.01 × generating equipment cost (yearly)
	Maintenance personnel	:	unit cost for maintenance personnel × no. of months

4) Transmission Line Extension

	Item	Unit	Price	Criteria
Fixed cost:	Transmission line	US$ / km	15,000	based on ONE's past performance and market survey
	Intra-village wiring	US$ / m	40	based on ONE's past performance and market survey
	House connection wiring	US$ / home	260	
Variable cost:	Power cost from the grid	US$ / kWh	0.1	ONE electricity tariff
	Maintenance personnel	US$ / mo. / village / km	50	estimated

Calculation method:

Fixed cost:	Transmission line	:	unit cost × distance to existing line
	Intra-village distribution line	:	unit cost × distribution line length (m)
	House connection/wiring	:	unit cost × no. of homes
Variable cost:	Power cost	:	power unit cost × power consumption
	Maintenance personnel	:	unit cost for maintenance personnel × no. of months

(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%. Calculation results are tabulated in Tables 5.3-1~5.3-11. Smaller values given in Tables 5.3-8~11 indicate greater cost effectiveness of electrification method.

Table 5.3-1 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 5.3-2 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 5.3-3 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

Table 5.3-4 20 Year Variable Cost with 6% Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	8,875	63,404	14,223	2,010	2,799	3,589
40	17,749	71,113	15,484	4,019	5,127	6,235
60	26,624	79,672	16,201	6,029	7,310	8,591
80	35,499	89,366	16,975	8,038	9,427	10,816
100	44,373	95,469	17,205	10,048	11,511	12,975
150	66,560	113,844	18,352	15,071	16,646	18,222
200	88,747	126,453	18,925	20,095	21,733	23,371

Table 5.3-5 20 Year Overall Cost with 6% Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	29,875	80,364	309,423	40,210	55,999	71,789
40	59,749	95,273	350,884	58,419	74,527	90,635
60	89,624	113,932	386,801	76,629	92,910	109,191
80	119,499	136,006	425,775	94,838	111,227	127,616
100	149,373	152,629	478,205	113,048	129,511	145,975
150	224,060	189,554	552,352	158,571	175,146	191,722
200	298,747	226,513	610,925	204,095	220,733	237,371

5.3-6 20 Year Variable Cost with 12% Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	5,660	62,594	9,262	1,309	1,823	2,337
40	11,320	70,303	10,084	2,617	3,339	4,060
60	16,980	78,433	10,551	3,926	4,760	5,594
80	22,639	87,636	11,055	5,235	6,140	7,044
100	28,299	93,668	11,204	6,543	7,496	8,449
150	42,449	111,919	11,951	9,815	10,841	11,867
200	56,598	124,224	12,325	13,086	14,153	15,220

Table 5.3-7 20 Year Overall Cost with 12% Discount Rate

(US$)

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	26,660	79,554	304,462	39,509	55,023	70,537
40	53,320	94,463	345,484	57,017	72,739	88,460
60	79,980	112,693	381,151	74,526	90,360	106,194
80	106,639	134,276	419,855	92,035	107,940	123,844
100	133,299	150,828	472,204	109,543	125,496	141,449
150	199,949	187,629	545,951	153,315	169,341	185,367
200	266,598	224,284	604,325	197,086	213,153	229,220

Table 5.3-8 Ranking of 20 Year Overall Cost with No Discount Rate

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	1	5	6	2	3	4
40	2	5	6	1	3	4
60	3	5	6	1	2	4
80	5	4	6	1	2	3
100	5	4	6	1	2	3
150	5	3	6	1	2	4
200	5	2	6	1	3	4

Table 5.3-9 Ranking of 20 Year Overall Cost with 6 % Discount Rate

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	1	5	6	2	3	4
40	2	5	6	1	3	4
60	2	5	6	1	3	4
80	3	5	6	1	2	4
100	4	5	6	1	2	3
150	5	3	6	1	2	4
200	5	3	6	1	2	4

Table 5.3-10 Ranking of 20 Year Overall Cost with 12 % Discount Rate

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	1	5	6	2	3	4
40	1	5	6	2	3	4
60	2	5	6	1	3	4
80	2	5	6	1	3	4
100	3	5	6	1	2	4
150	5	4	6	1	2	3
200	5	3	6	1	2	4

Table 5.3-11 Ranking of 20 Year Overall Cost with Respective Discount Rates of 0%, 6% and 12%

No.of H.H	PV System	Diesel	Micro Hydro	Grid 1km	Grid 2km	Grid 3km
20	3	15	18	6	9	12
40	5	15	18	4	9	12
60	7	15	18	3	8	12
80	10	14	18	3	7	11
100	12	14	18	3	6	10
150	15	11	18	3	6	10
200	15	8	18	3	7	12

5.3.3 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 site conditions.

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. As a result, villagers in the Project area are relatively passive in their posture towards the introduction of diesel generation. 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.

Considering the above discussed differences in basic nature of electrification method, power sources were analyzed in detail in terms of advantages and disadvantages as indicated below, and the basic strategy of electrification formulated.

(1) Solar Home System

Advantages:

- Installation is possible on a per home basis; installation is possible at any location where sunshine is available
- Operating cost is minimal, with the exception of cost for battery replacement
- Essentially no environmental impact
- Breakdown of one home system has no impact on other systems
- In the event of future grid extension, either step up voltage connection or diversion for other use is possible

Disadvantages:

- Power supply volume is constrained
- Only limited electrical appliances can be used

(2) Diesel Generation

Advantages:

- It is the most common method of decentralized electrification, and in this regard technology is mature
- It is possible to use electrical appliances commonly available on the market
- Connection is possible with future grid extension

Disadvantages:

- Continuous fuel supply is necessary (kerosene, diesel)
- Daily and otherwise periodical maintenance is necessary
- Concern for environmental impacts

(3) Micro-hydropower Generation

Advantages:

- Operation cost is the least
- Few environmental impacts
- Little maintenance required
- It is possible to use electrical appliances commonly available on the market
- Simple connection is possible with future grid extension

Disadvantages:

- Initial investment is high
- Operation is dependent on river discharge (in dry season)
- Necessary to coordinate discharge use with water for agricultural purposes

- Constraints on installation location for facilities

(4) Transmission Line Extension

Advantages:

- No constraints on power supply (for domestic purposes)
- It is possible to use electrical appliances commonly available on the market
- Easy maintenance

Disadvantages:

- Initial investment is high
- High power loss

5.3.4 Results of Power Source Selection

Basic strategy for selection of power supply source is tabulated in Table 5.3-12, based on the results of comparison of overall supply cost (fixed and variable cost) for each method of electrification and special features and characteristics of each power supply source.

Table 5.3-12 Basic Strategy for Electrification of Target Villages (comparison of overall cost including variable cost)

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 5.3-11, 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 5.3-14. 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, adopting the criteria set out in Table 5.3-13. Results of this are summarized in Table 5.3-15.

Table 5.3-13 ***Basic Strategy for Electrification of Target Villages (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 5.3-14 ***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 5.3-15 ***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

The following villages fall outside the scope of the basic electrification strategy. However, given observed conditions in the villages, it would be realistic to apply a corrected interpretation of Tables 5.3-12 and 5.3-13. Accordingly, the examination below was carried out, with the ultimate result of selection of power supply source tabulated in Table 5.3-16.

However, layout of households in each village was taken into consideration in final selection of power source. Particularly in the case of diesel generation, correction was made in comparison with PV generation where the target village encompassed a number of small hamlets scattered over a wide area.

Results of power source selection by village are indicated in Table 5.3-17~5.3-20.

1) No. 30 Bel Abbas village in Table 5.3-17 comprises 147 homes and the village would be subject to electrification by diesel generation according to applied criteria; however, these are scattered in a number of small hamlets and accordingly PV generation has been adopted in light of the high cost for distribution line in the case of diesel generation.

2) No. 6 Alla Oumzri village in Table 5.3-19 (48 homes) and No. 7 Id Sssior village (78 homes) exhibit ample spring discharge and have been preliminarily selected for electrification by micro-hydropower (see section 5.2.2). These villages would be subject to electrification by PV generation according to applied criteria; however, in light of the strong desire by CDER that precious hydropower potential be exploited to the extent possible, it was subsequently decided in close consultation with CDER to energize these 2 villages by micro-hydropower.

3) No. 13-2 Imskar and No. 115 Quiriz villages in Table 5.3-20 are both small and would be subject to electrification by PV generation according to applied criteria (Table 5.3-12); however, in light of the plan to extend existing transmission line past the subject area it was decided that these villages by subject to electrification by extension of the existing grid.

Table 5.3-16 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

As discussed in section 4.2, electrification by extension of existing transmission line applies criterion of per household electrification cost less than DH 10,000 under PERG. In this regard, comparison of per household construction cost for electrification by transmission line extension and the other candidate modes of electrification is shown in Tables 5.3-17~5.3-20. As can be seen from these results, the per household construction cost in all cases would exceed DH 10,000 if extension of the grid were adopted, and in line with PERG criteria other modes of electrification are to be employed. Accordingly, decentralized electrification has been incorporated under the Project with the exception of the few villages extremely close to existing transmission line. With regard the villages of Imskar, Oulad Mansour and Tlat Tedrara which are designated for connection to existing transmission line, these exhibit at present an electrification cost in excess of DH 10,000 for such connection. However, in light of their proximity to other villages already slated for grid extension under ONE planning, it is assumed that the cost to electrify these by this mode of power will drop below DH 10,000 per household in the future.

In the case of electrification by micro-hydropower, there are instances where multiple villages can be serviced by a single scheme. In this instance, construction cost comparison between transmission line extension and micro-hydropower must include a comparison of transmission line extension from the power station to each village with incorporation of multiple villages within a mini-grid. In the case of a mini-grid, connection by transmission line to the power station would begin with the closest village, with steady expansion of connection from that point to the other villages to be serviced under the scheme. Construction cost in this latter case where number of households is large results in a lesser overall transmission line length in comparison to running separate transmission lines directly from the power station to each village, with resultant lesser per household construction cost.

Accordingly, the mini-grid is shown to result in a cheaper electrification cost per household in terms of transmission line length as the number of user households increases.

Table 5.3-17 (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	19,646	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	Bouchiba 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	68,644	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	11.0	221,574	32,744
79	Afella Ouassif	26	40,899	14,645	10.7	183,848	65,832
81	Afella Ighil	10	17,147	15,964	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 5.3-17 (2/2) Villages to be Electrified by PV Generation (comparison of construction cost with transmission line extension)

			PV Generation		Grid extension		
No.	Douars	HH (2000)	Construction cost (DH)	Construction cost / HH (DH)	Distance from exsisting grid line (km)	Construction cost (US$)	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	Lakaarna	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 5.3-18 Villages to be Electrified by Diesel Generation (comparison of construction cost with transmission line extension)

			Diesel Generation		Grid extension		
No.	Douars	HH (2010)	Construction cost (DH)	Construction cost / HH (DH)	Distance from exsisting grid line (km)	Construction cost (US$)	Construction cost / HH (DH)
23	Agouns	125	78,865	5,760	6.0	202,250	15,064
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 5.3-19 Villages to be Electrified by Micro-hydropower Generation (comparison of construction cost with transmission line extension)

No.	Douars	HH (2010)	Micro-hydropower Generation: Construction cost (DH)	Micro-hydropower Generation: Construction cost / HH (DH)	Grid extension: Distance from exsisting grid line (km)	Grid extension: Construction cost (US$)	Grid extension: 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 5.3-20 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)	Grid extension: Construction cost (US$)	Grid extension: 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	Tlat 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

5.4.1 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.

- PV generation, diesel generation and extension of existing transmission line

  In making demand forecast for user households, the types of electrical appliances and hours of use as indicated by the average villager in the course of questionnaire survey was first examined (see Table 2.3-9). On this basis, it was assumed that household demand is 568 Wh/d with maximum power of 109 W to energize lighting, TVs, radios, etc. Also, villagers indicate a desire for heating, air conditioning and other electrically operated equipment. However, since this demand greatly exceeds the criteria applied under PERG of 240 Wh/d demand and maximum power of 65 W per household, it was decided in close consultation with CDER to adopt the PERG criteria under this Project as well to maintain uniformity of electrification efforts. This demand criteria was applied as well in the village-wise power source selection described in section 5.3. Demand in the case of public and commercial establishments was likewise subject to the same criteria. The subject criteria was applied in the cases of PV generation, diesel generation and extension of the existing grid.

- Micro-hydropower

  As discussed above, the demand indicated by questionnaire survey is much greater than actual demand forecast criteria applied, indicating anticipated latent demand following system construction. As discussed in section 5.2, there exists a considerable variation in natural conditions at the selected micro-hydropower sites, and overall these exhibit a generating potential in excess of demand according to the above criteria. Accordingly, not only is it possible to assume a larger demand per household, but where sufficient surplus potential is available it is also possible to provide power to multiple villages under a single scheme. In the case of micro-hydropower, it would thus be 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 (see section 5.4.3). Accordingly, demand is assumed at a supply capacity of 518 Wh/day with maximum power of 87 W per household. In the case of power demand for public facilities and commercial establishments, the foregoing criteria are applied assuming only that hours of power utilization are longer. Also, other demand such as power for refrigerators, etc. is assumed to absorb off peak energy generation.

④ Numbers of facilities to be electrified in each village by category of electrification method were calculated applying the base data in section 3.3.

In the following section 5.4.2, demand forecast in the cases of PV generation, diesel generation and transmission line extension is described; while section 5.4.3 presents the demand forecast in the case of micro-hydropower generation.

5.4.2 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.

(1) Household Use

Lighting:	10 W × 4 × 3 hr/d	120 Wh/d
TV:	17 W × 1 × 6 hr/d	102 Wh/d
Radio:	10 W × 1 × 3 hr/d	30 Wh/d
Subtotal:		252 Wh/d
Contingency (20%)		50 Wh/d
Total:		302 Wh/d
Per household demand (use rate of 80%):		240 Wh/d
Maximum power per household:		65 W*

* (10 W × 4 + 17 W × 1 + 10 W × 1) × 1.2 × 0.8 = 64.3

(2) Public Use

1) Schools

Lighting:	10 W × 12 × 1 hr/d	120 Wh/d
Radio:	10 W × 3 × 2 hr/d	60 Wh/d
Per school demand:		180 Wh/d
Maximum power per school:		120 W

2) Street lighting

Demand per streetlight:	20 W × 1* × 6 hr/d	120 Wh/d
Maximum power per street light:		20 W

* one street light per 5 households

3) Mosques

Lighting:	10 W × 5 × 2 hr/d	100 Wh/d
Speaker:	30 W × 1 × 2 hr/d	60 Wh/d
Per mosque demand:		160 Wh/d
Maximum power per mosque:		50 W

4) Clinics

Lighting:	10 W × 5 × 2 hr/d	100 Wh/d
Equipment:	25 W × 1 × 2 hr/d	50 Wh/d
Per clinic demand:		150 Wh/d
Maximum power per clinic:		50 W

(3) Commercial Use (shops, butchers)

Per shop demand:	10 W × 1 × 6 hr/d	60 Wh/d
Maximum power per shop:		10 W

5.4.3 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. In light of the relationship between demand and supply capacity, demand is assumed with a margin at 63 W in contrast to the 40 W for PV generation.

(1) Household Use

Lighting:	13 W × 4 × 6 hr/d	78 Wh/d
	10 W × 5 × 6 hr/d	300 Wh/d
TV:	17 W × 1 × 6 hr/d	102 Wh/d
Radio:	10 W × 1 × 6 hr/d	60 Wh/d
Subtotal:		540 Wh/d
Contingency (20%)		108 Wh/d
Total:		648 Wh/d
Per household demand (use rate of 80%):		518 Wh/d

Maximum power per household: 87 W*

* (13 W × 1 + 10 W × 5 + 10 W × 1) × 1.2 × 0.8 = 86.4)

(2) Public Use

1) Schools

Lighting:	10 W × 12 × 6 hr/d	720 Wh/d
Radio:	10 W × 3 × 6 hr/d	180 Wh/d
Per school demand:		900 Wh/d

Maximum power per school: 120 W

2) Street lighting

Demand per streetlight: 20 W × 1* × 6 hr/d 120 Wh/d

* one street light per 5 households

Maximum power per street light: 20 W

3) Mosques

Lighting:	10 W × 5 × 6 hr/d	300 Wh/d
Speaker:	30 W × 1 × 6 hr/d	180 Wh/d
Per mosque demand:		480 Wh/d

Maximum power per mosque: 50 W

4) Clinics

Lighting:	10 W × 5 × 2 hr/d	300 Wh/d
Equipment:	25 W × 1 × 2 hr/d	150 Wh/d
Per clinic demand:		450 Wh/d

Maximum power per clinic: 50 W

(3) Commercial Use (shops, butchers, etc.)

Per shop demand: 10 W × 1 × 6 hr/d 60 Wh/d

Maximum power per shop: 10 W

(4) Others

1) Refrigerator

Assumed that 20% of households in the year 2010 would utilize refrigerators (in the high water season only), with the exception of the Tidsi scheme.

Power per unit: 85 W
Hours of use: 24 hour per day

2) Heating and cooking

Assumed that 20% of households in the year 2010 would utilize heating / cooking equipment (in the high water season only), in the case of the Alla Oumzri and Id Ssior schemes.

Power per unit: 1,000 W
Hours of use: 24 hour per day

(5) Latent Demand

Sauna bath operation is conceivable for electricity consumption during off-peak hours, and such consumptive methods could be applied where necessary in place of the above described refrigerator, heating and cooking uses. In terms of commercial use of electricity, there are at present 98 milling plants (diesel, water wheel operated) in the Project area. Nevertheless, it will be necessary to compare the costs involved in a switch to electrical power. Also, there are 7 pottery kilns in the Project area; however these require continual heating power over 2~3 day periods and in this light further study is necessary to identify any latent demand in this regard.

(6) Supplemental Supply to Afra

As there is surplus generating potential under the Tidsi scheme, it is planned to supply supplemental power to Afra Douar (not on the original request list) by transmission line. Afra is located in Zerkten Commune Rurale and is approximately 2 km to the east of Tidsi. Number of households and population of Afra in 1996 are 65 and 600, respectively.

Daily load charts were subsequently prepared for each micro-hydropower scheme based on the demand forecast. These express the relationship between load and supply within the mini-grid. The daily load charts were formulated according to the following criteria.

① Load and operating hours were made as large as possible based on features of the scheme site and affordability to pay of the target villagers, and taking into consideration future demand increase and effective river utilization.

② Power generation scale is targeted at low discharge (Q_{275}), and where necessary power supply is to be constrained during the drought period each year (3 months: September~November). In principle during the said low water period, discharge is to be diverted for irrigation purposes during the off-peak hours. Necessary discharge to be diverted for irrigation during the drought period of September~November is assumed to be small based on estimates of time period for diversion to achieve necessary irrigation requirement as well as land area size of fields to be irrigated. (see Section 4.5 in Volume 2).

③ Planning attempts to maximize power consumption during the off-peak hours in the high water season. Surplus power corresponds to irrigation discharge and dummy load. In light of the fact that surplus generating scale is available under the micro-hydropower schemes (with the exception of the Tidsi scheme), it has been planned to direct this at refrigerator, heating and cooking demand. This demand can be altered to other purposes such as sauna bath operation (hamam) depending specific aspirations of the villagers concerned.

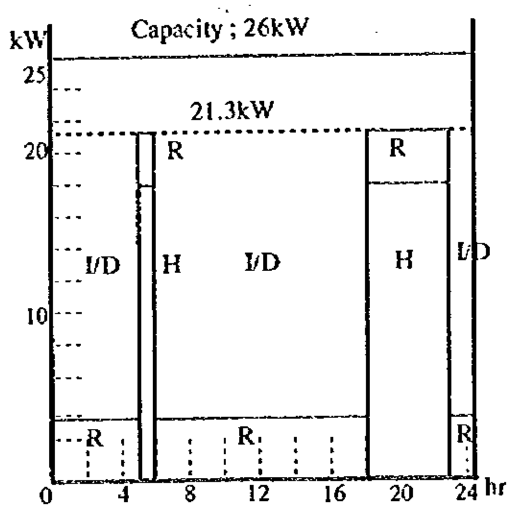
Predicted daily load charts for each subject scheme are indicated in the following:

Predicted Daily Load Charts (2010)

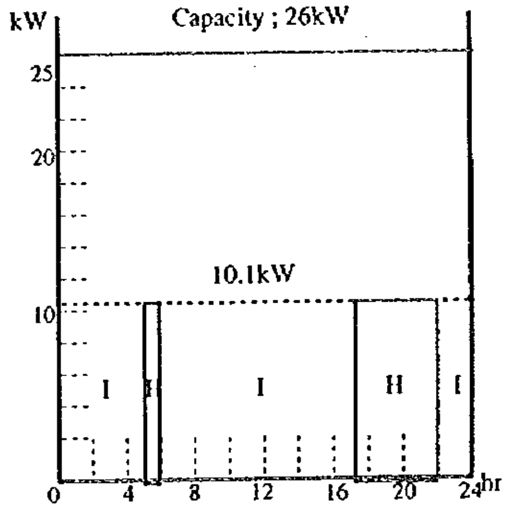
(Note) H ; Households, Public facilities and Commerce
R ; Refrigeratores
I/D ; Irrigation or Dummy load
I ; Irrigation
H/C ; Heating or Cooking

Adardour

(Rainy months ≧257 days)

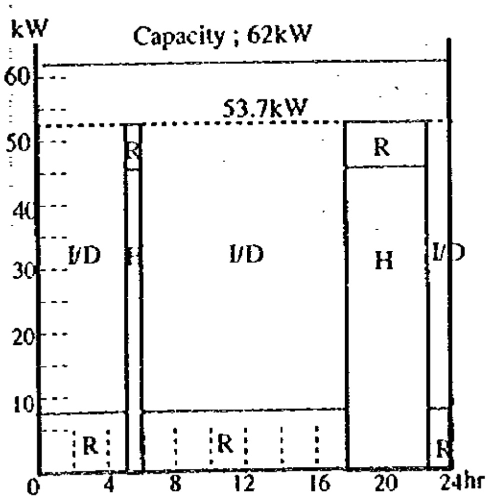


(Dry months ; 329 days)

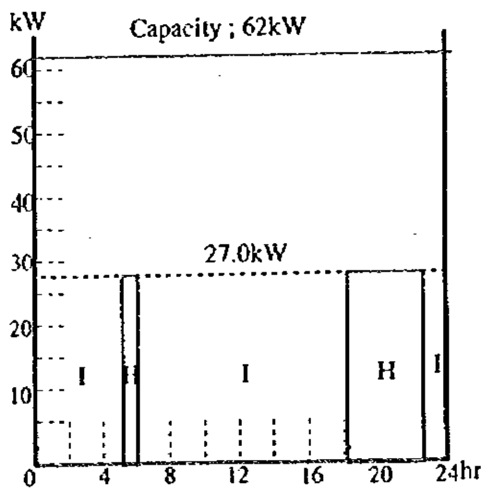


Inzaine

(Rainy months≧275 days)



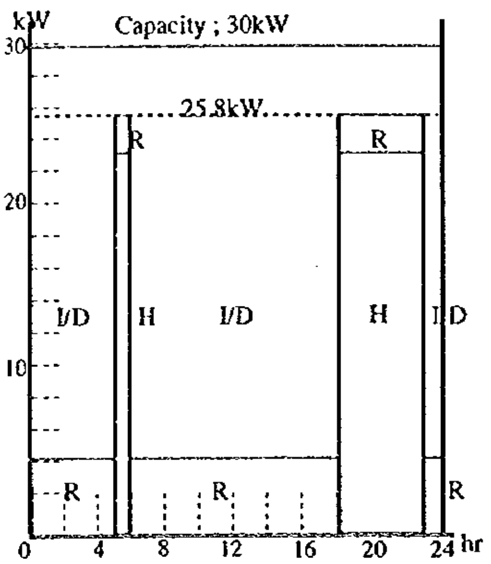
(Dry months ; 329 days)



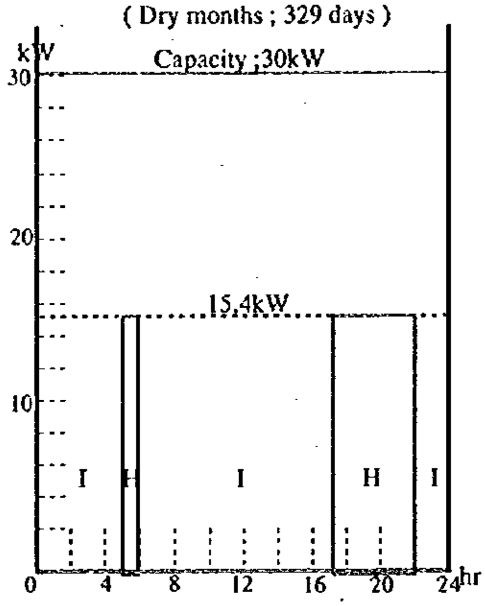
Predicted Daily Load Charts (2010), cont'd

Arg

(Rainy months ≧289days)

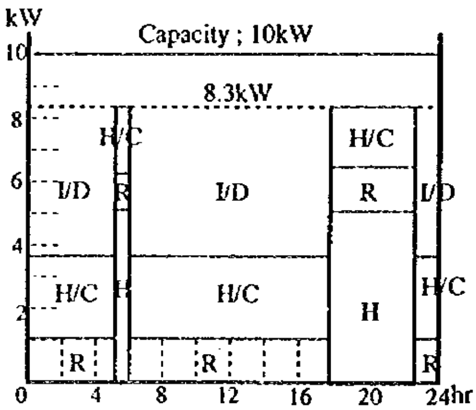


(Dry months ; 329 days)

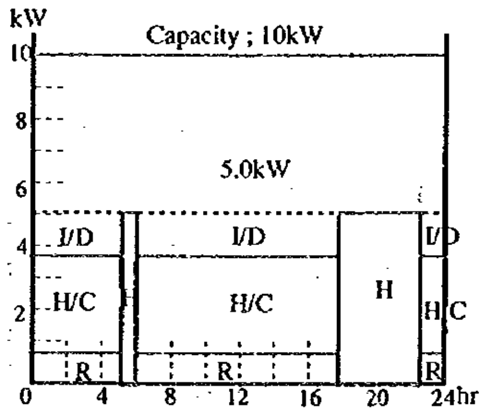


Alla Oumzri

(Rainy months ≧275 days)



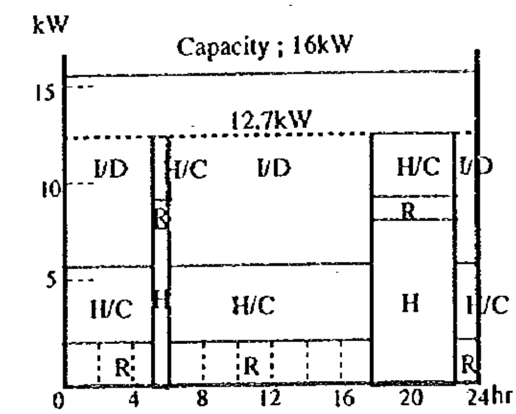
(Dry months ; 329 days)



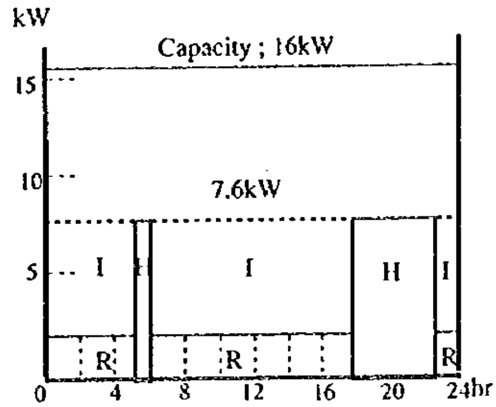
Predicted Daily Load Charts (2010), cont'd

Id Ssior

(Rainy months ≧275 days)

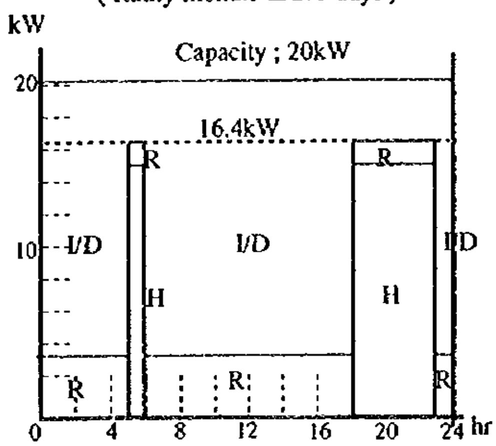


(Dry months ; 329 days)

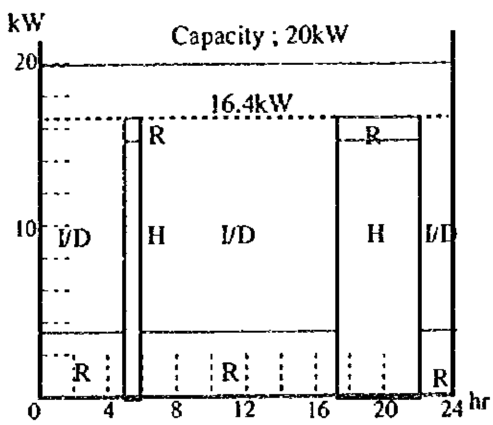


Anfli

(Rainy months ≧275 days)

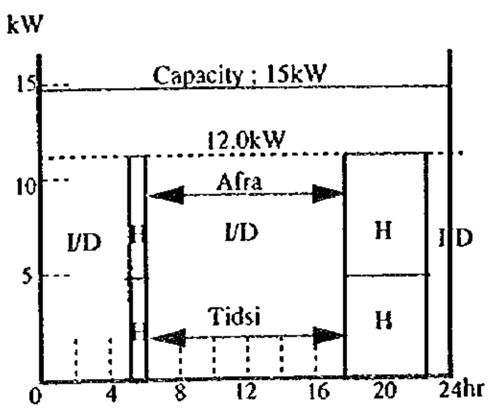


(Dry months ; 329 days)

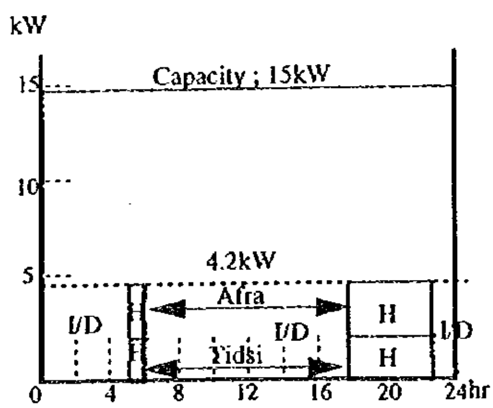


Tidsi

(Rainy months ≧198days)



(Dry months ; 329 days)



5.4.4 Results of Power Demand Forecast

The results of power demand forecast according to the above methodology and criteria with regard to PV generation, diesel generation, transmission line extension and micro-hydropower generation 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; supplemental power supply is to be made under the Tidsi scheme to Afra (not on the original request list)
2) 450,352 kWh / 365 = 1,233.84 kWh

Details of the results of power demand forecast are shown in Tables 5.4-1~5.4-4.

Table 5.4-1 Power Demand (2000) for PV Generation

No.	Douar	Households Nos	Households 75Wp	Households 55Wp	Schools Nos	Schools 75W	Schools 55W	Street lighting Nos	Street lighting 75W	Street lighting 55W	Mosques Nos	Mosques 75W	Mosques 55W	First aid Nos	First aid 75W	First aid 5W	Stores Nos	Stores 75W	Stores 55W	Butchers Nos	Butchers 75W	Butchers 55W	Total 75Wp	Total 55Wp	Nos of PV System
1	Tizi Oussem	76		152	3		6	15	15		1		2	0	0		4	4		0	0		19	160	99
2	Id Aissa	46		92	2		4	9	9		1		2	0	0		4	4		2	2		15	98	64
3	Tassa Ouirgane	58		116	1		2	12	12		1		2	0	0		2	2		0	0		14	120	74
4	Igrem	28		56	2		4	6	6		1		2	0	0		2	2		0	0		8	62	39
8	Aghella	67		134	1		2	13	13		1		2	0	0		2	2		0	0		15	138	84
9	Ikiss	71		142	1		2	14	14		1		2	0	0		1	1		0	0		15	146	88
12	Tinerhouhrine	31		62	1		2	6	6		1		2	0	0		3	3		1	1		10	66	43
17	Tacheddirt	63		126	2		4	13	13		1		2	0	0		6	6		1	1		20	132	86
18	Sqour	47	47		1	1		9		9	1	1		0		0	2		2	0		0	49	11	60
19	Amagdour	23	23		0	0		5		5	1	1		0		0	0		0	0		0	24	5	29
20	Tamaterte	42		84	2		4	8	8		1		2	0	0		0	0		6	6		14	90	59
26-1	Awin Mazouz	70	70		1	1		14		14	1	1		0		0	2		2	1		1	72	17	89
26-2	Bouchiha Ben Om	69	69		1	1		14		14	1	1		0		0	4		4	0		0	71	18	89
30	Bel Abbas	147	147		1	1		29		29	3	3		0		0	5		5	0		0	151	34	165
32	Derb Chem's	63	63		1	1		13		13	1	1		0		0	2		2	0		0	65	15	80
43	Ait Ouzkri	42	42		1	1		8		8	1	1		0		0	0		0	0		0	44	8	52
44	Ait Hmad	52	52		1	1		10		10	1	1		0		0	1		1	0		0	54	11	65
45	Tizgui	63	63		1	1		13		13	1	1		0		0	1		1	0		0	65	14	79
49	Anemi	94		188	1		2	19	19		3		6	0	0		3	3		0	0		22	196	120
51	Talat Ait Ihia	73		146	0		0	15	15		1		2	0	0		1	1		0	0		16	149	90
53	Adghouss	52		104	2		4	10	10		1		2	0	0		1	1		0	0		11	110	66
56	Tagadirt	52		104	0		0	10	10		1		2	0	0		0	0		0	0		10	106	63
57	Tifirt	94		188	2		4	19	19		1		2	0	0		2	2		0	0		21	194	118
58	Anfrioune	63		126	1		2	13	13		1		2	0	0		1	1		0	0		14	130	79
60	Tifratine	84	84		1	1		17		17	1	1		0		0	3		3	0		0	86	20	106
61	Aguenze	21	21		1	1		4		4	1	1		0		0	0		0	0		0	23	4	27
62	Ifit Baragha	37	37		0	0		7		7	1	1		0		0	1		1	0		0	38	8	46
63	Agadir Baragha	42	42		1	1		8		8	1	1		0		0	0		0	0		0	44	8	52
65	Adar Baragha	12	12		0	0		2		2	1	1		0		0	0		0	0		0	13	2	15
66	Tadchert	31	31		0	0		6		6	1	1		0		0	1		1	0		0	32	7	39
67	Tamsoult	5	5		0	0		1		1	0	0		0		0	0		0	0		0	5	1	6
68	Dar Jamaa Ait Ali	63	63		1	1		13		13	1	1		1		1	2		2	0		0	65	16	81
69	Agadir Ait Brahim	29	29		0	0		6		6	0	0		0		0	1		1	0		0	29	7	36
70	Iouraghan	19	19		0	0		4		4	1	1		0		0	0		0	0		0	20	4	24
71	Imiki	52	52		0	0		10		10	1	1		0		0	2		2	0		0	53	12	65
72	Ifit Ait Alla	23	23		0	0		5		5	1	1		0		0	1		1	0		0	24	6	30
73	Boukhelf	89	89		1	1		18		18	2	2		0		0	4		4	0		0	92	22	114
74	Addar Ait Ali	23	23		1	1		5		5	1	1		0		0	1		1	0		0	25	6	31
77	Ait M'Barek	31	31		0	0		6		6	1	1		0		0	1		1	0		0	32	7	39
78	Agadir Ait Bourd	63	63		0	0		13		13	1	1		0		0	1		1	0		0	64	14	78
79	Afella Ouassif	26	26		0	0		5		5	0	0		0		0	0		0	0		0	26	5	31
81	Afella Ighil	10	10		0	0		2		2	1	1		0		0	0		0	0		0	11	2	13
83-1	Anfeg	16	16		0	0		3		3	1	1		0		0	0		0	0		0	17	3	20
83-2	Aguersouak	21	21		1	1		4		4	1	1		0		0	0		0	0		0	23	4	27
85-1	Oumast	37	37		1	1		7		7	1	1		0		0	0		0	0		0	39	7	46
85-2	Ait Zitoun	37	37		0	0		7		7	0	0		0		0	0		0	0		0	37	7	44
86	Tagadirt	29	29		0	0		6		6	0	0		0		0	0		0	0		0	29	6	35
87-1	Zaouit	9	9		0	0		2		2	1	1		0		0	0		0	0		0	10	2	12
87-2	Izalaghan	13	13		0	0		3		3	1	1		0		0	0		0	0		0	14	3	17
88	Tigouder	25	25		2	2		5		5	0	0		0		0	0		0	0		0	27	5	32
89	Amezi	38	38		1	1		8		8	1	1		0		0	0		0	0		0	40	8	48
90	Agouni	31	31		1	1		6		6	1	1		0		0	0		0	0		0	33	6	39
91	Chaabat Tarik	56	56		1	1		11		11	2	2		0		0	2		2	0		0	59	13	72
92	Ighit Sdidene	15	15		0	0		3		3	1	1		0		0	0		0	0		0	16	3	19
93	Tizi	62	62		1	1		12		12	1	1		0		0	1		1	0		0	64	13	77
94	Aghbalou	94	94		2	2		19		19	1	1		0		0	2		2	0		0	97	21	118
95	Ait Hsain	14	14		0	0		3		3	1	1		0		0	1		1	0		0	15	4	19
96	Ait Boubker	15	15		1	1		3		3	1	1		0		0	0		0	0		0	17	3	20
97	Tazalourt	35	35		0	0		7		7	1	1		0		0	2		2	0		0	36	9	45
98	Tamsoulte	35	35		1	1		7		7	1	1		0		0	0		0	0		0	37	7	44
99	Tizgui	52	52		1	1		10		10	1	1		0		0	1		1	0		0	54	11	65
100	Ait Tirghit	52	52		1	1		10		10	1	1		0		0	0		0	0		0	54	10	64
101	Tachbibt Kabli	31	31		0	0		6		6	2	2		0		0	2		2	0		0	33	8	41
102	Tachbibt Echaloui	31	31		1	1		6		6	1	1		0		0	2		2	0		0	33	8	41
103	Asgoune	31	31		0	0		6		6	1	1		0		0	2		2	0		0	32	8	40
104	Ait Aamara Loued	84	84		1	1		17		17	2	2		0		0	3		3	0		0	87	20	107
106	Lakaama	31	33		0	0		6		6	1	1		0		0	0		0	0		0	32	6	38
113-1	Tarast	47	47		1	1		9		9	2	2		0		0	2		2	2		2	50	13	63
113-2	Assaka	47	47		0	0		9		9	1	1		0		0	5		5	0		0	48	14	62
117	Ansa	62		124	1		2	12	12		2		4	0	0		3	3		0	0		15	136	80
120	Ezzaouite	17		34	1		2	3	3		3		6	0	0		3	3		0	0		6	42	27
	Total 71	3,213			54			642			77			1			98			13			2,555	2,574	4,094

Table 5.4-2 Power Demand (2010) for Diesel Generation

No.	Douar	Households Nos	Households Output (kW)	Households Demand (kWh)	Schools Nos	Schools Load (kW)	Schools Demand (kWh)	Street lighting Nos	Street lighting Load (kW)	Street lighting Demand (kWh)	Mosques Nos	Mosques Load (kW)	Mosques Demand (kWh)	First aid Nos	First aid Load (kW)	First aid Demand (kWh)	Stores Nos	Stores Load (kW)	Stores Demand (kWh)	Butchers Nos	Butchers Load (kW)	Butchers Demand (kWh)	Maximum Output (kW)	Power Demand per day (kWh)
23	Agouns	125	6.25	30.00	2	0.24	0.36	25	0.50	3.00	1	0.05	0.16	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	8.92	33.52
47	Lamdinol	190	9.50	45.60	2	0.24	0.36	38	0.76	4.56	1	0.05	0.16	0	0.00	0.00	4	0.04	0.20	0	0.00	0.00	10.59	50.88
49	Tala	273	13.65	65.52	1	0.12	0.18	55	1.10	6.60	2	0.10	0.32	0	0.00	0.00	3	0.03	0.15	3	0.03	0.15	15.03	72.92
50	Anssmou	190	9.50	45.60	1	0.12	0.18	38	0.76	4.56	1	0.05	0.16	0	0.00	0.00	4	0.04	0.20	0	0.00	0.00	10.47	50.70
52	Toufkine	226	11.30	54.24	1	0.12	0.18	45	0.90	5.40	2	0.10	0.32	0	0.00	0.00	10	0.10	0.50	2	0.02	0.10	12.54	60.74
54	Douzrou	261	13.05	62.64	1	0.12	0.18	52	1.04	6.24	1	0.05	0.16	0	0.00	0.00	6	0.06	0.30	0	0.00	0.00	14.32	69.52
55	Ait Oumoss	178	8.90	42.72	1	0.12	0.18	36	0.72	4.32	1	0.05	0.16	0	0.00	0.00	5	0.05	0.25	0	0.00	0.00	9.84	47.63
59	Ait Smil	178	8.90	42.72	2	0.24	0.36	36	0.72	4.32	1	0.05	0.16	0	0.00	0.00	7	0.07	0.35	0	0.00	0.00	9.98	47.91
76	Ait Bourd	119	5.95	28.56	1	0.12	0.18	23	0.46	2.76	1	0.05	0.16	0	0.00	0.00	4	0.04	0.20	0	0.00	0.00	6.62	31.86
84	Ait Bouzid	141	7.05	33.84	1	0.12	0.18	28	0.56	3.36	1	0.05	0.16	0	0.00	0.00	2	0.02	0.10	0	0.00	0.00	7.83	37.64
114	Abadou	131	6.55	31.44	2	0.24	0.36	26	0.52	3.12	2	0.10	0.32	1	0.05	0.15	0	0.00	0.00	4	0.04	0.20	7.50	35.59
119	Ait Armenc	124	6.20	29.76	1	0.12	0.18	25	0.50	3.00	3	0.15	0.48	0	0.00	0.00	6	0.06	0.30	2	0.02	0.10	7.05	33.82
	Total 12	2,136	106.80	512.64	16	1.92	2.88	427	8.54	51.24	17	0.85	2.72	1	0.05	0.15	51	0.51	2.55	11	0.11	0.55	120.66	572.73

Table 5.4-3 Power Demand (2010) for Transmission Line Extension

No.	Douar	Households Nos	Households Output (kW)	Households Demand (kWh)	Schools Nos	Schools Load (kW)	Schools Demand (kWh)	Street lighting Nos	Street lighting Load (kW)	Street lighting Demand (kWh)	Mosques Nos	Mosques Load (kW)	Mosques Demand (kWh)	First aid Nos	First aid Load (kW)	First aid Demand (kWh)	Stores Nos	Stores Load (kW)	Stores Demand (kWh)	Butchers Nos	Butchers Load (kW)	Butchers Demand (kWh)	Maximum Output (kW)	Power Demand per day (kWh)
3-2	[illegible]	48	3.12	11.52	1	0.12	0.18	10	0.20	1.20	1	0.05	0.16	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	3.49	13.06
24	Oulad Mansour	83	5.40	19.92	2	0.24	0.36	17	0.34	2.04	1	0.05	0.16	0	0.00	0.00	2	0.02	0.10	0	0.00	0.00	6.05	22.58
34	Tlat Todrara	95	6.18	22.80	2	0.24	0.36	19	0.38	2.28	2	0.10	0.32	0	0.00	0.00	4	0.04	0.20	0	0.00	0.00	6.94	25.96
112	Landbouid	36	2.34	8.64	0	0.00	0.00	7	0.14	0.84	3	0.15	0.48	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	2.63	9.96
115	Quriz	26	1.69	6.24	1	0.12	0.18	5	0.10	0.60	1	0.05	0.16	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	1.96	7.18
	Total 5	288	18.73	69.12	6	0.72	1.08	58	1.16	6.96	8	0.40	1.28	0	0.00	0.00	6	0.06	0.30	0	0.00	0.00	21.07	78.74

Table 5.4-4 Power Demand (2010) for Micro-hydropower Generation

Scheme	No.	Douar	Households Nos	Households Output (kW)	Schools Nos	Schools Load (kW)	Street lighting Nos	Street lighting Load (kW)	Mosques Nos	Mosques Load (kW)	Stores Nos	Stores Load (kW)	Butchers Nos	Butchers Load (kW)	Refrigerators Nos	Refrigerators Load (kW)	Heating/Cooking Nos	Heating/Cooking Load (kW)	Maximum Output (kW)	Power Demand per year (kWh)
Adardour	46	Adardour	190	16.53	6	0.72	38	0.76	1	0.05	1	0.01	0	0.00	38	3.23	0	0.00	21.30	56,914
Inzaine	38	Inzaine	83	7.22	1	0.12	17	0.34	1	0.05	5	0.05	1	0.01	17	1.45	0	0.00	9.24	-
	36	Addouz	59	5.13	2	0.24	12	0.24	1	0.05	0	0.00	0	0.00	12	1.02	0	0.00	6.68	-
	35	Imin Tala	83	7.22	0	0.00	17	0.34	1	0.05	5	0.05	1	0.01	17	1.45	0	0.00	9.12	-
	37	Ain Ghad	51	4.44	1	0.12	10	0.20	1	0.05	4	0.04	0	0.00	10	0.85	0	0.00	5.70	-
	40	Dou Anammer	42	3.65	1	0.12	8	0.16	1	0.05	0	0.00	0	0.00	8	0.68	0	0.00	4.66	-
	39	Imi N'isly	102	8.87	0	0.00	20	0.40	1	0.05	5	0.05	0	0.00	20	1.70	0	0.00	11.07	-
	41	Igoundem	15	1.31	0	0.00	3	0.06	1	0.05	1	0.01	0	0.00	3	0.26	0	0.00	1.68	-
	42	Toug Lkheif	48	4.18	2	0.24	10	0.20	1	0.05	0	0.00	0	0.00	10	0.85	0	0.00	5.52	-
		Sub Total	483	42.02	7	0.84	97	1.94	8	0.40	20	0.20	2	0.02	97	8.25	0	0.00	53.67	148,900
Arg	11	Arg	89	7.74	1	0.12	18	0.36	1	0.05	1	0.01	0	0.00	18	1.53	0	0.00	9.81	-
	10	Amsakrou	65	5.66	2	0.24	13	0.26	1	0.05	4	0.04	0	0.00	13	1.11	0	0.00	7.35	-
	15	Ikiss	77	6.70	2	0.24	15	0.30	1	0.05	6	0.06	2	0.02	15	1.28	0	0.00	8.64	-
		Sub Total	231	20.10	5	0.60	46	0.92	3	0.15	11	0.11	2	0.02	46	3.91	0	0.00	25.81	73,645
Alla Oumz	6	Alla Oumzri	48	4.18	0	0.00	10	0.20	1	0.05	2	0.02	0	0.00	10	0.85	3	3.00	8.30	42,561
Id Ssior	7	Id Ssior	78	6.79	1	0.12	16	0.32	1	0.05	3	0.03	0	0.00	16	1.36	4	4.00	12.67	54,034
Anfli	21	Anfli	75	6.53	2	0.24	15	0.30	1	0.05	3	0.03	0	0.00	15	1.28	0	0.00	8.42	-
	22	Timichi	71	6.18	2	0.24	14	0.28	1	0.05	2	0.02	0	0.00	14	1.19	0	0.00	7.96	-
		Sub Total	146	12.70	4	0.48	29	0.58	2	0.10	5	0.05	0	0.00	29	2.47	0	0.00	16.38	52,092
Tidsi	118	Tidsi	48	4.18	0	0.00	10	0.20	1	0.05	3	0.03	0	0.00	0	0.00	0	0.00	4.46	-
	-	Afra	77	6.70	4	0.48	15	0.30	1	0.05	0	0.00	0	0.00	0	0.00	0	0.00	7.53	-
		Sub Total	125	10.88	4	0.48	25	0.50	2	0.10	3	0.03	0	0.00	0	0.00	0	0.00	11.99	22,203
		Total 18	1,301	113.19	27	3.24	261	5.22	18	0.90	45	0.45	4	0.04	236	20.06	7	7.00	150.10	450,352

5.5 Power Supply Plan

5.5.1 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. In the event of expansion of facility capacity (PV module, battery, etc.) to meet increased demand in the future, it is necessary to pay maximum attention to preventing excessive battery discharge. By instilling in users the sense that the SHS is part of the household itself, it can be expected that equipment will be handled with care with resultant long utility life.

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%. Another concern is air pollution as a result of exhaust emissions from the diesel engine. Provided that access is good for fuel delivery and transmission line loss is minimal, it is recommended to install the generating equipment as far from human habitation as possible.

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. A possibility in this regard would be to utilize power for milling, etc.

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.

- Existing transmission line is located at reasonably distance from the target village.
- A suitable site is available for the necessary switch gear and transformer facilities to run a branch line to the target village.
- Maintenance of switch gear and transformer equipment is possible.
- Number of village households is sufficient to make electrification cost effective.

5.5.2 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). Annual average sunshine volume is assumed at 5.4 kWh/m²/d (value obtained in Marrakech) and system efficiency at 60%.

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)

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%).

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:

Power supply source:	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 Afra (not on the original request list)
3) Indicates PV module capacity (kWp)
4) Indicates grid load

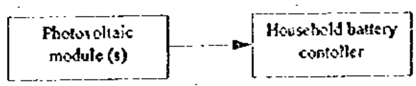
In the case of PV generation and distribution line facilities, scale is to be such as to supply power to the number of households in the target completion year for the Master Plan (2000).

Results of power supply planning study are indicated in Table 5.5-1~5.5.5.

(2) Power Supply Method

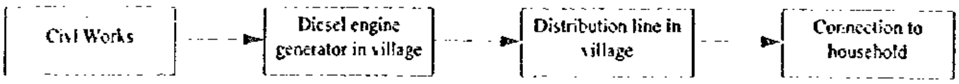
1) Solar Home System

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.

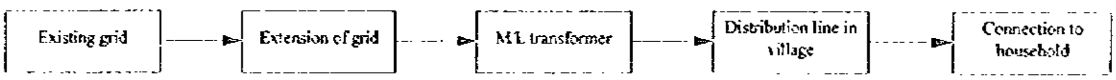


3) Micro-hydropower Generation

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.



5.5.3 Optimum Scale for Micro-hydropower Generation

The power generation scale applied to 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, as discussed in Section 5.4.1, 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 5.5.6 and the results of comparative study of cost effectiveness for optimum generating scale are indicated in Table 5.5-7. 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. Construction cost is based on the preliminary cost estimate set out in Chapter 6 of Volume II.

Facility use rate for the 7 micro-hydropower schemes is an average 29%. However, in the case where the said schemes are ultimately connected to the existing grid, utilization rate would increase to an estimated 94%. This implies a change in per kWh construction cost from US$ 9.5/kWh to US$ 2.9/kWh (not including value added tax, engineering fee, etc.).

Table 5.5-1 PV Module Composition

	Douar	Households			Schools			Street lighting			Mosques			First aid			Stores			Butchers			Total		Nos of
		Nos	75Wp	55Wp	Nos	75Wp	55Wp	Nos	75Wp	55Wp	Nos	75Wp	55Wp	Nos	75Wp	55Wp	Nos	75Wp	55Wp	Nos	75Wp	55Wp	75Wp	55Wp	PV Station
1	Tizi Oussem	76		152	3		6	15	15		1		2	0	0		4	4		0	0		19	160	93
2	Id Aissa	46		92	2		4	9	9		1		2	0	0		4	4		2	2		15	98	64
3	Tassa Ouirgane	58		116	1		2	12	12		1		2	0	0		2	2		0	0		14	120	74
4	Igrem	28		56	2		4	6	6		1		2	0	0		2	2		0	0		8	62	39
8	Aghella	67		134	1		2	13	13		1		2	0	0		2	2		0	0		15	138	84
9	Ikiss	71		142	1		2	14	14		1		2	0	0		1	1		0	0		15	146	88
12	Tinechoubrine	31		62	1		2	6	6		1		2	0	0		3	3		1	1		10	66	43
17	Tacheddirt	63		126	2		4	13	13		1		2	0	0		6	6		1	1		20	132	85
18	Sqour	47	47		1	1		9		9	1	1		0		0	2		2	0		0	49	11	60
19	Amagdour	23	23		0	0		5		5	1	1		0		0	0		0	0		0	24	5	29
20	Tamaterte	42		84	2		4	8	8		1		2	0	0		0	0		6	6		14	90	59
26-1	Awin Mazouz	70	70		1	1		14		14	1	1		0		0	2		2	1		1	72	17	89
26-2	Bouchiha Bon Omar	69	69		1	1		14		14	1	1		0		0	4		4	0		0	71	18	89
30	Bel Abbas	147	147		1	1		29		29	3	3		0		0	5		5	0		0	151	34	185
32	Derb Chem's	63	63		1	1		13		13	1	1		0		0	2		2	0		0	65	15	80
43	Ait Ouzkri	42	42		1	1		8		8	1	1		0		0	0		0	0		0	44	8	52
44	Ait Hmad	52	52		1	1		10		10	1	1		0		0	1		1	0		0	54	11	65
45	Tizgui	63	63		1	1		13		13	1	1		0		0	1		1	0		0	65	14	79
47	Anemmi	94		188	1		2	19	19		3		6	0	0		3	3		0	0		22	196	120
51	Talat Ait Ihia	73		146	0		0	15	15		1		2	0	0		1	1		0	0		16	148	90
53	Adghous	52		104	2		4	10	10		1		2	0	0		1	1		0	0		11	110	66
56	Tagadirt	52		104	0		0	10	10		1		2	0	0		0	0		0	0		10	106	63
57	Tifirt	94		188	2		4	19	19		1		2	0	0		2	2		0	0		21	194	118
58	Anfrioune	63		126	1		2	13	13		1		2	0	0		1	1		0	0		14	130	79
60	Tifratine	84	84		1	1		17		17	1	1		0		0	3		3	0		0	86	20	106
61	Aguenze	21	21		1	1		4		4	1	1		0		0	0		0	0		0	23	4	27
62	Ifit Baragha	37	37		0	0		7		7	1	1		0		0	1		1	0		0	38	8	46
63	Agadir Baragha	42	42		1	1		8		8	1	1		0		0	0		0	0		0	44	8	52
65	Adar Baragha	12	12		0	0		2		2	1	1		0		0	0		0	0		0	13	2	15
66	Tadchert	31	31		0	0		6		6	1	1		0		0	1		1	0		0	32	7	39
67	Tamsoult	5	5		0	0		1		1	0	0		0		0	0		0	0		0	5	1	6
68	Dar Jamaa Ait Ali	63	63		1	1		13		13	1	1		1		1	2		2	0		0	65	16	81
69	Agadir Ait Brahim	29	29		0	0		6		6	0	0		0		0	1		1	0		0	29	7	36
70	Iouraghan	19	19		0	0		4		4	1	1		0		0	0		0	0		0	20	4	24
71	Imiki	52	52		0	0		10		10	1	1		0		0	2		2	0		0	53	12	65
72	Ifit Ait Alla	23	23		0	0		5		5	1	1		0		0	1		1	0		0	24	6	30
73	Bockhelf	89	89		1	1		18		18	2	2		0		0	4		4	0		0	92	22	114
74	Addar Ait Ali	23	23		1	1		5		5	1	1		0		0	1		1	0		0	25	6	31
77	Ait M Barek	31	31		0	0		6		6	1	1		0		0	1		1	0		0	32	7	39
78	Agadir Ait Bourd	63	63		0	0		13		13	1	1		0		0	1		1	0		0	64	14	78
79	Afella Ouassif	26	26		0	0		5		5	0	0		0		0	0		0	0		0	26	5	31
81	Afella Ighil	10	10		0	0		2		2	1	1		0		0	0		0	0		0	11	2	13
83-1	Anfeg	16	16		0	0		3		3	1	1		0		0	0		0	0		0	17	3	20
83-2	Aguersouak	21	21		1	1		4		4	1	1		0		0	0		0	0		0	23	4	27
85-1	Oumast	37	37		1	1		7		7	1	1		0		0	0		0	0		0	39	7	46
85-2	Ait Zitoun	37	37		0	0		7		7	0	0		0		0	0		0	0		0	37	7	44
86	Tagadirt	29	29		0	0		6		6	0	0		0		0	0		0	0		0	29	6	35
87-1	Zaouit	9	9		0	0		2		2	1	1		0		0	0		0	0		0	10	2	12
87-2	Izalaghan	13	13		0	0		3		3	1	1		0		0	0		0	0		0	14	3	17
88	Tigouder	25	25		2	2		5		5	0	0		0		0	0		0	0		0	27	5	32
89	Amezi	38	38		1	1		8		8	1	1		0		0	0		0	0		0	40	8	48
90	Agouni	31	31		1	1		6		6	1	1		0		0	0		0	0		0	33	6	39
91	Chabat Tarik	56	56		1	1		11		11	2	2		0		0	2		2	0		0	59	13	72
92	Ighil Sdidene	15	15		0	0		3		3	1	1		0		0	0		0	0		0	16	3	19
93	Tizi	62	62		1	1		12		12	1	1		0		0	1		1	0		0	64	13	77
94	Aghbalou	94	94		2	2		19		19	1	1		0		0	2		2	0		0	97	21	118
95	Ait Hsain	14	14		0	0		3		3	1	1		0		0	1		1	0		0	15	4	19
96	Ait Boubker	15	15		1	1		3		3	1	1		0		0	0		0	0		0	17	3	20
97	Tazatourt	35	35		0	0		7		7	1	1		0		0	2		2	0		0	36	9	45
98	Tamsoulte	35	35		1	1		7		7	1	1		0		0	0		0	0		0	37	7	44
99	Tizgui	52	52		1	1		10		10	1	1		0		0	1		1	0		0	54	11	65
100	Ait Targhit	52	52		1	1		10		10	1	1		0		0	0		0	0		0	54	10	64
101	Tachbibt Kabli	31	31		0	0		6		6	2	2		0		0	2		2	0		0	33	8	41
102	Tachbibt Echatoui	31	31		1	1		6		6	1	1		0		0	2		2	0		0	33	8	41
103	Asgoune	31	31		0	0		6		6	1	1		0		0	2		2	0		0	32	8	40
104	Ait Aamara Loued	84	84		1	1		17		17	2	2		0		0	3		3	0		0	87	20	107
106	Lakaama	31	31		0	0		6		6	1	1		0		0	0		0	0		0	32	6	38
13-1	Farast	47	47		1	1		9		9	2	2		0		0	2		2	2		2	50	13	63
13-2	Assaka	47	47		0	0		9		9	1	1		0		0	5		5	0		0	48	14	62
117	Ansa	62		124	1		2	12	12		2		4	0	0		3	3		0	0		15	130	80
120	Ezzaouite	17		34	1		2	3	3		3		6	0	0		3	3		0	0		6	42	27
	Total 71	3,213			54			642			77			1			98			13			2,555	2,574	4,094

Table 5.5-2 PV Module Capacity (2000) (1/2)

Douar		Maximum Output (kW)	Capacity of PV Module (Wp)					Nos. of PV System
			Flat terrain	Mount. terrain	75Wp	55 Wp	Total	
1	Tizi Oussem	5.69	-	10,225	19	160	179	99
2	Id Aissa	3.52	-	6,515	15	98	113	64
3	Tassa Ouirgane	4.19	-	7,650	14	120	134	74
4	Igrem	2.24	-	4,010	8	62	70	39
8	Aghella	4.81	-	8,715	15	138	153	84
9	Ikiss	5.08	-	9,155	15	146	161	88
12	Tinerhouhrine	2.35	-	4,380	10	66	76	43
17	Tacheddirt	4.71	-	8,760	20	132	152	86
18	Sqour	3.43	4,280	-	49	11	60	60
19	Amagdour	1.64	2,075	-	24	5	29	29
20	Tamaterte	3.25	-	6,000	14	90	104	59
26-1	Awin Mazouz	5.03	6,335	-	72	17	89	89
26-2	Bouchiha Bon Omar	4.97	6,315	-	71	18	89	89
30	Bel Abbas	10.46	13,195	-	151	34	185	185
32	Derb Chem's	4.54	5,700	-	65	15	80	80
43	Ait Ouzkri	3.07	3,740	-	44	8	52	52
44	Ait Hmad	3.77	4,655	-	54	11	65	65
45	Tizgui	4.53	5,645	-	65	14	79	79
49	Anermi	6.79	-	12,840	22	196	218	120
51	Talat Ait Ihla	5.10	-	9,340	16	148	164	90
53	Adghouss	3.89	-	6,875	11	110	121	66
56	Tagadirt	3.64	-	6,580	10	106	116	63
57	Tifirt	6.80	-	12,245	21	194	215	118
58	Anfrioune	4.53	-	8,200	14	130	144	79
60	Tifratine	6.00	7,550	-	86	20	106	106
61	Aguenze	1.62	1,945	-	23	4	27	27
62	Ifit Baragha	2.61	3,290	-	38	8	46	46
63	Agadir Baragha	3.07	3,740	-	44	8	52	52
65	Adar Baragha	0.88	1,085	-	13	2	15	15
66	Tadchert	2.20	2,785	-	32	7	39	39
67	Tamsoult	0.35	430	-	5	1	6	6
68	Dar Jamaa Ait Ali	4.59	5,755	-	65	16	81	81
69	Agadir Ait Brahim	2.01	2,560	-	29	7	36	36
70	Iouraghan	1.36	1,720	-	20	4	24	24
71	Imiki	3.66	4,635	-	53	12	65	65
72	Ifit Ait Alla	1.65	2,130	-	24	6	30	30
73	Boukhelf	6.40	8,110	-	92	22	114	114
74	Addar Ait Ali	1.77	2,205	-	25	6	31	31
77	Ait M' Barek	2.20	2,785	-	32	7	39	39
78	Agadir Ait Bourd	4.41	5,570	-	64	14	78	77
79	Afella Ouassif	1.79	2,225	-	26	5	31	31
81	Afella Ighil	0.74	935	-	11	2	13	13
83-1	Anfeg	1.35	1,440	-	17	3	20	20
83-2	Aguersouak	1.62	1,945	-	23	4	27	27
85-1	Oumast	2.72	3,310	-	39	7	46	46
85-2	Ait Zitoun	2.55	3,160	-	37	7	44	44
86	Tagadirt	2.00	2,505	-	29	6	35	35

continue

Table 5.5-2 PV Module Capacity (2000) (2/2)

Douar		Maximum Output (kW)	Capacity of PV Module (Wp)					Nos. of PV System
			Flat terrain	Mount. terrain	75Wp	55 Wp	Total	
87-1	Zaouit	0.67	860	-	10	2	12	12
87-2	Izalaghan	0.95	1,215	-	14	3	17	17
88	Tigouder	1.97	2,300	-	27	5	32	32
89	Amezi	2.79	3,440	-	40	8	48	48
90	Agouni	2.31	2,805	-	33	6	39	39
91	Chaabat Tarik	4.10	5,140	-	59	13	72	72
92	Ighil Sdidene	1.09	1,365	-	16	3	19	19
93	Tizi	4.46	5,515	-	64	13	77	77
94	Aghbalou	6.80	8,430	-	97	21	118	118
95	Ait Hsain	1.03	1,345	-	15	4	19	19
96	Ait Boubker	1.21	1,440	-	17	3	20	20
97	Tazatourt	2.49	3,195	-	36	9	45	45
98	Tamsoulte	2.59	3,160	-	37	7	44	44
99	Tizgui	3.77	4,655	-	54	11	65	65
100	Ait Tirghit	3.76	4,600	-	54	10	64	64
101	Tachbibt Kabli	2.26	2,915	-	33	8	41	41
102	Tachbibt Echatoui	2.33	2,915	-	33	8	41	41
103	Asgoune	2.21	2,840	-	32	8	40	40
104	Ait Aamara Loued	6.05	7,625	-	87	20	107	107
106	Lakaama	2.19	2,730	-	32	6	38	38
13-1	Tarast	3.50	4,465	-	50	13	63	63
13-2	Assaka	3.34	4,370	-	48	14	62	62
117	Ansa	4.53	-	8,275	15	130	145	80
120	Ezzaouite	1.47	-	2,760	6	42	48	27
Total 71 (54+17)		233.19	201,080	132,525	2,555	2,574	5,129	4,094

(Total 333.605kW)

Table 5.5-3 Facility Output Under Diesel Generation (2010)

Douar		Maximum Output (kW)	Necessary Capacity (kW)	Installed Capacity	
				(kW)	(kVA)
23	Agouns	8.92	9.90	11.20	14.00
47	Lemdinat	10.59	11.70	14.00	17.50
48	Tnirt	15.03	16.70	21.60	27.00
50	Ansmrou	10.47	11.60	14.00	17.50
52	Toulkine	12.54	13.80	14.00	17.50
54	Douzrou	14.32	15.80	21.60	27.00
55	Ait Ourmane	9.84	10.90	11.20	14.00
59	Ait Smil	9.98	11.00	14.00	17.50
76	Ait Bourd	6.62	7.30	8.00	10.00
84	Ait Bouzid	7.80	8.60	9.60	12.00
114	Abadou	7.50	8.30	9.60	12.00
119	Ait Armene	7.05	7.80	8.00	10.00
Total 12		120.66	133.40	156.80	196.00

Table 5.5-4 Facility Output Under Micro-hydropoewr Generation (2010)

Scheme	Douar		Maximum Output (kW)	Installed Capacity (kW)	Dependable Capacity (kW)	Generated Energy(kWh) Rainy months	Dry months	Year
Adardour	46	Adardour	21.30	26.00	10.10	47,787	9,127	56,914
Inzaine	38	Inzaine	9.24					
	36	Addouz	6.68					
	35	Imin Tala	9.12					
	37	Ain Ghad	5.70					
	40	Dou Anammer	4.66					
	39	Imi N' isly	11.07					
	41	Igoundem	1.68					
	42	Toug Lkheif	5.52					
		Sub Total	53.67	62.00	27.00	129,344	19,556	148,900
Arg	11	Arg	9.81					
	10	Amsakrou	7.35					
	15	Ikiss	8.64					
		Sub Total	25.80	30.00	15.40	65,146	8,502	73,648
Alla Oumzri	6	Alla Oumzri	8.30	10.00	5.00	32,736	9,825	42,561
Id Ssior	7	Id Ssior	12.67	16.00	7.60	47,438	6,596	54,034
Anfli	21	Anfli	8.42					
	22	Timichi	7.96					
		Sub Total	16.38	20.00	20.00	39,245	12,847	52,092
Tidsi	118	Tidsi	4.46					
	-	Afra	7.53					
		Sub Total	11.99	15.00	4.20	14,137	8,066	22,203
Total 18			150.11	179.00	89.30	375,833	74,519	450,352

Table 5.5-5 Power System Load Under Extension of Existing Grid (2010)

Douar		Maximum Output (kW)	Grid Load (kW)
13-2	Imskar	3.49	3.84
24	Oulad Mansour	6.05	6.66
34	Tlat Tedrara	6.94	7.63
112	Lamhamid	2.63	2.89
115	Quriz	1.96	2.16
Total 5		21.07	23.18

Table 5.5-6 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 5.5-7 Composition of Cost Effectiveness for Optimum Generation 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
Alla 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

5.5.4 Selection of Pre-feasibility Sites

(1) Selection Strategy

In the previous section (5.2.3), optimum scale was examined for the 7 micro-hydropower sites and supply plan formulated which makes maximally efficient use of site potential. Of these, pre-feasibility study was later carried out after the master plan study stage to further upgrade survey accuracy for selected schemes deemed to have high development maturity and warrant early implementation.

Supplementary survey was and examination was done with regard to the following items as a basis, in close consultation with CDER, to evaluate development priority and subsequently select the candidate sites for pre-feasibility study.

Main evaluation items:

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)

(2) Evaluation of Development Priority

As a result of the above examination (see Table 5.5-8), development priority for each site was evaluated according to the following 3 levels.

Development priority A:	Development maturity is extremely high, and early implementation is warranted.
Development priority B:	Development maturity is high, and implementation following priority A schemes is warranted.
Development priority C:	Development maturity is somewhat high, and development is warranted upon completion of priority A and B schemes.

Table 5.5-8 Results of Study on Evaluation of Micro-hydropower Schemes

Micro-hydropower site	River (catchment)	Villages to be electrified: No. of villages	No. of households (Present / *Planned*)	Population (Present / *Planned*)	Access road	Need for adjustment between irrigation and hydropower discharge	River discharge: Drought discharge Q_{355} (m^3/s)	Low water discharge Q_{275} (m^3/s)
Adardour	Anougal (Amizmiz)	1	160 / *190*	700 / *847*	piste (L=20km)	yes	0.02	0.10
Inzaine	Anougal (Amizmiz)	8	407 / *483*	2,406 / *2,910*	piste (L=10km)	yes	0.07	0.33
Arg	Imenane (Rhenaya)	3	195 / *231*	1,940 / *2,347*	piste (L=12km)	yes	0.15	0.22
Alla Oumzri	Ougaedis (N'fis)	1	40 / *48*	280 / *339*	piste (L=2km)	no	0.10 (spring water)	0.10
Id Ssiar	<spring> (N'fis)	1	66 / *78*	500 / *605*	piste (L=6km)	no	0.10 (spring water)	0.10
Anfli	Ourika (Ourika)	2	123 / *146*	748 / *905*	piste (L=6km)	yes	0.08	0.46
Tidsi	Afoughal (Zat)	2	105 / *125*	916 / *1,097*	piste (L=7km)	yes	0.01	0.08

Note: For number of households and population, "present" indicates numbers as of 1997 and "planned" indicates planned values by 2010.

Results of evaluation ranking in line with the above are as follows:

1) Adardour site <u>Development priority A</u>

The intake point is located at the upper reaches of the river, and access road extends to the design site. Conditions of drought discharge, topography, geology, etc. are suited for micro-hydropower development. As target village is only 1, coordination of irrigation and power generating discharges is not a problem.

2) Inzaine site <u>Development priority B</u>

The intake point is located at the middle reaches of the river, and access road extends to the design site. Conditions of drought discharge, topography, geology, etc. are suited for micro-hydropower development. However, as target villages are 8, coordination of irrigation and power generating discharges is an issue which must be addressed.

3) Arg site <u>Development priority A</u>

The intake point is located at the middle reaches of the river, and access road extends to the design site. Conditions of drought discharge, topography, geology, etc. are suited for micro-hydropower development. Although target villages number 3, coordination of irrigation and power generating discharges is not seen to pose a problem.

4) Alla Oumzri site Development priority B

The intake point is located at the upper reaches of a mountain torrent, and spring water is utilized during the drought season. Conditions of topography, geology, etc. are suited for micro-hydropower development; however, 2 km of access road construction is necessary. As power station tailwater would be used for irrigation, coordination of irrigation and power generation discharges is not necessary.

5) Id Ssiar site Development priority C

The intake point is located at the upper reaches of a mountain torrent, and spring water is utilized during the drought season. Conditions of topography, geology, etc. are suited for micro-hydropower development; however, 6 km of access road construction is necessary. As target village is only 1, coordination of irrigation and power generating discharges is not a problem.

6) Anfli site Development priority C

The intake point is located at the upper reaches of the river, and conditions of drought discharge, topography, geology, etc. are suited for micro-hydropower development. However, 6 km of access road construction is necessary. As target villages are only 2, coordination of irrigation and power generating discharges is not a problem.

7) Tidsi site Development priority A

The intake point is located at the upper reaches of the river, and access road extends to the design site. Conditions of drought discharge, topography, geology, etc. are suited for micro-hydropower development. Although target villages number 2, coordination of irrigation and power generating discharges is not seen to pose a problem.

(3) Selection of Sites for Pre-feasibility Study

On the basis of the above study, the following scheme sites with a development priority classification of "A" were selected for pre-feasibility study.

No.	Scheme	Location	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

5.6.1 Start Up

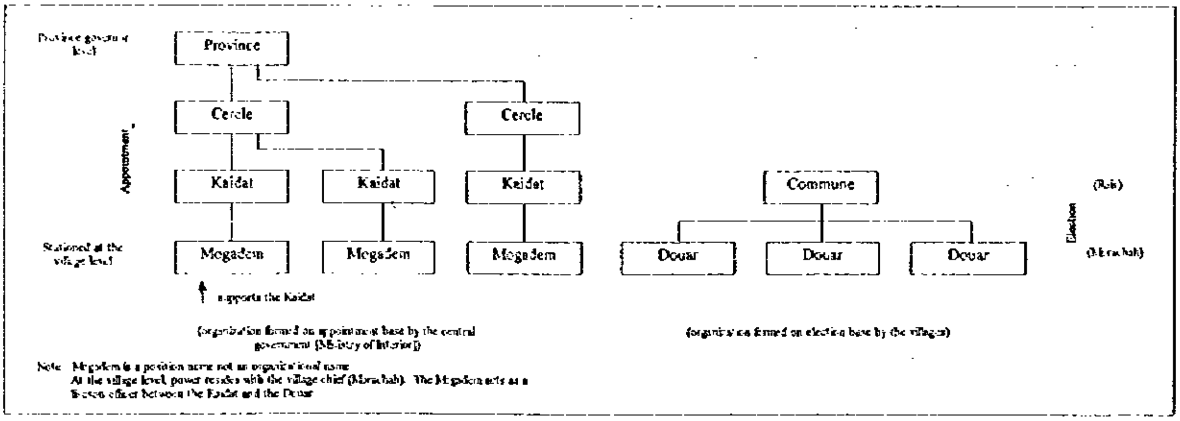
(1) Plan at Start up of Project

1) Creation of Users' Associations

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.

Formation of the envisioned users' associations and officer election is not considered to pose any problem since rural government administration in Morocco is carried out as well at the farmer level through village entities elected by the villagers themselves. Specifically, Moroccan rural administrative structure comprises two tiers, i.e. (i) a central government sub-organization in the region, (ii) a regional organizational structure comprising village units (Douar) which elect their own leaders and the super-organization (Commune) which encompasses multiple douars. In the case of (i), the head is appointed by the central government, while in the case of (ii) the douar forms the organizational foundation. The douar elect their leaders on the basis of self managed elections.

Figure 5.6-1 Government Administrative Organization and Village Organization



Nevertheless, attention must be given the influence on the users' associations by the village chiefs. There are many villages where the village chief is the only administrative officer who carries out both executive and accounting duties. Also, the village chief negotiates the allocation of road repair funds, etc. forthcoming from the Kaidat. The village chief in addition normally is a member of the electricity users' association in which capacity he impacts on the operation of the said association. Due to the village chiefs considerable direct and indirect connection with Project operation as seen from the foregoing, it would be appropriate to accord him an official advisory status with regard to the Project at the village level.

2) Establishment of Coordinating Committees

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 establish coordinating committees 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 commune, 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. (O&M role of the coordinating committees will be discussed later.) As indicated in Figure 5.6-1, the super-organization for the douar under the regional organizational structure is the commune. Accordingly, it would be effective to establish the coordination meetings at the commune unit level (possibly several communes in cases where number of douars in the separate communes is small), and have CDER chair the meetings.

(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. Also, labor costs for installation works at the village level in principal would be paid by the private contractor. However, provision of labor for access road construction would be expected to be provided by the government or villagers.

(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.

Of concern here is whether or not there would be sufficient demand for such a home use battery and whether a steady supply of the same would be possible. However, in unelectrified areas it is already a daily practice to recharge batteries at gas stations and utilize the same in the home, and in this regard a high demand for home use batteries is anticipated. In terms of supply, it is uncertain how available such batteries would be since marketing activities have not yet begun; however, the developers of the new battery are car battery manufacturers as well and it is assumed that effective distribution would be possible.

As to be discussed later, maintenance of the envisioned systems is to be performed in principle by private contractors, and this applies as well to battery replacement which would not be performed by the villagers themselves. If the contractors are instructed to procure the new home use type battery when replacement becomes necessary, this would serve to greatly reduce problems stemming from the type of battery used.

Also, In order to prolong battery life, it is important that battery discharge depth be controlled. If discharge depth can be kept below 50%, a 5 year life expectancy can be achieved even with currently available batteries. In the case of independent solar home systems where battery charge and discharge is repeated on a daily basis, establishment of an ample facility capacity will serve to prevent excessive discharge in light of the fact that there is no longer the need to transport the discharged battery to a charging station as has been the practice in the past.

5.6.2 Operation and Maintenance

In the case of development assistance including the subject Project, total investment will include a combination of funding under advantageous financial terms. In recent years a particularly frequent problem in this regard has been the economic and financial sustainability of the project after handing over to the recipient government. Where governments are fiscally strapped, supplemental financial support (in the form of subsidies, etc.) becomes difficult, and where such is done it often means budget reductions in other areas of publicly provided services. However, the subject project includes a mechanism for a certain degree of investment cost recovery, and therefore represents a mixed financing (quasi-government financing) approach. The important issue here is that (i) an appropriate supply cost (electricity tariff) is established for the publicly provided service (including maintenance), and (ii) that a high collection rate of monthly payments is sustained. Accordingly, the active use of the private sector in conjunction with the institutional capability of the executing agency is given emphasis to achieve the foregoing two.

(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. In the case of the French PPER project, there have been cases where the originally installed controllers malfunctioned and the villagers, realizing that battery charge was no longer possible, took it upon themselves to not wait until the controllers could be repaired, but rather directly connected the solar panel and battery by jumper cable. This resulted in a marked shortening of battery life. Also, as discussed previously, there are cases where the user has connected a battery, performance for which over time has dropped below a set voltage level, to radio and other appliances, resulting in excessive discharge and subsequent shortening of battery life. 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. The degree to which the foregoing can be effectively carried out will be the key to whether or not the PV generation system portion of the Project is sustainable. 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.

There are a number of contractors in Morocco which are engaged in the business of PV generation systems, and some of these have a very sophisticated level of technological expertise. Quite of few of these are based in Marrakech, and CDER has indicated its intention to make use of these for equipment installation, etc. Also, it is planned to electrify within this year some 90 villages mainly by PV generation under the French PPER phase II, and installation works in this regard will be performed by private contractors. In addition, with the support of Credit Agricole, efforts are underway in the private sector (NOOR WEB) to franchise (including necessary training) contractors in rural villages who are desirous of engaging in the marketing and after service of PV generation equipment. Ten months have elapsed since the start of this program, and already 6 contractors have begun operations in the villages. These firms maintain continuous liaison with ONE, and by the end of the year it is anticipated that some 30 contractors will be operating under franchise. In light of the foregoing, it is concluded that delegation of responsibilities for periodic equipment inspection to private contractors in Marrakech is amply feasible.

Content of inspection works will of course depend on the method of electrification; however, it is considered that daily inspection, weekly inspection, monthly inspection, 6 month inspection and yearly inspection would be conceivable. In the case of micro-hydropower and diesel generation, it is necessary the permanent operational personnel be stationed in the villages, and in this regard it is necessary that CDER and the private contractors train such persons to a level in the villages where they can perform on their own system operation and simple maintenance works. However, where more sophisticated facility repair measures are required under any of the envisioned systems (PV, diesel, micro-hydropower generation), the contractor so engaged would be called upon to perform the same. A 3 year after service period would be established, during which technicians of the private contractor would make frequent visits to the villages. During the same period, in the same manner as with the operational personnel, it will be necessary the CDER oversee that the general villager is trained to a certain level of maintenance technology. However, problems requiring more sophisticate levels of repair know-how can be expected to increase with aging of the systems. Accordingly, even after expiry of the above 3 year after service period, it would still be necessary that technicians of the private contractor still periodically visit the villages.

One conceivable approach in the above regard would be to permanently station an appropriately qualified technician at one location in each commune. This would be well in line with the present trend of private contractors in the Marrakech area moving into the area of generating system maintenance. A look at the example discussed above of expanded franchising of private contractors engaged in the installation of PV generation equipment indicates the feasibility of appropriately evaluated contractors desirous of marketing and installing equipment to establish agents in permanent residency in the village areas after having received basic training in equipment installation technology, and have these agents carry out equipment sale, installation and after service maintenance. To augment this, the franchised main company office would periodically dispatch highly trained engineers to visit its agents in the villages to resolve technical difficulties that may arise and carry out technology transfer. It is considered a high possibility that this trend will continue to grow in the future with regard to extension services for PV generating equipment and any assistance under Japan's cooperation program should make active use of such contractors at the system installation and maintenance level.

Also, in areas where such agents have not been established, it is necessary that contracts with the private contractor call for monthly service visits to the subject villages. However, in the case of such areas, there is the possibility that agents may not set up business under the above discussed franchise format. In this regard, contracts would call for periodic after service following facility installation, and contract zoning carried out for the Project area such that a single contract covers an appropriate combination of areas relatively easy to visit as well as more remote points in order to ensure the most effective after service activities. Method of users' monthly payment collection is discussed later.

Another conceivable approach would be to assign a responsible staff to the regional government administrative office (Kaidat, etc.) who would undertake periodic visits to the villages under his jurisdiction. However, in the event that this approach is adopted, there arise issues of potential lack of transportation means and budget. In light of the fact that the present policy of the Moroccan government is to utilize private contractors to the extent possible, the approach discussed here will not be considered under this Project.

(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). 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.

In the case of assistance forthcoming from Japan for the subject Project, it is concluded as well that a payment format and equipment ownership procedure taking into condsideration the above French and GTZ projects would be appropriate. However, it is necessary to look at precisely where ownership for all equipment and facilities should lie. Below, a details are presented in this regard with focus on PV generation for which system O&M is most difficult.

According to financial analysis in the case of PV generation, collection of a monthly payment per household of US$ 6.5 will enable system maintenance in the case of PV generating systems. Furthermore, US$ 6.5 per household is within the affordable to pay range of the targeted village population. A payment framework assuming a US$ 6.5 levy per month per household is indicated in the table below.

Table 5.6-1 Payment Framework Under Solar Home Systems (per household)

Item	Payment/ mo. (US$)		Collecting entity		Receiving agency
Electricity tariff (fixed)	1	→		→	CDER
Battery cost	3	→	Association	→	Banked by association (paid to contractor when necessary)
Maintenance cost	1.5	→		→	Private contractor
Association cost	1	→		→	Banked by association
Total payment	6.5				

Breakdown of monthly payment is a fixed electricity tariff of US$ 1, battery cost of US$ 3 (towards eventual battery replacement), maintenance cost to private contractor of US$ 1.5, and users' association cost US$ 1. This US$ 6.5 total is collected each month from each user household, out of which the electricity tariff is passed on to CDER and the maintenance cost to the private contractor. Battery cost and users' association cost is banked by the association.

In addition to the above monthly payment, a fixed join-up fee is paid to the users' association when a user becomes a member. With reference to other PV generation projects in the country, DH 500~1,000 per household would be considered an appropriate sum. This money would be banked along with the users' association cost portion of the user monthly payments, and serve as operating capital for the association. Details on intended use of this fund is discussed later.

Since electricity tariffs are minimized by a low initial investment recovery rate of 0%, equipment would remain in the ownership of CDER. If equipment were to be handed over to the users' associations prior to establishment of a functioning operation and maintenance structure, this would greatly diminish the right of CDER to remove equipment in cases where malfunctioning had occurred due to improper system O&M by the users, or in the event of extension of the existing grid into the target villages. Accordingly, the equipment is planned to remain under the ownership of CDER throughout the 20 year duration of the Project life.

(3) Relationship with GTZ Project

A micro-hydropower project is currently in progress in Asuni district under cooperation from Germany. The project site comprises 2 villages immediately downstream of villages targeted under this Project for electrification by PV generation, and upstream from other villages targeted under this Project for electrification by micro-hydropower. There is thus the potential that any imbalance in service under the two subject projects would be perceived among villagers as unfair.

It is necessary that the disadvantages of PV generation in terms of shorter hours of use, etc. compared to temporary or micro-hydropower sources of energy be clearly presented, and that explanation be made to the residents of the GTZ project area of the reasons for differences in payment framework with this Project.

(4) 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. The said training program in this regard would 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. With consideration to the foregoing, procedure in this regard would be as follows: ① At the time of coordinating meetings, CDER would collect the electricity tariff portion (monthly set fee) of the monthly payments by user households. ② During the first 3 years of Project operation, the O&M fees that otherwise would go to the private contractors would be banked by the users' association themselves and function as operating funds for the associations. After the third year of Project operation, the users' associations would then begin direct payment of the O&M cost portion to the private contractors. ③ The users' association cost and battery cost portion of the household monthly payments would be banked and managed by the associations.

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. In this regard, it would be assumed that (i) users' associations would be obligated to issue receipts and keep appropriate accounting records, (ii) copies of these would be submitted to CDER at the time of coordinating meetings, and (iii) CDER would take suitable measures to manage these records. Where households are delinquent in their monthly payments, disciplinary measures would be pursued on the basis of the said records which would comprise dismantling of system equipment for that household after elapse of a pre-determined warning period. In cases where records turn out to be incomplete to the point where it cannot be determined which households are delinquent in their payments, this would be deemed negligence on the part of the the users' association, who would then be forced to replace its officers after elapse of a pre-determined warning period.

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. This is the method adopted under PPER. Although no electricity use tariff is collected in the case of PPER, collected payments are banked separately depending on designation for loan repayment or O&M cost.

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. In the event of facility expansion, payment would be done on a monthly basis as up to that point via a combined payment of association join-up fee, facility use cost and users' association cost. In principle, it would be considered appropriate that the advanced payment to the private contractor for the initial 3 years of system after service be covered by outlay from this account as well; however, whether or not this can be done in actuality will depend on the financial and operational status of the associations.

(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. Direct technology transfer in effective management methodology would be achieved through the dispatch to CDER of expatriate management experts who would work closely with the agency in both the management of the subject Project as well as provide advice with regards to other CDER projects.

Particularly in the case of the solar home systems, the early stages of Project operation will involve a certain amount of trial and error utilization of equipment by the subject users. Although users will not be allowed to modify or customize the systems on their own, their will be the need on their part to learn that excessive electricity use such as running all the lights in the house at the same time that the TV is on will reduce in rapid battery voltage drop; while this can be avoided for example by turning off all the lights when viewing TV. However, it is anticipated that this will not be practiced in some households, resulting in excessive battery wear over the short term. Although users' association costs and battery cost are to collected at sums that include some safety margin, it would not be financially possible to respond to a sudden, large quantity replacement of batteries. If such a situation were to occur, it would be likely that electricity supply in the subject area would have to be suspended. Accordingly, it is extremely important that villagers be instructed in the correct use of equipment, either by home visitation by technical experts, or convening the user population of a single village at a designated location for instructional purposes. In undertaking such villager training, it would be anticipated that simple manuals, videos, and other appropriate educational media would be employed to heighten instructional effect. It would be possible in this regard to carry out a portion of this educational activity within the framework of the Japan Overseas Volunteer program.

Using lessons learned under the PV system educational program, the role of the JOV could then be expanded to an overall village development effort including villages electrified by micro-hydropower. Specifically in the mountain tourist area of Asni district, the PV generation and micro-hydropower schemes therein would provide a basis for village development based on simple processing of agricultural products.

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. Since it is normally anticipated that sunshine intensity is less in mountainous terrain than on level terrain, facility capacity for systems to be installed in the former are designed at 1.5 fold capacity those for level terrain under the Master Plan Study. In order to further upgrade the precision of facility capacity for mountainous areas, electrification on level terrain and in mountainous terrain would be done separately in the case of PV generation. 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. Accordingly, the 54 villages located on level terrain would comprise phase I, and the 17 villages in mountainous terrain would comprise phase II under the PV generation portion of the Project.

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 (100~230) 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. Since access road construction implies increased construction cost, priority was given in to hydropower schemes where access roads are already existent to some degree. 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 5.7-1)

(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)	506	2,068

Under Phase I above, 2,816 PV module sets would be procured an 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 (monthly installation rate would be 24 sets / assembly team). Since actual system installation can begin immediately upon arrival of the first shipments of modules in-situ, a 10~12 month assumed period for installation should be more than enough to complete the envisioned works within the overall allotted time period. In the case of Phase II, 2,313 sets would be installed within a 16 month period as is the case for Phase I.

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 a 2 month period will be required for the assembly and installation of each set, 2 assembly teams would be deployed to effect the required scheme construction within a 6 month 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. Canal features for each micro-hydropower site are as follows:

	Phase I	Phase II
Ardour scheme		
Headrace length (m)	685	--
Maximum discharge (m^3/s)	0.11	--
Arg scheme		
Headrace length (m)	1,175	--
Maximum discharge (m^3/s)	0.18	--
Tidsi scheme		
Headrace length (m)	750	--
Maximum discharge (m^3/s)	0.15	--
Inzaine scheme		
Headrace length (m)	--	1,200
Maximum discharge (m^3/s)	--	0.25
Anfli scheme		
Headrace length (m)	--	800
Maximum discharge (m^3/s)	--	0.25
Alla Oumzri scheme		
Headrace length (m)	--	600
Maximum discharge (m^3/s)	--	0.10
Id Ssior scheme		
Headrace length (m)	--	600
Maximum discharge (m^3/s)	--	0.10

As indicated above, the headrace length is greatest in the case of the Arg and Inzaine. Although it is planned under these schemes to use existing irrigation canal via rehabilitation and reinforcing works, a portion of new canal construction will be necessitated by differences in canal gradient and cross-section,.

Headrace construction would be carried out by a work group comprising an excavation sub-work group and canal structure sub-work group, each to comprise 8~10 workers. These groups would carry out their work tasks in parallel. Since work progress rate of 3 m/day is assumed for each sub-work group, total construction would by 1,200 m / 3 m / day / 25 days / month = 16 months. 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.

(3) Material and Equipment Procurement

Material and equipment procurement are assumed as follows on the basis of relevant survey:

	Main materials and equipment	Domestic procurement	Off-shore procurement
1) PV generating facilities			
	PV module	--	O
	Controller	--	O
	Battery	O	--
2) Diesel generating facilities			
	Diesel generator	--	O
	Distribution facilities	O	--
3) Micro-hydropower generating facilities			
	Civil facilities (including cement, steel, etc.)	O	--
	Turbine / generator	--	O
	Transmission / distribution facilities	O	--

Table 5.7-1 Project Implementation Schedule