JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CENTRE DE DEVELOPPEMENT DES ENERGIES RENOUVELABLES (CDER)
KINGDOM OF MOROCCO

MASTER PLAN STUDY ON DECENTRALIZED RURAL ELECTRIFICATION OF HAOUZ REGION IN KINGDOM OF MOROCCO

SUMMARY

JANUARY 1998

CHUO KAIHATSU CORPORATION
SANYU CONSULTANTS INC.

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COMPONENT OF THE REPORTS

ENGLISH

VOLUME-I	MASTER PLAN STUDY ON ELECTRIFICATION PLAN
VOLUME -II	PRE-FEASIBILITY STUDY ON MICRO-HYDROPOWER GENERATION
APPENDICES	INVENTORY
SUMMARY	

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RESUME

EXECUTIVE SUMMARY

I. Background and Objective of the Study

Rural electrification in Morocco commenced in the early 1980's with phase one of the Rural Electrification National Program (PNER-I), which was subsequently followed by phase II of the same program in the 1990's (PNER-II). However, as of 1994, rural electrification rate remains at 21% which is significantly lower that rural electrification rates in other countries of the same region (70~80%).

As a result, the Moroccan government has established rural electrification as a major policy objective, launching in 1993 the Decentralized Energy National Program (PNED) which aims at electrification via renewable energy sources including PV generation, micro-hydropower, etc. Further to this, the Global Regional Electrification Program (PERG) which integrates efforts under the aforementioned PNER and PNED was inaugurated in July 1995.

PERG aims at electrification of 2,000 villages by the year 2000, and ultimate completion of rural electrification nation-wide by 2010.

The subject Decentralized Rural Electrification of Haouz Region is a part of the PERG program. The Study in this regard comprises master plan study and pre-feasibility study components originally aimed at electrification of 6,200 households in 120 villages of the Haouz Region, which accounts for 9% of the households in the region. Current electrification rate of the said region is 14%. Electrification planning under the Study focuses on adoption of renewable energy sources including PV generation and micro-hydropower.

The electrification envisioned under the Study is to be completed by 2010, the same target year as adopted under PERG.

II. Study Components

The Study comprises the following stage-wise components which together make up a master plan for decentralized electrification of Haouz Region, and a pre-feasibility study for one part of that master plan.

(i) In the first stage of the Study, an inventory survey was carried out to ascertain the socio-economic conditions prevailing in the 120 villages contained in the original request for cooperation. Under the survey, a detailed investigation was carried out with regard to villager living standards, mode of livelihood and aspirations concerning electrification.

(ii) In the second stage of the Study, power demand was forecast for each village in response to conditions revealed as a result of the above inventory survey. Unit power desired per household was based in principal on the standard rural electrification criteria applied by CDER (Center for Renewable Energy

Development) of 65 W of power and 240 Wh/day consumption per household (87 W of power and 518 Wh/day of consumption per household in the case of micro-hydropower).

(iii) In the third stage of the Study, the optimum power supply facility plan was examined to meet the power demand calculated for each village. Candidate power supply categories were PV generation, micro-hydropower, diesel generation and extension of the existing grid, with the most appropriate approach being selected on the basis of technical and economical factors.

(iv) In the fourth stage of the Study, a pre-feasibility study was carried out for 3 of the 7 selected micro-hydropower schemes which were deemed most warranting of early development. The said pre-feasibility study was carried out for the following 3 scheme sites in order to ascertain technical and economical feasibility.

Site	Facility output (kW)	Household no.
Adardour	26	190
Arg	30	231
Tidsi	15	125

III. Formulation of Electrification Plan

(1) Target Villages for Electrification

Study was carried out for 120 target villages (7,272 households) as selected by CDER and confirmed in the Scope of Works and Minutes of Meeting signed between the Ministry of Energy and Mining (MEM) and the Japan International Cooperation Agency (JICA) on December 13, 1995.

As a result of this study, it was identified that a portion of the original villages are already slated for electrification by programs under ONE. Ultimately, 106 villages (present number of households: 6,205; design number of households under the Study: 6,938) were selected for electrification planning under this Study.

(2) Selection of Power Supply Source

Selection of power supply source was according to the following criteria.

(i) Electrification cost ceiling adopted by ONE for extension of the existing grid is DH 10,000/household. Accordingly, villages where power supply cost is under DH 10,000/household are to be electrified by extension of the existing grid.

(ii) With regard to villages where electrification cost is over DH 10,000/ household, consideration was given to the following technically feasible modes of electrification:

- PV generation
- Micro-hydropower
- Diesel generation

Since the area is not suited to adoption of wind power, this was eliminated from consideration.

(iii) Power demand for each power source category was basically determined adopting PERG criteria.

(PV generation, diesel generation)

- Maximum power per household: 65 W
- Consumed power per household: 240 Wh/day

(Micro-hydropower generation)

With regard to villages to be electrified by micro-hydropower, the fact that power generation of the same scale is possible both during the day and at night, and that facility scale is planned with leeway in mind, power demand values approximating scale of electrification aspired to by villagers on the basis of the questionnaire survey were adopted as opposed to the PERG criteria.

- Maximum power per household: 87 W
- Consumed power per household: 518 Wh/day

(iv) Concerning micro-hydropower as the energy supply source, field survey was carried out for the 28 villages preliminarily selected by CDER as candidates for electrification by this method. Ultimately, 7 sites were designated under the Study as exhibiting suitable natural conditions for micro-hydropower development. Number of villages finally selected for electrification under the said 7 schemes is 18.

In comparison to PV and diesel generation, micro-hydropower schemes feature less O&M cost, and accordingly becomes the most advantageous form of electrification in the case where facility construction cost is subsidized by the government. As a result, micro-hydropower was given priority for adoption under the Project for cases where natural site conditions provide adequate hydropower potential.

(v) With regard to diesel generation as the power source, pre-conditions for adoption are a steady and easily deliverable fuel supply, as well as availability of local technical and economic resources for generating plant operation and

maintenance. As a result, diesel generation was adopted under the Study only in the case of villages above a certain, appropriately determined size.

(vi) Under the category of PV generation, the 3 approaches indicated below are possible. However, the individual SHS (solar home system) was adopted under the Study whereby the PV module, battery, and controller are installed as one set in each household. This decision was based on the conclusion from past CDER experience that the BCS (battery charging station) and CDS (centralized distribution system) would pose technical and economical difficulties in Haouz Region in terms of system O&M.

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

IV. General Description of Electrification Planning

(1) PV Generation

PV generation (SHS) is as indicated below. Power is to be supplied by two types of PV module (75 Wp and 55 Wp) depending on the category of power demand (Wh/d), with module capacity as set out in the following table. Criteria assumed in this regard are 5.4 kWh/m²/d of sunlight volume (value in Marrakech) and 60% system efficiency.

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 subject to PV electrification are scattered in both plain and mountain areas. In the case of the later, a 50% surplus margin in module scale is adopted to compensate for estimated drop in sunshine intensity.

Number of villages to be energized by PV generation is 71. Total PV module capacity for the same is 233.19 kW.

General households:	3,213
Schools:	54
Street lights:	642
Mosques:	77
Clinics:	1
Commercial establishments:	111

(2) Diesel Generation

As a rural electrification method, diesel generation has been widely adopted in the past due to low cost of facility installation. However, this approach poses problems in terms of the need to deploy technical personnel for operation and maintenance, as well as the prerequisite for a stable and easily deliverable fuel supply. Given conditions in Haouz Province of numerous small villages scattered over a wide area, this is not the most advantageous approach in most cases.

However, in cases where numerous households are concentrated in a tight area with good road access for fuel delivery and availability locally of the technical capability for system operation and maintenance, diesel generation has been adopted under the Study.

The number of villages subject to electrification by diesel generation is 12, comprising the following:

General households:	2,136
Schools:	16
Street lights:	427
Mosques:	17
Clinics:	1
Commercial establishments:	62

Number of diesel generators is 12, with a total power output of 133.4 kW.

(3) Micro-hydropower Generation

Micro-hydropower is possible only under natural conditions of favorable discharge and available head. After examining the potential for micro-hydropower candidate sites in terms of natural conditions, suitability of ultimate micro-hydropower adoption was made on the basis of economic comparison with PV and other modes of energy supply.

A total of 18 villages are to be electrified under the 7 Projects by micro-hydropower, comprising the following:

General households:	1,301
Schools:	27
Street lights:	261
Mosques:	18
Commercial establishments:	49

In comparison to other power sources, demand under micro-hydropower schemes is set as larger under the Study as described above (maximum power at 87 W and consumed power at 518 Wh/day per household). In the target villages in this regard, it is envisioned that 236 units of refrigerator and 7 units of heater would be introduced.

Total output for the 7 sites of micro-hydropower generation is 179 kW, with breakdown as follows:

Site	Facility output (k)	Annual generated energy (kWh)
1. Adardour	26	56,914
2. Inzaine	62	148,900
3. Arg	30	73,648
4. Alla Oumzri	10	42,561
5. Id Ssior	16	54,034
6. Anfli	20	52,092
7. Tidsi	15	22,203
Total	179	450,352

Of the above, the Adardour, Arg and Tidsi sites where subject to pre-feasibility study under the Study.

(4) Extension of Existing Transmission Line

Consideration was also given the possibility of electrification by transmission line extension. Villages subject to such consideration were cases where per household electrification cost would be under DH 10,000, which is the ceiling set by ONE.

A total of 5 villages are planned for electrification by transmission line extension, comprising the following:

General households:	288
Schools:	6
Street lights:	58
Mosques:	8
Commercial establishments:	6

Overall electrification encompassing the above is summarized below.

VOLUME I : ELECTRIFICATION MASTER PLAN

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VOLUME II : MICRO-HYDROPOWER PREFEASIBILITY STUDY

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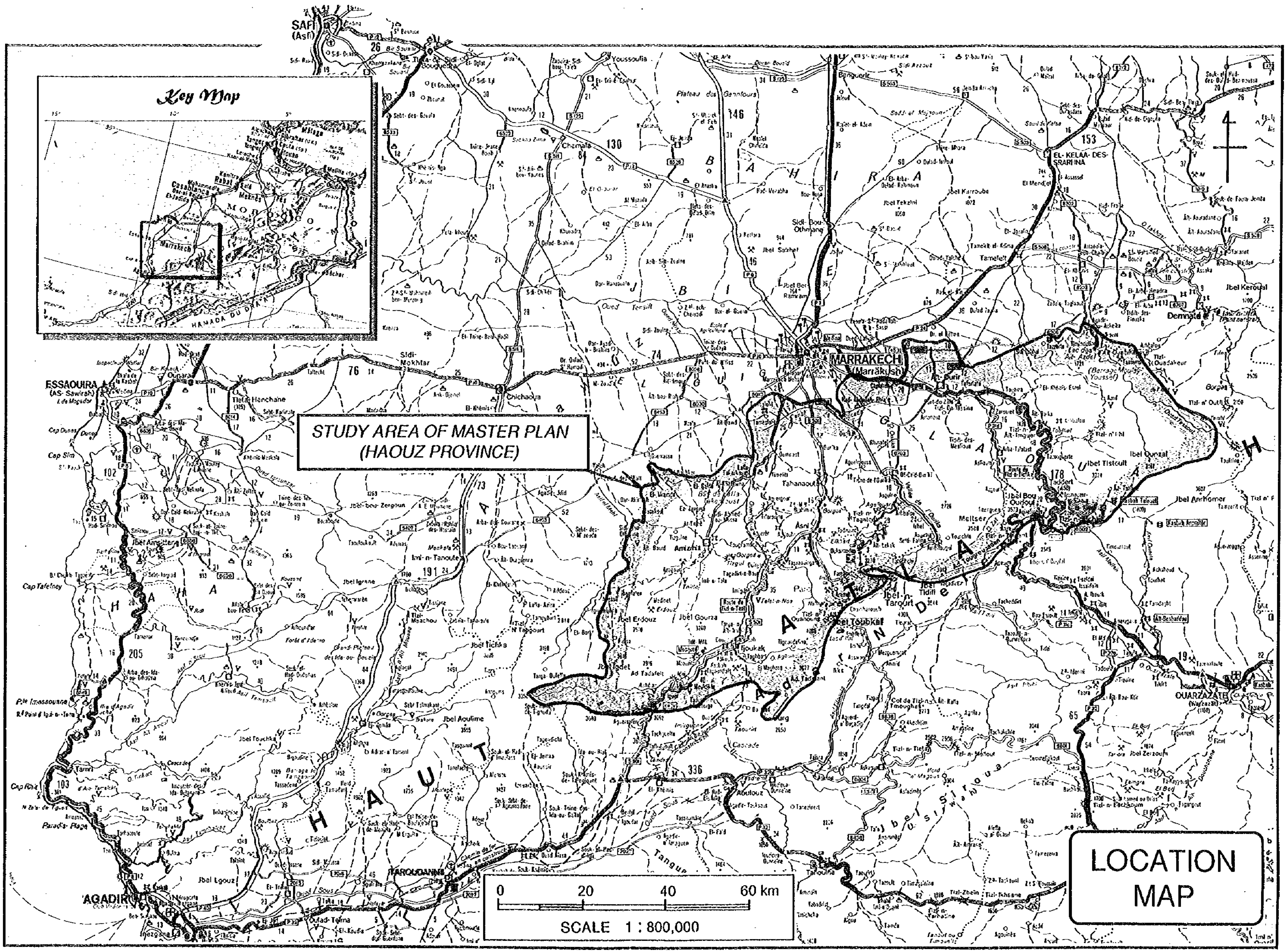
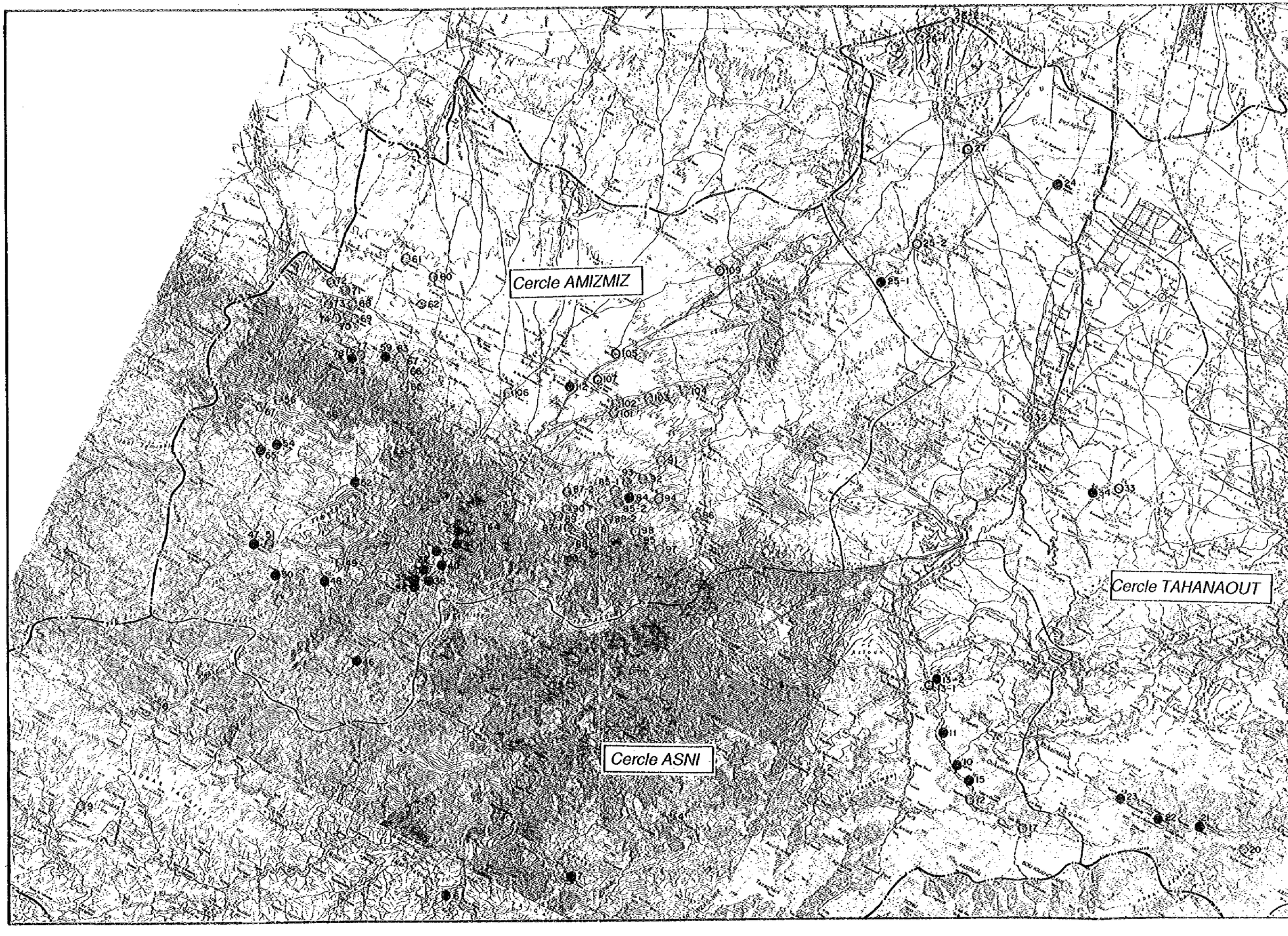
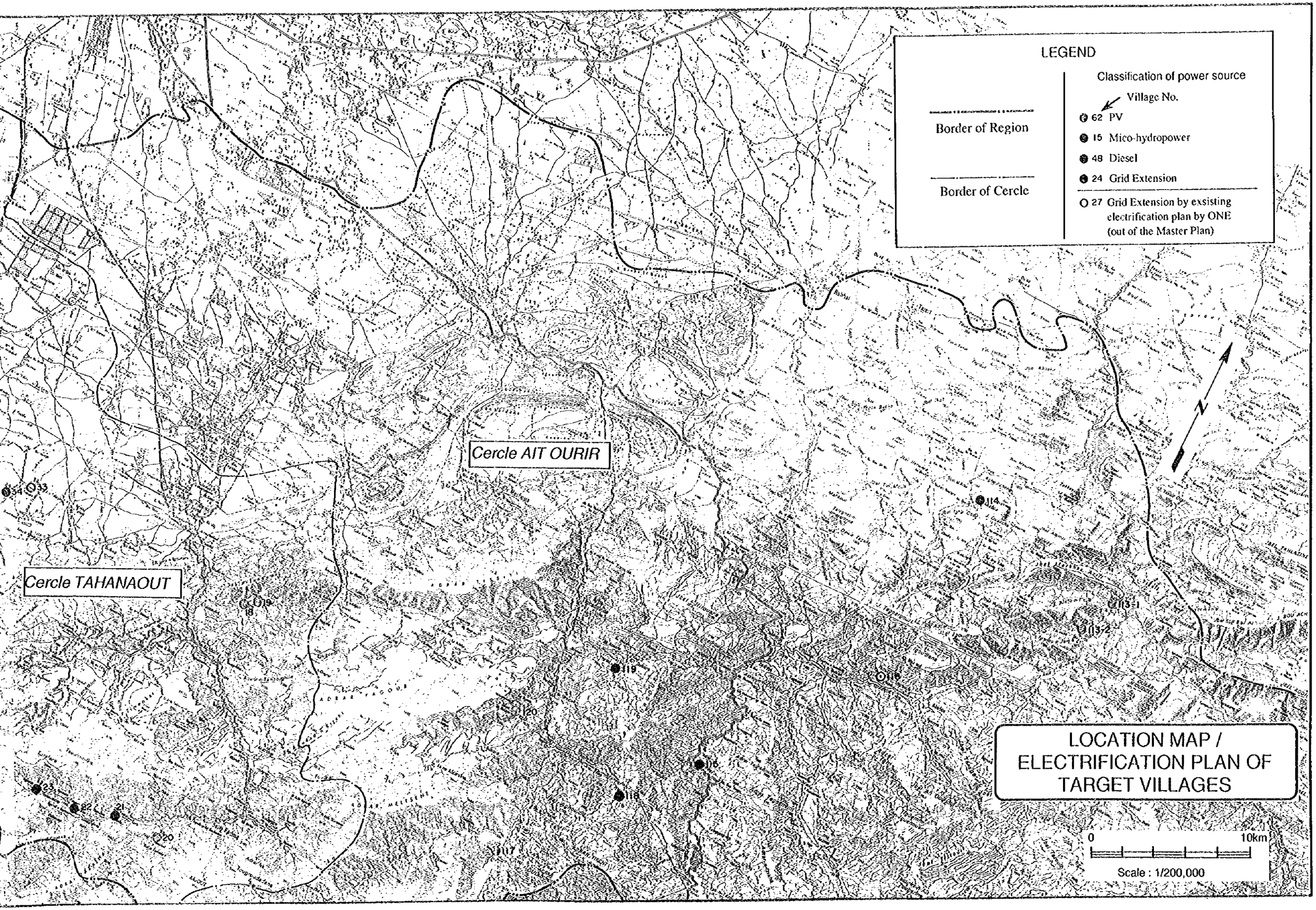
VOLUME I ELECTRIFICATION MASTER PLAN

Volume I embodies the Master Plan for electrification of 106 target villages selected from among an original 120 on the basis of questionnaire survey, and includes the results of financial and economic analysis.



Key Map
STUDY AREA OF MASTER PLAN
(HAOUZ PROVINCE)
LOCATION
MAP
0 20 40 60 km
SCALE 1 : 800,000
SAFI (Asfi)
Youssoufia
Benguerir
EL-KELAA-DES-SRARHNA
ESSAOUIRA (AS-Sawirah)
Chichaoua
MARRAKECH (Marrâkush)
Demnate
Imi-n-Tanoute
Tahanaout
Amizmiz
Asni
Ijoukak
Jbel Toubkal
OUARZAZATE (Warzazat)
TAROUDANNT
AGADIR
H A U T
A T L A S


Cercle AMIZMIZ
Cercle ASNI
Cercle TAHANAOUT


LEGEND
Classification of power source
Village No.
Border of Region
62 PV
15 Mico-hydropower
48 Diesel
Border of Cercle
24 Grid Extension
27 Grid Extension by exsisting electrification plan by ONE (out of the Master Plan)
Cercle AIT OURIR
Cercle TAHANAOUT
LOCATION MAP / ELECTRIFICATION PLAN OF TARGET VILLAGES
0
10km
Scale : 1/200,000

MASTER PLAN STUDY ON ELECTLIFICATION PLAN

Decentralized Electrification Plan by CDER

Power source	Nos. of Douars
Photovoltaic	71
M-hydropower	18
Diesel	12
total	101

Electrification plan by ONE

Power source	Nos. of Douars
Grid extension	5

Grand total of nos. of douars under the Masterplan Study	106

List of power source by Masterplan Study (1/2)

Cerele	Commue R.	Douar		Selected power source	Responsible agency	Scheme No.
		No.	Name			
Asni	Ouirgane	1	Tizi Oussem	Photovoltaic	CDER	P-01
		2	Id Aissa	Photovoltaic	CDER	P-02
		3	Tassa Ouirgane	Photovoltaic	CDER	P-03
	Imgdal	4	Igrem	Photovoltaic	CDER	P-04
	Talat N'Yacoub	6	Alla Oumzri	M-hydropower	CDER	H-10
	Ijoukak	7	Id Ssior	M-hydropower	CDER	H-20
	Ighil	8	Aghella	Photovoltaic	CDER	P-05
	Aghbar	9	Ikiss	Photovoltaic	CDER	P-06
	Asni	10	Amsakrou	M-hydropower	CDER	H-31
		11	Arg	M-hydropower	CDER	H-32
		12	Tinerhouhrine	Photovoltaic	CDER	P-07
		13-2	Imskar	Grid extension	ONE	G-01
		15	Ikiss	M-hydropower	CDER	H-33
		17	Tacheddirt	Photovoltaic	CDER	P-08
Tahanaout	Ourika	18	Sqour	Photovoltaic	CDER	P-09
		19	Amagdour	Photovoltaic	CDER	P-10
		20	Tamaterte	Photovoltaic	CDER	P-11
	Settifadma	21	Anfli	M-hydropower	CDER	H-41
		22	Timichi	M-hydropower	CDER	H-42
	Oukaimeden	23	Agouns	Diesel	CDER	D-01
	Tamesloht	24	Oulad Mansour	Grid extension	ONE	G-02
		26-1	Awin Mazouz	Photovoltaic	CDER	P-12
		26-2	Bouchiha Bon Omar	Photovoltaic	CDER	P-13
		30	Bel Abbas	Photovoltaic	CDER	P-14
		32	Derb Chem's	Photovoltaic	CDER	P-15
		34	Tlat Tedrara	Grid extension	ONE	G-03
Amizmiz	Anougal	35	Imin Tala	M-hydropower	CDER	H-51
		36	Addouz	M-hydropower	CDER	H-52
		37	Ain Ghad	M-hydropower	CDER	H-53
		38	Inzaine	M-hydropower	CDER	H-54
		39	Imi N'isly	M-hydropower	CDER	H-55
		40	Dou Anamer	M-hydropower	CDER	H-56
		41	Igoundem	M-hydropower	CDER	H-57
		42	Toug Lkheif	M-hydropower	CDER	H-58
		43	Ait Ouzkri	Photovoltaic	CDER	P-16
		44	Ait Hmad	Photovoltaic	CDER	P-17
		45	Tizgui	Photovoltaic	CDER	P-18
		46	Adardour	M-hydropower	CDER	H-60
	Azgour	47	Lemdinat	Diesel	CDER	D-02
		48	Tnirt	Diesel	CDER	D-03
		49	Anermi	Photovoltaic	CDER	P-19
		50	Ansmrou	Diesel	CDER	D-04
		51	Talat Ait Ihla	Photovoltaic	CDER	P-20
		52	Toulkine	Diesel	CDER	D-05
		53	Adghouss	Photovoltaic	CDER	P-21

List of power source by Masterplan Study (2/2)

Cercle	Commue R.	Douar		Selected power	Implemented by	Scheme No.
		No.	Douar			
Amizmiz	Azgour	54	Douzrou	Diesel	CDER	D-06
		55	Ait Outmane	Diesel	CDER	D-07
		56	Tagadirt	Photovoltaic	CDER	P-22
		57	Tifirt	Photovoltaic	CDER	P-23
		58	Anfrioune	Photovoltaic	CDER	P-24
	Dar Jamaa	59	Ait Smil	Diesel	CDER	D-08
		60	Tifratine	Photovoltaic	CDER	P-25
		61	Aguenze	Photovoltaic	CDER	P-26
		62	Ifit Baragha	Photovoltaic	CDER	P-27
		63	Agadir Baragha	Photovoltaic	CDER	P-28
		65	Adar Baragha	Photovoltaic	CDER	P-29
		66	Tadchert	Photovoltaic	CDER	P-30
		67	Tamsoult	Photovoltaic	CDER	P-31
		68	Dar Jamaa Ait Ali	Photovoltaic	CDER	P-32
		69	Agadir Ait Brahim	Photovoltaic	CDER	P-33
		70	Iouraghan	Photovoltaic	CDER	P-34
		71	Imiki	Photovoltaic	CDER	P-35
		72	Ifit Ait Alla	Photovoltaic	CDER	P-36
		73	Boukhelf	Photovoltaic	CDER	P-37
		74	Addar Ait Ali	Photovoltaic	CDER	P-38
		76	Ait Bourd	Diesel	CDER	D-09
		77	Ait M'Barek	Photovoltaic	CDER	P-39
		78	Agadir Ait Bourd	Photovoltaic	CDER	P-40
		79	Afella Ouassif	Photovoltaic	CDER	P-41
	Ameghrass	81	Afella Ighil	Photovoltaic	CDER	P-42
		83-1	Anfeg	Photovoltaic	CDER	P-43
		83-2	Aguersouak	Photovoltaic	CDER	P-44
		84	Ait Bouzid	Diesel	CDER	D-10
		85-1	Oumast	Photovoltaic	CDER	P-45
		85-2	Ait Zitoun	Photovoltaic	CDER	P-46
		86	Tagadirt	Photovoltaic	CDER	P-47
		87-1	Zaouit	Photovoltaic	CDER	P-48
		87-2	Izalaghan	Photovoltaic	CDER	P-49
		88	Tigouder	Photovoltaic	CDER	P-50
		89	Amezi	Photovoltaic	CDER	P-51
		90	Agouni	Photovoltaic	CDER	P-52
		91	Chaabat Tarik	Photovoltaic	CDER	P-53
		92	Ighil Sdidene	Photovoltaic	CDER	P-54
		93	Tizi	Photovoltaic	CDER	P-55
		94	Aghbalou	Photovoltaic	CDER	P-56
		95	Ait Hsain	Photovoltaic	CDER	P-57
		96	Ait Boubker	Photovoltaic	CDER	P-58
		97	Tazatourt	Photovoltaic	CDER	P-59
		98	Tamsoulte	Photovoltaic	CDER	P-60
		99	Tizgui	Photovoltaic	CDER	P-61
		100	Ait Tirghit	Photovoltaic	CDER	P-62
	Sidi Badhaj	101	Tachbibt Kabli	Photovoltaic	CDER	P-63
		102	Tachbibt Echatoui	Photovoltaic	CDER	P-64
		103	Asgoune	Photovoltaic	CDER	P-65
		104	Ait Aamara Loued	Photovoltaic	CDER	P-66
		106	Lakaaina	Photovoltaic	CDER	P-67
		112	Lamhamid	Grid extension	ONE	G-04
Ait Ourir	Ait Aadel	113-1	Tarast	Photovoltaic	CDER	P-68
		113-2	Assaka	Photovoltaic	CDER	P-69
	Abadour	114	Abadou	Diesel	CDER	D-11
	Zerkten	115	Quriz	Grid extension	ONE	G-05
		-	Afra	M-hydropower	CDER	H-72
	Tighdouine	117	Ansa	Photovoltaic	CDER	P-70
		118	Tidsi	M-hydropower	CDER	H-71
		119	Ait Atmane	Diesel	CDER	D-12
		120	Ezzaouite	Photovoltaic	CDER	P-71

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

As of 1994 the electrification rate of rural areas in Morocco has reached only 21% which is clearly a low level in comparison to 84% for the same in the case of Egypt, 80% for Algeria and 70% for Tunisia.

Against the above background, the Government of Morocco has accorded high priority to rural electrification and has pursued the same through a number of basic programs formulated since the beginning of the 1980s. Under the Global Regional Electrification Program, it is planned to complete electrification of all rural area by the year 2101, at a rate of roughly 100,000 households per annum over the 15 year period 1996~2010.

Against the above background, the Ministry of Energy and Mining (Renewable Energy Development Center [CDER] as counterpart agency) requested cooperation from the Japanese government in the formulation of a master plan for the electrification of Haouz Region, targeted at the energizing of 120 villages.

1.2 Study Objective

The objective of the Study is to formulate a master plan for electrification of 120 villages in Haouz Province on the basis of an inventory study to be carried out for all alternatives to meet electricity demand of the area, including micro-hydropower, PV generation, etc., and to identify and carry out a pre-feasibility study for high priority micro-hydropower sites. Further to the above is the transfer of technology from the JICA Study Team to the Moroccan side counterparts such that the said counterparts will be capable of independently executing future studies similar to this Study. Technology transfer is to be achieved through study works performed jointly by the Team experts and there counterparts in the respective disciplines under the Study and will aim to upgrade the planning capability of the Moroccan side in the rural electrification sector.

1.3 Scope of the Study

The Study is to be carried out in accordance with the Scope of Work and Minutes of Meeting as signed on December 13, 1995 between the JICA Preparatory Study Team and Ministry of Energy and Mines (MEM) of the Kingdom of Morocco. The Study comprising the stages is described below.

(1) Inventory Study and Master Plan Formulation

An Inventory Study is to be carried out for the target 120 villages in Haouz Region to examine the electrification options including micro-hydropower, PV generation, extension of the existing grid, etc., and on this basis formulate a master plan for rural electrification of the region.

(2) Pre-feasibility Study

Topographical survey, geological survey, meteo-hydrological survey, structural design, environmental survey and economic - financial analysis will be carried out for the 3 high priority sites. Recommendations will also be made on future project planning, and organizational set up for operation and maintenance.

1.4 Study Execution

The Master Plan Study was commenced in March 1996 and was completed in January 1998.

1) Inventory Study:

First phase field works	May 19 ~ October 15, 1996	(submittal of Inception Report) (preparation · submittal of Progress Report 1)
First phase home office works	October 1 ~ December 30, 1996	(preparation of Interim Report)

2) Pre-feasibility Study:

Second phase field works	January 15 ~ March 21, 1997	(submittal of Interim Report) (preparation · submittal of Progress Report 2)
Third phase field works	May 11 ~ June 9, 1997	
Second phase home office works	June 10 ~ August 29, 1997	(preparation of Draft Final Report)
Fourth phase field works	October 25 ~ November 8, 1997	(submittal of Draft Final Report)

1.5 Modification of Number of Target Villages

Under the original request by the Moroccan government, 120 villages were targeted under the master plan study. In the course of the Study, the following modifications in target villages were made on the basis of such criteria as redundancy with other on-going projects, etc. The final number of 106 target villages was determined in close consultation with CDER. (see Table 1-1 and section 3.6 for detail)

Table 1-1 Trace of the changes of target villages for the study

					Number of Douars (-)	Number of Douars (+)
1) Number of nominated douars by CDER at initial stage					120	
2) Number of excluded douars due to exsisting electrification plan of ONE or GTZ, confirmed at preparatory meeting of reconnaissance survey on 03/June/96.					-10	0
<Excluded Douars>						
No.		Douars	Commune Rurale	Cercle		
(1)	5	Tizgui (GTZ)	Imgdal	Asni		
(2)	14	Tanghist (GTZ)	Asni			
(3)	16	Ouanskra (GTZ)				
(4)	28	Tilouna (ONE)	Tahanaout	Tahanaout		
(5)	29	El Mars (ONE)				
(6)	31	Azib Skeum (ONE)				
(7)	80	Ameghras (ONE)	Ameghrass	Amizmiz		
(8)	108	Tayzelt (ONE)	Sidi Badhaj			
(9)	110	Makhfamane (ONE)				
(10)	111	Tizifrite (ONE)				
3) Number of excluded douars due to newly founded electrification plan of ONE. And replaced or newly proposed by CDER and Houz Provincial Office during reconnaissance survey.					-3	7
No.		Excluded douars	Newly proposed	Commune Rurale	Cercle	
(1)	10	Tagadirt N'Ait Ali	Amsakrou	Asni	Asni	
(2)	12	Ouaouesseft	Tinerhouhrine			
(3)	13	Tinitine	El Bour			
(4)	13 -2	-	Imskar			
(5)	25 -2	-	Oumnas	Tamesloht	Tahanaout	
(6)	26 -2	-	Bouchiha Bon Omar			
(7)	113 -2	-	Assaka	Ait Aadel	Ait Ourir	
4) Number of excluded douars due to the exsistance of douars was not found during reconnaissance survey.					-3	0
No.		Excluded douars	Reason of exclusion	Commune Rurale	Cercle	
(1)	64	Baragha	no existence	Dar Jamaa	Amizmiz	
(2)	75	Ait Ali	no existence			
(3)	82	Ighil	duplication with No.81, and combined as Affella Ighil	Ameghrass		
5) Number of divided douars due to administrative reason, as confirmed by the Caidat Office					0	3
No.		Initial douars	Divided douars	Commune Rurale	Cercle	
(1)	83	Agoursouker Aufg	Anfeg	Ameghrass	Amizmiz	
	83 -2		Aguersouak			
(2)	85	Oumast Et Ait Zitoune	Oumast			
	85 -2		Ait Zitoun			
(3)	87	Zaouit Izlaghan	Zaouit Izalaghan (Dar Brahim Ou			
	87 -2		Ali)			
Total of decrease and increase					-16	10
Balance					-6	
Number of douars for the Inventory Survey					114	
6) Number of newly nominated douars for mycro-hydropower scheme at planning stage.					0	1
No.		Douars	Commune Rurale	Cercle		
(1)	-	Afra	Zerkten	Ait Ourir		
7) Number of excluded douars due to the newest electrification plan of ONE confirmed at final stage of field survey.					-9	0
No.		Douars	Commune Rurale	Cercle		
(1)	13 1	El Bour	Asni	Asni		
(2)	25 1	Oulad Lahjar	Tamesloht	Tahanaout		
(3)	25 2	Oumnas				
(4)	27	Del El Ain				
(5)	33	Sour Tedrara	Tahanaout			
(6)	105	Igouder	Sidi Badhaj	Amizmiz		
(7)	107	Ait Aamar El Bour				
(8)	109	Chouirige				
(9)	116	Tabant Ighi	Zerkten	Ait Ourir		
Total of decrease and increase					-9	1
Balance					-8	
Number of douars for the Masterplan Study					106	

CHAPTER 2 SOCIO-ECONOMIC CONDITIONS

2.1 Socio-economic Conditions of Haouz Province

2.1.1 General Condition of the Study Area

(1) General Conditions

- Haouz province within which the Study area lies belongs to the Tensift Economic Zone, which is one of the major economic zones of Morocco. Marrakech is an economic center of the Tensift Economic Zone.

- Population of Haouz province is 434,810 as of 1994, which is equivalent to 12% of the population of the Tensift Economic Zone, or 1.7% of the national population. Population density is 70/km^2 in the province.

- The province is divided into 4 cercles, which are Asni, Tahanaout, Amizmiz and Ait Ourir.

- Agriculture and stock raising are the dominant industries in the province. Most of the province is mountainous area, where access to many villages is difficult. Villages are thus isolated from outside civilization, and without electricity service.

- The province is backward in literacy rate and education, with about 50% of males and 70% of females not attending school.

(2) Commune Rurales in the Study Area

Cercle:	Asni	Tahanout	Amizmiz	Ait Ourir	Total
No. of commune rurales	7	6	10	15	38
Urban areas	--	1	1	1	3

(3) Topographical Classification of the Study Area

From the aspect of altitude, the Study area is divided into four (4) categories as indicated below:

Topographical classification:	Flat	Piedmont	Hilly	Mountainous
Elevation (m):	7	6	10	15

2.1.2 Population and Households of Haouz Province and the Study Area

(1) Population and Households according to National Census

According to the National Census (1994), the population of Haouz province is 434,810, of which rural population accounted 92%. Total households is 67,444, and average members of one household are 6.4 .

(2) Changes in Commune Rurales Make-up of the Four Cercles of Haouz Province

Statistical data for 1994 was applied as base data for the Study. This is in light of the fact that population and households on a cercle-wise basis within the province cannot be comparatively studied on the basis of year wise statistical data due to emergence in some cases of new commune rurales as a result of population shifts within the province.

(3) Growth Rates for Population and Households in Haouz Province

The Study adopted the following rates in this regard (1982~94 data of the Department of Statistics)

Population growth rate : 1.37% (regional)
Household growth rate : 1.24% (regional)

2.1.3 Industries in Haouz Province

(1) General

- Agriculture and stock raising are the dominant industries, while commerce and mining are minor.
- Average annual income per household is estimated at DH 29,000 in the Study villages, of which agriculture and stock raising account for 46% and 32%, (total of 78%) respectively.
- Average working members per household are 3.3 persons, with ratio of working member composition at 73% for the agricultural sector.

(2) Agriculture, Livestock and Forestry

(Agriculture)

- Agricultural land comprises 20.5% of the total area of the province, and major crops are cereal crops such as wheat and barley, and tree crops such as olive, almond and apples.
- Almost all land holdings are under 5 ha (87%). Average land holding size in the 4 cercles of the Study area is 4.42 ha.

- Gross income from major crops is highest for apples (DH 24,000/ha), followed by vegetables (DH 10,000/ha), pulses/potato (DH 8,750/ha) and cereals (DH 2,400/ha)

(Livestock)

- In addition to agriculture, livestock is important in the province. Livestock raising accounts annually for about DH 9,400 or 32% of the total income per household.

- Livestock (cattle, sheep, goat, donkey / mule) of about 535,000 head are raised in the province, and average livestock population per household is 8.8 head.

- Farm gate price of livestock products is DH 4,700 /head for cattle, DH 340 /head for sheep, DH 280 /head for goat, DH 30 /bird for poultry, DH 2.90 /lit for milk and DH 0.90 /egg for chicken eggs.

(Forestry)

- Forest covers an area of about 2,723 km^2, or 44% of the total provincial area.

- Forest is administered and protected as a resource by the "Service Forestier de Marrakech (Forest Service of Marrakech)". The most dominant tree species is holm oak, which accounts for more than half of the forest area.

- 88% (2.4 t per household) of consumed firewood is collected from forest.

(3) Industry

Industry is not yet developed in Haouz province, although the province is located favorably in terms of close distance from Marrakech. The cottage handicraft industry reportedly employs 6,000 persons and is significant for the province.

(4) Tourism

Although Haouz Province is rich in tourism resources, these have not been fully developed. It is recommended that the electrification planning under the subject Study be pursued in order to achieve the desired development of these resources.

(5) Mines

Major mining in Morocco is phosphate mining; however, little of this resource is found in Haouz province. Major mines of the province are zinc, lead, copper, barium and rock salt. In particular, production of zinc accounts for 82% of national production.

2.1.4 Road Conditions in Haouz Province and in the Study Area

(1) Road Classification

Roads are classified into two categories, namely trunk road (under the responsibility of the Ministry of Public Works) and communal road (under the responsibility of the commune rurale. Trunk roads are further classified into national road, regional road, and provincial road. Communal roads are further classified into piste roads, tertiary roads, and footpaths.

(2) Accessibility

Among the above roads, the communal roads play a more important role than the trunk roads in access to the remote villages. The roads actually leading into the villages are mainly piste roads (unpaved, but motorable) and/or footpaths (passable on foot or by donkey), with very few tertiary roads (passable by cart) available. Accordingly, accessibility is generally governed by the length and altitude of piste road and footpath.

2.1.5 Social Conditions in Haouz Province

(1) Public Water Supply

Provision of public water supply is under the responsibility of "Office Nationale de l'Eau Potable (ONEP)". However, ONEP has carried out water supply development only in urban area, and no public water supply systems are consequently available in rural area including the Study area. As a result, villagers must prepare their own water supply systems privately or jointly by means of providing wells or conveying water from streams and springs.

(2) Education

The educational system in Morocco comprises Koranic school (ages 3~4), preschool (ages 3~6), primary school - first cycle (ages 6~12), primary school - second cycle (ages 12~15), secondary school (ages 16~18) and university. Up through the primary school - first cycle, education is compulsory. School enrollment rate in the Study villages remains at only around 40%.

2.2 Socio-economic Conditions of the Study Villages

2.2.1 Study Villages

Through several meetings with CDER and concerned organizations such as ONE and the Haouz Provincial Office, the originally requested 120 villages where ultimately modified to 114 as follows:

	CDER Initial Plan	Study Douars
Douars	120	114
Households	8,219	7,272
Population	49,305	45,556

2.2.2 Distribution of the Study Villages

Cercle-wise breakdown of numbers of commune rurales and Study villages is as follows:

Cercle	Nos. of commune rurales	Nos. of Study villages
Asni	7	15
Tahanaout	5	16
Amizmiz	5	74
Ait Ourir	4	9
Total	21	114

2.3 Questionnaire Survey

2.3.1 Execution of Questionnaire Survey

(1) Methodology of the Questionnaire Survey

The questionnaire survey was carried out under contract basis as follows:

Contractor	:	Maghreb Projets
Period	:	June~July 1996
Target villages	:	113 (no. of households: 7,227; population: 45,169)
Questionnaire recipients	:	Village leaders (113 persons) and households (992 households, 13.7 of total)

(2) Major Items of the Questionnaire Survey

The questionnaire to the village leaders comprised 17 items, and that to the village households comprised 13 items, as a basis for identifying socio-economic conditions in the Study area.

(3) Software for Compilation and Methodology of Creation of Inventory

The results of the questionnaire survey have been compiled by SPSS software by the Contractor. On the basis of questionnaire survey results, data analysis was done and an inventory prepared which comprises a village-wise data base for 114 villages. Inventory items are as follows:

- Electrification
- Socio-economy and environment

- PV generation facilities
- Micro-hydropower facilities
- Diesel generation facilities

2.3.2 Analysis of Findings of Questionnaire Survey

Results of questionnaire survey for the 992 sampled households in the Study villages were collated according to the following categories, and applied as base data for the Study.

(1) Analysis of household and houses
(2) Analysis of household budget and occupations
(3) Analysis of energy consumption
(4) Electricity related analysis
(5) Analysis of drinking water and irrigation water
(6) Analysis of natural conditions and disasters
(7) Analysis of environmental aspects
(8) Public and industrial facilities

2.3.3 Questionnaire Survey Analysis

The Study Team tabulated the questionnaire survey results for the foregoing items (1)~(8), and analyzed the same with regard to the following:

Questionnaire item	Content of analysis
(1) Analysis of household and houses	No. of household members, rooms, dwelling dimensions, family composition and dwelling type for the 4 cercles and 21 commune rurales
(2) Analysis of household budget and occupations	1) General nature of income; 2) agricultural and animal husbandry income,; 3) no. of agricultural workers, and annual expenditure and expense per household
(3) Analysis of energy consumption	1) Annual fuel consumption per household and 2) annual expenditure for fuel per household
(4) Electricity related analysis	1) Proliferation of electrical appliances, 2) electrification level desired by villagers and 3) capacity of average household to pay for electricity
(5) Analysis of drinking water and irrigation water	1) Sources of potable and irrigation water and 2) status of insufficiency of potable and irrigation water
(6) Analysis of natural conditions and disasters	No. of villages which suffer from flooding and landslide, and elevation range for occurrence of the same
(7) Analysis of environmental aspects	Commune rurales which suffer from excessive tree cutting and overgrazing, and elevation range for occurrence of the same
(8) Public and industrial facilities	Nature of public and industrial facilities

2.4 Supplemental Survey of Previous Decentralized Electrification Projects

In order to reflect the results of planning under decentralized electrification projects in other provinces in the subject Study, supplemental survey was carried out of projects executed under the Pilot Project for Rural Electrification (PPER) as indicated below.

Province	Description	Supplemental survey method
Aziral	PV generation and micro-hydropower	Questionnaire survey
Safi	PV generation	Interview survey and existing data collection
Errachidia	Diesel generation	Interview survey and existing data collection

2.4.1 Case Study of Electrification in Azilal Province

(1) Project Scale

The said project was completed in June 1995 with assistance from the French government. Battery charging facilities for PV generation and micro-hydropower facilities were established to service 195 households (benefit population: 1,473) in 5 villages.

(2) Salient Project Features

Beneficiary Villages and Households in the Azilal PPER Project

Project Beneficiary Villages	Total Households		Member Households		Sample Households	
	Households	Population	Households	Rate	Households	Rate
Micro-hydrostation	**108**	**810**	**98**	**90.7%**	**10**	**9.3%**
Tirika	48	405	46	95.8%	4	8.3%
Ait Yahia	30	190	27	90.0%	3	10.0%
Ait Oukrim	30	215	25	83.3%	3	10.0%
PV Battery Station	**87**	**663**	**56**	**64.4%**	**8**	**9.2%**
Aghri	42	301	26	61.9%	4	9.5%
Oukta	45	362	30	66.7%	4	8.9%
Total	**195**	**1,473**	**154**	**79.0%**	**18**	**9.2%**

(3) Project Operation and Maintenance

1) PV Battery Charging Station

The total of 84 batteries are rotated from one household to another by the 56 subscriber households. A special association elected under law by the villagers has been created for PV electrification.

2) Micro-hydropower Facilities

Operation of the micro-hydropower schemes is by associations of beneficiaries (run by a president and 10 other officers).

(4) Project Impact

Beneficiaries under the project evaluate the impact of the micro-hydropower and PV battery charging stations are as follows:

- Children are able to continue school studies at night
- Adults are able to continue working at night
- TV viewing hours per day have increased

Degree of satisfaction with project impact is as follows:

	Greatly satisfied	Moderately satisfied	Dissatisfied
Micro-hydro	60%	40%	0%
PV generation	25%	37.5%	37.5%

(5) Current Problems affecting Aziral PPER

Supplemental survey indicated the following problems (causes are described in the annexed materials).

1) Problems with Battery Charging Station under PV Generation

- Battery life is too short
- There is no way to tell to what degree the battery has been recharged
- Sufficient O&M support is not available
- There is a wide disparity in the quality of fluorescent light tubes, with some lasting up to 1 year, while other fail after only 1 month.
- In addition to problems with battery life, excessive discharge rate results in batteries being unusable.
- Portable amorphous PV panels experience a drop in output after 1 year of use.

2) Problems with Micro-hydropower Facilities

- Generating capacity is not sufficient to meet power demand growth
- Generation shuts down during storms
- Certain beneficiaries do not pay their monthly electricity tariffs
- Two blackouts occur weekly.
- Milling machines are not used very much.

2.4.2 Study of Safi Province and Errachidia Province

(1) PV Generation in Safi Province

<General Project Description>

Method of electrification is by PV battery charge station (BCS), as well as individual home installed systems (SHS) at the option of the users. The location of the BCS facility is 20 km from Safi city center, near the coast. Project description is as follows:

No. of targeted villages	:	10
No. of electrification associations	:	10
No. of targeted households	:	544
No. of subscribers serviced	:	339 = 62%
No. of subscribers on waiting list	:	119 = 22%
No. of facility expansions	:	189 = 56%
Total no. of subscribers including waiting list	:	458 = 85%

(2) Diesel Power Generation in Errachidia Province

<General Project Description>

Under the PPER project, Errachidia province was selected as representative of the Atlas range southern slope ~ sub-Sahara zone characterized by low rainfall. Within the province, the villages of Tigra-Ait Ouakki (Assoul C.R.), Lahroun (Amellago C.R.), and Meissi (Meissi C.R.) were further selected as experimental villages for the introduction of diesel generating facilities. Project features are as indicated below.

Village name	Tirga-Ait Ouakki	Lahroun	Meissi
Province	Errachida	Errachida	Errachida
Circle	Assoul	Assoul	Arfoud
C.R.	Assoul	Amelago	Meissi
Location:			
X	522	542	544
Y	157.5	153	70
Elevation (m)	1,500	1,280	825
No. of households	130	82	102
Member households	112	70	90
Public electrical facilities			
Mosques	3 × lighting kit 2 × amplifier	1 × lighting kit 1 × amplifier	1 × lighting kit 1 × amplifier
Street lighting	13	7	9
Schools	1 × lighting kit	1 × lighting kit	2 × lighting kit

CHAPTER 3 BASE STUDY FOR PLAN FORMULATION

3.1 Natural Conditions in the Study Area, and Need for Electrification

The Haut Atlas mountain range with 3,000 masl class peaks runs along the south boundary of Haouz Province within which the Study villages lie. The highest peak is Mt. Toubkal at 4,167 masl. Topography exhibits steadily descending elevation moving northward through foot hills and hill tracts to the Haouz plain at 500~600 m elevation. The Study villages are scattered through this area of varied topography. Asa result, a tremendous amount of labor is required for energy resupply (battery recharge, fuel delivery, etc.). Also, in order to obtain fuel wood, deforestation has progressed with dangerous impact on the natural environment.

3.2 Survey of Natural Conditions

3.2.1 Meteorology as Indicated by Existing Data

In the basin of the main tributaries there exits some meteorological synoptic posts, however, the whereabouts of their data records could not be confirmed. Accordingly, the data obtained from the Meteorological Station in Marrakech, which has relatively long-term observation records, was used to comprehend the general meteorological conditions of the Study area.

(1) Climate of the Study Area

Marrakech is situated inland and exhibits a continental climate with Mediterranean undertone. Temperature throughout the year differ greatly, with low temperatures occurring in the winter. Monthly mean temperature fluctuates from 11.8° C (January) to 29.2° C (July). Maximum monthly temperature fluctuates from 18.4° C (January) to 37.7° C (July). Minimum monthly temperature fluctuates from 5.3° C (January) to 20.8° C (July). Humidity fluctuates from 40.9% (July) to 58.5% (January). Daylight hours fluctuate from 197.8 hr (February) to 324.6 hr (June). Rainfall fluctuates from 1.8 mm (June) to 52.7 mm (March)

Although Marrakech (El 463 m) is located in relatively low piedmont of the Atlas range, the Study area is almost all higher mountain terrain. Accordingly, meteorological conditions are more severe than that of Marrakech, particularly with regard to low temperatures and heavy snow in the winter.

(2) Precipitation

Daily rainfall record and isohyetal map were collected to study flood discharge and spatial characteristics of precipitation. Daily rainfall data for 15 years (1980/81 - 1994/95) were collected for 5 observation stations in the Study area.

3.2.2 Temperature and Rainfall Estimates

The meteorological observation stations on the northern slope of the Haute Atlas range to the south of Marrakech are almost all located below 2,000 m elevation, have only sparse data, and carry out no observations other than for rainfall and temperature. The records were deemed inappropriate for the Study due to numerous time gaps, and low reliability.

To address this, average temperatures and rainfall amounts for the Project area was estimated by extrapolating from records available at the Marrakech observation station.

(1) Temperature

Due to the fact that data is sparse for observation stations at higher elevations corresponding to that of the Project area, mean monthly temperatures were estimated according to 5 existing gauging stations and 7 micro-hydropower scheme areas.

(2) Precipitation

Since the micro-hydropower scheme sites are at points of high elevation of the Haute Atlas piedmont, observation data is almost non-existence as in the case of other general meteorological data. Rainfall amount was accordingly calculated assuming a straight line proportional relationship between rainfall and elevation up to a certain altitude.

3.2.3 Hydrological Survey

(1) Hydrological Data Collection

In order to survey the generation potentiality of the envisioned microhydro sites, existing gauging stations in the study area were surveyed. As a result five (5) existing gauging stations were identified, and the data from these adopted for the Study.

(2) Study of Hydrological Data

1) Basin Hydrological Characteristics

In order to identify hydrological characteristics of the subject basins, runoff coefficients and specific discharges for each of the Study area basins were calculated, and these values checked by comparison with runoff coefficients and specific discharges for the Study area from other existing data.

2) Average Discharge

The daily discharge data were used to estimate mean daily, monthly and yearly discharge for the hydrological years of the gauging stations.

3) Design Discharge

Daily discharge data of each hydrological year for the stations were sequenced in ordinal magnitude to obtain the design discharge, Q_{max}-Q_{365}.

The specific value of Q_{185} and Q_{275} ranges from 5.37-2.72 l/s/km^2 and 3.11-0.7 l/s/km^2, respectively, indicating that discharge characteristics differ greatly from basin to basin.

3.2.4 Sunshine Intensity in Mountain Region

The Study area in Haouz Province is located on the southern side of the Atlas Haut range at elevations ranging 500~2300 m. The Study area exhibits an average 5.3~5.6 kWh/m²/day, placing its sunshine intensity value within the 5.3~5.6 kWh/m²/day range.

In the case of adopting PV generation systems in the mountainous areas of Haouz region, there will be numerous instances where the subject villages are located in valleys. Accordingly, locations of PV generation systems have been confirmed in the field such that effective sunlight hours available would be not be reduced due to blockage of sunlight by mountain mass.

On the other hand, it is anticipated that there will be some differentiation between plain and mountain areas in terms of frequency of cloud cover and rainfall. Although it would be best to install sunshine meters in the target mountain villages for precise collection of data on sunshine hours, due to the constraints under the Study it was decided instead to request a record of weather conditions to be taken at the time of water level gauging at the discharge observation stations as a basis for inferring fair weather rate (%).

Under the subject Master Plan, capacity of PV generating modules for systems in mountain villages which meet the criteria below is to be 1.5 times that of systems targeted for plain region in order to achieve design power supply during periods of lesser sunshine intensity.

① Villages located at elevations over 1,500 m
② Villages where rainfall is in excess of 600 mm per year

3.3 Base Data Study for Electrification Planning

3.3.1 Villager Aspirations regarding Electrification, and Affordability to Pay Electricity Tariffs

Villager aspirations regarding electrification, and affordability to pay electricity fees as identified through socio-economic questionnaire survey are as follows:

① 98% of villagers desire electrification to power lighting, radio and television appliances. Those desiring electrification solely for lighting, or solely for television and radio use comprise only 2%.

② 21% of villagers also desire electrification for other electrical appliances such as refrigerator, etc.

③ Village chiefs and average villagers indicate an average capacity for initial investment of DH 1,990 and DH 1,050, respectively.

④ Village chiefs and average villagers indicate an average affordability for monthly electricity fees of around DH 140 and DH 70, respectively.

⑤ Annual village household income is over DH 30,000, of which DH 15,000 is saved.

Under PERG projects, beneficiaries pay 25% of investment. Where this is paid on an installment basis, the amount is DH 40 per month over a 7 year period; when paid in a single lump sum the amount is DH 2,252. (In the case of a 50 W PV system, cost is DH 9,000, 25% of which is DH 2,250.)

3.3.2 Study on Electrification by Extension of Existing Transmission Lines

Distance from existing 22 kV transmission line to target villages was categorized into two, i.e. (i) 5 km or more from existing lines, or (ii) over 10 km distance, or power line routes would be over very rugged terrain, as a basis for carrying out a preliminary study of the appropriate method of electrification.

3.3.3 Village Household Number, Population and Residential Area

Number of households and population for power forecast were calculated on the basis of 2010 as the target year, and the results of this calculation applied as base data for electrification planning.

3.3.4 Nos. of Facilities to Utilize Power By Category

(1) Schools to be Electrified

The present status of the target villages as of 1996 with regard to schools was studied. Power demand forecast for schools was based on assumptions of (i) that the number would not increase in the future, and (ii) the number of light fixtures per school.

(2) Public and Commercial Facilities to be Electrified

The present status as of 1996 of the target villages with regard to public and commercial facilities was collated for each village.

(3) Present Status of Flour Milling and Pottery Industries

The present status as of 1996 of the target villages with regard to flour milling and pottery industry was studied. However, the power demand for these industries was considered outside the scope of the subject Study (see section 5.3 (2)-1)).

3.4 Base Study of Power Supply Source

A base study was carried out for the 5 decentralized electrification options for the Study area as indicated below.

(1) PV generation
(2) Wind power
(3) Micro-hydropower
(4) Diesel generation
(5) Extension of existing transmission line

Of the above, (4) is basically eliminated from consideration as a renewable energy source; however, this mode of electrification will be pursued where so desired by the subject villagers. With regard to (5), this is considered as a viable power source option where conditions are judged optimum for the same.

(1) PV Generation

PV generation is adopted as a power source under the envisioned project due to the fact that in the case of the Haouz region daily sunshine hours fall within the range 5.3~5.6, as well as the fact that mountain shadow does not impact on effective sunshine hours per day.

(2) Wind Power

In the case of electricity generation by wind power, a minimum wind velocity of 5~6 m/s is necessary. In the case of the Haouz region, wind velocity is a low 2~3 m/s which indicates wind conditions insufficient for wind power generating schemes. Accordingly, this method of electrification has been eliminated from consideration under the Study.

(3) Micro-hydropower

The Haut Atlas range extends along the south of Haouz Province, and is a region of relatively abundant rainfall (400~500 mm per year) in Morocco. Topographically, the area features sharp topography with ample head available along mountain rivers and torrents. Accordingly, micro-hydropower has been adopted as an electrification method under the Study.

(4) Diesel Generation

Although diesel generation is not a renewable energy source, it represents a mode of decentralized rural electrification which has been pursued in the past. In light of the fact that diesel generation requires a constant supply of fuel, conditions of fuel transport to the envisioned site is a major item to be examined when considering the adoption of this mode of electrification.

(5) Extension of Existing Transmission Line

Villages in the Study area which are to be connected to the existing grid by projects already underway by ONE have been eliminated from planning under the Study. However, in the case of other villages which in the course of planning are deemed to be effectively serviced by connection to existing transmission line, extending the grid remains as a candidate option under the Study. In cases where villages are ultimately designated as most appropriate for connection to existing transmission line, implementation is to be carried out by ONE within its own project framework.

3.5 Study on Methods of PV Generation

(1) Methods of PV Generation

Comparative study was carried out for the following 3 candidate methods of PV power supply under the envisioned Project:

① SHS: solar home system
② BCS: battery charging system
③ CDS: centralized distribution system

(2) Evaluation of the 3 Methods

Of the 3 types of conceivable PV generation method, ① (SHS) is adopted where user households are scattered, and power demand is extremely small. Method ③ (CDS) is on the other hand adopted where user households are located in relatively concentrated manner, and comparatively robust power demand is present. Method ② (BCS) is not given high marks on the basis of past performance on projects which have adopted this method. Specifically, users feel inconvenience in the need to carry batteries to recharging stations, and there are cases where users neglect the proper timing for battery recharge which results in excessive discharge and subsequent shortening of battery life. Accordingly, this method is eliminated from incorporation under the Study.

(3) Comparison of SHS and CDS

A case study was carried out for the SHS and CDS methods as a basis for comparison of construction cost and technical evaluation in light of the differing design of the two types of system. On the basis of this study, it was determined not to adopt the CDS under the Study (CDER likewise was negative with regard to CDS).

1) Quantitative Comparison

Results of quantitative comparison of SHS and CDS are as follows:

Item	Solar home system	Centralized method
Supplied power	Direct, low voltage current (12 V, 24 V)	Alternating current (110 V, 220 V); requires transformer and inverter
Distribution line	Not necessary	Distribution line necessary from power source to each user
Facility site	Household roof or pole near house is sufficient	Space must be sufficient for panel and power source equipment installation, and battery placement
Engineering and maintenance works	Possible with simple technical skills	Sophisticated electrical engineering skills required
Method of use	Improper use has no impact on other users	Excess utilization by one user impacts on other users
Electrical equipment	Requires direct, low voltage current equipment only	Standard electrical equipment available on the market can be used
Connection to grid	Some improvements required	Can be easily accomplished

2) Comparative Case Study

Comparative study examined construction cost for 3 cases, i.e. 50 households, 100 households and 150 households.

Construction Cost Comparison

unit: US$/household

No. of households	SHS	CDS
Case 1 (50 households)	1,050	1,960
Case 2 (100 households)	1,050	1,560
Case 3 (150 households)	1,050	1,293

(4) Technical Evaluation

In cases where numbers of user households and individual demand per user are small, method evaluation from a technical standpoint indicates the following disadvantages for CDS. As a result, it was concluded that the SHS approach would be more effective under the Project.

① Costly transmission and distribution facilities are necessary.
② System reliability is poor (with regard to post construction O&M)

(5) PV Generation Methods used in Morocco

PERG, the umbrella program for the decentralized electrification under this Study, assumes adoption of either the SHS or BCS approach. On the basis of discussions with CDER (counterpart agency for the Study) at the start of field works, it was confirmed that CDER was in favor of SHS adoption under this Study.

(6) Future Issues

The PV electrification methods of SHS and CDS have respective advantages and disadvantages in terms of construction cost and O&M after construction. In consideration of the future connection of the subject area targeted for electrification to the main power grid, it is desirable that various technological developments be further pursued with regard to the centralized system such as small capacity NFB (no fuse breaker) and improvements in terms of transmission loss.

3.6 Target Villages for Electrification under the Master Plan

(1) Confirmation of Villages to be Electrified by ONE

At the start of the phase 1 field works, it was identified that 7 of the 120villages contained in the original Study request were already slated for connection to the existing grid under electrification planning already in effect by ONE. These were accordingly eliminated from the scope of the Study. Also, during the latter part of the said phase 1 field works, another 3 villages were identified as already subject to ONE electrification planning and these too were eliminated from the Study scope.

In order to preclude any other redundancy in electrification planning, detailed study of ONE's electrification program was carried out in close collaboration with the agency, and as a result an additional 9 villages were identified as warranting exclusion from the Study.

(2) Target Villages for Electrification under the Master Plan

The inventory survey was carried out for 114 villages. Due to exclusion of the 9 villages indicated above, the total number of villages was reduced to 105. However, with the addition of one village (not included in the original request) for electrification by micro-hydropower, the final number of target villages for electrification under the Master Plan is 106 (see section 5.2).

CHAPTER 4 POWER SURVEY

4.1 Electric Power Situation in Morocco

4.1.1 Electric Power Enterprises

The energy sector in Morocco is under the jurisdiction of the Ministry of Energy and Mining (MEM). The counterpart agency for this Study, CDER (Center for Renewable Energy Development), as well as ONE (National Electric Power Corporation) as well fall under the supervision of MEM.

Public power generation power projects are carried out solely by ONE; however, there are some private companies that develop power for private use. The latter account for only 12~13% of total on-line facility scale.

Control of power transmission projects is the sole jurisdiction of ONE; nevertheless, there are public distribution entities which supervise power distribution in such large urban centers as Casablanca and Marrakech in which case power is bought from ONE for sale to area consumers. Table 4-1 indicates entities engaged in electric power distribution and their respective proportions of total power sales.

Table 4-1 Public Power Distribution Entities

Name	Service area	Sales proportion (%)
ONE	All residential area excluding public authorities	46.3
Public authority:		51.7
RAO	Casablanca, Mohamadia, Ain Harouda, Beni Iklef	24.3
RED	Rabat-Sole, Tamara, Skhirati, Bouznika, Boaknadel	7.3
RADEEF	Fes	4.0
RAID	Tanger, Asilah	4.0
RDE	Tetouan, Larache, Chefchaouen, M'Dig	3.3
RADEEA	Marrakech, Sidi-Bou-Outmane	2.9
RADEEM	Meknes	2.6
RAK	Kenitra, Mehdia, Fourat	1.7
RADEES	Safi	0.9
RADEEJ	El Jadida, Azemmour, Sidi Bouzid, Chtouka, Moukay, Abdellah	0.6

4.1.2 Power Generation and Consumption

Total annual generated power in 1991 was 9,874 GWh (8,675 GWh by ONE and 1,199 GWh by private companies). ONE thus accounts for 88% of total power generation. Total power sales by ONE amount to 7,765 GWh with transmission and distribution power loss at around 11%.

Table 4-2 shows the annual generated power for the period 1986~1992, and Table 4-3 indicates annual power consumption by use for the period 1982~1991.

Table 4-2 Annual Generated Power

(unit: GWh)

Year	ONE			Private			Total
	Thermal	Hydro	Subtotal	Thermal	Hydro	Subtotal	
1986	4,075	1,025	5,100	480	17	497	5,597
1987	5,918	806	6,724	715	0	715	7,439
1988	6,622	936	7,558	1,407	1	1,408	8,966
1989	7,001	1,157	8,158	923	0	923	9,081
1990	7,412	1,220	8,632	1,285	0	1,285	9,917
1991	7,409	1,266	8,675	1,199	0	1,199	9,874
1992	8,030	981	9,011	1,314	0	1,314	10,325

Table 4-3 Annual Power Consumption

(unit: GWh)

Voltage range	Purpose	1982	1989	1990	1991
High and middle voltage	Industry	1,478	2,215	2,330	2,470
	Mining	529	687	721	720
	Public utilities	209	418	452	475
	Agriculture and fishing	246	392	430	442
	Potable water	201	274	299	330
	Transportation and communication	169	257	285	307
	Commercial and service	239	205	227	236
	Subtotal	3,071	4,448	4,744	4,980
Low voltage	Power	73	99	113	113
	Public	93	190	218	210
	Household	1,197	2,106	2,268	2,462
	Subtotal	1,363	2,395	2,599	2,785
	Total	4,434	6,843	7,343	7,765

4.1.3 Power Facilities

As of 1995, ONE owns 2,531.8 MW of thermal capacity, 926.7 MW of hydropower capacity for a total of 3,458.5 MW of power generating facilities. Transmission facilities comprise the high voltage transmission grid which has been established mainly along the coast providing power to such major urban centers as Casablanca, the capital of Rabat, etc. Trunk transmission lines are 225 kV cable, supplemented in some areas by 150 kV lines. In rural areas (for example Haouz province), transmission lines are 60 kV capacity. Medium voltage distribution lines presently comprise 20, 22, 30 and 5.5 kV cables; however, ONE is currently in the process of standardizing these at 22 kV capacity. In Haouz province, these are all 22 kV.

4.1.4 Power Demand Forecast

ONE's power demand forecast for the period 1992~2010 envisions 8% power demand growth rate per annum to the year 2000, after which demand growth would be 7%. In 1994, CDER and ONE jointly decided on a strategy for renewable energy development. Unelectrified households in Morocco stood at 1,921,958 (population: 12,650,033) and this number is anticipated to increase to 2.3 million households (population: 13.8 million) by 2003 and to 2.6 million households (population: 15.9 million) by 2010.

However, power demand forecast was revised in 1996 to envision power demand growth of 4% in 1996, and 6% for the period 1997~2010. The revision was prompted by the difficulty in extending the existing grid into rural areas due to the distances and costs required.

4.1.5 Power Source Development Plan

The power source development plan by ONE in response to power demand growth envisions thermal generating capacity of 3,892 MW and hydro / wind power generating capacity of 1,326.5 MW by the year 2004 (total generating capacity of 5,218 MW). In 1997, the decentralized rural electrification plan (ERD) was launched under PERG to improve electrification rates in rural areas by means of decentralized energy systems (PV generation, etc.).

4.1.6 Electricity Tariffs

As an alternative strategy to the immediate term grid expansion program by ONE, the Global Regional Electrification Program was launched on August 2, 1995 aimed at global rural electrification. As a result, the electricity tariff structure in Morocco is two-tiered, i.e. tariffs set by ONE and tariffs under PERG.

(1) ONE Tariffs

The ONE electricity tariff framework assumes a base charge depending on power used, to which a surcharge is added of DH 0.842/kWh for electricity for lighting purposes, and DH 1,060/kWh for electricity used to energize facilities, appliances,

equipment, etc. Under the framework, monthly electricity fees for the typical household are DH 20~40.

(2) PERG Tariffs

The PERG program aims to electrify all regions of Morocco by 2010, at an annual rate of 100,000 households over the 15 year period 1996~2010. To achieve this, project costs are to be borne 25% by the beneficiary households, 20% by the commune rurales / users' associations, and the remaining 55% by ONE. Examples of cost burden sharing for each type of electrification are described below:

1) Extension of Existing Transmission Line

In the case of cost sharing by ONE, the commune rurale and the beneficiary households:

Criteria: Villages to be energized are selected by COSPER (National Rural Electrification Committee)

Cost sharing: -The commune rurale bears a cost of DH 2,085 (in the case of payment by installment, this becomes DH 500 per year for 5 years) for each beneficiary household.
-Each beneficiary household bears a cost of DH 2,252 (in the case of payment by installment, this becomes DH 40/month for 7 years).
-ONE bears the remaining cost.

2) Diesel Generation

In the case of cost sharing by ONE, the commune rurale and the beneficiary households:

Criteria: Villages to be energized are selected by COSPER (National Rural Electrification Committee)

Cost sharing: -The commune rurale bears a cost of DH 2,085 (in the case of payment by installment, this becomes DH 500 per year for 5 years) for each beneficiary household.
-Each beneficiary household bears a cost of DH 2,252 (in the case of payment by installment, this becomes DH 40/month for 7 years).
-ONE bears the remaining cost.

3) PV Generation

PV generation comprises solar home systems installed in individual households. Energizing capacity is 4 lights.

Cost sharing: -The users' association bears a cost of DH 1,440 for each beneficiary household.
-Each beneficiary household bears a cost of DH 60/month for 7 years.
-ONE bears the remaining cost.

4.2 Rural Electrification in Morocco

4.2.1 History of Rural Electrification

Rural electrification commenced in the 1970's under programs carried out by Le Ministere de l'Energie et des Mines and Ministere de l'Agriculture et de la Mise en Valeur Agricole. In 1975, a special fund for electrification was established corresponding to 4.5% of ONE's development profit. The fund was applied to grid expansion projects for ONE's supply service centers.

In the early 1980's, the Moroccan government launched The National Rural Electrification Program (PNER) aimed at ultimately electrifying all rural areas in the country. The program is being implemented in 2 stages. According to the study report (Sigmatrch, May 1987) at the conclusion of PNER-1, living standards in electrified villages had been improved and economic activities expanded. PNER-2 subsequently followed; however, achieved targets of village electrification by 1994 were less than anticipated due to funding difficulties.

In August 1995, the Moroccan government embarked on the Global Regional Electrification Program (PERG). Within this framework, the special program ERD (decentralized rural electrification) was launched in June 1997 which elicits the participation of the Ministry of the Interior in garnering cooperation of regional autonomies. ERD establishes the details for implementation of decentralized rural electrification under PERG.

4.2.2 PNER (Rural Electrification National Program)

PNER-1

This comprises the first stage under PNER, and was implemented over the period 1982~86. In the course of PNER-1, 286 villages totaling 64,000 households were electrified, corresponding to an average rate of 50 villages per year. To achieve this, facility construction included 1,340 km of middle voltage transmission network, 1,215 km of low voltage distribution network, 341 locations of middle/low voltage substations, and 5 locations of high/middle voltage substations.

PNER-2

PNER-2 is scheduled for implementation over the period 1990~99. As of the present, 600 villages have been targeted and 25,000 households electrified. Target facilities at the end of this stage are 4,800 km of middle voltage transmission network, 3,200 km

of low voltage distribution network and 910 locations of middle/low voltage substations.

4.2.3 Global Rural Electrification Plan (PERG)

ONE has been the principal executing entity for rural electrification projects in Morocco, and these have centered on expansion of the existing grid under PNER. However, as the target villages become located at greater distance from the said grid, the cost involved in achieving electrification through extension of transmission lines increases accordingly ultimately reaching a point where this approach is no longer cost-effective.

On the other hand, since the creation of CDER with assistance from USAID in 1982, empirical research and development efforts have been pursued with regard to the utilization of renewable energy sources.

Against the above background, a new cooperative framework has emerged between CDER and ONE since 1994 to jointly pursue the exploitation of renewable energy sources in isolated areas. ONE has show particular interest in the incorporation of renewable energy schemes under rural electrification planning, and has subsequently nominated CDER as a member of the National Rural Electrification Committee (COSPER) marking a new institutional strategy in the form PERG.

PERG aims at a unified effort at rural electrification integrating the past experience of both ONE and CDER. An implementation proposal for the program has been evolved, and a master plan is now in the process of being formulated with scheduled completion at the end of 1997.

(1) Targets

Under PERG, the following targets are set:

① Electrification of the entire country by the end of 2010
② Integration of electrification technology (connection to existing transmission grid, development of renewable energy sources, and introduction of diesel generation)
③ Project costs are to be shared among ONE, regional autonomies and subscribers

(2) Action Plan

A master plan for rural electrification is to be formulated to incorporate the following.

① Creation of a data base for rural electrification
② Extension forecast for existing transmission line
③ Adoption of decentralized electrification approaches (wind power, PV energy, small-scale independent grid diesel, micro-hydropower)

④ Setting of objective and realistic standards with consideration to technical and socio-economic aspects

(3) Funding

The subject plan has as its target the electrification of 100,000 households per year at a cost of DH 10,000 per household. Accordingly, necessary funding is envisioned at DH 15 billion over 15 years.

In procuring such funding, the cooperation of all parties involved will be necessary (local autonomies, subscribers and ONE). Under the plan, the following sharing of financial burden is envisioned:

① 20% : ONE (at an annual rate of DH 200 million)

② 35% : Development tax (in addition to a sign-up fee for subscribers, a 2 centime [DH 0.02] per kilowatt is to be collected from users)

③ 20% : Local autonomies (at an annual rate of DH 200 million from tax base)

④ 25% : Subscribers (at DH 250 million per year in total, with option to repay over a 7 year period at the interest rate imposed on ONE by its source of lending)

(4) Organization

In order to pursue PERG under the optimum conditions, the roles of related agencies are to be clarified as follows:

① MEM : Confirmation of action plan and the execution of related studies. It is necessary that action plans be concurred to by a committee comprising representatives from the related sectors.

② ONE : Strengthening of national electrification programs. In addition to formulating action plans that maximize local autonomy institutional and know-how capabilities, ONE would undertake technical and funding management.

③ CDER : Extension and development of renewable energy technologies, maximizing CDER's extensive experience and engineering capability regarding decentralized electrification.

(5) Moving Forward with Decentralized Rural Electrification (ERD)

As a special project within the PERG framework, the Moroccan government established the ERD (decentralized rural electrification) program in June 1997. Electrification under the said program encompasses the following 2 approaches.

- Diesel generating schemes connected to a rural mini-gird at investment of DH 4,000~8,000 per household.

- Solar home system (SHS) installment and centralized battery charging stations at investment of DH 5,000~12,000 per household.

4.2.3 Rural Electrification Centered on CDER Activities

(1) Establishment and Role of CDER

Following the oil crisis in 1979, the Moroccan government placed new focus on the utilization of renewable energy sources culminating in the establishment of Le Centre de Developpement des Energies Renouvelables (CDER) in May 1982. The mission of this agency is as follows:

① To carry out studies and research on the promotion, development and utilization of renewable energy sources.
② System and equipment adjustment.
③ Identification of the technical, economical and social advantages of renewable energy.
④ Establishment of an engineering framework to pursue the above.

(2) CDER Objectives

The philosophy behind CDER activities encompass the following:

① Utilization of renewable energy sources in rural areas.
② Reevaluation of policy to address the issue of alternative energy sources.
③ Provision of new energy supply sources, and by so doing improve living standards.

On the basis of the above philosophy, CDER has the following objectives:

① Strengthening of the role of the public sector in the areas of scientific research and development with regard to renewable energy sources.
② Management and direction of important projects in the areas of rural electrification, effective use of energy in the tertiary industrial and private home sectors.
③ Involvement of CDER in the commercial and industrial sphere through the identification of products adapted to local conditions and with good marketing potential.

④ Pursuit of study and engineering projects.

(3) Activities and Achievements of CDER

Since its inception, CDER has carried out numerous projects in the areas of PV heated water, electrification (PV energy, hydropower, wind power), groundwater pumping by PV power, and the production of biogas, as well as a wide range of general studies related to the foregoing.

Since 1992, major projects in which CDER has been involved are as follows:

①	National Decentralized Electrification Project (PNED)	
②	Special Energy Project (PSE)	assisted by GTZ (Germany)
③	Rural Electrification Pilot Project (PPER)	assisted by France
④	Rural Solar Electrification Project (PRES)	assisted by KfW (Germany)
⑤	Solar heating system (80 MW)	
⑥	Wind power generation project in the northern region (3 MW)	assisted by KfW (Germany)
⑦	Biogas research project	assisted by GTZ (Germany)
⑧	Village electrification project	assisted by Spain

(4) CDER Organization

The General Director of CDER is stationed in Casablanca, and serves simultaneously as the Director of ONE. CDER's main headquarters is in Marrakech, and its organization centers administratively on the Secretary General. A CDER branch is located in Rabat which is responsible for liaison with other central government agencies and the promotion of special projects.

(5) Description of CDER

Budget : DH 9,421,930 (FY 1996)

Personnel : As of May 1997:

Total	84
Engineers	19
Technicians	20
Administration	19
Others	26
Temporary personnel	18

Legal status : Special corporate body under MEM, established for the purpose of rural decentralized electrification. At present, no plan for privatization.

(6) Renewable Energy

Renewable energy sources being given attention by CDER are as follows:

① PV energy
② Wind power
③ Biogass energy
④ Hydropower

(7) Decentralized Rural Electrification

1) Basic Criteria for Electrification

In Morocco, there are approximately 35,000 villages which cannot be practically electrified over the short term by extension of the existing grid. Average number of households in these villages is around 50. In order to electrify these villages, CDER contemplates the following 3 basic approaches.

① Wind power generation in combination with battery charging centers.
② Separate PV power generation schemes
③ Mini power grids based on micro-hydropower and diesel generation.

2) Role

In light of the above activities, the role of CDER is as follows.

① Development of independent, decentralized electrification schemes.
② Promotion of the extension of electrification.
③ Training of technical personnel in electrification by renewable energy sources.
④ Project monitoring · management.
⑤ Selection, testing and management of equipment related to renewable energy development.

(8) Village Electrification Project Achievement

Main efforts at village electrification by CDER have been carried out jointly with various international donor agencies. As of the present, approximately 10,000 households have been electrified applying various renewable energy technologies, and it is anticipated that 20,000 households will be so electrified by 1998.

Principal projects currently in progress are PPER (Pilot Rural Electrification Program) being jointly implemented with ADME (Development and Control Agency) of France, and SAER (Regional Energy Supply Program) being carried out with cooperation from GTZ of Germany.

The most marked achievement has occurred under PPER. This project was commenced in 1990 with 50% funding each by the Moroccan and French governments, and under phase 1 electrification of 30 villages has been completed in 1995 at a cost of DH 30 million. Under phase 2, another 90 villages (210 systems) are scheduled to be electrified in 1997. SAER on the other hand is not limited solely to electrification, but aims to supply all energy needs of remote areas (in 1988, SHS were trial installed in 120 households).

4.2.4 International Collaboration on Rural Decentralized Electrification Programs

CDER has extensive experience with projects implemented in collaboration with various international funding agencies. Major such projects are described below. (see Table 4-4, and 4-5).

(1) United States (USAID)

1982
Funding amount: US$ 7 million
Description of assistance:
CDER building
PV test equipment
Computer
4 month training course at Seri in the US
PV pump facilities: 15 locations (implemented jointly by CDER and USAID);150 locations of clinic PV lighting (100 W)

(2) France (ADEME)

1990: Study commenced under 50 : 50 funding outlay by the Moroccan and French governments (PPER)
Phase-1: PV electrification of 30 villages in 1995 at a cost of DH 30 million
Phase-2: 210 PV systems (90 villages) in 1996 including public facilities (clinics, schools, mosques, etc.). Electricity is used for TV, indoor lighting, street lighting. Revolving fund format.

(3) Germany (GTZ)

PV electrification extension program: 120 households in 1988; 400 households in 1996
Planning, cost estimation, economics for biogass, improvement of fuel wood energy efficiency, etc.
Micro-hydropower (under 20 kW) at 2 locations near Marrakech
CDER restructuring: particularly regarding upgrading of technical skills of CDER personnel through training programs, engaging of instructors from outside, dispatch of personnel overseas, etc.

(4) Spain

1994: Equipment supply and training of personnel in Spain
Village electrification plan: Electrification completed for 10 villages, 500 households

(5) Canada (CIDA)

1994: PV pump facilities at 5 locations
1995: PV pump facilities at 130 locations
PV pump facilities at 2 other locations in cooperation with Ministry of Interior

(6) China

1996: Grant of 2 micro-hydropower units

Table 4-4 Projects with International Collaboration (completed or ongoing)

Project name	Framework	Partner	Description
Moroco Demonstration Phase	CDER-USA cooperation	=USAID =CDER	1982(US$ 7mill) CDER facilities PV test equipment Training PV pump Clinic PV lighting 150
PSE-MAROC *	Moroc-German cooperation	CDER-GTZ	1988SHS120 1996SHS400 -one BCS station -2MCH(mini hydro)
** ***	Moroc-Canada	MOI-CIDA	1994 PV pump 5 1995 PV pump 130
PPER	Moroc-France cooperation	CDER/MOI -ADEME -CDER	phase-1:1995-1996 cooperation 30 villages-1500 households (PV,MCH diesel) Budget: 30mill. DH 50% Morocco 50% France Phase-2: 1996-1997 90 villages(210 villase planed) public facilities by rotating fund
Power Village	Morocco-Spanish cooperation		10 villages, (SHS,BCS,PV pumping)
PNFD-MCH	Morocco-China cooperation	Electrification	electrification of 2 villages

* Program includes PV, bio-gas, bio-mass, planing estimation economics, mini hydro, CDER restructuring.
** CDER involved in technical matter only.
*** More than 200PV pump are installed by now.

Table 4-5 Projects with International Collaboration (under planning)

Project name	Framework	Partner	Description
PNED-CEE	Morocco - EC	CDER,MEM -CEE	electrification of approx.150 villages (~5000homes)
PERG-KFW	Morocco - Germany	ONE-CDER	electrification of approx. 150 villages(~7500homes) Budget: 70% KFW, 30% ONE
PNED--JICA	Morocco - Japan	CDER - JICA	rural electrification of Haouz region electrification of approx. 200
PERG	National Plan	ONE - CDER	villages (~100,000homes)