JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NO. 32

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

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

MAIN REPORT
VOLUME-II

JANUARY 1998

CHUO KAIHATSU CORPORATION
SANYU CONSULTANTS INC.

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Taferiat G,S

Tamsioht

Tahannaout

Tahanaout G,S

Aghbalou G,S

Tidsi MHG

Imin El Hamam G,S

Inzaine MHG

Arg MHG

Anfli MHG

Iguir Nkouris G,S

Adardour MHG

Id Ssior MHG

Alla-Oumzri MHG

LEGEND

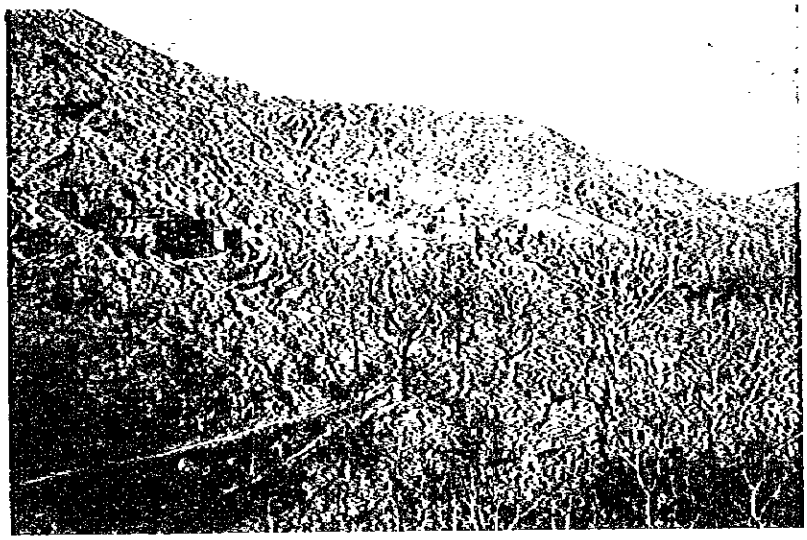
- Micro Hydro Station
- Micro Hydro Station for pre-F/S Study
- Gauging Station (Exsisting)

0 5 10 15 km

SCALE

Location Map of Microhydro Generation Schemes

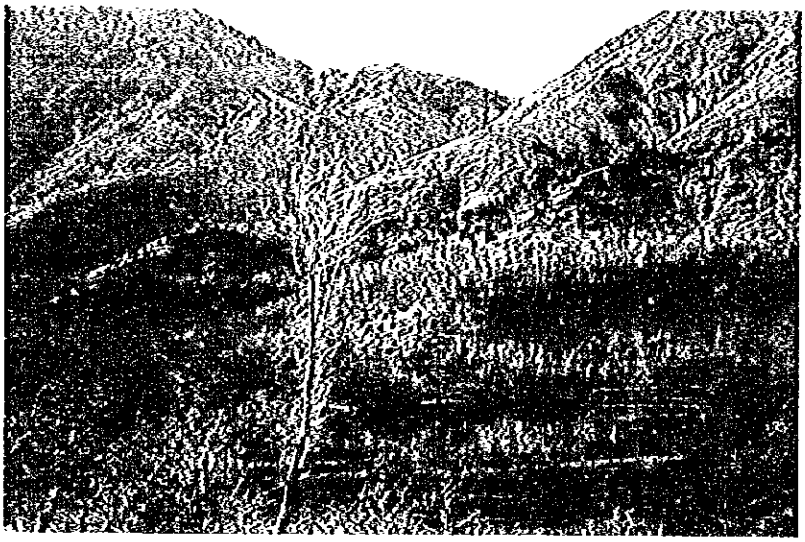
PHOTOGRAPHS



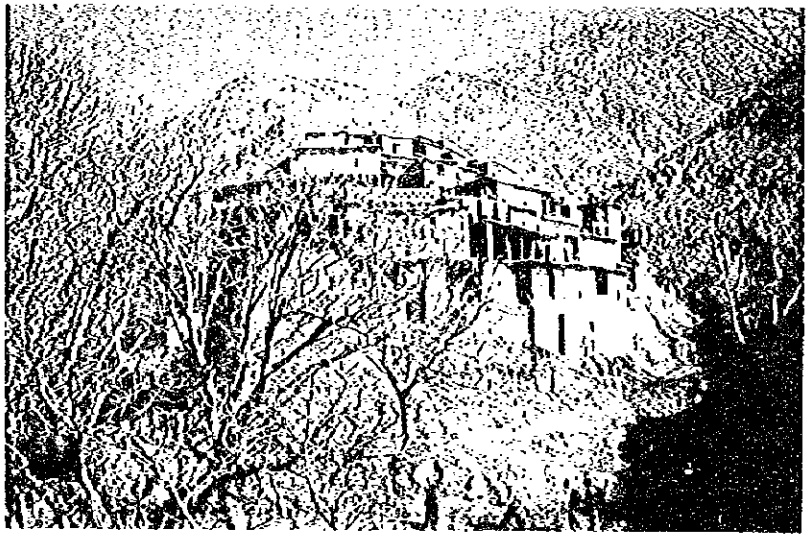
Adardour village on left bank of Anougal river

Adardour village on right bank of Anougal river

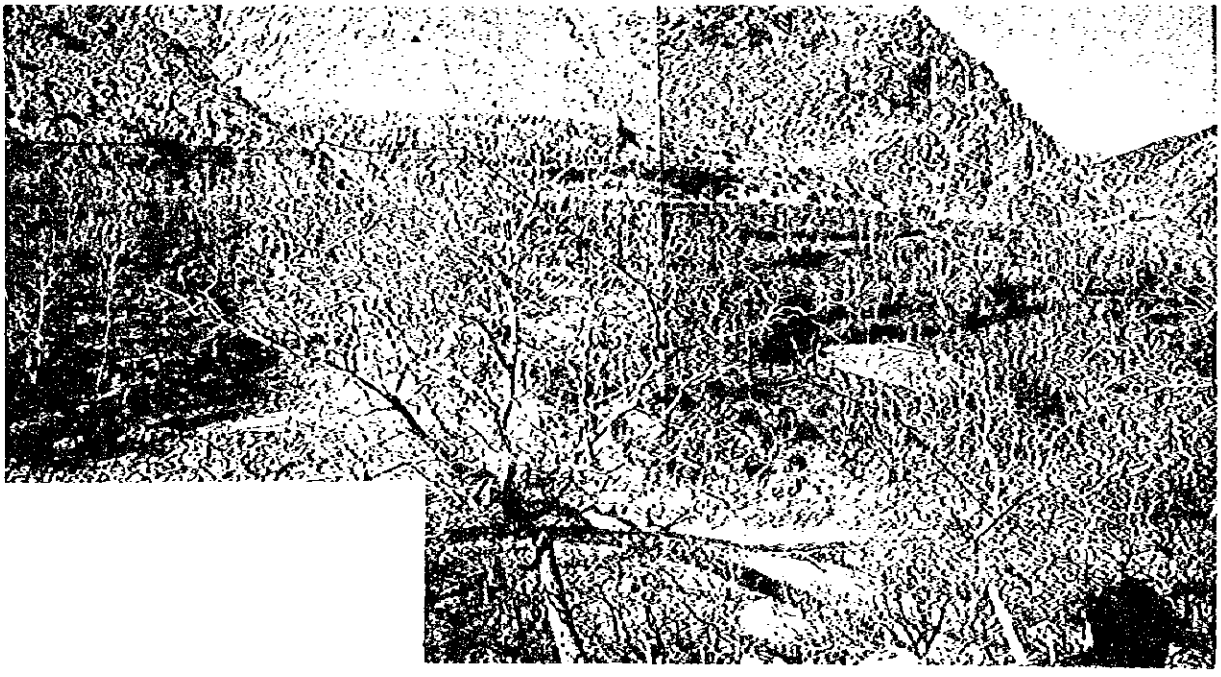
Adardour microhydro generation site on left bank of Anougal river
(penstock and powerhouse site)



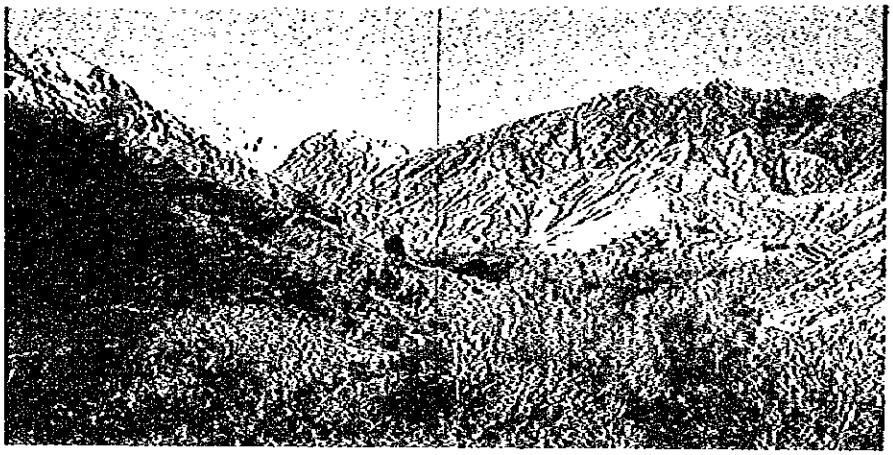
Arg village on left bank of Imenane river



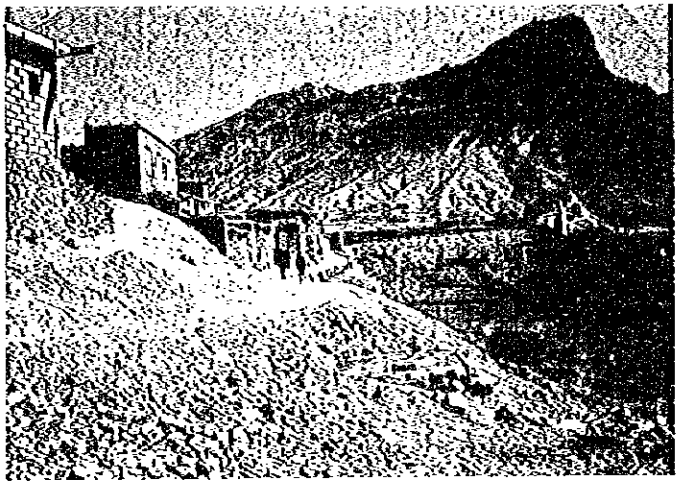
Arg village on right bank of Imenane river



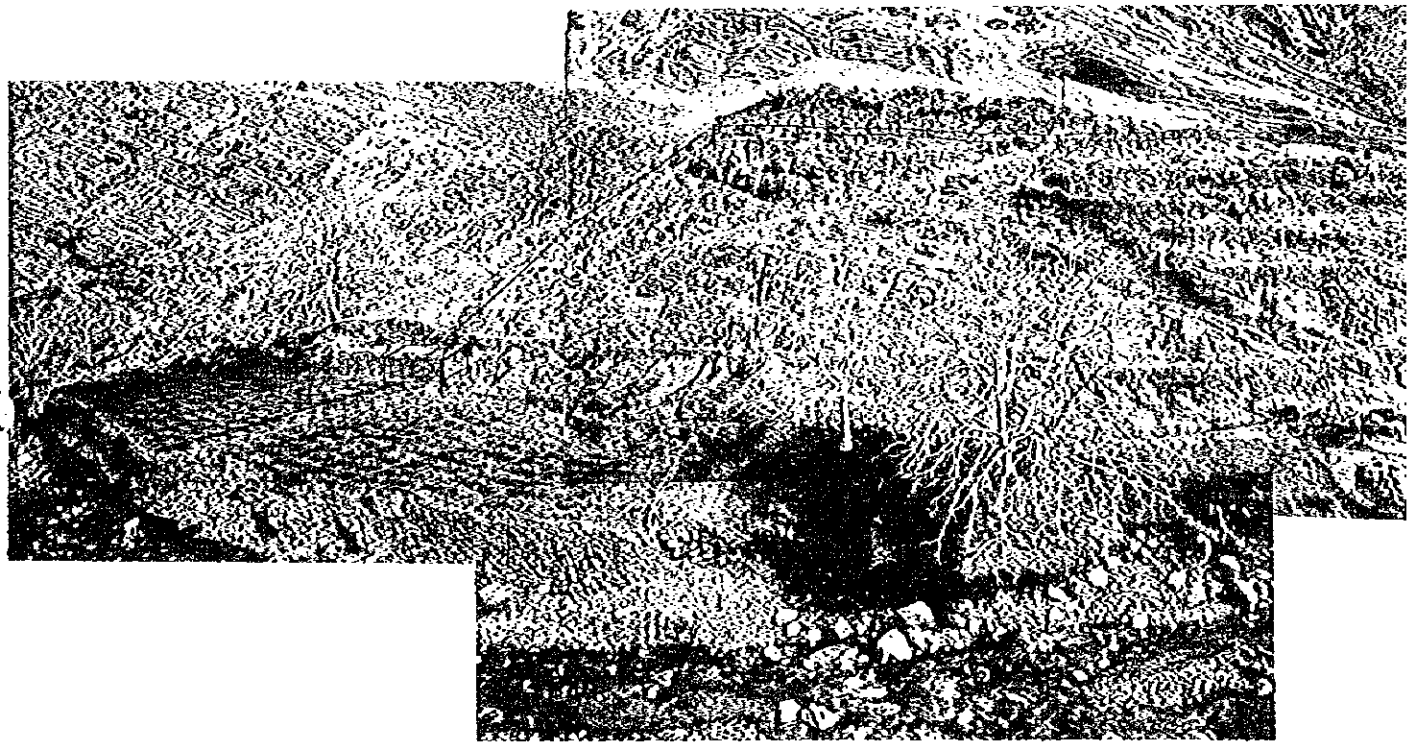
Arg microhydro generation site on left bank of Imenane river
(penstock and powerhouse site)



Tidsi village on left bank of Yagour riv



Afla village on right bank of Afoghal river



Tidsi microhydro generation site on right bank of Yagour river
(penstock and powerhouse site)

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	

FRENCH

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.

Summary of Electrification by Power Source Category

	PV	Diesel	Micro-hydropower	Grid extension	Total
1. Target villages	71	12	18	5	106
2. Target households	3,213	2,136	1,301	288	6,938
3. Supplied entities:					
General households	3,213	2,136	1,301	288	6,938
Schools	54	16	27	6	103
Street lights	642	427	261	58	1,388
Mosques	77	17	18	8	120
Clinics	1	1	--	--	2
Commercial establishments	111	62	49	6	228
Total	(4,098)	(2,659)	(1,656)	(366)	(8,779)
4. Power source facility capacity	233.19	133.4	179	--	545.59
5. Preliminary cost estimate	5,811	1,313	5,766	450	13,340
Remarks:	SHS PV module: 75 Wp × 2,555 55 Wp × 2,574	12 units	7 sites		

VOLUME II : MICRO-HYDROPOWER PREFEASIBILITY STUDY

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND UNITS OF MEASUREMENT

(1) Abbreviations

ADEME	Agence de l'Environnement de la Maitrise de l'Energie et le Ministere des Affaires Etrangeres de France	Development and Control Agency
BCS	–	Battery Charging System
CDER	Centre de Developpement des Energies Renouvables	The Center for Renewable Energy Development
CDS	–	Centralized Distribution System
Cercle	Cercle	District
COSPER	Comite de Suivi des Programmes d'Electrification Rurale	Committee of Supervision of Rural Electrification Program
C.R. / Commune R.	Commune Rurale	Rural Commune
DGLL	Direction Generale des Collectivites Locales	The Ministry of Autonomy
Douar	Douar	Village
EC	–	European Community
ECU	–	European Community Unit
El	–	Elevation above Sea Level
ERD	Electrification Rurale Decentralisee	Dicentralized Rural Electlification
GTZ	Deutche Gesellshaft fur Technishe Zusammenarbeit (German)	–
HH	–	Household
JICA	–	Japan International Cooperation Agency
KfW	Kreditanstelt fur Wiederaufbau (German)	–
MEM	–	Ministry of Energy and Mining
MHG	–	Micro-hydropower Generation
M/M	–	Minutes of Meeting

ONE	Office National de l'Electricite	National Electric Power Corporation
ONEP	Office National de l'Eau Potable	The Waterworks Bureau
PERG	Programme d'Electrification Rurale Global	Global Regional Electrification Program
PNED	Programme National d'Electrification Decentralisee	Decentralized Electrification National Program
PNER	Programme National d'Electrification Rural	Rural Electrification National Program
PPER	Programme Pilote d'Electrification Rurale Decentralisee	Pilot Decentralized Rural Electrification Program
PSE	(German)	Special Energy Supplying Program
PSER	(German)	Regional Energy Supplying Program
PV	--	Photovoltaic
SAER	(German)	Regional Energy Supplying Program
SHS	--	Solar Home System
S/W	--	Scope of Work
USAID	--	United States Agency for International Development

(2) Units of Measurement

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Area

mm2	=	square millimeter
cm2	=	square centimeter
m2	=	square meter
ha	=	hectare
km2	=	square kilometer

Volume

cm3	=	cubic centimeter
lit	=	liter
m3	=	cubic meter

Weight

g	=	gram
kg	=	kilogram
ton	=	metric ton

Time

s	=	second
min	=	minute
hr	=	hour
d	=	day
y	=	year

Electrical measures

V	=	volt
kV	=	kilovolt
A	=	ampere
W	=	watt
kW	=	kilowatt
MW	=	megawatt
GW	=	gigawatt
Wp	=	watt peak
kWp	=	kilowatt peak

Other measures

%	=	percent
PS	=	horsepower
°	=	degree
'	=	minute
"	=	second
°C	=	degree centigrade
10^3	=	thousand
10^6	=	million
10^9	=	billion (milliard)
ppm	=	parts per million
pH	=	scale of acidity

Derived measures

lit/s	=	cubic liters per second
m3/s	=	cubic meters per second
Wh	=	watt hour
kWh	=	kilowatt hour
GWh	=	gigawatt hour
kWh/y	=	kilowatt hours per year
kVA	=	kilovolt ampere
rpm	=	revolutions per minute

Money

DH	=	Dirham
US$	=	US dollar (US$ 1 = DH9.31 as of May 1997)
¥	=	Japanese Yen (US$ 1 = ¥115.0 as of May 1997)