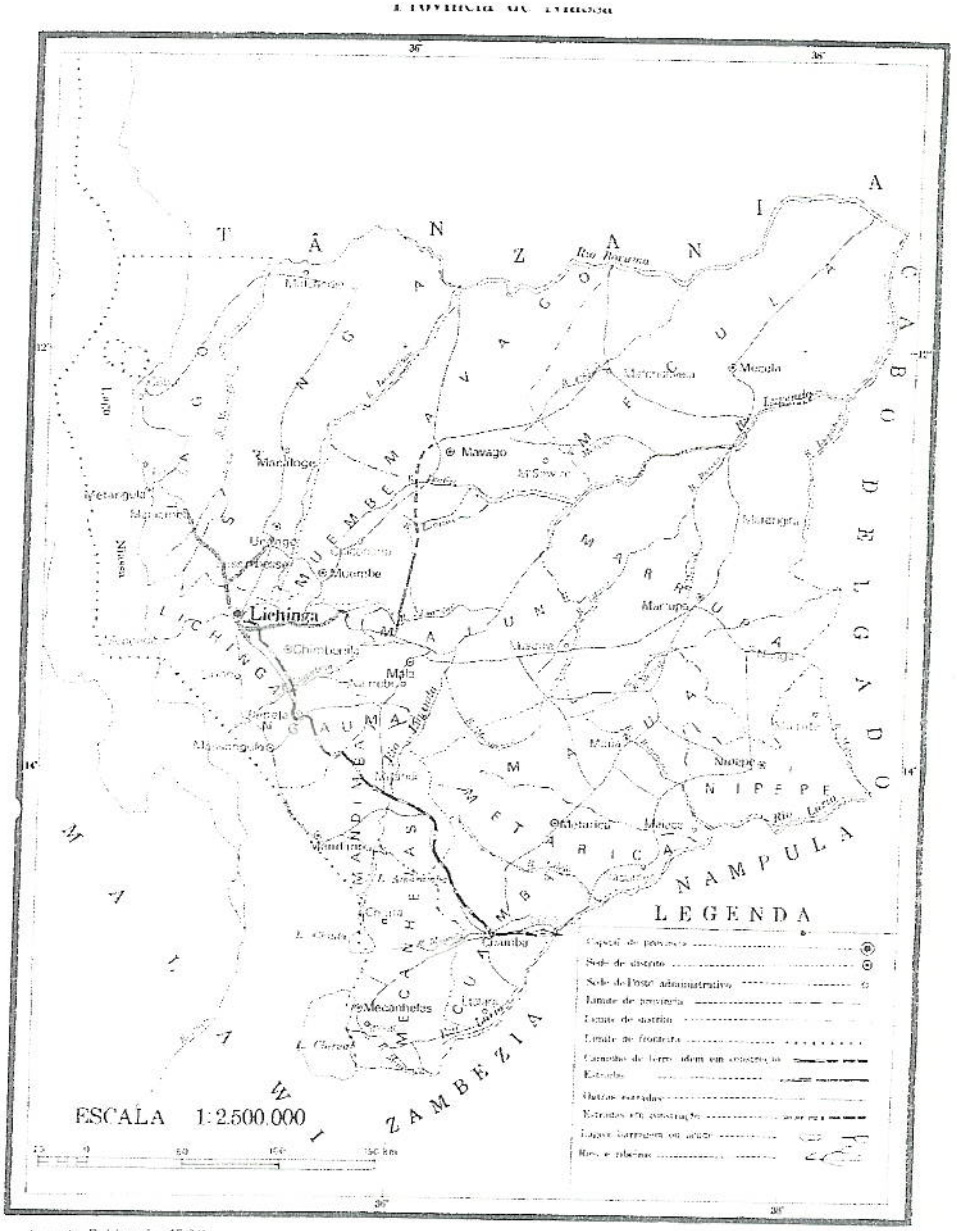
4.12 Quality Assurance

The Contractor shall use the quality assurance system: "ISO 9001 Quality System Model for quality assurance in design/development, production, installation and servicing", or similar.

The accepted Quality Assurance certification systems are:

- Photovoltaic Global Approval Programme (PV-GAP) Mark or Seal;
- International Electro-technical Commission Quality Assessment System for Electronic Components (IECQ) approval;
- Certification according to ISO 9000 Series;
- Quality Assurance certification in accordance with national certification systems in the country of origin, equivalent to PV-GAP, IECQ or ISO 9000.

Appendix 1: Project Area Map



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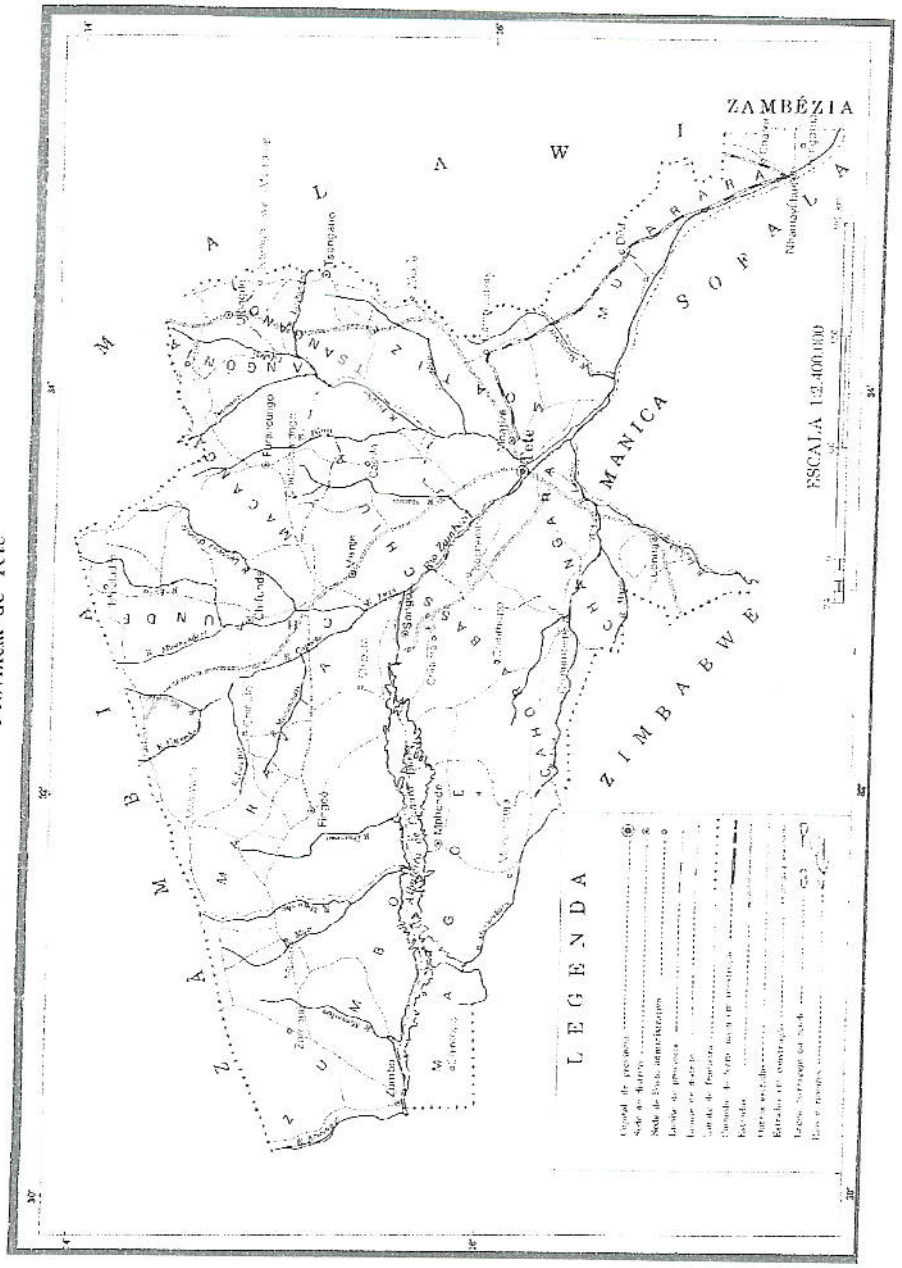


Appendix 2: Project Site Data

NIASSA PROVINCE

	District	Nr.	Locality	Sanitary Uni	Qty	HC - II	HC - I	Staff House	HC - II	HC - I	Staff House	W. ambulatory Service	With Internment	Services	
1	Cuamba	1	Lúrio	Mitucue	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
2	Lago	2	Metangula	Mcululca	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Lago	3	Cobue	N'Goo	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
3	Lichinga	4	Meponda	Meponda	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Lichinga	5	Lione	Chala	1	x			1			No	Yes	PAV/SMI	Maternidade
4	Majune	6	Malanga	Malanga	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
	Majune	7	Malanga	Lugenda	1	x			1			No	Yes	PAV/SMI	Maternidade
5	Mandimba	8	Mandimba	Lipusu	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Mandimba	9	Mandimba	Mcululca	1	x			1			No	Yes	PAV/SMI	Maternidade
6	Marrupa	10	Marangira	Marangira	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Marrupa	11	Nungo	Nungo	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
7	Maúa	12	Maúa	Maúa	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
	Maúa	13	Mainca	Mainca	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Maúa	14	Mainca	Muapula	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
8	Mavago	15	M'Sawine	M'Sawine	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Mavago	16	Mavago	Mavago	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
9	Mecanhelas	17	Chiúta	Chiúta	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Mecanhelas	18	Insaca	Mecanhelas	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
10	Mecula	19	Mecula	Mecula	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
	Mecula	20	Mecula	Gomba	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
11	Metarica	21	Metarica	Metarica	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
	Metarica	22	Metarica	Namacunde	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
12	Muembe	23	Chiconono	Chuanjota	1	x			1			No	Yes	PAV/SMI	Maternidade
	Muembe	24	Chiconono	Chiconono	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
13	Ngauma	25	Massangulo	Ngauma	1	x		x	1		2	Yes	Yes	PAV/SMI	Maternidade
	Ngauma	26	Massangulo	Chissimbir	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
14	Nipepe	27	Nipepe	Cheia-Cheia	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
15	Sanga	28	Macaloge	Macaloge	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade

TETE PROVINCE

1	Angónia	29	Mpenha	CS Mpenha	1	x		x	1		2	No	No	PAV/SMI	Maternidade
	Angónia	30	Dómue	CS Domue	1	x		x	1		2	No	Yes	PAV/SMI	Maternidade
	Angónia	31	Lifidzi	CS Lifidzi	1	x		x	1		2	No	No	PAV/SMI	Maternidade
	Angónia	32	Fonte Boa	CS Fonte Boa	1	x		x	1		2	No	No	PAV/SMI	Maternidade
2	Changara	33	Marara	CS Marara	1	x		x	1		2	No	No	PAV/SMI	
	Changara	34	Luenha	CS Luenha	1	x		x	1		2	No	No	PAV/SMI	
	Changara	35	Mazoe Ponte	CS Mazoe Pon	1	x		x	1		2	No	No	PAV/SMI	Maternidade
	Changara	36	Chipembere	CS Chipembe	1	x		x	1		2	No	No	PAV/SMI	
	Changara	37	Ntemangau	CS Ntemanga	1	x		x	1		2	No	No	PAV/SMI	Maternidade
3	Chiúta	38	Caunda	CS Caunda	1	x		x	1		2	No	No	PAV/SMI	
	Chiúta	39	Manje	CS Manje	1	x		x	1		2	Sim	Yes	PAV/SMI	Maternidade
4	Macanga	40	Furancungo	CS Furancung	1	x		x	1		2	Sim	Yes	PAV/SMI	Maternidade
5	Magoe	41	Daque	CS Daque	1	x			1			No	No	PAV/SMI	
6	Moatize	42	Nkondedzi	CS Nkondedzi	1	x		x	1		2	No	No	PAV/SMI	
7	Mutarara	43	Charre	CS Charre	1	x		x	1		2	No	No	PAV/SMI	
	Mutarara	44	Doa	CS Doa	1	x		x	1		2	No	No	PAV/SMI	
8	Tsangano	45	Tsangano	CS Tsangano	1	x			1			Sim	No	PAV/SMI	Maternidade
9	Zumbo	46	Muze	CS Muze	1	x			1			No	No	PAV/SMI	Maternidade
	Zumbo	47	Zumbo	CS Zumbo	1	x		x	1		2	Sim	No	PAV/SMI	Maternidade
10	Chifunde	48	Luia	CS Luia	1	x		x	1		2	No	No		
	Chifunde	49	Chifunde	CS Chifunde	1	x		x	1		2	Sim	Yes	PAV/SMI	Maternidade
11	Moravia	50	Fingoe	CS Fingoe	1	x		x	1		2	Sim	Yes	PAV/SMI	Maternidade

Appendix 3: Weather Data

The following solar data have been used for this functional design.

DATA OF RADIATION AND TEMPERATURE IN MOZAMBIQUE FROM 1970 TO 2005 (MEASURED BY THE NATIONAL INSTITUTE OF METEOROLOGY-INAM)

Month	NIASSA			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	5.1	20.4	24.6	16.3
Feb	5.1	20.5	24.7	16.3
Mar	4.8	20.2	24.6	15.9
Apr	5	19.3	23.9	14.7
May	5	17.4	22.9	12.2
Jun	4.4	15.5	21.1	10
Jul	4.8	15	20.6	9.5
Aug	5.3	16.4	22.4	10.5
Sep	6	18.8	25.2	12.6
Oct	6.1	21	27.2	14.9
Nov	5.8	21.5	27	16.1
Dec	5.2	20.7	25.3	16.4

Month	TETE			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.6	28.6	33.6	23.6
Feb	6.2	28.4	33.4	23.5
Mar	6.3	28.3	33.5	23
Apr	5.7	27.3	32.9	21.5
May	5.1	25	31.2	18.5
Jun	4.6	22.4	28.9	16.2
Jul	4.7	22.1	29	15.8
Aug	5.2	24.2	30.8	17.5
Sep	5.8	27	33.7	20.3
Oct	6.1	29.5	36.1	22.8
Nov	6.8	30.3	36.6	24
Dec	6.6	29.1	34.7	23.7

Appendix 4: Site Acceptance Test (SAT)

Site information

□ Site name: _____

□ Province: _____

□ District: _____

□ Date: _____

Structural issues

□ Orientation towards North ±15°
□ Tilt (15-35°)
□ No external shading on PV array
□ Structure and PV modules are properly secured to roof or ground
□ Holes in roof and walls are repaired (water thigh)
□ Battery storage in vented battery encasing

Electrical issues, DC

□ The polarities are correct
□ The system voltage are below maximum values
□ Diodes are installed correct
□ The overcharge protection is installed properly
□ The cables are of the correct size
□ All cables are properly attached to walls and roof
□ All DC appliances are DC labelled

Functions

PV modules

String number	Solar Intensity Measured W/m^2	Open Circuit Voltage Measured V	Short Circuit current Measured A	Short Circuit Current, Calculated* A
1				
2				
3				
4				

* Short Circuit Current Calculated = Short Circuit Current Measured X 1000 / Solar Intensity Measured

Battery

□ Air temperature during test (°C) :

Cell number	Specific gravity	Cell Voltage V	Specific gravity A	Cell Voltage V
1				
2				
3				
4				
5				
6				

Charge Controller

□ Array current present at the input
□ Array voltage present at the input
□ Output voltage ok
□ Output current ok

Summary

□ Total power output (W) :
□ Actual solar intensity (W/m^2):

Quality Assurance

□ End-user Manual exists
□ Technical Manual exists
□ Local staff member trained

Comments:

_____

_____

_____

_____

Approval

Appendix A:
Technical Specifications
(Educational Buildings)

DRAFT September 05 - 2006

Appendix A:
Technical Specifications
(Educational Buildings)

DRAFT September 05 - 2006

Table of Contents

1	**Introduction**	3
2	**Scope of Works and Supply**	4
2.1	To be Provided by the Contractor	4
2.2	To be Provided by the Employer	6
2.3	Introduction	7
2.4	Existing Situation	7
2.5	Site Surveys	7
2.6	Detailed Design and Engineering	7
2.7	Completeness of the Supply	8
2.8	Standards and Recommendations	8
2.9	Installation and Supervision	9
2.10	Test	9
2.11	Site Acceptance Test	9
2.12	Training	9
3	**Technical Specifications**	11
3.1	Photovoltaic Modules	11
3.2	Battery	12
3.3	Charge Controller	13
3.4	Cables	13
3.5	Switches, Sockets and Protection	14
3.6	Grounding (earthing)	14
3.7	Structures	14
3.8	Appliances	15
3.9	Warranty	16

Table of Appendices

Appendix 1: Project Area Map
Appendix 2: Project Site Data
Appendix 3: Weather Data
Appendix 4: Site Acceptance Test (SAT)

1 Introduction

This purpose of this tender is to electrify 50 educational sites in the regions of 8 Provinces of Mozambique (Cabo Delgado, Niassa, Tete, Sofala, Manica, Inhambane, Gaza and Maputo). The electrification is based solely on stand-alone solar photovoltaic.

Design, supply and installation, commissioning of the equipment and training of local staff are included in the scope of works.

2 Scope of Works and Supply

2.1 To be Provided by the Contractor

The stand-alone solar photovoltaic system shall be implemented on a turnkey basis and single responsibility basis.

For each school the following solar PV systems shall be implemented:

- System E-CR/AO : Classroom(s) and administration office
- System E-SH : Staff house.

All classrooms shall be supplied from the same solar PV system. The administration office shall use the same solar PV system as the classroom(s).The number of classrooms to be electrified per site can be found in

- Appendix 1: Project Area Map
- Appendix 2: Project Site Data
- Appendix 3: Weather Data
- Appendix 4: Site Acceptance Test (SAT).

Staff house shall be electrified as appendix 2.

The E-CR/AO system shall as a minimum comprise:

Solar PV system
Photovoltaic array
Charge controller
Battery
Wires, fuses, switches, plugs, earthing
Structures

DC appliances *per* classroom:

DC appliances, per classroom*)	Quantity	DC load Power W	Hours of use/day	Days per week	Energy load, week days Wh/day	Amp-hour load, week days Ah/day
General lighting	6	18	5	5	540	45,0
Outdoor lamp	1	8	8	5	64	5,3
DC Outlet for TV (14***)	1	33	2	7	66	5,5
TOTAL					**670**	**55,8**
Corrected)**						**67,0**

*) The number of classrooms per site can be found in Appendix 2.

**) Battery efficiency factor of 85 %, and wire efficiency factor of 98.

***) Only one class room shall have a TV per site.

DC appliances in administration office:

DC appliances	Quantity	DC load Power W	Hours of use/day	Days per week	Energy load, week days Wh/day	Amp-hour load, week days Ah/day
General lighting	4	18	5	5	360	30,0
Outdoor lamp	1	8	8	5	64	5,3
TOTAL					**424**	**35,3**
Corrected*)						**42,4**

*) Battery efficiency factor of 85 %, and wire efficiency factor of 98 %.

The E-SH systems shall as a minimum comprise:

Solar PV system
Photovoltaic array
Charge controller
Battery
Wires, fuses, switches, plugs, earthing
Structures

DC appliances	Quantity	DC load Power W	Hours of use/day	Days per week	Energy load Wh/day	Amp-hour load Ah/day
General lighting	2	8	5	7	80	6,7
Reading light	1	18	3	7	54	4,5
Outdoor lamp	1	8	8	7	64	5,3
DC outlet	1	15	3	7	45	3,8
TOTAL					243	20,3
Corrected*						24,4

*) Battery efficiency factor of 85 %, and wire efficiency factor of 98 %.

The scope of works and supply shall include the following:

- Site surveys;
- Project engineering and detailed design of the system;
- Project management;
- Supply, installation, supervision, testing and commissioning of all equipment and materials;
- Training in operation and maintenance of local staff;
- Documentation, including a manual;
- Any other works and supplies which are deemed necessary for the completion of stand-alone solar photovoltaic.

2.2 To be Provided by the Employer

The following will be provided by the Employer:

- Equipment rooms or other available space (ready for installation) for the supplied equipment;
- Roof area, façade area or ground area for the solar photovoltaic array.

For each project site, a local staff member will follow the installation at all times, and is to be training in daily maintenance of the systems during the installation.

2.2.1 General Information and Requirements

2.3 Introduction

This section describes the general requirements of the Works and Supply. Particular technical requirements for equipment and accessories are described in the respective sections.

2.4 Existing Situation

The present situation at all sites is described in The Project Site Data attached as appendix to the bidding documents.

2.4.1 Electricity and Water

No electricity supply is available at the sites. Water may need to be transported several kilometres.

2.4.2 The Project Area

The project area is the region of 8 Provinces of Mozambique (Cabo Delgado, Niassa, Tete, Sofala, Manica, Inhambane, Gaza and Maputo). The area is shown on the map enclosed in Appendix 1.

2.5 Site Surveys

The Contractor shall carry out a site survey for all sites and verify/update the data given in these bidding documents.

During the detailed site survey phase, the Contractor shall liaise with the Employer to identify the infrastructure, i.e. the locations of the PV array, the equipment room and the DC appliances.

2.6 Detailed Design and Engineering

The work shall include the Contractor's detailed design needed to manufacture, procure, supply, erect and commission all equipment in accordance with the functional requirements of these bidding documents.

The detailed design shall include the following:

- Calculation and specification of the solar PV system;

- System availability : 95%;
- Average annual horizontal solar radiation : 6,1 kWh/day/m^2 (Cabo Delgado), 5,2 kWh/day/m^2 (Gaza), 5,5 kWh/day/m^2 (Inhambane), 5,8 kWh/day/m^2 (Manica), 5,3 kWh/day/m^2 (Maputo), 5,3 kWh/day/m^2 (Niassa), 5,7 kWh/day/m^2 (Sofala), and 5,8 kWh/day/m^2 (Tete). Source : INAM – National Institute of Meteorology);
- Discharge rate of battery: C20 at temperature of 25°C.

The detailed design shall be approved by the employer before installation works is initiated.

2.7 Completeness of the Supply

All services, apparatus, accessories and installation materials which may not have been specifically mentioned, but which are usual or necessary in the respective materials/ equipment for the completeness of the finished plant and equipment in an operational status, shall be deemed to be included in the supply and shall be provided by the Contractor without any extra charge.

2.8 Standards and Recommendations

All components, materials and equipment shall be designed, manufactured and tested in accordance with the relevant sections of the latest editions of the standards and regulations mentioned below. If the product bears the PVGAP mark no further test certifications are needed.

- National Standards;
- PVGAP
- ITU-R (CCIR) recommendations;
- ITU-T (CCITT) recommendations;
- ISO Standards;
- IEE Wiring Regulations;
- IEC Standards;
  - IEC61215:1993 Crystalline Silicon Terrestrial PV modules
  - IEC 61427 Secondary cells and batteries for solar PV energy systems.

- IEC60896: Stationary lead acid batteries
- IEC60335: Safety on Household and similar appliances

- ETSI/ CENELEC Standards;

In addition hereto, the plant and equipment shall comply with other specific standards/recommendations and regulations as stipulated in the other sections of these bidding documents.

2.9 Installation and Supervision

The installation and supervision of the equipment shall be carried out by the Contractor on a turn-key basis.

All installation drawings, work procedures and methods required to ensure the proper installation and alignment of the equipment shall be provided.

After completion of the installation work, the Contractor shall restore the site to its initial condition.

2.10 Test

The contractor shall in collaboration with the employer perform a test of two of the first systems installed. The test shall be performed for at least 2 days and include monitoring of the solar insulation, energy output from the solar panels and total consumption in the period. The details of the monitoring as well as selection of the sites for monitoring shall be agreed with the employer before the test. The contractor shall provide documentation for the test as agreed with the employer.

2.11 Site Acceptance Test

Upon installation and commissioning, the system shall be inspected, and a Site Acceptance Test (SAT) shall be carried out by the Contractor in order to verify that the plant and equipment are in compliance with the specifications.

The Employer shall be entitled to witness the tests.

The results of the test shall be documented using the Site Acceptance Test Sheets enclosed in Appendix 4. The test results shall be handed over to the Employer.

The staff member shall follow all steps of the installation. During the installation the contractor shall go trough the *entire* "End-user manual" and the "Technician's Manual for Installation, Operation and Maintenance" (see section 4.11.2) when appropriate during the installation.

3 Technical Specifications

3.1 Photovoltaic Modules

Crystalline modules are required and shall comply with relevant PV GAP standard is PVRS 2 "Crystalline silicon terrestrial Photovoltaic (PV modules)". Te design qualifications and type approval of the PV modules shall comply with IEC 61215 "1993 Crystalline Silicon Terrestrial PV modules."

The deviation of electrical parameters from the nominal values by the manufacturer must not exceed:

- Nominal power : -10% to +20%
- Short circuit current : 15% to +20%
- Open circuit voltage : -10% to +15%

The encasing of the modules is done in category IP55 in relation to EEC/IEC 1215.

The PV shall be able to withstand temperatures between 0°C to 95°C.

The solar power systems shall consist of solar cells/modules and charge controller connected to batteries of nominal voltage of 12 V.

The solar modules shall be mounted on a roof or on the ground, with roof mounting as first priority. The orientation of the PV array is due north. In case due north is not possible, an orientation ±25° from north is acceptable. The slope of the PV modules shall between 15-35°. The slope must not be below 15° due to the self-cleaning.

The backside of the PV modules shall be freely ventilated. Roof mounted PV modules shall be mounted at a distance of at least 7 cm from the roof

Each PV modules shall be clearly marked with the text indicating that the modules belong to MINED.

A blocking diode is required between the PV array and the charge controller.

A circuit breaker is required between the PV array and charge controller for the purpose of maintenance.

3.2 Battery

The battery shall be of the type "deep cycle" with flooded lead-acid electrolyte. The battery shall be manufactured for the purpose of PV systems. and sealed maintenance-free battery with no topping up requirements.

The battery's nominal Depth of Discharge - at 2000 operation cycles - shall be between 35% and maximum 60%. During operation, the Depth of Discharge must not exceed the battery's nominal maximum Depth of Discharge. The design should be based on maximum Depth of Discharge.

The battery nominal capacity (at C20) shall be

$$C = \frac{CorrectedDailyLoad * N}{DoD}$$

Where

C	is the capacity, Ah
CorrectedDailyLoad	is the average corrected daily load, Ah/day
N i	s the number of autonomy days, decimal number
DoD	is the actual rated Depth of Discharge of the battery, decimal number.

The working temperature is between 0-55°C. The self-discharge of the battery at 25°C must not exceed 6% of the rated capacity per month.

Batteries shall be supplied complete with accessories. The battery shall be delivered and installed in a well-vented battery enclosure that prevents users from coming in contact with battery terminals or battery electrolyte. The enclosure must be made of acid resistant materials.

For a flat plate battery shall comply with IEC Standard 61427 IEC:2001 Ed.2 "Secondary Cells and Batteries for Solar Photovoltaic Energy Systems - General Requirements and Methods of Test". The battery capacity should be at least 100% of the nominal C20 capacity after the "5th C20 test" and it should

3.3 Charge Controller

Charging of the batteries shall be controlled automatically with the following features:

- Temperature compensated charging through an external probe;
- Function in accordance with Pulse Width Modulation (PWM) or On/Off;
- Overcharge protection. High Voltage Disconnection (HDV) must be at the battery end voltage that correspond to 0% of the Depth of Discharge (DoD);
- Over-discharge protection, e.g. by disconnecting the load;
- Series charge controller with solid state relay;
- Protection against reverse polarity must be provided in both the PV modules and battery lines;
- Reserve leakage current must be less than 500 micro-Amperes (current from battery to "dark" module);
- Deep discharge protection. Low Voltage Disconnection (LVD) must be at the battery end voltage that correspond to maximum allow Depth of Discharge (DoD).

The charge controller must support at least 25% more than the nominal current.

The battery consumption voltage drop must be under 0,5 V. The input battery drop must be under 0.5 V.

The voltage drop across the Charge Controller when charging or discharging should be less than 5% of the nominal system voltage.

The controller shall function in the range of 0-50°C, and must withstand at least 90% of rated current from the PV module to battery and from battery to load at this temperature interval.

The controller shall not be installed in the battery enclosure (battery box).

3.4 Cables

The contractor shall include 75 m of cable per solar photovoltaic system in his

$$S = \frac{0{,}3 * L * I_m}{\Delta V}$$

where

S	is the cross section, m^2
L	is the cable length, m
Im	is the maximum current, A
ΔV	is the maximum allowed voltage drop, %

The maximum allowable value of voltage drop (ΔV) must be less than

- 5% between the Charge Controller and the DC load
- 3% between the PV modules and the Charge Controller
- 3% between the Charge Controller and Inverter
- 1% between the Charge Controller and the Battery

All cables used outdoor shall be UV-resistant and waterproof.

Cables must be colour coded in accordance with the existing electric coding norms.

3.5 Switches, Sockets and Protection

DC sockets must be used with reverse polarity protection. DC fuses and circuit breakers must be rated for DC service. The equipment shall be rated at least 20% more than the design voltage and current.

Allow for one socket per room.

3.6 Grounding (earthing)

All metallic enclosures and structures of the system must be bonded and grounded using the shortest practical route to an adequate earth contact using an uninterrupted conductor of at least 16 mm^2 cross-section.

The maximum allowed earth resistance must be 10 Ohms with the maximum bonding resistance (between the metal parts of the devices and metal parts of the consumer earth terminal) of 0.2 Ohms.

The maximum allowable earth resistance between consumer and earth terminal to earth spike must be 1.7 Ohms, including earth electrode.

Support structures must be made of stainless steel, aluminium or galvanized iron, and must be able to withstand wind speeds of 120 km/h so as to be able to resist at least 20 years of outdoor exposure without suffering significant damage or corrosion.

3.7.1 Fence

If the PV modules are placed on the ground fencing shall be delivered and installed. Assume that 40% of systems will be situation on the ground. No any specific specifications in respect of the fencing.

3.8 Appliances

3.8.1 Compact Fluorescent Lamp (CFL) and Tubular Lamp (TL)

All general and outdoor lighting shall be of the type CFL or TL.

Luminous yield of the total ballast and fluorescent lamp system must be al least 35 lumens/Watt. Ballast must ensure safe and regulated ignition within 10 seconds in the voltage range from 10.3 to 15 V over 0 to +45°C. Minimum electrical efficiency of the ballast should be 80% in the voltage range from 10.3 to 15 V.

The electrical waveform at the fluorescent lamp terminal must be symmetric in time to within 10 percent (i.e., 60%/40% waveform maximum differences in symmetry over voltage range of 11.0 to 12.5 Vdc at an ambient temperature of 25°C).

There must be no blackening or reduction in the output (reference Lux) by more than 10%, observed after 1,000 on/off cycles, and the lamp must still be operational after 5,000 on/off cycles.

- General use: Wide angle with high luminance (330 to 370 lumen);
- Localised use: Narrow angle with medium to high luminance (180 to 220 lumen);
- Luminous yield of the total ballast and fluorescent lamp system must be at least 35 lumens/W.
- Task specific use: Work specific, for example dim light.

The DC component of the current through the fluorescent lamp should be zero.

A suitable filament pre-heating circuit should be provided. The lamp should be protected against reverse polarity.

Standby consumption (in no-tube condition) of ballast should be less than 10% of rated capacity.

3.8.2 LED Cluster Lamp

Reading light shall be of the type LED.

Power consumption must be less than 2 Watt/cluster. LED clusters must operate flawlessly at voltages between 10.3 to 15 V and temperature from 0°C to + 45°C.

To protect eyes from intense light, a white LED cluster should shine through a solid angle of at least 45°, for proper diffusion.

3.9 Spare Parts

The Contractor shall compose and deliver an optimal package of spare parts equal to 2,5 % of the Contract sum. The spare part package shall minimum include the following items.

Item
PV modules
Batteries
Battery interconnects
Battery fuse
Charge controller
Inverter
Wiring
Indoor lights
Exterior lights
Appliances
Distilled water

3.10 Warranty

- 5 years for batteries;
- 2 years for all other parts of the PV system, including all DC and AC appliances.

3.11 Documentation to be Provided by the Contractor

3.11.1 General

All documents shall be prepared in the English language.

The following information shall be delivered for each solar PV system:

PV modules

- Brand and name of the manufacturer
- Model and type
- Manufacturer's serial number of the system indicating the year of manufacturing
- Rated peak Watt per module
- Maximum Rated Current
- Maximum Rated Voltage
- Short Circuit Current
- Open Circuit Voltage
- Quantity of modules
- Total installed nominal power, W_p

Battery

- Brand and name of the manufacturer
- Model and type
- Rated capacity in Ampere-hours at the discharge rate C20
- Quantity of batteries
- Total installed rated capacity (C20), Ah.

Charge Controller

- Brand name
- Type (On/Off or PMW) and model
- Maximum input current
- Maximum load current
- Nominal voltage
- Size of fuses
- Quantity

DC appliances

- Brand name

Other component

- List of other components (wires, switches, fuses, outlets, grounding, etc.)
- Name, model and type
- Quantity.

Energy

State the expected annual energy production per solar PV system calculated with the Retscreen tool using solar data of Appendix 3.

Drawings

Schematic of the solar PV system.

3.11.2 Documentation after Award of Contract

The documentation to be supplied after award of Contract shall include:

- Detailed design documentation including installation drawings;
- End-user manual;
- Technician's Manual for Installation, Operation and Maintenance.

Detailed Design Documentation

The documentation shall include specifications and calculations, which shall be submitted in 2 copies to the Employer for approval **no later than 1 month** after the signing of the contract. A period of 2 weeks shall be allowed for the Employer's examination and approval of this documentation.

The documentation to be prepared by the Contractor in connection with the detailed design shall be sufficiently detailed for the purposes of:

- Assembly and erection details of solar panels arrays;
- Erection drawings for all other equipment;
- Calculation of battery capacities and charger ratings;
- Schematic diagram of generating set control;
- Detailed schematic diagrams of DC supply, its distribution and supervision with accompanying description;
- Layouts and detailed drawings of cables etc.;

End-user Manual
The End-user Manual shall include:

- Theory of operation of the SPVS with a discussion on: battery charging by the array; functions, battery low voltage protection and battery overcharge protection. The relationship between energy available on a daily basis and sunlight conditions should be clearly and simply explained;
- A description of all user interactive hardware including disconnect switches and status indicators;
- Procedures for proper system operation, including a list of load limitations and any problem loads. Suggested operation, including load conservation during periods of inclement weather and/or a low voltage disconnect event. The procedures for that checking the photovoltaic array is not shaded and how to prevent shading must be explained;
- Any user maintenance items;
- Procedures for emergency shut-down and for extended periods of system non-use;
- A trouble-shooting guide for users.

Technician's Manual for Installation, Operation and Maintenance
The technician's manual shall include:

- A complete list of all system components, with associated manufacturers literature, specifications and warranties;
- Complete installation instructions;
- Installation protocol with the initial start-up numbers from the approval test and general measurement values
- Explanation to the user of the system operating principles, load management requirements, impact of shading of the array and how to check and avoid it, user maintenance checks and how to conduct them;
- A recommended annual maintenance schedule, with complete maintenance instructions;
- A detailed trouble-shooting guide referencing all the system components. This shall include repairs and diagnostic procedures that can be done by

- A functional block diagram, electrical single-line drawing showing the placement of all hardware and ratings of all components and physical layout;
- Emergency shut down procedures.

The Contractor shall supply documentation in the form of manuals and all necessary documentation concerning the operation of the equipment in the English language.

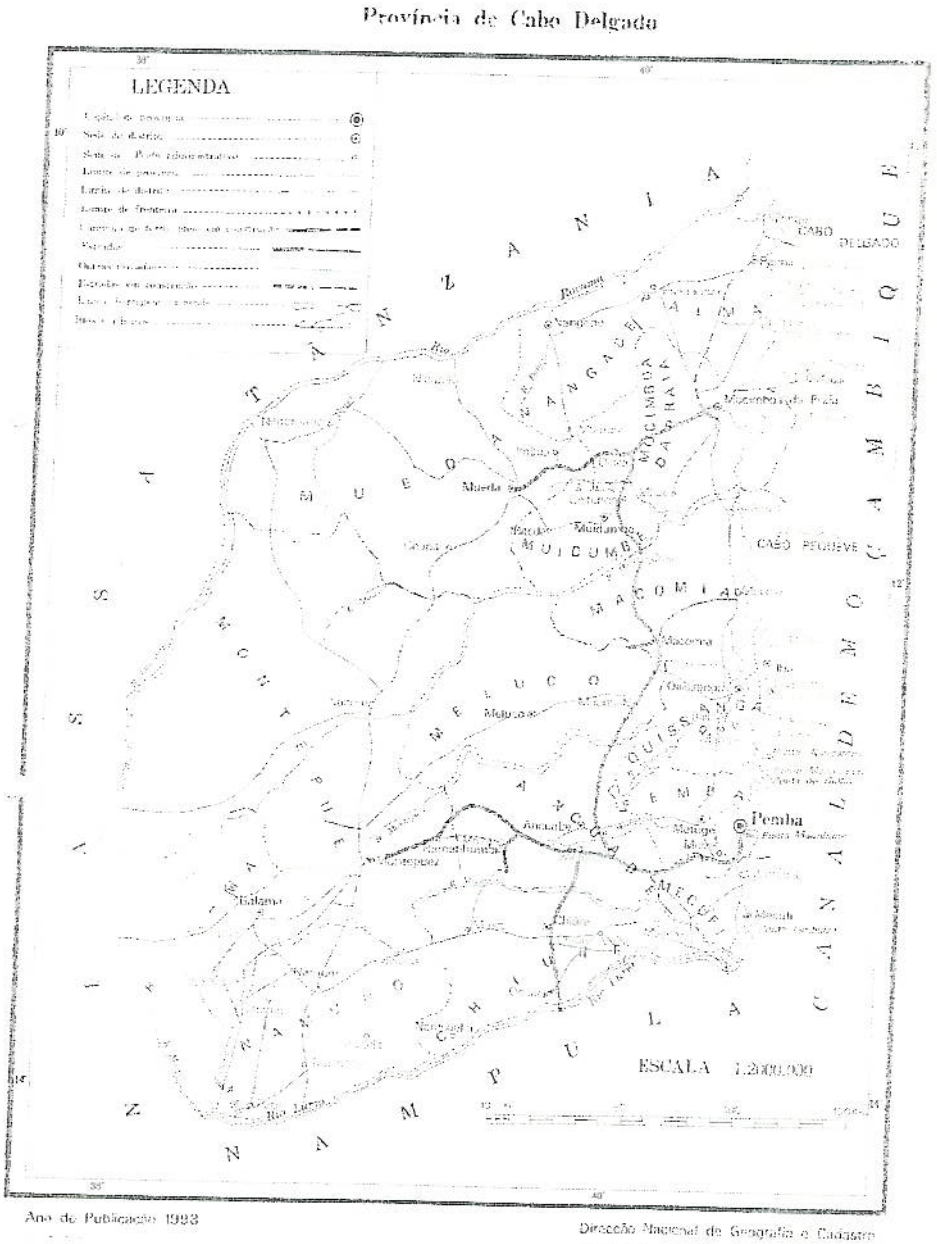
3.12 Quality Assurance

The Contractor shall use the quality assurance system: "ISO 9001 Quality System Model for quality assurance in design/development, production, installation and servicing", or similar.

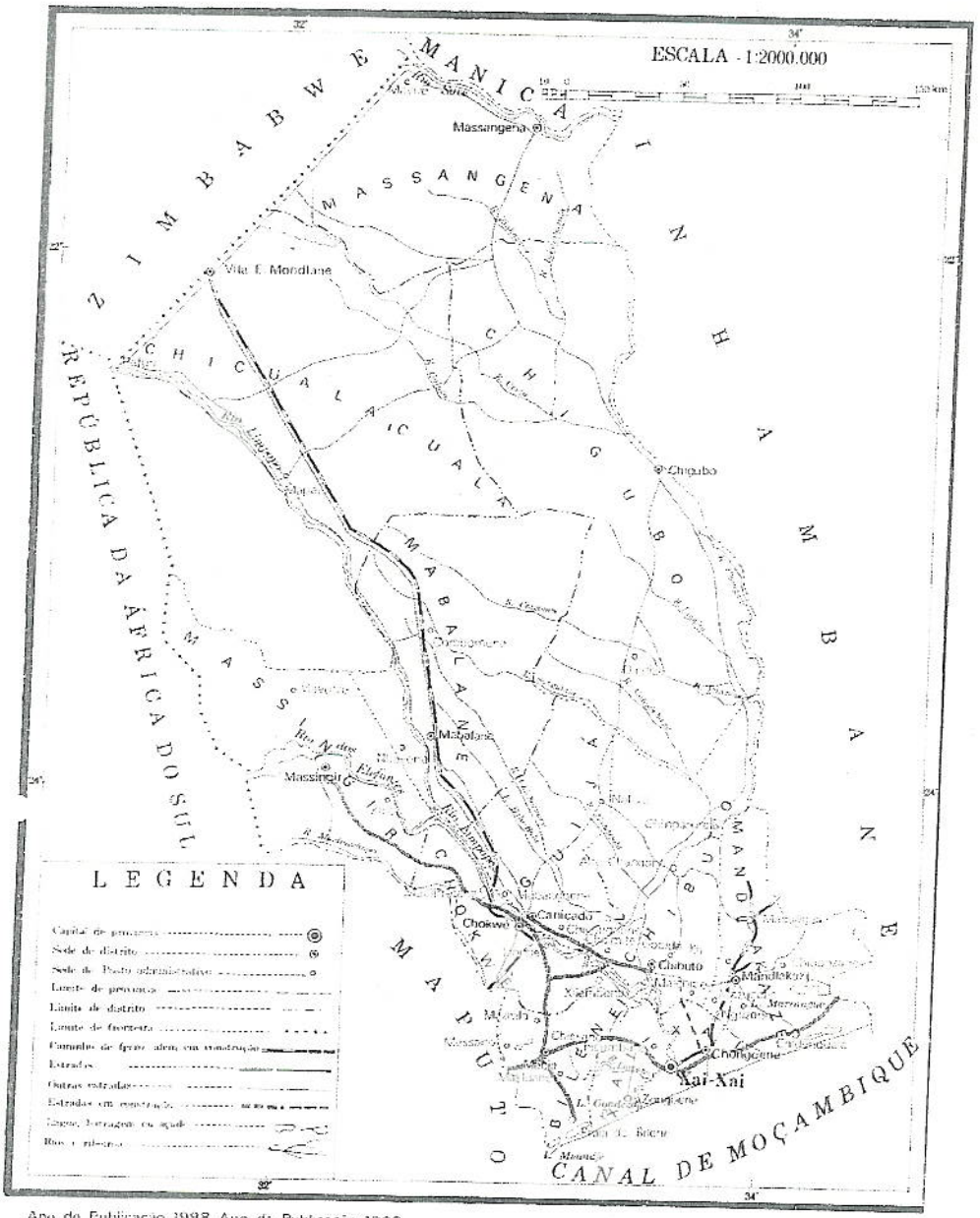
The accepted Quality Assurance certification systems are:

- Photovoltaic Global Approval Programme (PV-GAP) Mark or Seal;
- International Electro-technical Commission Quality Assessment System for Electronic Components (IECQ) approval;
- Certification according to ISO 9000 Series;
- Quality Assurance certification in accordance with national certification systems in the country of origin, equivalent to PV-GAP, IECQ or ISO 9000.

Appendix 1: Project Area Map



Província de Gaza



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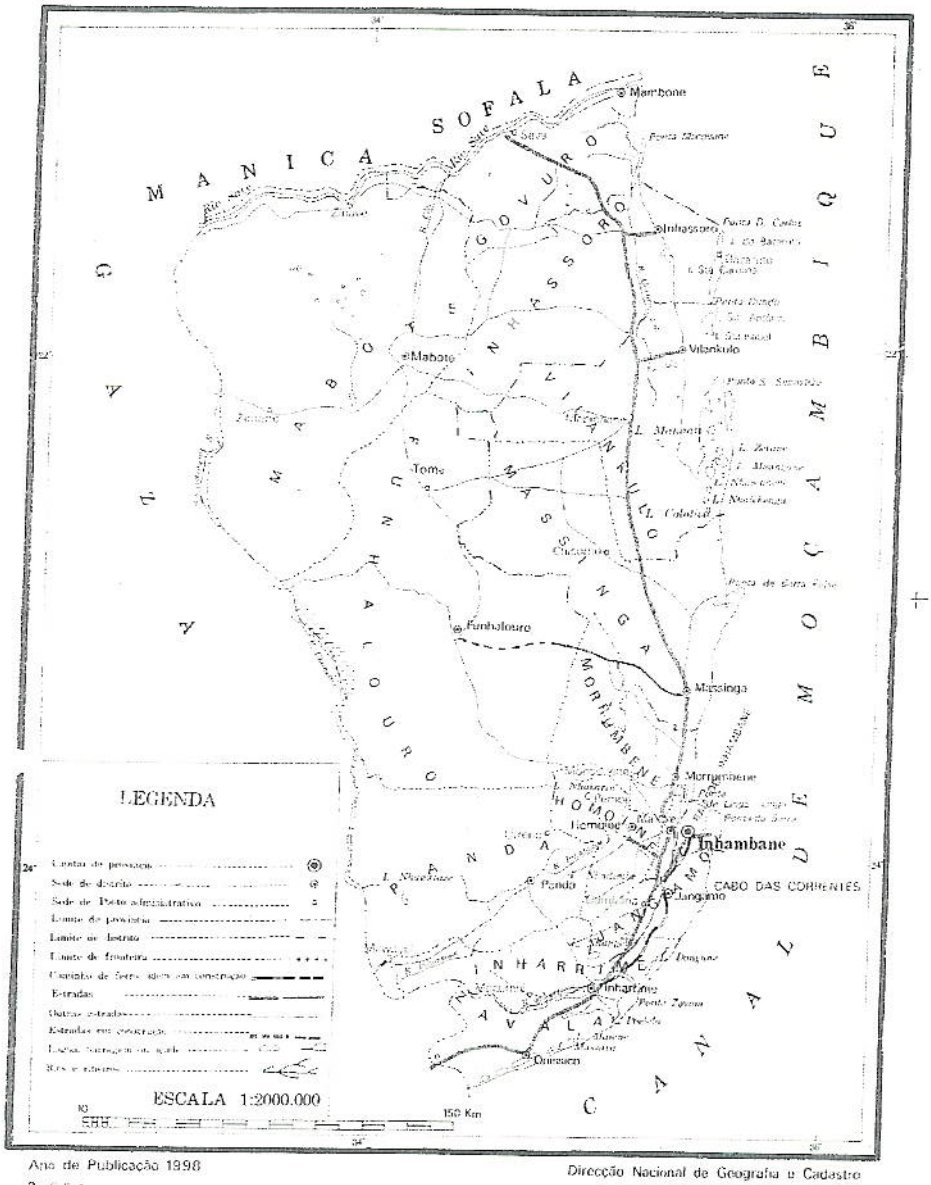
Direcção Nacional de Geografia e Cadastro
DINAGECA

Província de Inhambane



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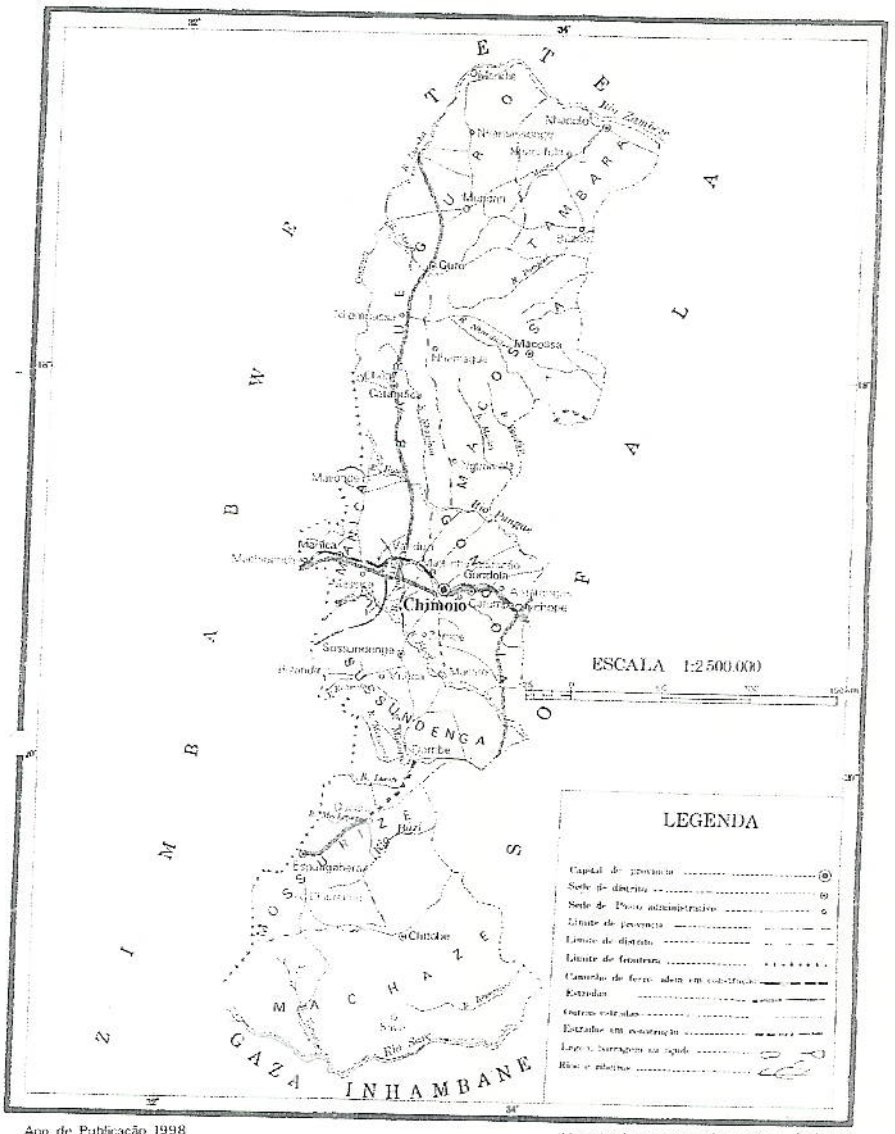
DINAGECA

Província de Manica



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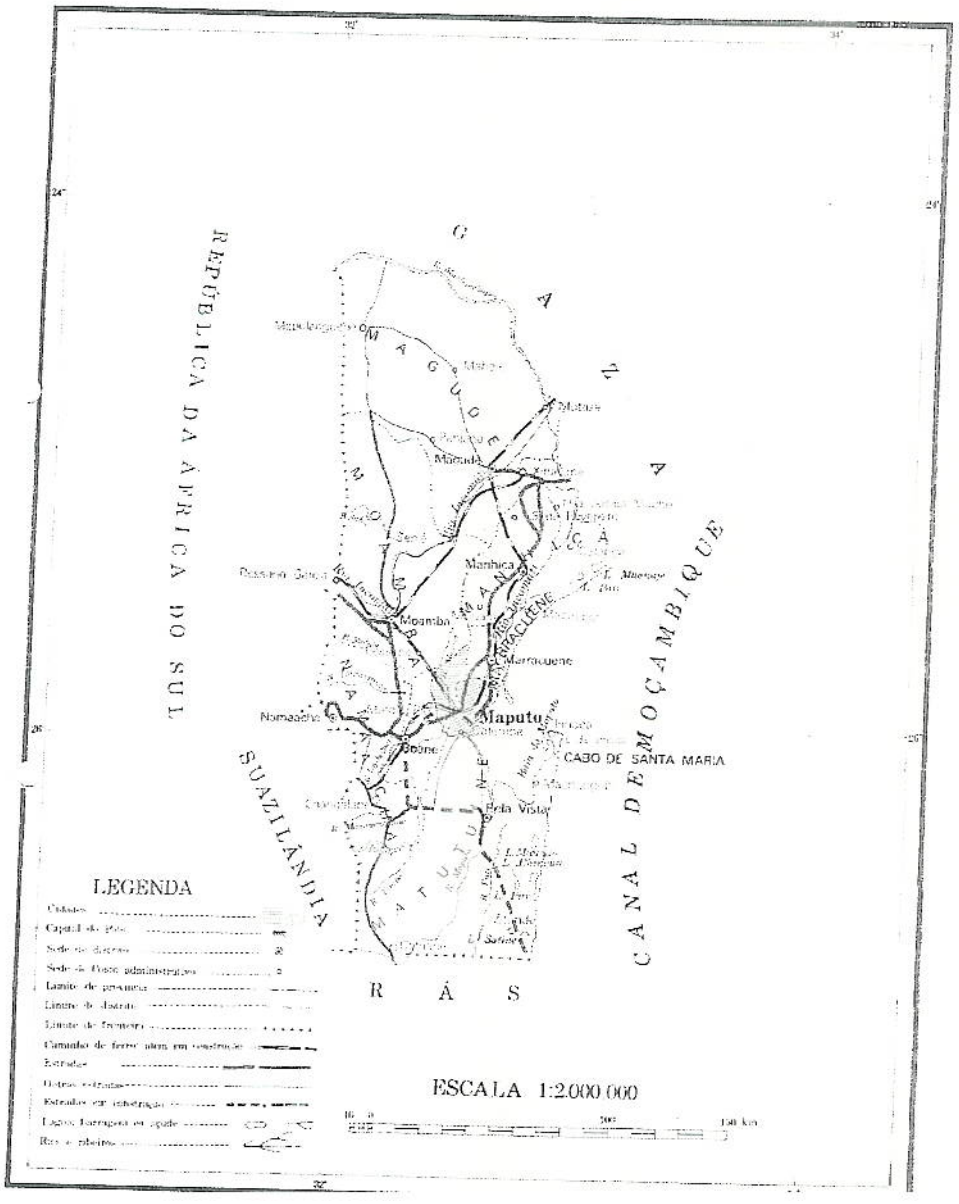
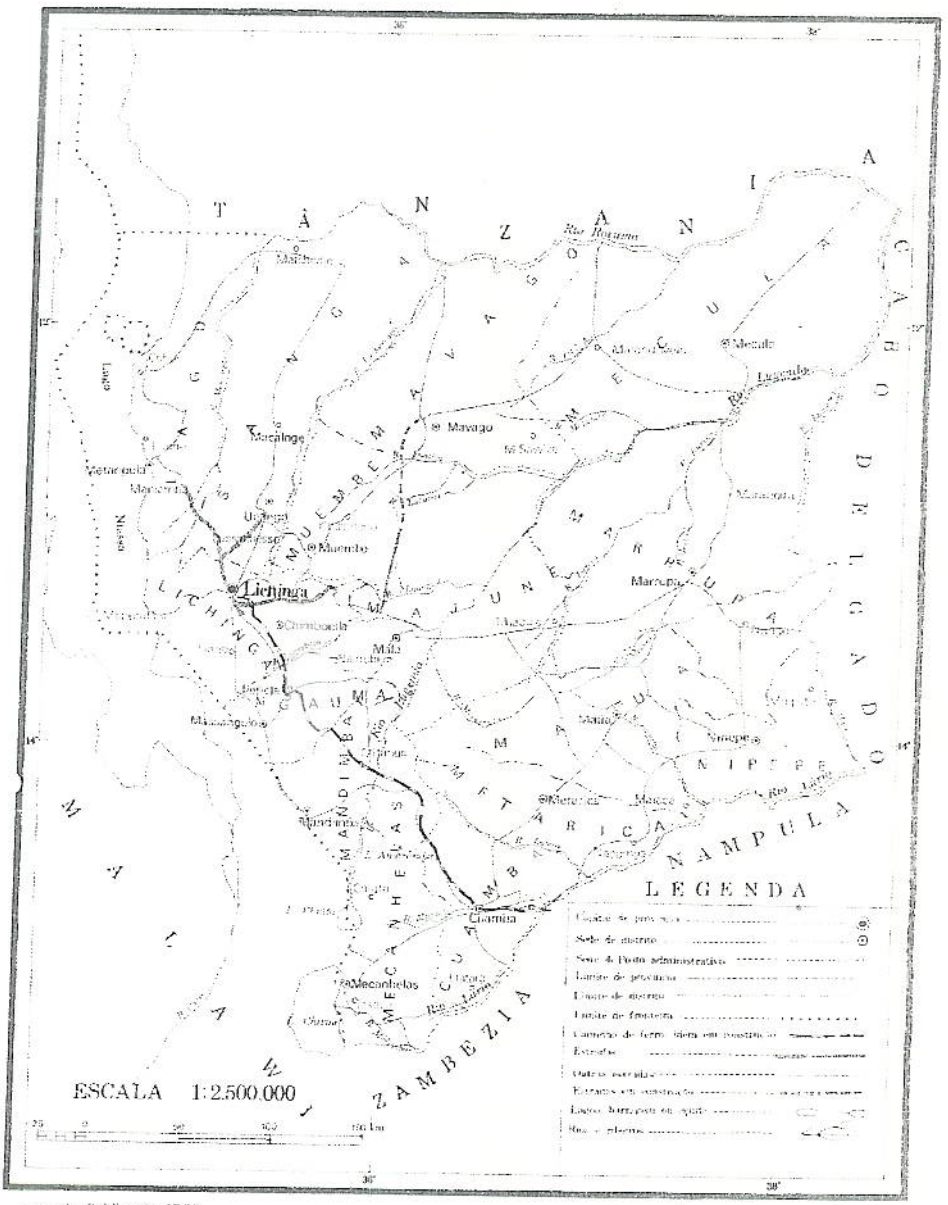
DINAGECA

Provincia de Maputo





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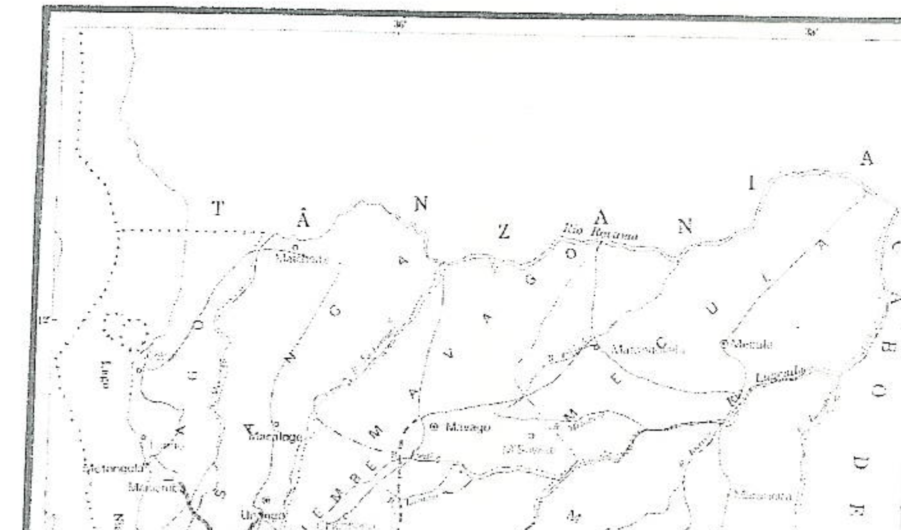
Província de Niassa



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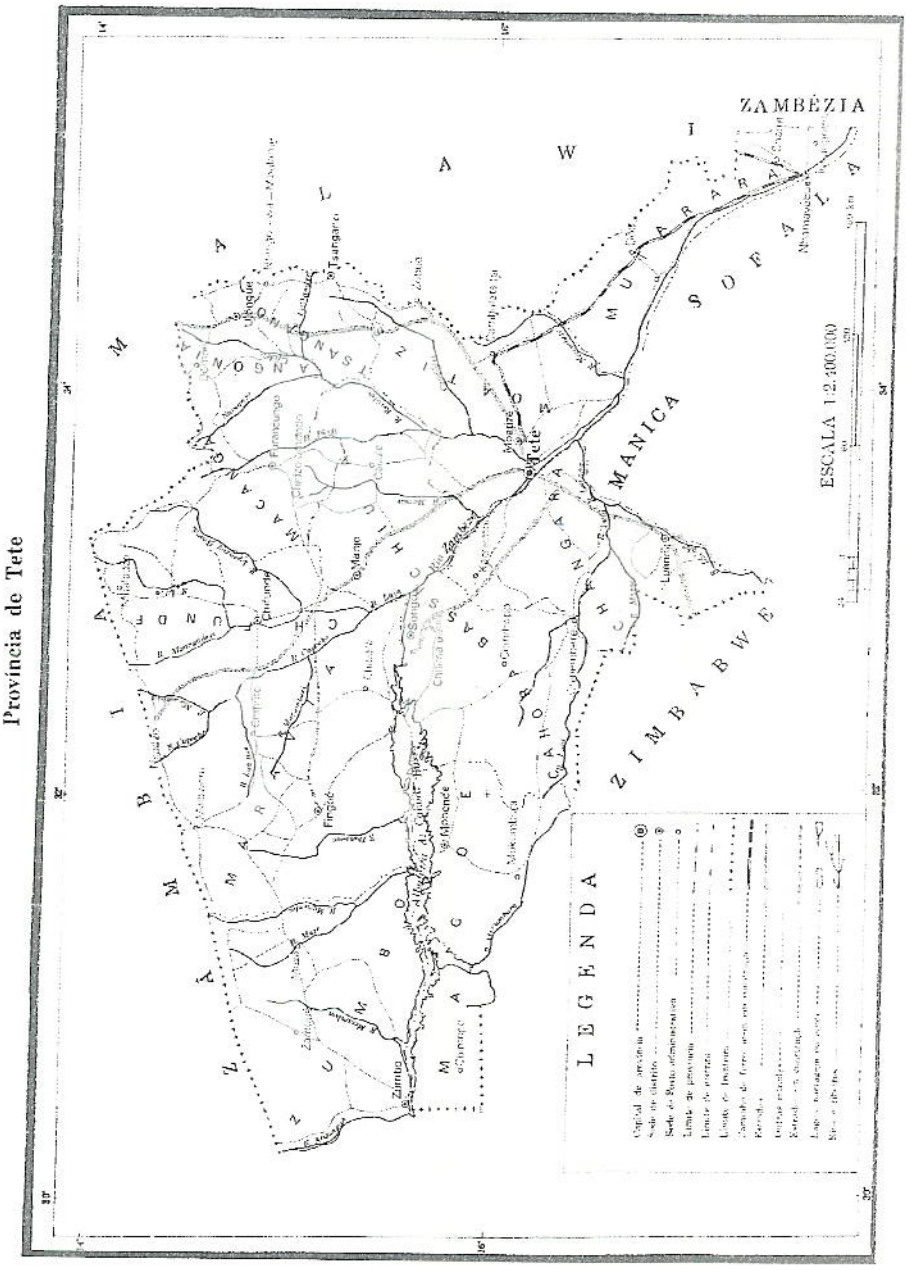
Província de Tete



Appendix 2: Project Site Data

Provincia da Cabo Delgado

N/O	NOME DA ESCOLA	Nº de Blocos	Salas de aula por tipo de construção			Nº de casas para professores	Sistemas seleccionados			Localização	
			cimento	outros	Total		Class room	Administ	Staff	Distrito	Posto Administrativo
1	Escola Primária do 2º Grau de Ocua	3	8		8	8	3	1	3	Ciúre	Ocua
2	Escola Primária Completa de Ibo	2	4		4		1	1	0	Ibo	Ibo - Sede
3	Escola Primária Completa de Macomia	3	5		5	3	2	1	1	Macomia	Macomia - Sede
4	Escola Primária Completa III Congresso	3	6		6		3	1	0	Mocimboa da P.	Mocimboa - Sede
5	Escola Primária Completa de Mueda	5	10		10	2	3	1	1	Mueda	Mueda - Sede
6	Escola Primária Completa de Namuno	3	5		5	5	2	1	2	Namuno	Namuno - Sede
7	Escola Secundária de Metuge	4	7		7		3	1	0	Pemba Metuge	Metuge - Sede
8	Escola Primária Completa de Nangade	3	8		8	1	3	1	1	Nangade	Nangade - Sede

Provincia do Gaza

9	Escola Secundária de Chigulvitane	3	7		7	1	3	1	1	Mandlakazi	Chalala
10	Escola Primária Completa de Manguinze	3	8		8	1	3	1	1	Mandlakazi	Mandlakazi- Sede
11	Escola Primária Completa de Mavodze	2	3		3	1	1	1	1	Massingir	Mavodze
12	Escola Primária Completa Mao-Tse-Tung	3	4		4		2	1	0	Bilene	Chissano
13	Escola Primária Completa de Muzamane	4	10		10	1	4	1	1	Chicualacuala	Mapai
14	Escola Primária Completa Combumune Estação	1	2		2		1	1	0	Mabalane	Combomune

Provincia de Inhambane

15	Escola Primária Completa de Mavila	3	3	4	7		3	1	0	Zavala	Zandamela
16	Escola Primária Completa de Muvamba	3	4	3	7		3	1	0	Massinga	Chicomo
17	Escola Primária do 1º Grau de Save	2	4	2	6		1	1	0	Govuro	Save
18	Escola Primária Completa de Mabote	5	10		10		4	1	0	Mabote	Mabote
19	Escola Primária Completa de Funhalouro	3	5	2	7		2	1	0	Funhalouro	Funhalouro
20	Escola Primária Completa de Panda	4	7	10	17		3	1	0	Panda	Panda

Provincia de Manica

21	Escola Primária Completa de Honde	3	5	6	11	2	3	1	1	Báruè	Honde
22	Escola Primária Completa de Nhassacora	5	8	3	11	3	3	1	2	Báruè	Nhampassa
23	Escola Primária Completa de Nhacolo	8	19	2	21	10	8	1	4	Tambara	Nhacolo
24	Escola Primária Completa de Búzua	2	4		4	4	1	1	2	Tambara	Búzua
25	Escola Primária Completa de Campange	4	7		7	3	3	1	2	Tambara	Nhacolo

Provincia de Maputo

26	Escola Primária Completa Abel Jafar	4	12	5	17	3	4	1	2	Marracuene	Marracuene - Sede
27	Escola Primária Completa de Mumemo	3	5	5	10	6	2	1	2	Marracuene	Marracuene - Sede
28	Escola Primária Completa de Mulelana	3	4		4		2	1	0	Boane	Matola Rio
29	Escola Primária Completa Filipe Samuel Magaia	3	6		6	3	3	1	2	Marracuene	Marracuene - Sede

Provincia de Niassa

30	Escola Primária Completa de Maúa	3	7		7	2	3	1	1	Maúa	Maúa Sede
31	Escola Primária Completa de Nipepe	4	11	2	13	2	4	1	1	Nipepe	Nipepe - Sede
32	Escola Primária Completa Acordos de Lusaka	3	9		9	2	4	1	1	Mavago	Mavago-Sede
33	Escola Primária Completa de Muembe	3	6		6	2	3	1	1	Muembe	Muembe - Sede
34	Escola Primária do 2º Grau de Macaloge	3	5		5	1	2	1	1	Sanga	Macaloge
35	Escola Primária Completa de Massangulo	2	3		3		2	1	0	Ngáuma	Ngáuma - Sede
36	Escola Primária Completa 16 de Junho	2	2	1	3		1	1	0	Mecula	Mecula - Sede

Provincia de Sofala

37	Escola Primária do 1º Grau de Galinha	1	3		3	2	1	1	1	Muanza	Galinha
38	Escola Primária Completa de N'situculo	2	4		4	5	2	1	2	Muanza	Galinha
39	Escola Primária Completa de Nhampoca	5	9		9	6	3	1	3	Nhamatanda	Tica
40	Escola Primária Completa de Muda-Mufo	3	7	7	14	4	3	1	2	Nhamatanda	Tica
41	Escola Primária do 2º Grau de Maringué	2	7		7	7	2	1	3	Maringué	Maringué - Sede
42	Escola Primária Completa de Sôbué	2	4		4	5	1	1	1	Maringué	Sonue

Provincia de Tete

43	Escola Primária Completa de Marlene	1	7		7	1	2	1	1	Angónia	Dómué
44	Escola Primária Completa de Mussaca	3	12		12	2	4	1	1	Moatize	Zóbue
45	Escola Primária Completa de Manje	3	12		12	2	4	1	1	Chiúta	Chiúta
46	Escola Primária Completa de Inhangoma	2	5	4	9	1	2	1	1	Mutarara	Inhangoma
47	Escola Primária Completa de Marara	3	6		6	4	3	1	2	Changara	Marara
48	Escola Secundária de Tsangano	3	6		6	1	3	1	1	Tsangano	Tsangano
49	Escola Secundária de Mágué	3	6		6	5	3	1	2	Mágué	Mhende
50	Escola Primária Completa 1º de Maio	3	4	3	7	4	2	1	2	Macanga	Furancungo

Appendix 3: Weather Data

The following solar data have been used for this functional design.

DATA OF RADIATION AND TEMPERATURE IN MOZAMBIQUE FROM 1970 TO 2005 (MEASURED BY THE NATIONAL INSTITUTE OF METEOROLOGY-INAM)

Month	CABO DELGADO			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	5.9	27.3	30.9	23.6
Feb	5.3	27.1	30.9	23.4
Mar	5.8	27	30.9	23.2
Apr	5.9	26.5	30.9	22.4
May	5.5	25.2	29.7	20.7
Jun	5.1	23.8	28.4	19
Jul	5.2	23.2	27.7	18.6
Aug	6	23.5	28	19
Sep	6.8	24.5	28.9	20.2
Oct	7.3	25.8	29.7	21.9
Nov	7.3	26.9	30.5	23.3
Dec	6.7	27.4	30.9	23.9

Month	NIASSA			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	5.1	20.4	24.6	16.3
Feb	5.1	20.5	24.7	16.3
Mar	4.8	20.2	24.6	15.9
Apr	5	19.3	23.9	14.7
May	5	17.4	22.9	12.2
Jun	4.4	15.5	21.1	10
Jul	4.8	15	20.6	9.5
Aug	5.3	16.4	22.4	10.5
Sep	6	18.8	25.2	12.6

Month	TETE			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.6	28.6	33.6	23.6
Feb	6.2	28.4	33.4	23.5
Mar	6.3	28.3	33.5	23
Apr	5.7	27.3	32.9	21.5
May	5.1	25	31.2	18.5
Jun	4.6	22.4	28.9	16.2
Jul	4.7	22.1	29	15.8
Aug	5.2	24.2	30.8	17.5
Sep	5.8	27	33.7	20.3
Oct	6.1	29.5	36.1	22.8
Nov	6.8	30.3	36.6	24
Dec	6.6	29.1	34.7	23.7

Month	SOFALA			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.6	26.8	31.2	24.6
Feb	6.3	26.7	30.8	24.7
Mar	5.9	26.4	30.2	24.2
Apr	5.5	24.4	29	22.4
May	4.7	22.1	27.3	19.6
Jun	4.2	20.3	25.5	17.4
Jul	4.4	19.7	24.9	16.9
Aug	5	20.7	26.1	17.9
Sep	5.7	22.2	27.2	19.6
Oct	6.4	23.8	28.6	21.4
Nov	6.7	25.4	29.9	23.1
Dec	6.6	26.2	30.6	24.1

Month	MANICA			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.7	23.9	28.5	19.5
Feb	6.5	23.8	28	19.5
Mar	6.2	23.1	27.7	18.6
Apr	5.5	21.5	26.5	16.8
May	4.9	19.7	25.2	14.2
Jun	4.5	17.7	23.2	12.2
Jul	4.7	17.4	23	11.8
Aug	5.3	18.9	24.8	12.9
Sep	5.9	21.2	27.4	14.9
Oct	6.2	22.9	28.9	16.8
Nov	6.6	23.7	29.1	18.2
Dec	6.1	23.8	28.5	19.1

Month	INHAMBANE			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.8	26.9	31.1	22.9
Feb	6.5	27	31.1	23
Mar	5.8	26.4	30.6	22.3
Apr	5.1	24.8	29.2	20.5
May	4.3	22.8	27.4	18.2
Jun	3.9	20.9	25.7	16.2
Jul	4.1	20.3	25.1	15.6
Aug	4.8	21.1	25.6	16.5
Sep	5.5	22.4	26.6	18.1
Oct	6.1	23.7	27.8	19.6
Nov	6.6	25	28.9	21
Dec	6.7	26.1	30.2	22

Month	GAZA			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.6	26.5	31.3	21.8
Feb	6.3	26.2	31	21.9
Mar	5.5	25.5	30.2	20.7
Apr	4.6	23.7	29.2	18.5
May	3.9	21.2	27.4	15.4
Jun	3.4	18.9	25.3	12.7
Jul	3.6	18.5	25.1	12.3
Aug	4.3	20	26.5	13.6
Sep	5.1	21.9	28	15.9
Oct	5.8	23.4	29.1	17.7
Nov	6.3	24.7	30.6	19.5
Dec	6.7	25.8	31	20.8

Month	MAPUTO			
	Global solar radiation (kWh/m2/day)	Temperatures (°C)		
	Monthly means	Monthly means	Maximum Monthly average	Minimum Monthly average
Jan	6.9	26	29.9	22.2
Feb	6.6	26	29.7	22.2
Mar	5.8	25.4	29.3	21.5
Apr	4.9	23.8	28.1	19.4
May	4.1	21.8	26.6	16.8
Jun	3.8	19.6	24.8	14.5
Jul	3.8	19.3	24.4	14.1
Aug	4.5	20.4	25.5	15.3
Sep	5	21.6	26.2	17
Oct	5.7	22.5	26.7	18.4
Nov	6	23.9	27.8	19.9
Dec	6.8	25.2	29.2	21.3

Appendix 4: Site Acceptance Test (SAT)

Site information

□ Site name: _____

□ Province: _____

□ District: _____

□ Date: _____

Structural issues

□ Orientation towards North ±15°
□ Tilt (15-35°)
□ No external shading on PV array
□ Structure and PV modules are properly secured to roof or ground
□ Holes in roof and walls are repaired (water thigh)
□ Battery storage in vented battery encasing

Electrical issues, DC

□ The polarities are correct
□ The system voltage are below maximum values
□ Diodes are installed correct
□ The overcharge protection is installed properly
□ The cables are of the correct size
□ All cables are properly attached to walls and roof
□ All DC appliances are DC labelled

Functions

PV modules

String number	Solar Intensity Measured W/m^2	Open Circuit Voltage Measured V	Short Circuit current Measured A	Short Circuit Current, Calculated* A
1				
2				
3				
4				

* Short Circuit Current Calculated = Short Circuit Current Measured X 1000 / Solar Intensity Meas...

Battery

□ Air temperature during test (°C) :

Cell number	Specific gravity	Cell Voltage V	Specific gravity A	Cell Voltage V
1				
2				
3				
4				
5				
6				

Charge Controller

□ Array current present at the input
□ Array voltage present at the input
□ Output voltage ok
□ Output current ok

Summary

□ Total power output (W) :
□ Actual solar intensity (W/m^2):

Quality Assurance

□ End-user Manual exists
□ Technical Manual exists
□ Local staff member trained

Comments:

_____

_____

_____

_____

Approval

□ Approved
□ Date
□ Name
□ Signature