JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF MINERALS, ENERGY AND WATER RESOURCES
ENERGY AFFAIRS DIVISION
THE REPUBLIC OF BOTSWANA

Republic of Botswana

FINAL REPORT
FOR
THE MASTER PLAN STUDY
ON
PHOTOVOLTAIC RURAL ELECTRIFICATION
IN
THE REPUBLIC OF BOTSWANA

FEBRUARY, 2003

UNICO INTERNATIONAL CORPORATION

ELECTRIC POWER DEVELOPMENT CO., LTD.

Preface

In response to a request from the Government of Botswana, the Government of Japan decided to conduct the Master Plan Study on Photovoltaic Rural Electrification in the Republic of Botswana, and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Botswana a study team headed by Mr. Isao Shizuma, UNICO International Corporation, and organized by UNICO International Corporation and Electric Power Development Co., Ltd. from September 2000 to February 2003.

The team held discussions with the officials concerned of the Government of Botswana and conducted a series of field study. After its return to Japan, the team conducted further studies and compiled the results in this report.

I hope this report will be utilized for contributing to the master plan formulation and implementation of photovoltaic rural electrification in Botswana.

I wish to express my sincere appreciation to all those who participated in this study project for their close cooperation with the team.

February 2003

川上隆朗

Takao Kawakami
President
Japan International Cooperation Agency

February 2003
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Kawakami

Letter of Transmittal

We are pleased to submit to you a final report on " The Master Plan Study on Photovoltaic Rural Electrification in the Republic of Botswana." The report reflects opinions and views of the Energy Affairs Division of the Ministry of Minerals, Energy and Water Resources, and other government offices and organizations, as well as Japanese government offices and organizations concerned.

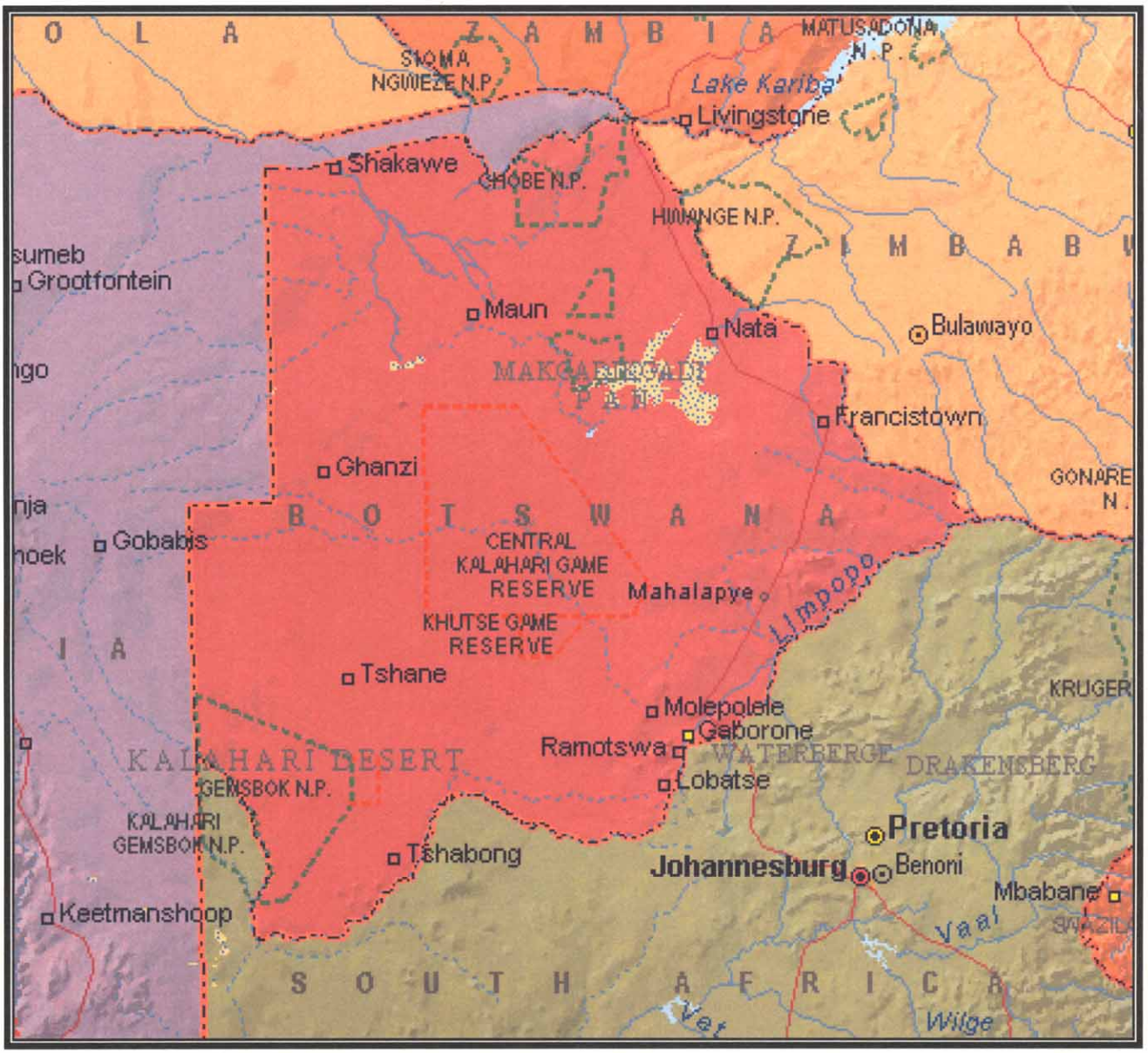
The report proposes a photovoltaic rural electrification plan for the entire country and an implementation plan to carry out rural electrification as a feasible project. We firmly believe that the plan will contribute greatly to promotion of social equality and rural development. In particular, when the proposal made in this report is realized as part of the Ninth National Development Plan, which will start in 2003, it will help promote the rise in standards of living and industrial development in the country.

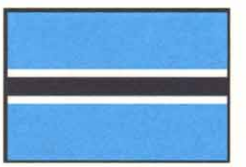
Finally, we would like to express our gratitude to your agency, the Ministry of Foreign Affairs, and the Ministry of Economy and Industry for extensive support and guidance.

Very truly yours,

静間勇夫

Isao Shizuma
Team Leader,
The Master Plan Study on
Photovoltaic Rural Electrification
in The Republic of Botswana





REPUBLIC OF BOTSWANA

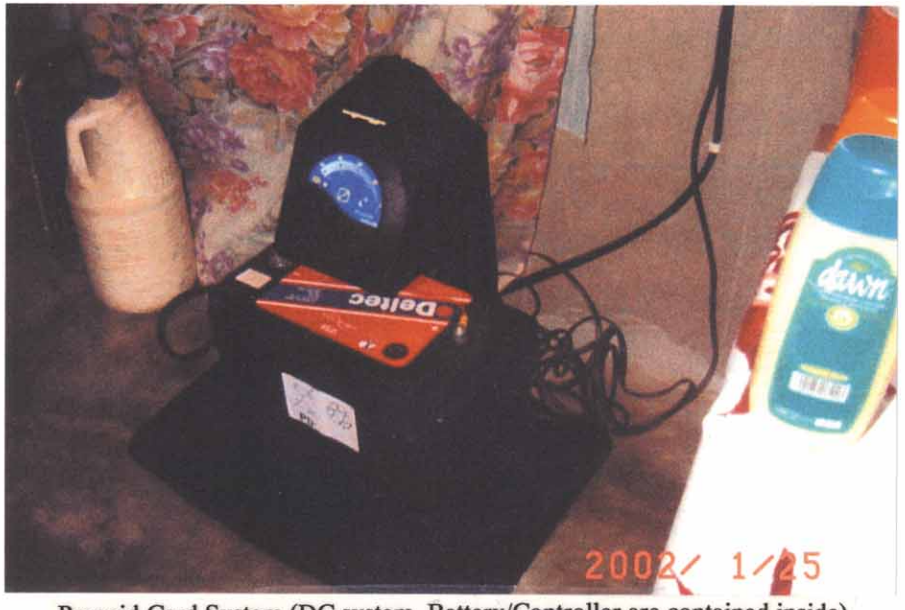
AC Light (11W)

Prepaid Card System (Battery/Controller are contained inside)

200Wp SHS AC (50Wp x 4 panels)

DC Light (11W)

50Wp SHS DC



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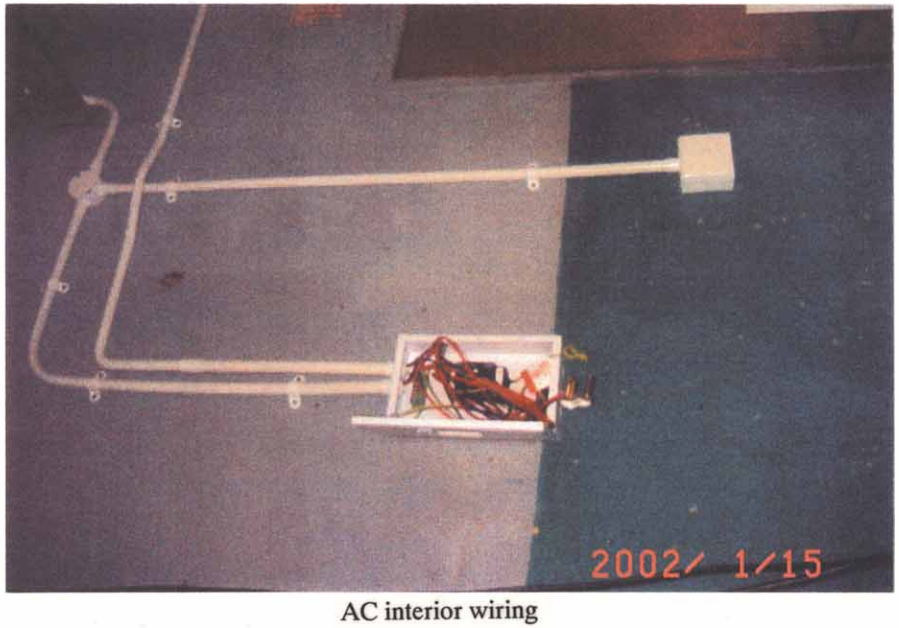
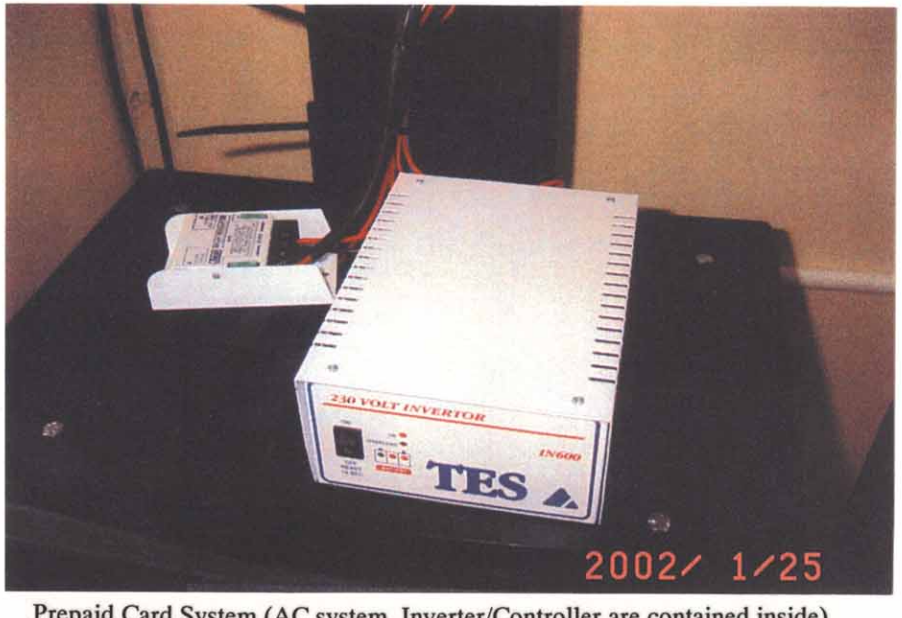
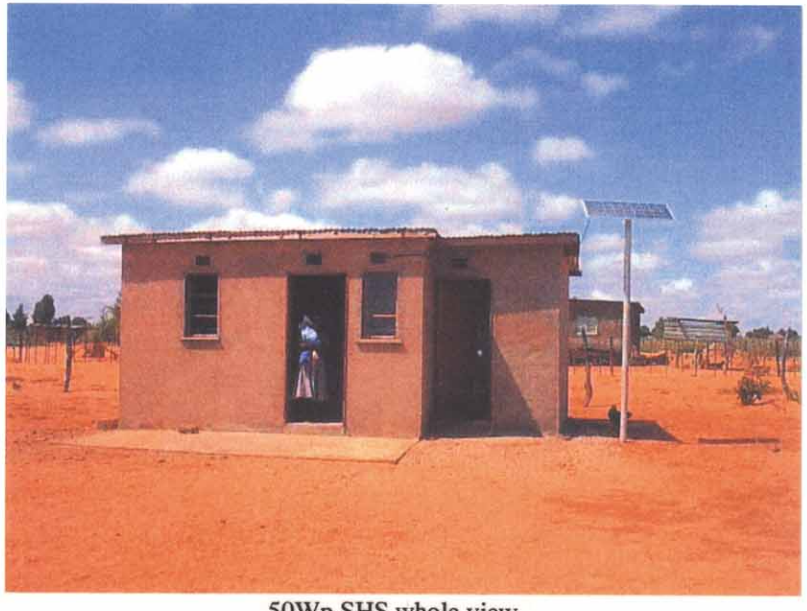


AC interior wiring

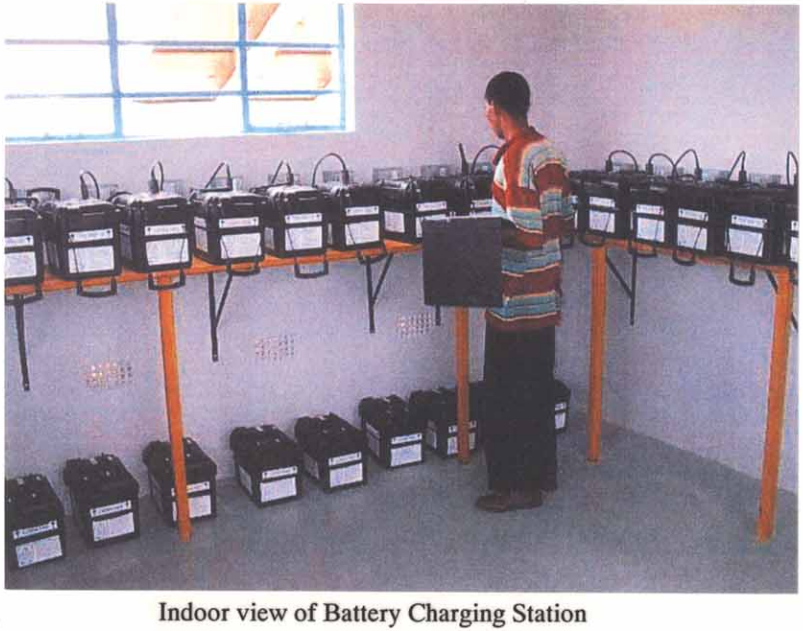


Prepaid Card System (AC system, Inverter/Controller are contained inside)

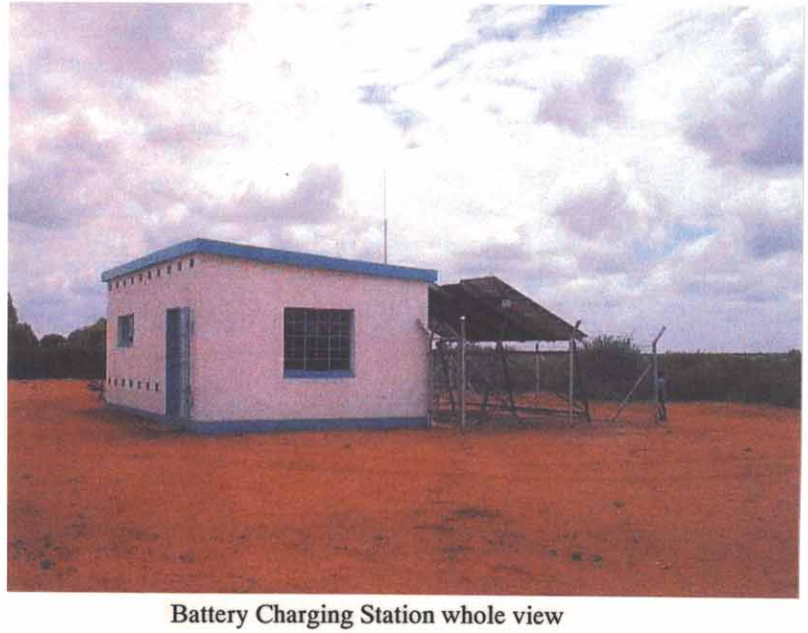
Battery Charging Station PV panels
(60Wp multi-crystalline x 10 panels, 50Wp Amorphase x 10 panels)



50Wp SHS whole view



Indoor view of Battery Charging Station



Battery Charging Station whole view

Acronyms & Nomenclature

Acronyms	Nomenclature
AC	Alternating Current
BCS	Battery Charge Station
BEMP	Botswana Energy Master Plan
BOS	Balance of System
BoTeC	Botswana Technology Center
BPC	Botswana Power Corporation
BTC	Botswana Telecommunication Corporation
DC	Direct Current
DEMS	Department of Electrical and Mechanical Services
DVET	Department of Vocational Education and Training
DWA	Department of Water Affairs
EAD	Energy Affairs Division of MMEWR
EIRR	Economic Internal Rate of Return
ESCO	Electricity Supply Company
ESMAP	The Energy Sector Management Assistance Program sponsored by WB and UNDP with financial participation from public and private donors
FED	Final Energy Demand
FIRROI	Financial Internal Rate of Return on Investment
GDP	Gross Domestic Product
GEF	Global Environmental Facility
HIES	Households Income and Expenditure Survey made in 1993/1994
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monetary Fund
IRR	Internal Rate of Return on Investment
JICA	Japan International Cooperation Agency
LPG	Liquefied Petroleum Gas
MCST	Ministry of Communications, Science and Technology
MFDP	Ministry of Finance and Development Planning
MLG	Ministry of Local Government
MLHE	Ministry of Lands, Housing and Environment
M/M	Minutes of Meeting
MMEWR	Ministry of Minerals, Energy and Water Resources
MOA	Ministry of Agriculture
MOE	Ministry of Education
MSP	Ministry of State President
MWTC	Ministry of Works, Transportation and Communication
NCC	National Crafts Certificate
NDP	National Development Plan (Currently NDP8 : The 8th NDP)
NGO	Non Governmental Organization
NPV	Discounted Net Present Value
NPV-REP	National PV - Rural Electrification Program
NRSE	New and Renewable Sources of Energy
PES	Primary Energy Supply
PV	Photovoltaic Electricity
RCS	Rural Electrification Collective Scheme

Acronyms & Nomenclature

Acronyms	Nomenclature
RE	Rural Electrification
RIIC	Rural Industries Innovation Center
RIPCO	Rural Industries Promotion Company
ROI	Return on Investment
RSA	Republic of South Africa
S/W	Scope of Work
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SHS	Solar Home System
TC	Technical College
T/L	Transmission Line
TV	Television
UN	United Nations
UNDP	United Nations Development Program
USD	United States Dollar
VAC	Village Advisory Committee
VDC	Village Development Committee
VTC	Vocational Training Center
WB	World Bank

Unit

Acronyms	Nomenclature	Conversion Factor
$	Unites States Dollar	
P	Pula	Exchange Rate $1 = P6.5
Th	Thebe	1/100 P
R	Rand (RSA)	R1 = ¢ 100
T	Tera	10^{12}
G	Giga	10^{9}
M	Mega	10^{6}
k	kilo	10^{3}
h	hour	
m	month	
y	year	
A	Ampare	
V	Volt	
W	Watt	
Wp	Watt peak of PV module	
J	Joule	1kWh = 3.6 x 10^{6} J

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Appendix 5 Institutional Framework for Promotion of PV Rural Electrification

Appendix 6 Socio Economic Situations and PV Potential in Botswana Rural Area

Appendix 7 Selection of the Target Villages for PV Electrification

Appendix 8 PV System Design and Environmental Measures

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Chapter 1 Introduction

Chapter 1 Introduction

1.1 Background and Objective of the Study

In Botswana, electrification of rural villages has been rapidly promoted by means of extension of the existing power transmission lines. However, due to a relatively high cost for grid connection - which is not affordable for many village households, the electrification rate in the rural sector remains much lower than that in the urban sector, i.e., 4% vs. 26% (Energy Master Plan 1996), not to mention a large difference between regions.

To accelerate rural electrification, the government emphasizes the use of decentralized energy sources in addition to the continued efforts to expand the grid coverage and reduce the connection charge and payment conditions.

Botswana enjoys one of the best solar energy regimes in the world. Various studies have concluded that solar energy applications have potential for widespread use in Botswana.

The Botswana Energy Master Plan Summary Report (1993) concluded that "Solar energy is the only renewable energy source which has the potential to make large scale, strategic impact on the country's future energy supply". The SADC Study on PV Market (1992) indicated a substantial market potential for PV in the region, Botswana included. These studies suggest a lot of potential for PV application.

Both the first and second phases of Botswana Energy Master Plan (BEMP) recommended the use of solar energy for both electricity generation and water heating. The BEMP Final Phase among others recommended:

Integration of PV electrification into the national electrification program
Allocation of PV electrification to a suitable organization

Based on the recommendations, the government has supported the use of renewable energy, solar energy in particular, through the successive Development Plans. During the 7th National Development Plan (NDP 7) the focus was placed on technology development and dissemination with an emphasis to meet the energy needs of the rural

areas. The private sector was encouraged to develop some of the solar energy products and components.

During NDP 8 the main policy objective is to promote photovoltaic electrification in an orderly way with adequate coordination, institutional support, financing and technical standards.

Parallel to the policy pronouncements the government has also initiated a number of programs to promote solar energy. In 1991 the Energy Affairs Division of the Ministry of Minerals, Energy and Water Resources initiated a pilot project to install, monitor and evaluate solar energy technologies in Manyana Village. The objective was to assess the socio-economic viability of solar energy technologies in a village environment, with a view to replicate them in other parts of the country should they prove viable.

Following the positive outcome of the pilot project the National PV Rural Electrification Program (NPV-REP) was initiated in 1997. This program was implemented by Rural Industries Innovation Center (RIIC) and offers loans to individual households and small businesses to purchase PV home systems repayable over a period of 4 years. Although the program was expected to install about 237 systems per year, only 300 were installed over a period of 4 years.

Reasons cited for the low uptake of the systems include lack of clear strategies to achieve the preset targets, poor record management and the project having to cover too many areas with limited resources. The program also faced a high defaulting rate due to the lack of follow-ups and failure to take appropriate action e.g. repossession of systems.

Japan International Cooperation Agency (JICA) undertook a project formation study work during 1997 and 1998. As a result of field study and discussions with the competent parties in Botswana, JICA concluded that the feasibility and level of expected effects of implementation of a photovoltaic electrification project in Botswana were high. Thereafter, the Botswana Government submitted an official request to the Government of Japan for a development study. Subsequently, JICA dispatched a preliminary mission to Botswana in December 1999 and in February 2000 the Scope of Work (S/W) was signed and exchanged between the two countries.

1.2 Objective of the Study

The study is designed to formulate a master plan for promotion of rural electrification in Botswana by using photovoltaic electrification over the ten year period, starting in 2003.

1.3 Study Area

The study covers villages and small settlements, called localities, throughout the country.

1.4 Implementation Phases

The study was conducted in the following three phases.

(1) Phase I: Preliminary study (September 2000 – end of March 2001)
- Data collection, socioeconomic surveys of selected villages and localities, and development of policy recommendations for PV rural electrification

(2) Phase II: Field verification of the PV promotion project (April 2001 – end of March 2002)
- To evaluate adequateness and viability of programs recommended in Phase I, a PV promotion and dissemination project (Dissemination Project) was conducted in three villages, and data and information was collected through the monitoring of the project to form the basis of modifying the original project plan.

(3) Phase III: Formulation of the master plan (April 2002 – end of March 2003)
- Based on the results obtained in the above two phases, a Master Plan for PV Rural Electrification was formulated and proposed.

1.5 General Outline of the Report

The Master Plan for PV Rural Electrification was developed according to the process described in Chapter 4. To ensure that major elements of the Master Plan are developed and implemented in the sequence envisaged in the process, the report sets

forth discussions and recommendations accordingly. A general outline of each chapter is as follows.

Chapter 1 "Introduction" discusses the background and the primary objective of the Master Plan and its inception.

Chapter 2 "Overview of Botswana, Energy and Power Sector" outlines the country's political, social and economic conditions and raises the issues to be addressed in the development of the Master Plan for PV Rural Electrification, such as energy and electricity supply conditions, particularly the history of PV use.

Chapter 3 "Goals and Objectives of PV Rural Electrification Master Plan" defines the significance and objective of PV Rural Electrification in the country in the context of ongoing national policies and programs.

Chapter 4 "Development Process for the Master Plan for PV Rural Electrification" designs and proposes the formal process of developing the Master Plan for PV Rural Electrification.

Chapter 5 "Institutional Framework for Promotion of PV Rural Electrification" describes an institutional setup required for the central government and its relevant departments to implement the Master Plan for PV Rural Electrification and proposes candidate organizations for implementation of PV electrification projects.

Chapter 6 "Socio-Economic Situations and PV Potential in Botswana Rural Areas" analyzes a future outlook for the Master Plan, including the estimates of PV electrification demand in the rural villages to be covered by the Master Plan and the ability to pay the charge, on the basis of the results of the socioeconomic surveys and the Dissemination Project. It then proposes the potential scope of PV Rural Electrification.

Chapter 7 "Selection of the Target Villages for PV Electrification" selects villages to be PV-electrified and sets the target electrification rate for such villages. Also, potential electricity demand by public facilities in the villages is estimated. Selection criteria for the villages to be

PV-electrified are proposed. Prioritizing the selected villages for PV electrification is proposed.

Chapter 8 "PV System Design and Environmental Protection Measures" outlines PV system design requirements and specifications (SHS, battery charging station, PV system for public facilities) proposed for the target villages, and proposes environmental protection measures to be considered in the PV electrification project.

Chapter 9 "Operation and Management of the PV Electrification System and Service" proposes a system and organization for operation and management of the PV electrification project, including the service provision system, the rate structure, the organization of the implementation body, the institutional setup for overall project implementation, the field fee collection system, the maintenance organization, and user contract administration.

Chapter 10 "Manpower Development" discusses the current state of the technical education and training system for PV and proposes programs to be implemented to improve education and training.

Chapter 11 "Financial Planning" proposes a financial plan for the PV rural electrification project in consideration of the country's financial condition and the project's feasibility outlook.

Chapter 12 "PV Rural Electrification Project Planning and Implementation Procedures" proposes the project planning and implementation procedures as well as a preliminary schedule for implementation of the Master Plan.

Chapter 13 "PV Rural Electrification Project Planning Model and Financial/Economic Analysis" formulates a detailed project plan including an annual budget for the entire project period by taking into account the issues identified and discussed in the previous chapters. Key issues are then addressed through financial and economic analyses of the project on the basis of assumptions made in the project plan, and solutions are proposed to make the project viable.

Chapter 14 "Implementation Strategies for PV Rural Electrification" proposes a set of strategies to be taken to achieve the goals and objectives defined in Chapter 3 and address the issues raised in the subsequent chapters.

Appendix 1 to 14

Various data used to support the discussions and proposals in the above chapters and the results of evaluation and analysis are presented in Appendices 1 through 14.

Appendix 15 The details of the Dissemination Project are described.