Chapter 5 Institutional Framework for Promotion of PV Rural Electrification

Chapter 5 Institutional Framework for Promotion of PV Rural Electrification

5.1 Present Division of Authority and Responsibility Among Administrative Entities

The past and ongoing PV electrification projects implemented in the country have been involving a number of government agencies and departments. However, the initiatives have been taken without a general framework to maximize their overall effectiveness.

A PV rural electrification project has a limited impact on economic development in a region, which lacks basic infrastructures. The PV electrification project must therefore be combined with such infrastructure projects if it is to produce effective results. Regional economic development is also needed to increase personal income and thus make the PV electrification service affordable, thereby helping the project to become commercially viable on a sustainable basis.

In this conjunction, Botswana Energy Master Plan (June 1996) proposed policy objectives to introduce the PV system in the country in an orderly way with adequate coordination with related government and other organizations, institutional and financial support, and the establishment of financing and technical standards. For the policy measure, it proposed to include PV electrification in the national electrification planning process and to entrust responsibility for rural electrification to a competent organization.

According to the proposed policy, EAD has been promoting several PV dissemination projects. However no national electrification plan has been formulated and a general framework to ensure coordinated efforts with regional development initiatives has still to be fully established.

5.2 Establishment of the New Institutional Framework for Implementation of PV Rural Electrification

5.2.1 The Proposed Institutional Framework: Desirable Division of Responsibilities and Roles and Effective Alliance with Related Organizations

(1) Central National Electrification Coordination

As discussed in Chapter 3, it is necessary to integrate and optimize national electrification and national development plans. As part of its efforts, the National Electrification Coordinating Committee (NECC) is to be established. The main objective of the NECC is to advise Minister on the national electrification (NE) to reach the goal of targeted access and to integrate electrification with other development initiatives. In addition to the above mentioned, NECC will:

- consider all issues relevant to the legislation, funding, planning, monitoring and evaluation of sustainable, integrated NE, aimed at the targeted access to a basic, affordable electricity service;
- facilitate the integration of grid and non-grid electrification with other infrastructure development activities
- investigate and make recommendation on the allocation of institutional responsibilities to implement and manage the electrification program.

(2) Central Management of PV Rural Electrification Projects

As mentioned in Section 5.1, PV project management should be centrally controlled. The Management Committee of PV Rural Electrification should be established under EAD's chairmanship. The Committee will be responsible for:

- approval of project plans
- monitoring and audit on project implementation
- technical and management support for the implementation body

5.2.2 Selection of the PV-based Rural Electrification Project Implementation Body

(1) Selection criteria

In selecting an Implementation Body for the PV-based rural electrification project, the following criteria were established on the basis of basic requirements for the Implementation Body.

a) The Implementation Body should be a government or public organization, provided that it cannot be the central government in consideration of the decentralization policy of the Botswana government.
b) The Implementation Body should maintain close relationships, including a proper route of communication, with the central government (particularly EAD as the agency in charge of energy policy) and local communities.
c) The Implementation Body should have the ability to manage the national project, i.e., the well-established organization, resources and experience in project management.
d) The Implementation Body should have expertise and experience in rural electrification, especially PV-based electrification, provided that technology required for SHS electrification should not be as high as that used for grid operation and management.
e) The Implementation Body should require minimum levels of organizational reform and new investment to achieve its objective.
f) The Implementation Body should actively use and promote the private sector for sustainable growth of PV-based electrification and have successful experience in cooperation with the private sector.
g) The Implementation Body should have the ability to integrate PV-based rural electrification with development of local communities.
h) The Implementation Body should be firmly committed to implementation of the PV-based rural electrification project.

Under the above selection criteria, the study team selected five candidate organizations (BPC, RIIC, BoTeC, DEMS and MLG/district councils) for review and evaluation. EAD was excluded because it was responsible for promotion and coordination of the PV-based rural electrification project. Also excluded are new organizations that are to be established for the project in consideration of minimum cost requirements.

(2) Evaluation of the candidate organizations

Based on the above criteria, the study team evaluated the candidate organizations.

The study team recommends BPC as the most suitable Implementation Body for the PV-based rural electrification project for the following reasons.

1) BPC was originally mandated to grid construction and management. EAD has a mandate to carry out PV rural electrification, and EAD thus makes it possible for BPC to promote PV rural electrification, since BPC is under direct control of MMEWR (EAD).
2) BPC is fully capable of undertaking PV rural electrification on the strength of its infrastructure in rural areas.
3) On the other hand, BPC is highly centralized in its approach to rural electrification. Its top-down approach can and probably will cause problems when it is applied to the projects in the rural villages and localities. Instead, BPC should take a bottom-up approach using the existing rural organizations or their ways of doing things. BPC is willing to take the approach.
4) BPC shows a strong intention to drive PV rural electrification, due to the fact that some of the remaining un-electrified villages and the localities will not be connected to the grid in future, making the planned effort economically viable.

5.2.3 Alliance with Related Organizations

(1) Alliance with district institutions

The PV project should be implemented for a village or a locality as the minimum unit of service coverage. In the selection process, candidate villages should be rated according to priority in consultation with the district council. Also, PV electrification of public facilities in villages, which has been promoted by the district council, should be transferred to the Implementation Body, and the budget should be allocated to ensure its active promotion.

Also, full consideration should be given to local development plans made by the district development committee and the village development committee, and efforts should be made to develop application of PV systems not only for SHS but also for water pumping, street lights and so on.

As for education and training of maintenance personnel, budget allocation should be made to train field maintenance staff by sharing resources with brigades or other facilities managed by the district council.

(2) Encouragement of the PV electrification related industries

To promote supply and installation of PV equipment and systems throughout the country, it is important to develop the industrial base that can meet the needs for system supply, installation and servicing in the commercially competitive manner. At present, existing contractors in the country are not capable of serving rural regions, including the organization and technical capability to provide after-sales service, not to mention qualified personnel.

In addition, the market should be developed to supply and service consumer electrical appliances at reasonable costs, such as lamps, radios and TVs, which demand will grow rapidly with PV electrification Availability of such products and services will further promote the installation of PV systems.

(3) Involvement of NGOs and other organizations

NGOs have played important roles in assisting villagers in various infrastructure projects and village empowerment in various.
The better management of the PV project in a village maximizing community involvement will be attainable in collaboration with NGO's grass roots activity. NGO's participation in PV rural electrification is recommended.

Chapter 6 Socio-Economic Situations and PV Potential in Botswana Rural Areas

Chapter 6 Socio-Economic Situations and PV Potential in Botswana Rural Areas

6.1 Definitions of Urban, Urban Villages, Rural Villages and Localities

(1) Administrative District

Botswana has nine (10) districts and seven (7) sub-districts in total.

(2) Definition of villages

Although there is no official definition, a village is usually typified by the presence of a tribal authority (a Chief, a Tribal Authority, Chief's Representative or Headman) and availability of certain facilities such as schools, clinics or health centers, tribal administration offices, Botswana Police offices, water reticulations and so on.

(3) Definition of Localities

A locality is defined as any settlements with a name and identifiable boundaries. Any localities, whose residents pay allegiance (settlements of disputes, provision of social functions etc.) to a named village is regarded as an associated locality to the village. Localities are categorized in the following settlements.

Land Area: A settlement for a base of ploughing and weeding seasons
Cattle Post: A settlement for a base of grazing cattle
Freehold Farm

(4) Population in Botswana

According to the quick report for 2001 Population and Housing Census issued in April 2002, population of census districts, sub-districts and city/towns in 1991 and 2001 are shown in the Table 6.1-1. This table also indicates population of Localities (small settlements) administratively under villages.

Table 6.1-1 Population in Botswana

Census District	Census Sub-District	Villages 1991 Nos	Villages 1991 Population	Villages 2001 Nos	Villages 2001 Population	Localities (Small settlements) 1991 Nos	Localities 1991 Population	Localities 2001 Nos	Localities 2001 Population	Total (Villages + Localities) 1991	Total 2001
Southern		70	98174	88	137,040	645	49,215	424	34,612	147,389	171,652
South East		5	37,744	5	51,610	134	5,840	139	9,013	43,584	60,623
Kweneng		36	106,072	45	173,771	618	64,365	775	56,564	170,437	230,335
Kgatleng		19	44,442	22	65,452	229	13,328	215	8,055	57,770	73,507
Central	Serowe/Palapye	41	81,887	43	125,675	735	46,584	859	27,360	128,471	153,035
	Mahalapye	33	62,654	36	92,538	519	32,779	498	17,273	95,433	109,811
	Bobonong	14	26,669	17	47,298	338	26,889	408	19,666	53,558	66,964
	Boteti	12	19,176	15	33,874	338	16,283	431	14,183	35,459	48,057
	Tutume	35	66,085	40	94,093	345	33,964	492	29,421	100,049	123,514
North-East		32	34,846	42	45,476	139	8,508	163	3,923	43,354	49,399
North West	Ngamiland East	18	34,375	24	54,280	293	23,436	395	20,790	57,811	75,070
	Ngamiland West	21	14,071	24	30,537	164	22,652	180	19,105	36,723	49,642
	Chobe	9	9,427	9	14,890	84	4,699	91	3,368	14,126	18,258
Ghanzi	Ghanzi	15	13320	17	22,230	217	11,399	399	10,940	24,719	33,170
Kgalagadi	Kgalagadi South	20	14,105	21	20,589	79	5,689	121	5,349	19,794	25,938
	Kgalagandi North	15	10,024	14	14,525	26	1,316	70	1,586	11,340	16,111
Sub Total		395	673,071	462	1,012,878	4,903	366,946	5,660	281,208	1,040,017	1,305,086
City or Town	Gaborone		133,468		186,007					133,468	186,007
	Francistown		65,244		83,023					65,244	83,023
	Lobatse,		26,052		29,689					26,052	29,689
	Selibe-Phikwe		39,772		49,849					39,772	49,849
	Orapa		8,827		9,151					8,827	9,151
	Jwaneng		11,188		15,179					11,188	15,179
	Sowa		2,228		2,879					2,228	2,879
Sub Total			286,779		375,777					286,779	375,777
Grand Total										1,326,796	1,680,863

(Source: 1991 and 2001 Population and Housing Census)

6.2 Socio-Economic Survey

The Study team carried out the Socio-Economic Survey in order to investigate the socio-economic conditions in the rural Botswana, to estimate electric power demand, to evaluate the potential for photovoltaic electrification and to obtain base data for evaluation and selection of villages where the Dissemination Project would be implemented.

The Study team and MMEWR-EAD selected typical 10 villages to be surveyed, which could represent rural Botswana.

Table 6.2-1 10 Villages for Socio-economic Survey

District	Sub-district	Villages	(1) Pop. (1991)	(2) Est. Pop. (2001)	(3) Pop. (2001)	(4) Est. H/Hs (2001)	(5) HHs (2001)
Southern	Ngwaketse	Lorolwana	574	679	952	136	190
South East		(not selected)					
Kweneng		Dutlwe	767	877	1,017	175	203
Kgatleng		Oliphant's Drift	378	429	758	91	152
Central	Serowe/Palapye	Gojwane	618	1,011	1,041	202	208
	Mahalapye	Kudumatse	905	1,150	1,339	230	268
	Bobonong	Motlhabaneng	622	892	1,276	178	255
	Boteti	Makalamabedi	883	1,313	1,117	263	223
	Tutume	(not selected)					
North East		(not selected)					
Ngamiland	South	(not selected)					
	North	(not selected)					
Chobe		Parakarungu	594	862	806	172	161
Ghanzi		Kule	656	773	741	155	148
Kgalagadi	South	Khawe	424	643	517	129	103
	North	(not selected)					

(1) Population of Housing Census 1991

(2) Estimated of figures based on the data of 1991 census and Population Projection 1991-2021 Medium Variant

(3) Population of Housing Census 2001

(4) Estimated number of Households in 2001 based on the data (2) (average family size: 5)

(5) Estimated number of Households in 2001 based on the data (3) (average family size: 5)

6.2.1 Socio-Economic Status

6.2.1.1 Non-PV Electrified Households

(1) Households total cash income

Figure 6.2-1 shows cash income (per month) distribution curves (cumulative) by village summing up all households cash incomes. This income does not include income in kind. Villages with higher cash income distribution are Oliphant's Drift, Dutlwe, and those with lower distribution are Lorolwana, Khawa, Parakarungu.

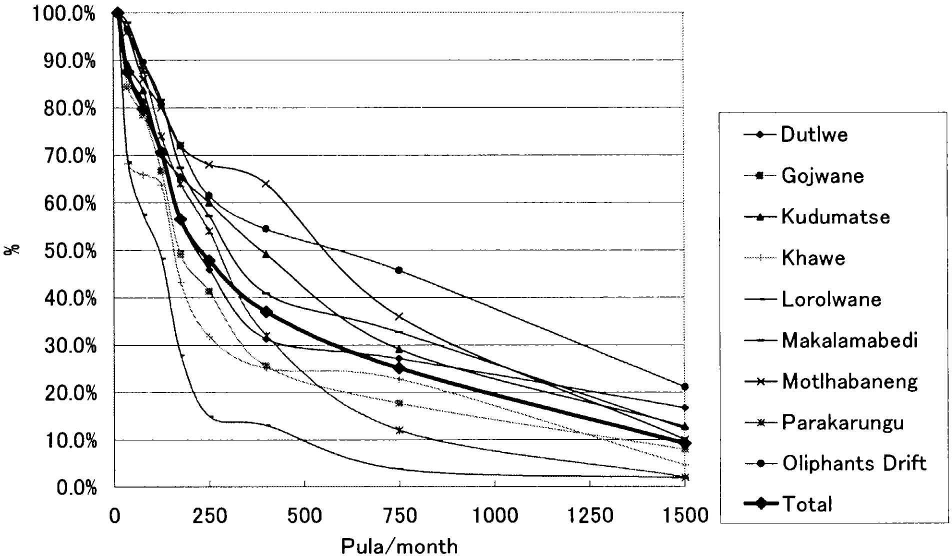

Figure 6.2-1 Cash Income Distribution by Village

(2) Households expenditure

Households expenditure is shown in Table 6.2-2. The majority of rural households (93% or 483 out of 520) spend their incomes on buying food followed by those who buy energy, clothes, education and health. About 43% of those buying food spend up to P100/month and 33% spend between P100 and P200/month, 15% between P200 and P300/month and the rest above P300/month. In the case of energy, 85% of the households surveyed spend P50 or below. About 53% of those who are saving money in month are saving less than P100 and 38% are saving more than P200.

Table 6.2-2 Households Expenditure in Month

Expenditure	Total sample	0-50P	50-100P	100-150P	150-200P	200-300P	300P-
Food	**483**	19%	24%	19%	14%	15%	9%
Rent	**17**	29%	71%				
Education	**323**	83%	10%	3%	3%	0	1%
Clothes	**352**	55%	16%	9%	7%	6%	7%
Energy	**471**	85%	8%	3%	1%	3%	1%
Entertainment	**101**	84%	4%	4%	3%		5
Health	**261**	94%	2%	1%	1%	1%	2%
Others	**66**	32%	8%	18%	12%	17%	14%
Savings	294	38%	15%		17%	13%	18%

88% of the households use paraffin and 90% of them consider it their main lighting fuel. Candles are also used by 67% of the households. Candles are mostly used as a backup lighting energy source.

Expenditure levels on paraffin and candles mainly fall within P10/month category in 44% of total households, 56% of households using paraffin and 85% of households using candles respectively. The expenditures on paraffin and candles less than P20/month for 77% of total households, 89% of households using paraffin and 91% of households respectively.

Table 6.2-3 shows the energy used for appliances and the expenditure levels. Expenditure for radio and TV (combined) is in the P20 category account for 54% of the households using these appliances.

Table 6.2-3 Energy for Appliances and Expenditure Levels

Appliance	Total users	Main energy source	Users of main energy source	0-20P	20-50P	50P-
Radio	311	Dry battery	258	175	98	17
TV	33	Liquid battery	18	11	7	7
Refrigerator	56	LPG	50	4	6	41

(3) Willingness to pay

Willingness to use PV system was indicated through this socio-economic survey as follows. Villages with the largest numbers of households willing to pay are Oliphant's Drift (94.8%), Dutlwe (91.8%) and Kudumatse (85.5%) while Kule (29.8%) and Khawa (36%) had the least number of households willing to pay for PV system use.

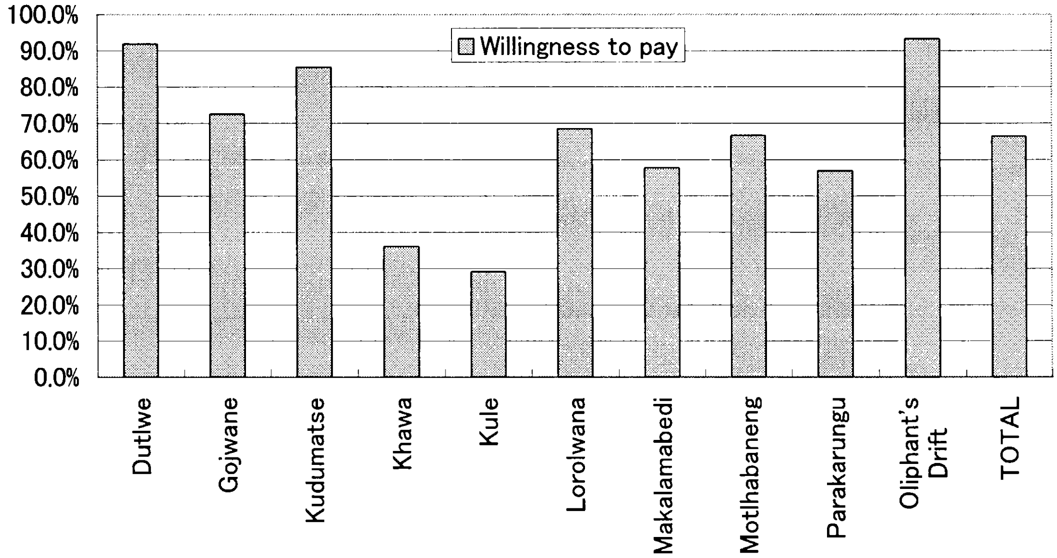

Figure 6.2-2 Willingness to Pay

(4) Ability to pay

PV systems size for which households are able to pay are shown in Table 6.2-4. 96% of those who showed willingness to pay showed ability to pay.

Table 6.2-4 System Size for which Households are Able to Pay

System size	Households	Ratio of able to pay (%)	Ratio against No. of total H/Hs(%)	Ration of those willing to pay(%)	Payable (P:Month)
2-Light system	166	50.0	31.9	48.0	30 – 50
3 to 4 lights	73	22.0	14.0	21.1	51 – 100
6lights + radio	27	8.1	5.2	7.8	101 – 150
3to 4 lights + B&W TV	3	0.9	0.6	0.9	151 – 200
3 to 4 lights + Color TV	19	5.7	3.7	5.5	201 – 250
3 to 4 lights + refrigerator	44	13.3	8.3	12.7	251 –
Total	332	100	63.7	96.0	–

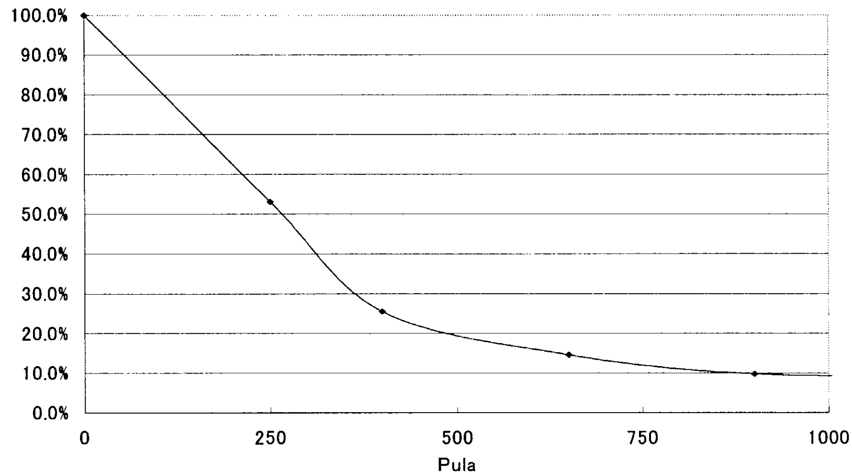

Figure 6.2-3 Max. Payable Deposit (10Villages)

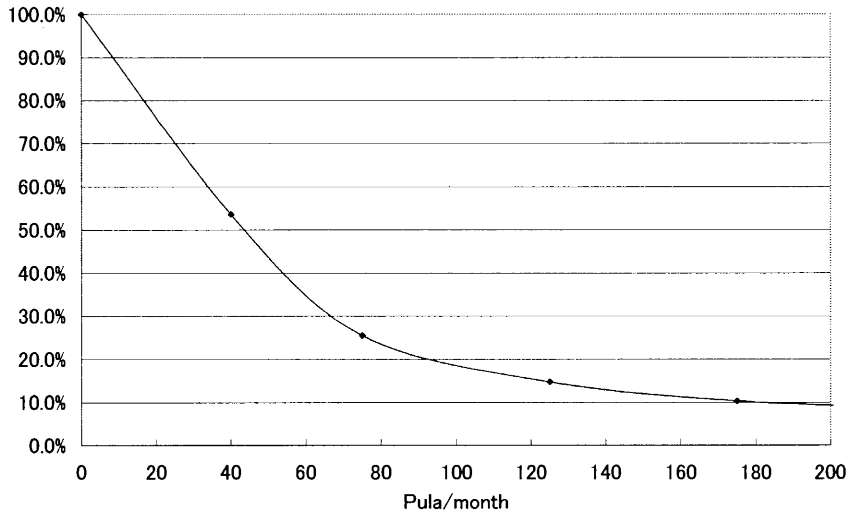

Figure 6.2-4 Max. Payable Monthly Repayment (10Villages)

Based on the above survey results, maximum payable deposit and maximum payable monthly payment are illustrated in Figure 6.2-3 and 6.2-4. According to Figure 6.2-3 and 6.2-4, about 54% of households can pay more than P40 per month and P250 as a deposit.

6.2.1.2 Non-PV Electrified Public Facilities

(1) Financing and procurement for PV system

The public facilities are allocated a budget that is managed by the central Government or the District Councils. Council facilities in particular do not handle funds except where they charge for fees/rents, conduct fund raising or receive donations.

(2) Willingness to use PV system

Nearly all (94%) the public facilities interviewed indicated willingness to use PV systems. PV has been mainly for lighting in the government institutions but 97% of those willing to use the PV system would want to power both lighting and appliances.

(3) Ability to pay

84.4% of the public facilities expressed ability to pay for the various PV system sizes and the majority would like to buy the system which can power 3 to 4 lights and a refrigerator (>200Wp). 37.5% of the facilities who indicated ability to pay deposits can pay P2000 to P3000. An even higher proportion (68.7% of total facilities) indicated they could pay P300 to P600 monthly installments. The main source of income to pay for the PV in public facilities was obviously given as the budget in 65.6% of the facilities and 9.4% will use other means (e.g. profit for private) and only 3.1% will use donations.

6.3 Survey on Localities

There are 5,660 localities in the country of which total population is estimated to reach approximately 280,000 in 2001. They were not covered by the Socio-economic survey described in Section 6.2 and their actual living and other conditions are not known in detail. While the extension of the grid reduces the number of non-electrified villages at a rapid rate, most localities will likely remain unserved while a small percentage will benefit from the project.

The Study team decided to conduct field surveys for selected localities to understand their current conditions. The study team visited two localities (Dipotsana and

Southern District) as well as localities around Kudumatse where the Dissemination Project projects were planned. Then, the survey results were analyzed to identify local conditions peculiar to the localities.

Dipotsana has public facilities, such as an elemental school, a health post and a VDC, and thus the central part looks similar to a village except for the absence of the chief or police. As one moves away from the center, houses used as cattle raising depots are sparsely distributed (each house is as much as 1km apart from the nearest one) and there is no evidence of human settlement. Under this setting, it is likely that the demand for PV electrification mainly exists for public facilities and houses located in the central area, while there is little demand among surrounding households.

Similarly, localities in the vicinity of Kudumatse have 150 or less population each (30 houses or less if the average number of persons is assumed to be five per household) and do not have a center containing public facilities. Again, there seems to be no immediate demand for PV electrification.

Therefore it is reasonable to assume that only localities that have relatively large population (population 200 or more is assumed) and function as an established settlement need PV electrification, whereas those that virtually serve as a cattle post or a land firm have little needs.

6.4 Socio-Economic Survey for Participants in the Dissemination Project

A socio-economic survey was followed for participants in the Dissemination Project in Motlhabaneng, Kudumatse, Lorolwana by the same survey method mentioned in Section 6.2.

(1) Cash income distribution

Total cash income in households for SHS users and BCS users are shown in the below table as well as that of Socio-economic survey results (average of 10 villages). The income of SHS users in 3 villages remarkably exceeds the average income of respective villages. The income of BCS users in

Lorolwana slightly exceeds the average income of Lorolwana, however, is less than that of the average of 10 villages.
Thus, it is understandable that BCS users are relatively composed of low income brackets and BCS is considered as the facility for the poor.

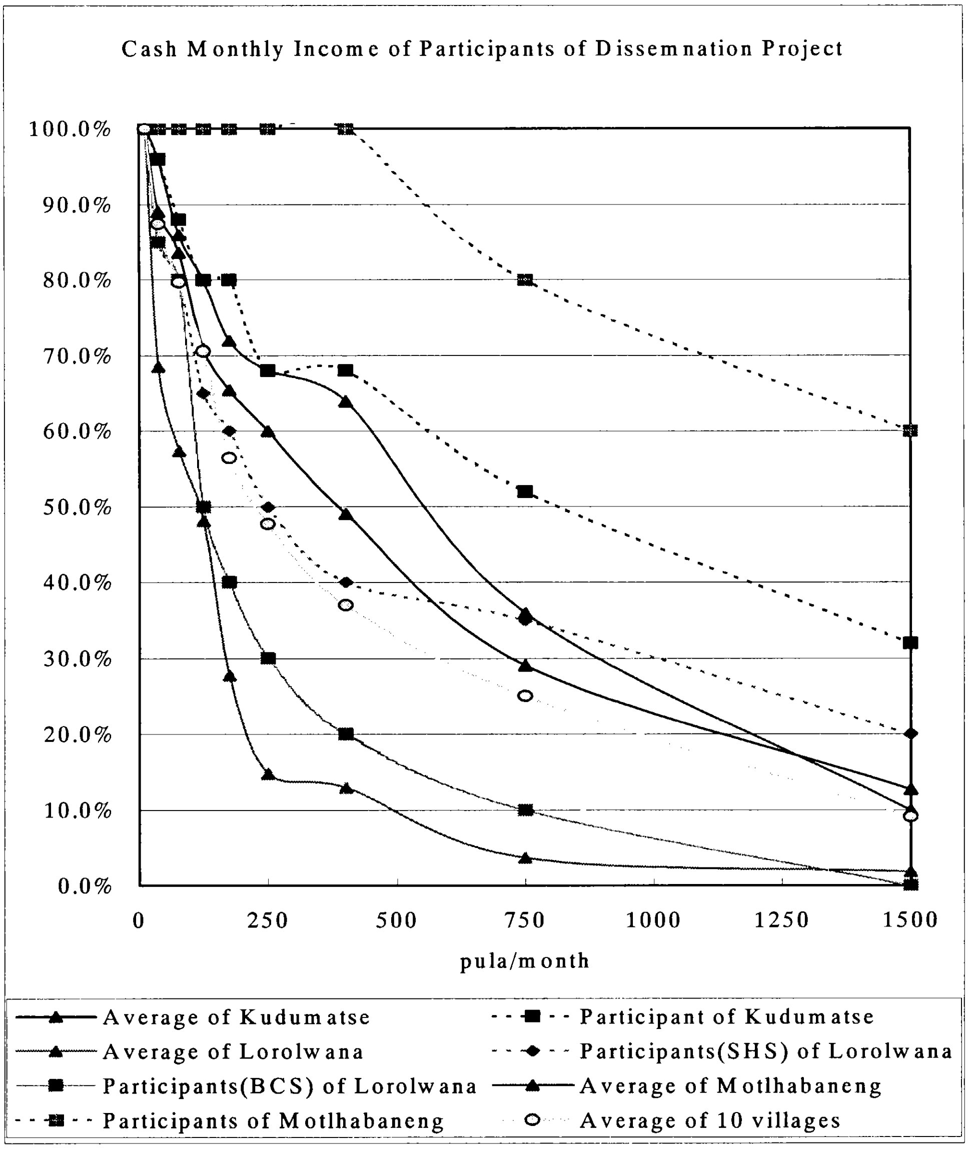

Figure 6.4-1 Cash Monthly Income of Participants of Dissemination Project

(2) PV potential Demand by PV size

PV potential demand by PV size was estimated based on the results of "PV size and Ratio of potential PV users in Socio-economic survey. Actual PV size distribution in the Dissemination Project is summarized in the below table, which shows a big difference in the larger size of PV systems.

Table 6.4-1 PV Demand by Size in the Dissemination Project

	Socio-economic survey	Motlhabaneng	Kudumatse	Lorolwana	Total
50Wp SHS	55.0%	67.6%	75.0%	87.5%	77.1%
100Wp SHS	22.0%	20.6%	17.5%	10.0%	15.8%
150Wp SHS	8.1%	2.9%	5.0%	2.5%	3.5%
200Wp SHS	0.9%	0.0%	2.5%	0.0%	0.9%
250Wp SHS	5.7%	8.8%	0.0%	0.0%	2.6%
350Wp SHS	13.3%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

6.5 PV Market Potential

6.5.1 PV Demand by Size in Households

It was clarified through the Socio-economic survey that there would be a certain needs by a PV system size in conjunction with user's income status, affordability and housing status etc.

As described in Section 6.4, it was found that the actual distribution by PV size in participants in the Dissemination Project was far from the results of the Socio-economic survey. The actual results are adopted to assess a potential PV demand by a PV size.

Table 6.5-1 PV Demand by PV size

PV system	PV size adopted by the Study team	PV demand by PV size	
		Result of Socio-economic survey	Adoption based on the actual results of the Dissemination Project
2-Light	50Wp	50.0%	77.1%
3-4Light	100Wp	22.0%	15.8%
6 Light + radio	150Wp	8.1%	3.5%
3-4 Light + B&W TV	200Wp	0.9%	0.9%
3-4 Light + Color TV	250Wp	5.7%	2.6%
3-4 Light + small Refrigerator	350Wp	13.3%	0.0%
Total		100%	100%
Average PV size per household		122Wp	68Wp

6.5.2 PV Demand by Size in Public Facilities

In order to assess the potential demands for the public facilities the following public facilities are listed up, of which clinic (or Health post), Primary school, Kgotla and VDC are very common in a standard village. Therefore demands for such four facilities are named as "Minimum demand in public facilities" and total demands for all facilities below are names as "Maximum demands in public facilities".

Table 6.5-2 Min. and Max. Demands for Public Facilities per One Village

No.		Demand of 4 Light + Fridge (corresponding to 350Wp)	PV demand (Wp)
1	Clinic (Health Post)	100%	350
2	Primary school	80%	280
3	Kgotla	100%	350
4	VDC	100%	350
5	Police	43%	150
6	Veterinary office	67%	235
7	Others	67%	235
Min. demands/village (Sum of 1 to 4)			1,330
Max. demands/village (Sum of 1 to 7)			1,950

Note) the above % indicates willingness to pay in surveyed public facilities.

The above results derive the average demands per one village, which is adopted to assess potential demands for public facilities in PV electrified villages.
Average demands: 1,650Wp per one PV electrified village

As for public facilities in localities, the PV demand is assumed to be 350Wp based on the assumption that a locality has either an elementary school or a health post in average.

As a result, potential demands of public facilities in villages and localities are summarized in the Table 6.5-3.

Table 6.5-3 PV Demands of Public Facilities

Category	Wp
Villages	1,650
Localities	350

6.5.3 Willingness/Ability to Pay Curve Adopted

The ability to pay curve obtained in Socio-economic survey (Figure 6.2-4) has been assessed and reviewed though the Dissemination Project.

(1) Ratio of Participants in the Dissemination Project

The number of participants in the Dissemination Project, the number of households in each village and other related data are summarized in Table 6.5-4. The number of participants, who signed the contract with the Implementation Body and paid the deposit money and for whom PV systems were installed, was 114 in total at the beginning of the Project, however eleven participants had not paid monthly charges for more than 3 months due to their absences, the lack of money, etc. Accordingly, the number of substantial participants decreased to 103 as of December, 2002.
Information on the population of 3 villages in 2001 was updated in accordance with the Population and Housing Census 2001, which was issued in April, 2002. According to the Census 2001, it is found that the population growth of 3 villages was more than predicted value as shown in

Table 6.2-1. The number of households in the villages was obtained on the assumption that the average family size in the villages was five.

Table 6.5-4 Dissemination Project: Monitoring Results Summary

		Motl.	Kud.	Lorol.	Total	Ratio of Willingness/ Ability to Pay
①	Total No. of HHs (year of 2001)	255	268	190	713	
②	Original Participants in Mar. 2002 (SHS)	34	40	40	114	
③	Ratio (②/①)	13.3%	14.9%	21.1%	16.0%	
④	No. of Repossesion (for 10months)	3	2	6	11	
⑤	Net Participants in Dec, 2002 SHS)	31	38	34	103	
⑤-1	50Wp SHS	(21)	(29)	(30)	(80)	14.4%
⑤-2	100Wp SHS	(6)	(7)	(3)	(16)	3.2%
⑤-3	150Wp SHS	(1)	(2)	(1)	(4)	1.0%
⑤-4	200Wp SHS	(0)	(0)	(0)	(0)	0.4%
⑤-5	250Wp SHS	(3)	(0)	(0)	(3)	0.4%
⑥	Ratio (⑤/①)	12.2%	14.2%	17.9%	14.4%	
⑦	No. of BCS Users	-	-	34	-	
⑧	Ratio (⑦/①)	-	-	17.9%	-	

(2) Willingness/Ability to Pay in the Dissemination Project

Based on data in Table 6.5-4, the willingness/ability to pay in the Project is estimated as follows;

P40/month, corresponding to the monthly tariff of 50Wp SHS: 14.4%
P80/month, corresponding to the monthly tariff of 100Wp SHS: 3.2%
P120/month, corresponding to the monthly tariff of 100Wp SHS: 1.0%
P160/month, corresponding to the monthly tariff of 100Wp SHS: 0.4%
P200/month, corresponding to the monthly tariff of 100Wp SHS: 0.4%

The above percentage is calculated on the assumption that the willingness/ability to pay, which is represented by monthly charges paid by the participants, correspond to that for average villagers in the villages.
The willingness/ability curve in the Project is drawn in Figure 6.5-1 as a title "Result of the Dissemination Project at the first year".

(3) Willingness/Ability to Pay Curve in the Nationwide Project

According to the time frame to introduce PV system surveyed in the Socio-economic survey those who wished to introduce PV systems reached 65% of total villagers. About 16% of showed "immediately", about 33% of respondents showed "Later/next year" and about 16% of respondents showed "Need to consider/Don't know". The evaluation had been done in the Socio-economic survey that "Immediately", "Later/next year" and "Need to consider/Don't know" represented an urgent demand, a middle term demand and a long term demand respectively.

Actual results, i.e., the ratio of participants of 16% or 14.4%, in the Dissemination Project, almost coincide with the results of the Socio-economic survey for the immediate demand.

The group who answered "Later/next year", which is considered to be the candidate customers who will join the Dissemination Project if the Project still continues to solicit villagers for the participation. However, this prediction is not able to be validated because new applicants for the Project will not be planned. If we follow the result of the Socio-economic survey, 235 households, which is 33% of total number of households in 3 villages, might wish to participate in the Project for coming 2-3 years. There exists a certain number of villagers who wish to have PV systems if the Implementation Body resumes applications in the Project. Number of households in waiting list would be, according to the System Monitoring Agents assigned in the villages, about 30 villagers in Motlhabaneng, about 30 in Kudumatse and 10 in Lorolwana, which is not as many as the prediction of the Socio-economic survey. The Study team also does not feel that there would be almost twice of potential waiting villagers as the actual number of participants n the Dissemination Project in the villages for coming 2 to 3 years, considering the difficulties that the Implementation Body and the Study Team experienced in the Project in collecting deposit money and continuous monthly charges from the participants.

Target PV electrification rate is set up at 40% in rural Botswana as mentioned in Section 7.1 and the willingness/ability to pay for PV systems is considered to be P40/m correspond to 40% in rural Botswana. Therefore it is set up that the willingness/ability to pay will be 14% in the first year, 16% in the second year and 10% for the years afterwards and finally reach 40% in the future as shown in Table 6.5-5.

The willingness/ability to pay-curve adopted in the Nationwide Project is shown in Figure 6.5-1 based on aforementioned discussions. The figure includes the curve in the first year, in the second year and in the future as well as the result of the Socio-economic survey for the reference.

Table 6.5-5 Willingness/Ability to pay (yearly movement)

	Result of the Dissemination Project	Nation-wide Project	Socio-economic survey	
1st year	14.4%	14%	"Immediately"	16%
2nd year	-	16%	"Later/next year"	33%
3rd year onward	-	10%	"Need to consider/Don't know"	16%
Total	-	40%		65%

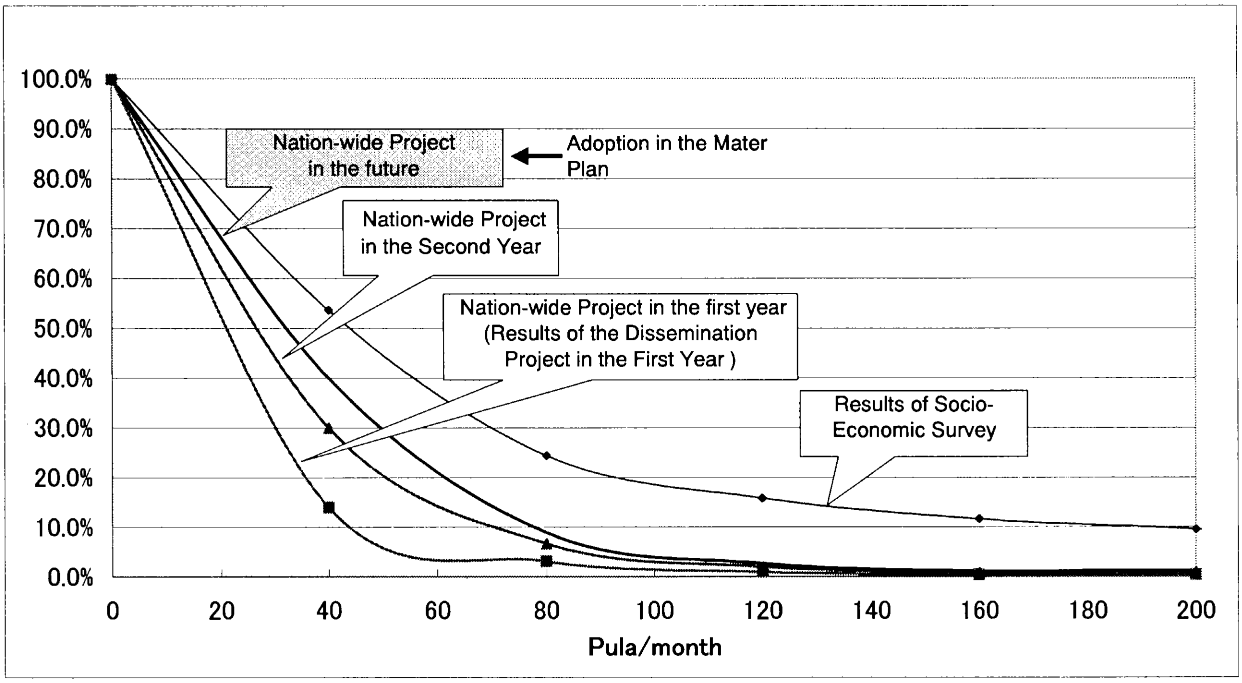

Figure 6.5-1 Willingness/Ability to Pay for the Monthly Charge Adopted in Master Plan

Chapter 7 Selection of the Target Villages for PV Electrification

Chapter 7 Selection of the Target Villages for PV Electrification

7.1 PV Electrification Rate and Tariff Level

As mentioned in Chapter 2, the electrification rate by means of grid expansion is projected to reach about 60% of households in grid-connected villages within 10 years. Given the projection and in overall consideration of the following factors, the target PV electrification rate is set at over 40% of households at P40/m/50Wp tariff level in the target villages during the projected Master Plan period for PV rural electrification (from 2003 to 2012) based on the following facts and assumptions.

1) The grid electrification rate is projected to reach 60% as shown in Section 2.2.4.
2) On the other hand, in case of PV electrification;
   a) The service level accomplished by PV electrification is more limited than that of grid electrification as described in this Chapter
   b) Villages to be served by PV electrification are located in rural areas with lower income than those accessible to the grid
   c) Tariff for PV electrification beneficiaries is higher than that of BPC's tariff (grid electrification beneficiaries) to enable the implementation body of PV electrification to sustain its operation, giving the priority to cost recovery as described in this Chapter, Chapter 9 and 13.
   d) The tariff level for SHS should be the same level as the monthly expenditure for lighting and battery for electrical appliances spent in rural households. Such expenditures are supposed to be P30 to P50/m as described in Section 6.2.3.1 (2) hereof. The tariff level for SHS should also be the similar level as grid-connected user's tariff level including monthly charge for connection fee based on RCS, which is supposed to be P50/m per rural household. Taking the above-mentioned consideration into account, the tariff level for SHS (50Wp) is set P40/m. In this case, if Figure 6.2-4 curve for ability-to-pay is applied, expected electrification rate is supposed to be 55%. However, as described in Section 6.5.3 hereof, the most provable ability-to-pay curve is assumed as Figure 6.5-1 and the attainable electrification rate is assumed as 40%.

Taking the above into consideration, target PV electrification rate will be set up at 40% which is rather lower than that of grid electrification rate.
At the same time, to achieve the objective of PV rural electrification, efforts will be made to raise the electrification rate by introducing the BCS system to the villages and

localities of specific size, thereby to supply electricity to low income households as far as possible. If accomplished, this will exceed the levels of neighboring countries except South Africa (that aims at universal access to electricity by 2010) and North African countries where electrification has already reached a significant level.

7.2 Least-cost Options for Rural Electrification

The service provided by SHS is more limited than that provided by the grid in that SHS is essentially confined to lighting, with a few additional low-load uses such as cassette players or small TVs used for a few hours in the evening. Nevertheless, a long grid extension makes neither economic nor technical sense for villages with such small loads, unless consumer density is extremely high.

Where a substantial prospect for substantial load growth exists, however, the grid connection is technically the ideal way to provide electricity. The two options are sufficiently different to be mutually exclusive.
Thus, it is obvious that power consumption level is important for the selection of PV electrification villages as well as the distance from the existing grid tie-in point.

7.2.1 Rural Household Electricity Consumption

The average consumption in rural households in Botswana is 122Wp (14.6kWh/m) and 68Wp (8.2kWh/m) obtained though the socio-economic survey mentioned in Chapter 6 and the Dissemination Project respectively.
The reason why rural households in Botswana have relatively lower power consumption is considered that because the grid has already been extended to major villages, most of un-electrified villages are as small as having population less than 1000 which is corresponding to 200 households approximately, and such villages have neither small industries nor sufficient income level villagers who can buy electric appliances. The average power consumption per household in such village is, therefore, assumed to be maximum 200Wp (24kWh/m) even including the demand of public facilities, on which the life cycle cost evaluation between PV and grid electrification is done from the next section.

7.2.2 Cost Comparison of SHS Versus the Grid-based Electrification

Break-even distances for various village sizes on the basis of costs for PV and Grid electrification at electricity consumption levels of 100Wp (12.2kWh/m), 200Wp (24.3kWh/m), and 400Wp (48.7kWh/m) equivalent per household are calculated. The results are shown in Figure 7.2-1.

In the case of per household electricity use in an SHS scheme being on the order of 200 Wp (24.3kWh/m), when the village is made up of 50 households of actual connection, a distance from the grid of 13.7 km and when the village is made up of 200 households a distance from the grid of 53.5 km is taken as the breakeven point. For such villages that are located far from the breakeven points, SHS schemes are advantageous.

In Botswana most of un-electrified villages and localities have less than 200 households (1,000 population) and actual connection rate to electricity will be up to 60% of the total households. Average consumption will be less than 24kWh/m. Therefore, the villages and localities that are located from the grid in a distance far from the breakeven point for the consumption level of 200Wp can be the candidates for PV electrification.

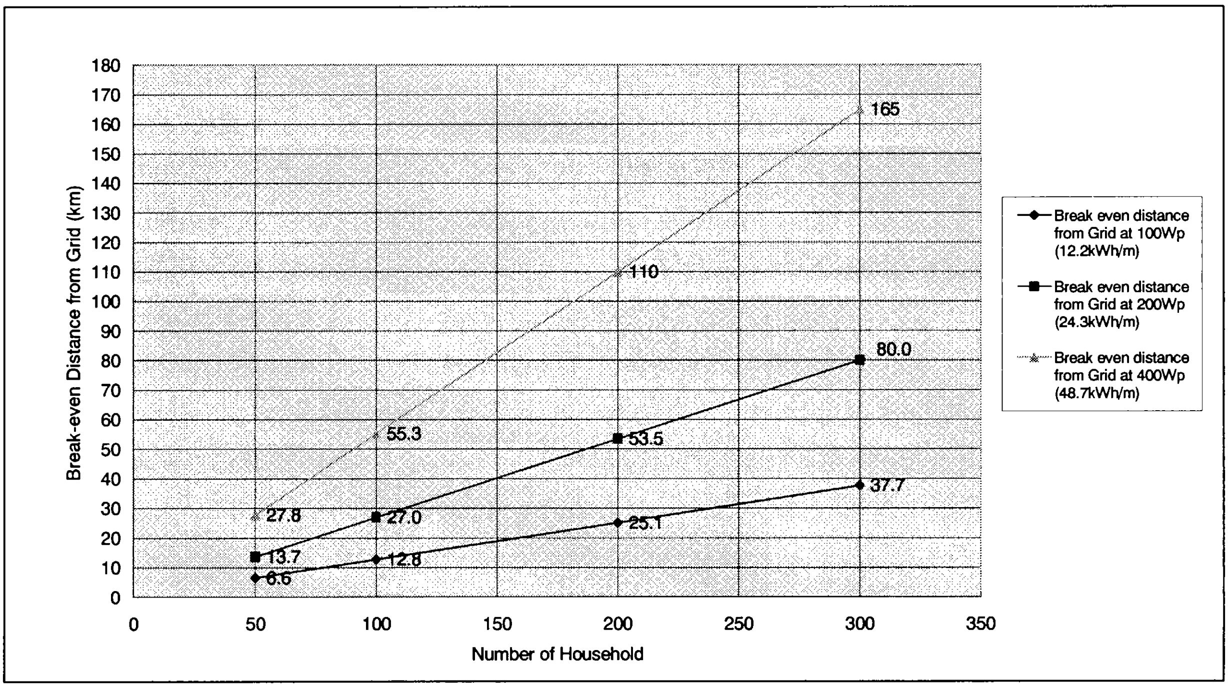

Figure 7.2-1 Break-even Distance from Grid for Grid Versus SHS

7.2.3 Comparison of Cost Recovery of SHS Versus the Grid

Simulation was made using actual data from BPC's grid extension project covering 72 villages to compare cost recovery in the case of PV electrification.

Assumptions

1) 72 villages (estimated population of 109,577 in total) were supposed to have 21,915 households (assuming that each household consists of five persons), and 60% of which, 13,149 households would be electrified by grid connection or the PV system.
2) Electricity demand was assumed to be ranging between 100Wp and 200Wp in case of SHS. On the other hand, electricity demand by households connected to the grid would be expected to be larger. Namely case studies for the loads of 100Wp (12.2 kWh/m) equivalent, 20, 50 kWh/m and 100 kWh/m were examined.
3) Capital investment and system operation and maintenance costs required during the 20-year period are discounted at an annual rate of 15% to obtain their net present value (NPV). Then, a) an incremental cost due to grid connection (P/kWh) and b) the SHS cost (P/kWh) were estimated.
4) In addition, revenues are estimated on the basis of electricity charges under BPC's current tariff rate structure in the case of grid connection, and the monthly rate of 50Wp – P40/m in the case of PV electrification. Based on the estimated revenues (NPV), the cost recovery rate over 20 years is determined to recoup the above total cost.

General findings are as follows:

a) The incremental cost for grid extension and connection is affected by electricity demand. Even if the grid connection rate of 60% is achieved, the incremental cost will be in the range of 17.2 to 2.2 P/kWh, 10 to 70 times the current rate of BPC (0.2523 P/kWh). Thus, under the current rate structure, only 2.7% of the total cost excluding connection cost can be recovered from electricity charges collected from households to be electrified in case the load of 20 kWh/m per household would be expected. Even in case of 100 kWh/m per household load, 13.3% of the total cost would be recovered.

   The connection cost to the grid (reticulation cost) is fully recovered by RCS. Then, taking the cost recovery of the connection cost into account, the percentages of total cost recovery are 18.2 to 27.9%.

b) As for the SHS system, the unit cost per kWh is P14.7 to P15.7/kWh. However, if the monthly rate of 50Wp – P40 is collected, the cost recovery rate will be 41.8 to 44.8% of total cost for SHS 100Wp and SHS 200Wp respectively.

The above analysis indicates that rural electrification by grid extension is rarely feasible due to low demand, which comes from low population density of the country, absence of local industries, and dominance of low-income households. As grid connection will extend to rural areas with less favorable conditions, it is the time to discuss and determine whether grid extension will be continued by providing government subsidy or a strategic shift will be made to PV rural electrification.

7.2.4 Cost Comparison of SHS with PV Mini-grid Electrification

Similar comparison of costs for PV mini-grid and SHS was made.
The result shows that the PV mini-grid system is only viable in densely populated areas with a high level of consumption. Non-cost factors include the difficulty in maintenance of the mini-grid system located in remote villages.
The same conclusion can be said about the diesel mini-grid system.

7.2.5 Selection of the Least Cost Option

The analysis and evaluation made in 7.2.1 through 7.2.4 indicates that the least cost solution for electrification of un-electrified villages in the country is the SHS system.

7.3 Criteria for The Village Selection for PV Rural Electrification

Criteria for the selection of areas for PV electrification will be:

1) The area is further than break-even distance apart from the grid as shown in Figure 7.2-1 supposing 200 Wp (24.3 kWh/m) load and in the area, a prospect of substantial load growth will not exist.
2) The willingness to pay fee for service is high (more than 40% of total households).
3) The village is willing to organize autonomy to operate and maintenance PV systems.
4) Plans are in progress for developing the area to empower the inhabitants.
   NDP9, settlement policy and other development plans in the target areas should be carefully taken into account. The areas where major load growth is expected or

where the settlement will soon be vanished according to settlement policy shall be reexamined for the target areas for PV electrification.

NECC proposed in Chapter 5 shall coordinate various development plans.

5) The willingness of inhabitants and village leaders to improve living standard is very high.

In order to specify PV electrified villages and localities and to give priorities of PV electrification to specified villages and localities, weighted method to the above parameters is applied, which is described in the next section.

7.4 Selection of PV Electrified Villages

7.4.1 Selection of PV Electrified Villages

Based on the criteria in Section 7.3, following procedure is adopted to make a selection of PV electrified villages and localities and prioritize PV electrification to selected villages and localities.

(1) First selection (Classification for Grid and PV electrified villages and exclusion of small scale localities)

Villages and localities were classified on the basis whether PV electrification is economical or not. And then small localities which are considered to be difficult to sustain PV operations are excluded from PV electrification targets.

1) Villages and localities which have been grid electrified or are planned to be grid electrified in the future are excluded from PV electrified targets.

2) Supposing that the average power consumption per household is 200Wp and the target electrification rate reaches 40%, villages and localities are only selected as PV electrification targets which are located far from the break-even points from the existing grid tie-in points indicated in Figure 7.2-1.

3) Selection of localities
Localities with 200 or more population should be served by the project.

The reasons why localities having population less than 200 are out of PV electrification target in this report are;

- It is not likely in such locality that there exists a kind of central part with any of public facility and an autonomy organization within a settlement. Such small settlement seems to have a limited function of cattle or land farm for people to stay temporarily.
- Even if such locality has a central part with public facilities and has a certain demand of PV electrification, the establishment and operation of PV operation unit within a settlement proposed in this report seems to be difficult because of very few households as many as sixteen in case that PV electrification rate is 40% to total number of households in a locality having population 200 (average family size is taken five people).
- The population of such localities decreased by 25% from 1991 to 2001 in 10 years. This trend would continue in the next decade. Since PV electrification for small localities would be undertaken the latter half of the master plan period, the population of such localities is considered to decrease further.
- Those localities should be reviewed as the next targets of PV electrification after the end of this Master Plan period.

(2) Second selection (Prioritizing the selected villages and localities for PV electrification)

Prioritizing of PV electrification is made for the villages and localities selected as PV electrification targets in the previous paragraph.

Based on the basic criteria mentioned in Section 7.3, the criteria for priority setting are established using several quantitative parameters as follows.

1) Population (as of the year of 2001)

PV demand and the level of needs are considered to be proportional to the population in villages and localities. Considering implementation of PV electrification project, management setup, one of the key factor for success, such as, for money collection and maintenance in the village will be organized more easily in proportional to population of the village.

2) Population growth (Population incremental ratio between 1991 and 2001)

This is a parameter of activation of the villages and localities. Increase of PV demand and the level of needs and easiness of formation of autonomous organization are considered to be proportional to this parameter.

3) Infrastructure

The availability of infrastructure (e.g., VDC, school, clinic) is also one of parameters showing how well a village or locality is organized and managed as an integrated community. Generally, these community infrastructures are available in the villages, but not well in the localities.

Table 7.4-1 Priority Setting Parameters

	Rating score (full)	Criteria	Score assigned
Population	60	Over 1,000	60
		700 ~ 999	50
		500 ~ 699	40
		300 ~ 499	30
		200 ~ 299	20
		100 ~ 199	10
		Less than 99	5
Population growth rate	30	Over 50%	30
		30% ~ 49%	20
		10% ~ 29%	10
		0% ~ 9%	0
		-20 ~ 0%	-5
		-20%	-10
Infrastructure	10	VDC, school, clinic available (village)	10
		No VDC, school, clinic (locality)	0
Total	100		

(3) Result

The villages and localities were rated according to the above criteria and are arranged according to the total score, as follows.

Table 7.4-2 Rating of Villages and Localities by Number

Score	Village		Locality		Total		Year of PV electrification
	No.	Cumulative total	No.	Cumulative total	No.	Cumulative total	
Over 90	11	11	0	0	11	11	Suitable for PV electrification
80～90	15	26	1	1	16	27	
70～80	29	55	7	8	36	63	
60～70	15	70	22	30	37	100	
50～60	23	93	37	67	60	160	
40～50	19	112	20	87	39	199	
30～40	12	124	24	111	36	235	
20～30	14	138	24	135	38	273	
10～20	7	145	35	170	42	315	
0～10	3	148	102	272	105	420	
Less than 0	0	148	77	349	77	497	
Total	148		349		497		

Assuming that villages and localities that obtain the total score of 10 points or more are qualified for PV electrification, 145 villages (total population of 61,767) and 170 localities (60,666), totaling 315 (122,433 population), should be selected.

7.5 10-year PV Electrification Program

Assuming that the selected villages and localities will be electrified over a ten-year period, the program should proceed in the following sequence.

- The entire country is divided into six zones, as shown below, and PV electrification will be carried out for selected villages and localities in each zone every year. The arrangement is designed to ensure that the project is carried out evenly throughout the country, considering a sufficient number of PV installation jobs to be conducted in each zone. It is expected that the equalized work volume of PV electrification will be contracted with PV installation contractors.

- Villages and localities will be PV-electrified each year according to the rating score. The following table shows the number of villages and localities to be selected in each zone and for each year.

Table 7.5-1 Preliminary Selection of Villages and Localities by Zone and Year (Number of Village/Localities)

	PV year	1	2	3	4	5	6	7	8	9	10	Total
Zone 1	Ngwaketse	4	3	2	5	1	1	3	6	3	3	31
	Barolong	2	2	3	1	2	6	2	1	4	4	27
	Ngwaketse West	0	1	0	0	1	0	1	0	0	0	3
	South East	0	0	1	0	2	0	1	0	0	0	4
Zone 2	Kweneng East	0	1	3	2	5	2	3	3	4	3	26
	Kweneng West	5	3	2	2	0	1	2	1	1	1	18
	Kgatleng	0	1	0	1	0	2	0	1	0	1	6
Zone 3	North East	0	1	4	1	2	2	0	0	0	1	11
	Serowe/Palapye	2	3	1	3	2	2	2	4	4	1	24
	Bobonong	3	1	0	1	1	1	3	1	1	3	15
Zone 4	Mahalapye	1	2	3	2	3	0	1	0	1	2	15
	Boteti	0	0	2	0	0	0	1	1	0	2	6
	Tutume	5	4	1	4	3	6	4	5	5	3	40
Zone 5	Ngamiland East	0	3	5	3	3	4	3	1	3	3	28
	Ngamiland West	6	3	2	3	2	3	3	5	4	3	34
	Chobe	0	0	0	0	1	0	1	0	0	0	2
	Delta	0	0	0	1	1	0	0	1	0	1	4
Zone 6	Ghanzi	1	0	1	0	2	1	2	1	0	1	9
	Kgalagadi South	1	0	1	0	0	0	0	1	1	1	5
	Kgalagadi North	0	2	0	2	0	1	0	0	1	1	7
	Total	30	30	31	31	31	32	32	32	32	34	315

(1) PV electrification system

In order to benefit far more people with PV electrification, it is recommended to install the BCS system in parallel with the SHS system for villages and localities with 500 or more population. For smaller settlements, only the SHS system will be installed as the BCS system becomes inviable in terms of complexity and cost.

Table 7.5-2 PV System Installation Plan

Project Year		1	2	3	4	5	6	7	8	9	10	Total
SHS	No. of households in 2001	5,776	3,423	2,872	2,459	2,268	2,552	2,129	2,219	1,944	1,688	27,330
	Population growth rate	1.069	1.093	1.118	1.143	1.169	1.195	1.222	1.25	1.278	1.307	
	No. of households in the PV installation year	6,176	3,743	3,211	2,811	2,651	3,051	2,603	2,774	2,485	2,206	31,711
	No. of households to install the PV system	2,470	1,497	1,284	1,124	1,060	1,220	1,041	1,110	994	882	12,682
BCS	No. of households/localities for PV installation	25	15	6	7	0	4	3	2	0	0	62
	Population in 2001	21,404	11,950	3,681	4,152	0	2,508	1896	1,365	0	0	46,956
	No. of households in 2001	4,778	2,667	822	927	0	560	423	305	0	0	10,482
	Population growth rate	1.069	1.093	1.118	1.143	1.169	1.195	1.222	1.25	1.278	1.307	
	No. of households in the PV installation year	5,109	2,916	919	1,060	0	669	517	381	0	0	11,571
	No. of households to install the PV system	1,022	583	184	212	0	134	103	76	0	0	2,314

In addition, the PV system size requirements need to be determined. The results of the socio-economic surveys indicated an average electricity demand of 122Wp per household, while actual demand confirmed in the dissemination project amounted to 68Wp on average.
For the Master Plan for the ten-year installation program, 68Wp per household should be used.

As for public facilities, 1,650Wp per village and 350Wp per locality are assumed.

PV installed capacity for SHS, public facilities, BCS and total capacity during 10 years Master Plan period are shown in Figure 7.5-1 in case the target SHS electrification rate is 40% of all the households and BCS users account for 20% of total households in villages and localities where the BCS system is installed. Grand total installation capacity reaches 1,200kWp in Master Plan period.

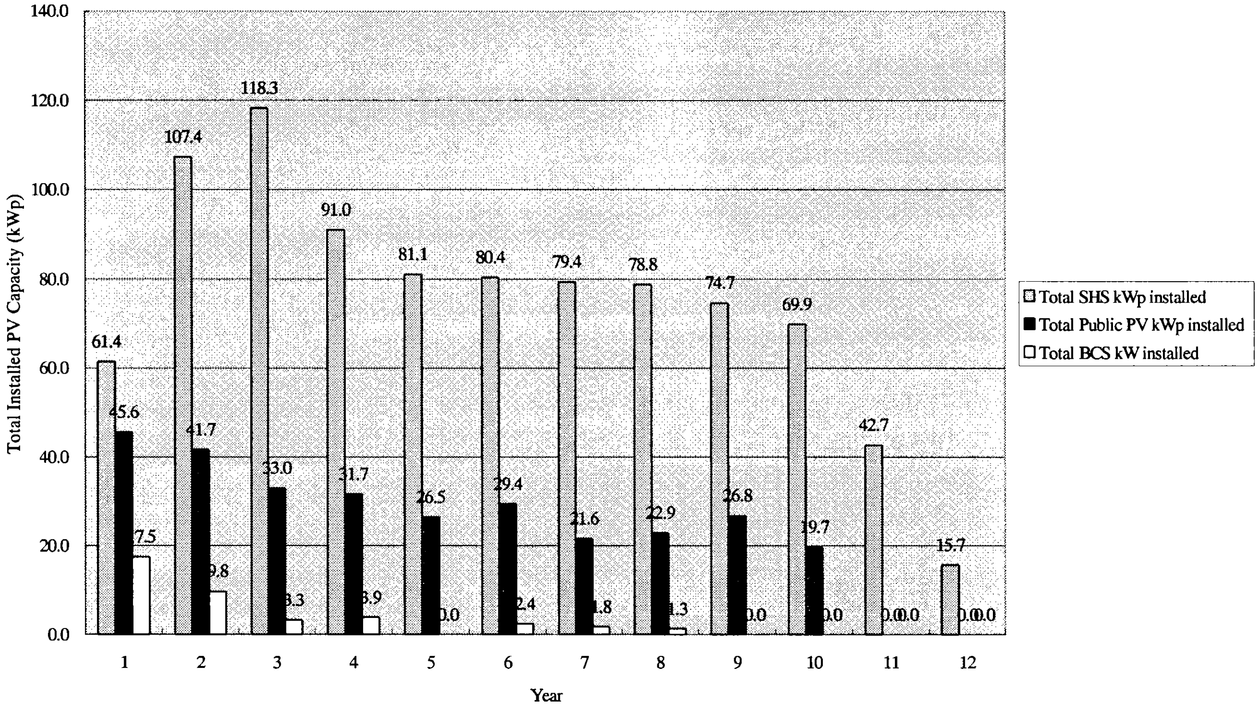

Figure 7.5-1 PV Installed Capacity (SHS, Public, BCS)

7.6 Total Electrification Rate achieved

Total electrification rate achievable in the year of 2012 for all villages and localities (excluding cities, towns) is summarized in Table 7.6-1. It will be 49.6% in case of grid electrification rate 60% and PV electrification (SHS/BCS: 40%/20%) and will be 42% if grid electrification rate stays around 50%.

Table 7.6-1 Total Electrification Rate by means of Grid and PV Electrification

Year		Census 2001	2,012
Villages			
	No.	462	462
	Population	1,023,878	1,279,848
	No. of Households	228,544	285,680
Localities			
	No.	5,660	5,660
	Population	281,208	351,510
	No. of Households	62,770	78,463
Total Population (village+ locality)		1,305,086	1,631,358
Total No. of Households (village+ locality)		291,314	364,143
Villages/Localities which have been and planned to be grid-electrified by 2009			
	No.	290	290
	Population	939,721	1,174,651
	No. of Households	209,759	262,199
Villages/Localities where grid electrification is considered to be economical			
	No.	59	59
	Population	49,575	61,969
	No. of Households	11,066	13,832
Villages/Localities to be grid electried			
	No.	349	349
	Population	989,296	1,236,620
	No. of Households	220,825	276,031
Villages/Localities to be electrified by SHS/BCS			
	No.	315	315
	Population	122,433	153,041
	No. of Households	27,328	31,711
Total Electrification Rate (in case of grid electrification rate 60%)			
	No. of Households electrified by grid		165,619
	No. of Households electrified by SHS/BCS (40%/20%)		14,996
	Total Electrified Households		180,615
	Total electrification Rate		49.6%
Total Electrificatio Rate (in case of grid electrification rate 50%)			
	No. of Households electrified by grid		138,016
	No. of Households electrified by SHS/BCS (40%/20%)		14,996
	Total Electrified Households		153,012
	Total electrification		42.0%
Percentage of households in villages/localities where grid or PV are catered for versus total number of households in villages/localities			
	Total number of households in villages/localities where grid or PV are catered for		307,742
	Percentage of households in villages/localities where electricity are catered for versus to total number of households in villages/localities		84.5%

Chapter 8　PV System Design and Environmental Measures

Chapter 8 PV System Design and Environmental Measures

8.1 Adequate Technology for PV Rural Electrification

(1) System configuration

① On the basis of the evaluation results in Chapter 7, The PV system used for the project is primarily of Solar Home System (SHS) type.

② The centralized PV system will be installed at important public facilities, including a local government office, a police office and a meeting hall.
The centralized system will also be installed at schools, medical clinics and other public facilities not electrified.

③ The battery charger station (BCS) will be provided. For users who cannot afford to pay for the SHS system, the battery will be leased and recharged at the BCS.

(2) System design

1) Sizing

System design should take into account the customer's capacity to pay the monthly fee and requirements (customer needs). Important design conditions are summarized as follows.

① The SHS system should be configured on the basis of the standard 50Wp panel to allow capacity increase according to the user's request by installing an additional panel.
In principle, the PV-SHS system capacity should be determined according to electricity generation capacity of the PV panel, as follows.
To reserve grid connectivity in the future, the 240V-AC system is used for the system size of over 150Wp, while 12V-DC for less than 150Wp.

② The centralized PV system capacity (generation capacity) should be determined for each village according to actual demand. The centralized PV system for public facilities (CPS) should also have design flexibility in terms of capacity.
The centralized PV system should be designed to provide electricity to streetlights in the locality center and water supply pumps of schools and medical clinics.

③ The capacity of the BCS should be determined according to actual demand (user's request).

2) System design should give consideration to the streamlining of maintenance work and prevention of system failure due to incorrect operation by the customer.

   SHS system

   - The system should integrate batteries, a battery box, a battery charger controller and a distribution board (outlets and switches) into one unit (box).

3) Pre-paid card system

   To facilitate collection of the electricity charge, it is recommended to use the pre-paid card system, which should be incorporated into the above one unit system.

8.2 Environment and Health Protection

8.2.1 Environmental Benefits of Solar Home Systems

Not only are PVs environmentally superior to kerosene and dry cells, they also have advantages over other electricity supply options. PV modules generate electricity without emitting gases that cause global warming, local air pollution or acid rain, or causing water pollution or noise.
Since stand-alone PV systems provide electricity without power lines, their use in protected forest areas and buffer zones can be particularly valuable for ecosystem preservation. Power-line corridors can open access for the development of forested areas, change the diversity of species within ecosystems, and cause ecosystem fragmentation. Furthermore, power-line construction and maintenance activities themselves can be quite disruptive.

Based on the report on the study covering villages in the country, entitled "Urban and rural energy in Botswana: needs and requirement", EAD, July 2001), it is estimated that 193kg of CO_2 discharge per year can be cut off for each 50Wp SHS system, which is calculated on the basis to replace household consumption of paraffin used for lighting purpose. 4,780 tons of CO_2 discharge can be eliminated each year, if the PV system is installed according to the business plan in Chapter 13.

8.2.2 Negative Environmental Impact

A negative environmental impact from SHS dissemination can result from the improper disposal of lead-acid batteries. While careful recycling of lead-acid batteries is the best way to prevent this, current recycling practices vary substantially by country. As SHSs become widespread, it will be important to encourage well-managed battery recycling programs.

Lead usually tops the list of substances classified as hazardous in environmental legislation. Strict legal control should be imposed to protect the environment from harm caused by the use or transportation of lead and products containing it.

Chapter 9 Operation and Management of the PV Electrification System and Service

Chapter 9 Operation and Management of the PV Electrification System and Service

9.1 Service Delivery System

The PV system can be delivered to customers in either of the following two systems.

(1) Direct Sales and Microcredit Arrangement for PV Systems

As the most common approach, described by the World Bank as the open market approach, there is a roughly unrestricted market in which PV dealers and developers can conduct direct sales and -with government, donor, and nongovernmental organization involvement- establish PV microcredit, leasing, or direct sale programs.

This approach has been applied in Botswana such as NPV-REP. In Botswana, the government arranged the National PV credit scheme that requires a down payment of 15% with the rest paid in 4 years at an interest rate equal to the prime rate. However, the payment conditions are still not acceptable for potential customers and the rapid dissemination has not been attained. By lowering down-payment and prolonging payment terms, it might be possible to attain the dissemination rate as recent grid connection increase. However, in this case, users need to maintain the PV system by themselves or pay a maintenance fee under a separate agreement to the system supplier or a service company. It is necessary to raise the user's awareness of the PV system, so that the system can be operated stably. Otherwise, the system will be abandoned and the payment will fall into arrears. Due to the constraints associated with the low population density, low skill levels of villagers and remoteness of the rural communities, profitability for such maintenance will be low and adequate service cannot be expected.

(2) ESCO Approach including Leasing and Fee-for Service Approach

In the dispersed area ESCO a public or a private electric utility, rural electric cooperative, or other institution is granted a concession for providing electricity services to unserved populations and provides maintenance and various services to the users.

To overcome the constraints associated with the low population density, low skill levels, and remoteness of rural communities, the most feasible approach is to provide PV-generated electricity on a fee-for-service basis by a utility rather than through the sale of hardware to individual consumers. The fee-based approach would require that the utility owns and maintains the SHSs installed in its customers' premises. Trained staff will visit the customers regularly to service the installed systems, including repair, and collect a service fee. The fee is intended to recover utility's operating costs, including a capital recovery charge. The headquarters will manage the accounts, inventory, procurement, and training.

The ESCO approach can remove the barrier to access to PV system by spreading the heavy capital cost over the service life of PV system.

The ESCO allows the relocation of the PV systems in case of arrears and users' switching power source from PV to grid-based electricity as a result of extension of the grid to the villages, if the systems have been maintained well and the performances of the systems can be guaranteed, because the systems are the properties of the ESCO.

(3) Recommendation

The ESCO approach is recommended for PV rural electrification in Botswana.

9.2 Organization of the Implementation Body

9.2.1 Establishment of the PV Project Management System and Division of Responsibilities

The Implementation Body for the PV-based rural electrification project, should be managed in the following manner.

(1) Basic approach

NPV-REP, currently underway, encourages a supply contract with a group of households, which is fairly small. As a result, the project serves customer groups that are dispersed throughout the country, resulting in lack of efficiency and poor technical service. The PV Rural Electrification Master Plan recommends that the project takes care of a single village as a minimum unit of service. This means, participants will be solicited from each village, and system installation and maintenance, collection of user charge, and other services will be carried out for each village. This way, the project can be implemented in an efficient and cost-effective way.

(2) Promotion and coordination setup for PV Rural Electrification in Central Government

The institutional framework for PV rural electrification is recommended in Chapter 5. PV Rural Electrification Managing Committee coordinates and monitors the operation and management implemented by the Implementation Body.
The National Electrification Coordination Committee coordinates to facilitate the consistency of PV electrification with national electrification plan and other development activities.

(3) Organization and role of the Implementation Body's head office

As the PV Rural Electrification Master Plan should be implemented on a long-term basis, a permanent organization (tentatively called the "PV-RE" Department) should be established with clear authority and responsibility. PV system installation, accounting and other specialized activities will be handled by the Implementation Body's related departments (matrix organization), while the PV-RE department should be responsible for cost control. In addition, the department should be responsible for tariff, project management, profit management, maintenance service, supervision of local offices, and other matters directly related to the project. Finally, the PV rural electrification project should be managed as an impendent account that is clearly separated from other projects.

(4) Organization and role of local offices

The Implementation Body's local offices and depots should be used as local service bases, which are staffed by full-time service personnel. Proposed concept for the implementation of PV rural electrification is that as much works and responsibilities as possible should be transferred to the local offices in order to minimize operation costs, to maintain close contact with customers and to make quicker actions for customer's needs.

(5) Village Organization and its Role

Effective implementation of rural and remote electrification projects requires a high level of commitment by local communities concerned. In the past, those projects with a high level of community involvement – consensus, support, and participation – have been the ones which have proven the most successful.

Community participation creates ownership, and ownership leads to success. Even the best crafted plan and the best funded rural electrification project can be frustrated if the local community is not brought fully into the process. Local community members are in the best position to assess their willingness to support electrification efforts and to express the intent to choose the best options, especially when they are well informed of the plan in advance.

It is recommended to have the Village Advisory Committees (VAC) established voluntarily by local residents. VAC will support the Implementation Body in the solicitation of applicants, the conclusion of customer agreements, the collection of deposit money, and the installation of PV systems in the village.

For the monthly collection of the user charge, the Implementation Body entrusts the sale of pre-paid cards to sales agents, who are mostly grocery shops in the village and get paid a certain percentage commission for sales. Therefore, incentive is given for expansion of the customer base.

For first-line maintenance of the PV systems, the Implementation Body concludes the agent agreement with a villager who monitors all the PV systems installed in the village. The maintenance person will not be able to do sophisticated repair or maintenance work, but he will hear customer's complaints and teach them the correct way of system operation, and if he cannot solve the trouble, he will refer it to the Implementation Body's local office. He also checks all the PV systems to see if they are abused.

In the villages where BCS are installed, the system monitoring agents also operate BCS, charging the discharged batteries which BCS users bring, supplying the charged batteries, and maintaining BCS systems.

Note that the organization and division of responsibilities should be modeled after by all the villages that will be PV-electrified in the future.

(6) Private Company and its role

In Botswana, it is mandatory requirements for governmental and parastatal organizations to minimize their manpower. For this reason, it will be very effective to fully utilize private companies for such services that the private companies can substitute Implementation Body's works. However, as discussed in Chapter 5, the private PV industries in Botswana are still underdeveloped and company creditability is still in low level. Therefore, it is recommended that some parts of local office's roles of Implementation Body may be contracted out to the contractors who undertake purchasing and installation of PV systems in the respective zones proposed in Chapter 7. Some of their roles will be daily works such as maintenance and tariff collection supervision including conclusion of contracts with the sales agents and the system monitors in place of Implementation Body and spare part control.

9.3 Customer Service to be Provided by the Implementation Body and Tariff System

9.3.1 Content of Service

(1) Granting of the right to use the PV system

(2) Monitoring and maintenance of the installed system

(3) Collection of the user charge and contract renewal

(4) Removal of system equipment

(5) Intermediary service for household equipment and wiring

9.3.2 Tariff System

(1) Monthly service charge

The customer will pay to the Implementation Body a fixed fee, as determined according to capacity of the installed PV panel, for electricity supplied from the PV system and system maintenance service. (Refer to Table 9.3-1)

(2) Deposit

The customer will initially deposit with the Implementation Body the amount equivalent to three months of the above fixed fee as the collateral for failure to pay the monthly fee or damage to the system due to the customer's negligence. The deposit money will be reimbursed, without interest, when the PV service is terminated. (Refer to Table 9.3-1)

Table 9.3-1 Fee for Services

System category		Capacity	Monthly tariff (P/month)	Deposit (P)
For Households				
Solar Home system	Class 50	50Wp	40	120
	Class 100	50Wp×2 sets (100Wp)	80	240
	Class 150	50Wp×3 sets (150Wp)	120	360
	Class 200	50Wp×4 sets (200Wp)	160	480
	Class 250	50Wp×5 sets (250Wp)	200	600
Battery Charge System		Battery 30Ah	P5/fixed fee P1/charge	–
For Public facilities				
	Class 500	50Wp×10sets (500Wp)	600	1800
	Class 1000	50Wp×20sets (1000Wp)	1200	3600

Note 1) The deposit means "Security money" corresponding to 3 months tariff.

- This money to be allotted in case the users arrears monthly payment.
- This money to be allotted for the loss/damage of the facility due to users fault.
- The balance to be returned to the user on surrender (No interest).

Note 2) Battery System: Households who wishes to participate in the project, but are difficult to pay such monthly charge as above, can be supplied battery.

Beneficiaries shall pay P5.0/m as a fixed fee and will be able to replace discharged battery with a fully charged battery at P1.0.

9.4 Supplier Contract

9.4.1 Scope and Duration of the Supplier Contract

The PV system should be supplied and installed by a supplier who has been selected through the bidding process and is responsible for a specific district or region. The supplier will also be responsible for customer training, maintenance, supply of equipment and materials, and other auxiliary services on a long-term basis. The long-term and area-wide contract is inevitable as the supplier is expected to establish a local office and service organization in order to ensure reliable and high quality service on a long-term basis.