No.

The Master Plan Study
on
Rural Electrification
Using
Renewable Energy Resources
in the
Northern Part of the Republic of Ghana

Final Report
(Main Report)

May 2006

Japan International Cooperation Agency
Economic Development Department

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Preface

In response to the request from the Government of the Republic of Ghana, the Government of Japan decided to conduct the Master Plan Study on Rural Electrification by Renewable Energy Resources in the Northern Part of the Republic of Ghana, and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent the Study Team, headed by Mr. Masayasu ISHIGURO of Nomura Research Institute, Ltd. and organized by Nomura Research Institute, Ltd. and Chubu Electric Power., Inc. to Ghana five times from February 2005 to May 2006.

The Study Team had a series of discussions with the officials concerned of the Government of the Republic of Ghana and Ministry of Energy, and conducted related field surveys. After returning to Japan, the Study Team conducted further studies and compiled the final results in this report.

I hope that this report will contribute to the promotion of the plan and to the enhancement of amity between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ghana, Ministry of Energy for their close cooperation throughout the Study.

May 2006

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

May 2006

Mr. Tadashi IZAWA
Vice President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We have concluded the Master Plan Study on Rural Electrification Using Renewable Energy Resources in the Northern Part of the Republic of Ghana, and hereby present the final report for Study.

The Study was implemented on the basis of a contract with the Japan International Cooperation Agency (JICA) by Nomura Research Institute, Ltd. and Chubu Electric Power Co., Inc. over a period of approximately 16 months, from February 2005 to May 2006.

The Study consisted of preparation of a Master Plan premised on establishment of a setup enabling promotion of off-grid electrification on a sustained basis utilizing photovoltaic (PV) power generation systems in the three northern regions of Ghana. Besides taking up problems that have affected past PV projects, the Study Team examined advisable approaches to rural electrification (RE) through both on-grid and off-grid programs, and identified tasks for the future in the institutional and organizational aspects as well. In parallel with this work, the Study Team made in-depth examinations and analyses in the technical aspect, on subjects such as procedure for forecasting demand in RE promotion, segmentation between on-grid and off-grid programs, postulation of electrification models, and establishment of technical standards. As the culmination of these operations, the Study Team made recommendations concerning the approach to RE through PV systems from a holistic standpoint.

We are convinced that the implementation of these recommendations will enable sustainable RE promotion in Ghana and, by extension, make a substantial contribution to social advancement in the northern regions.

We earnestly hope that the Ghanaian government will actively apply the technology and know-how transferred through the Study and implement the recommendations in this report on a priority basis.

We are deeply indebted to the concerned personnel of the JICA, the Ministry of Foreign Affairs, and Ministry of Economy, Trade and Industry for their support and advice. We are also grateful for the assistance and support received in the implementation of the Study from the Ghanaian government and other concerned Ghanaian institutions as well as the JICA office and the Japanese embassy in Ghana.

Very truly yours,

Masayasu ISHIGURO
Team Leader
The Master Plan Study on Rural Electrification
Using Renewable Energy Resources in the
Northern Part of the Republic of Ghana

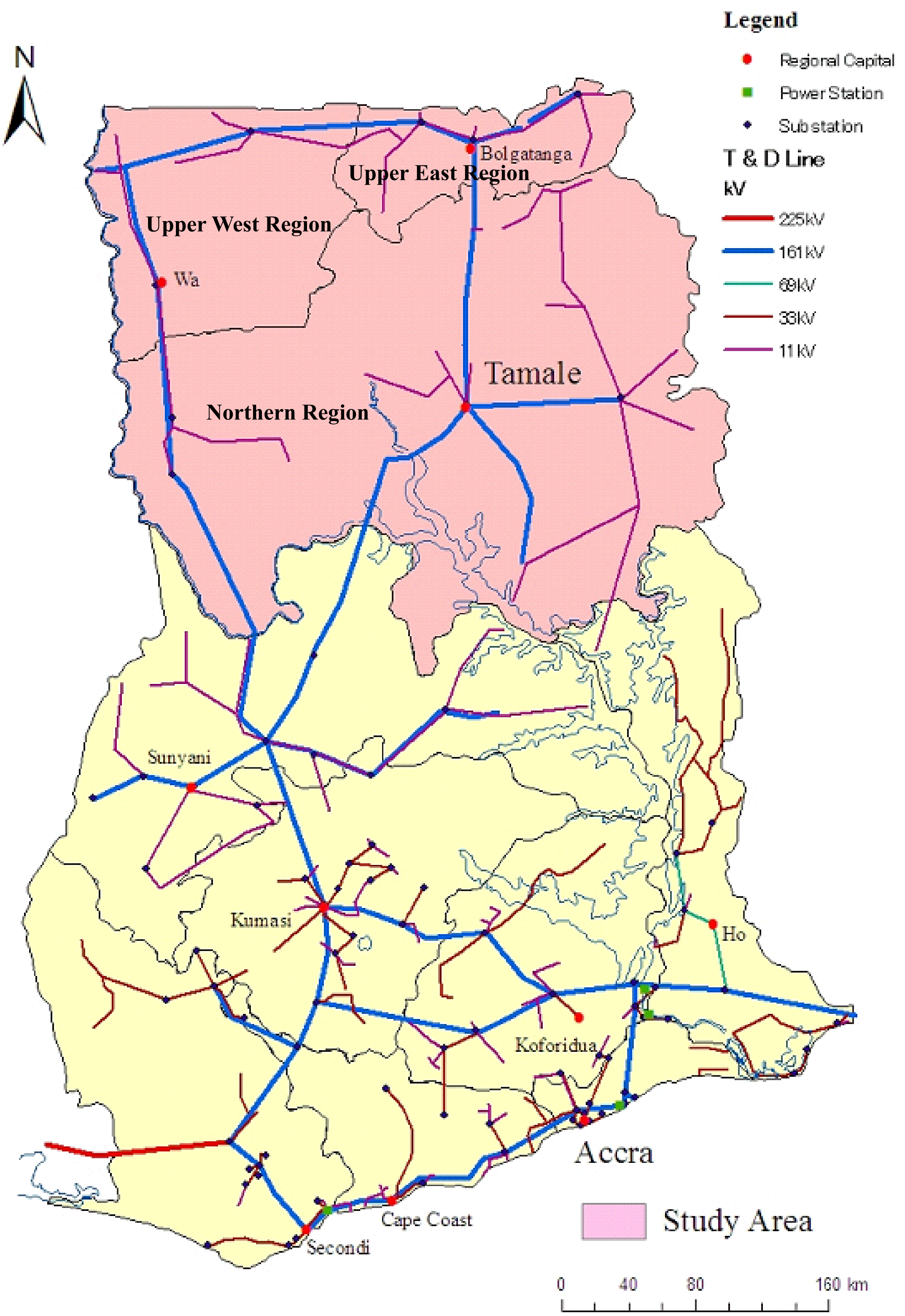
Table of Contents

List of Tables

List of Figures

Acronyms

AC	Alternating Current
B&W	Black and White
BCS	Battery Charging Station
DANIDA	Danish Agency for Development Assistance
DC	Direct Current
EC	Energy Commission
ECG	Electricity Company of Ghana
ESCO	Energy Service Company
GEF	Global Environmental Facilities
GIS	Geographic Information System
HIPC	Highly Indebted Poor Country
HV	High Voltage
ICT	Information and Communication Technology
JICA	Japan International Cooperation Agency
JSS	Junior Secondary School
MOE	Ministry of Energy
MOEdu	Ministry of Education
MOH	Ministry of Health
NED	Northern Electrification Department
NES	National Electrification Scheme
NGO	Non Governmental Organization
O&M	Operation and Maintenance
PV	Photo Voltaic
RESCO	Rural Energy Service Company
RESPRO	Renewable Energy Service Project
SHEP	Self Help Electrification Programme
SHS	Solar Home System
TV	Television
VRA	Volta River Authority



(Source) JICA Study Team

Figure: Transmission and Distribution Network in Ghana

Executive Summary

This master plan study was executed in accordance with an intergovernmental agreement between the Republic of Ghana and Japan as a project of technical assistance promoted by the Japan International Cooperation Agency (JICA).

In addition to relatively low income levels, the three northern regions of Ghana are characterized by a low population density and scattered sitting of communities. These factors drive up the cost of extending distribution lines, and electrification by extension of the grid is consequently not making much progress.

The northern regions have a lot of solar radiation, and there are high expectations for electrification with off-grid systems applying photovoltaic (PV) power generation. Thus far, solar home systems (SHS) have been installed in projects funded by donors.

The major such project was the Rural Energy Service Project (RESPRO), which was implemented with funding from the Global Environmental Facility (GEF). The RESPRO applied a new business model, i.e., fee-for-service. In this model, the RESPRO attempted to maintain the business by collecting fees from residents for the SHS operation, without transferring the ownership to them. The fees were held to the level of the lifeline tariffs, the lowest ones applied in on-grid electrification (about 2 dollars per month). Nevertheless, this low level of fees caused problems for the continued subsistence of the business. The RESPRO is finding it financially difficult to remain in operation, and may not even be able to replace spent batteries without an injection of additional funds.

While the government has attempted various pilot projects, it has not been able to build a model that could definitely be termed successful in respect of operational sustainability.

The problems facing PV electrification are not merely a matter of economic merit. Even more important is the situation surrounding the Self-Help Electrification Programme (SHEP), which is at the base of rural electrification (RE) in Ghana and is casting a pall over the implementation of all PV projects.

Off-grid electrification is positioned as a supplement to on-grid electrification. Nevertheless, the yearly planning in the SHEP was lacked coherence as far as continuity was concerned; quite often, distribution lines suddenly were extended to communities that were originally not supposed to be reached by them. This situation is compelling the relocation of about half of the approximately 2,000 SHS already installed.

In its promotion of PV electrification from now on, Ghana must consider the overall conformance of RE plans encompassing both on- and off-grid approaches, and devise a project scheme that will enable sustained operation and management (O&M) of PV facilities.

Because PV electrification is saddled with problems in a fundamental area (the RE framework), the

Study Team did not make a PV electrification project list. Instead, it considered matters essential for the formulation of RE programs, i.e., determination of the right size of system for electrification subjects (households, commercial facilities, and public facilities), the establishment of criteria for selection of areas for PV electrification, and the procedure for estimating demand on the community basis. It also devoted its efforts to preparation of the basic organizational setup through the establishment of standards for PV technology and practice, and the compilation of data using a geographic information system (GIS).

In addition to this technical approach, the Study Team presented important guidelines that function as principles to be applied in the promotion of RE in the three northern regions.

One is the need for downsizing business models applied in off-grid PV electrification. Ordinary households in the northern regions have low income and are able to spend only about 14,000 cedi (1.5 dollars) per month on electricity. This indicates that almost none of them would be able to purchase SHS. The RESPRO experience also evidences that PV projects could not be supported with application of a fee-for-service model with fees on the level of lifeline tariffs.

To resolve the problem posed by the low ceiling on the economic burden able to be shouldered by residents, it is necessary to apply an electrification model that holds down costs through use of battery charge stations (BCS) as opposed to the diffusion of SHS targeted in the past. This study, however, found that only 20 % of all households would be able to shoulder the burden of even BCS. Among commercial facilities as well, the share able to shoulder the electrification cost comes to 25 % for BCS and 5 % for SHS, for a total of only 30 %.

Another question is the extent to which the government will be able to provide funding for PV projects under its financial constraints. The government, too, has only limited funds, and the main funding would have to come from donors or the fund for highly indebted poor countries (HIPC). The government must make more effective use of its finite funds.

The subjects of PV electrification projects funded directly by the government ought to be confined to public facilities. Judging from its financial situation, it is highly doubtful that the government has the margin to fund projects even in the private sector. It is advisable to have the private sector electrified through direct sales of SHS by private enterprises to users and the launch of BCS businesses on the private-sector basis.

It must also be noted, however, that private enterprises in this field are still in their infancy and are not yet completely self-supporting in respect of financial and human resources. To furnish these enterprises with indirect support, the government must provide them with business opportunities through its procurement activity for installation of SHS on public facilities, and thereby foster the growth of the industry while backing expansion of the market in the private sector.

1. Background and objective

As fundamental support for its pursuit of socioeconomic advancement across the country, the Ghana government formulated the National Electrification Scheme (NES). In keeping with the NES, it has been promoting RE through the on-grid approach, i.e. extension of distribution lines, in the context of the SHEP.

The three northern regions of Ghana, which are poor relative to the national average, are characterized by a low population density and scattered sitting of communities. These factors drive up the cost of extending distribution lines, and on-grid electrification is consequently not making much progress. As a result, the three regions have low electrification rates. In contrast, they have a lot of solar radiation, and there are high expectations for electrification with off-grid systems applying PV power generation as an alternative to grid extension.

In the governmental RE policy, nevertheless, there is a basic agreement that the purpose of off-grid electrification is to supplement on-grid electrification. Even so, the government has not hammered out clear policy answers to questions occurring at the stage of project implementation, such as the parties which are to actually undertake PV electrification, how electrification costs are to be recovered in the northern regions with their mostly impoverished populations, and how off-grid electrification can be sustained in the face of problems of continuity in the yearly SHEP plans.

Furthermore, the continuation of fee-for-service projects being executed by the RESPRO in the three northern regions is already reaching its limit. In terms of both finances and organization, it is becoming difficult to continue these projects.

As indicated by the current status of off-grid PV electrification, it is getting to be time for the Ghana government to revise its strategy for off-grid PV electrification.

Against this background, in implementing this master plan study, the Study Team emphasized a multifaceted and wide-ranging perspective on off-grid PV electrification in the three northern regions, encompassing the technical, financial, and institutional aspects. This is why the output does not consist of a list of candidate sites for projects over the coming 20 years, as is typically prepared for ordinary master plans.

There are two major reasons for this emphasis on strategy for promotion of off-grid PV electrification as the objective of this master plan study, as follows.

In the first place, the framework of the SHEP, the project for nationwide electrification, is not entirely rational as viewed from the standpoints of the continuity and consistency of its yearly plans, and also faces both technical and economic difficulties. More specifically, the conditions applied in selection of villages (rural communities) for electrification under the SHEP are simply a limited distance from the nearest distribution line and community payment for the necessary utility poles.

The projects lack rationality in that they do not take account of geographical continuity and investment (cost) effectiveness, and have progressed with this deficiency unremedied.

Meanwhile, off-grid electrification plans are, of course, greatly affected by on-grid ones. As noted above, off-grid electrification is positioned as a supplement to on-grid electrification, but the SHEP yearly plans have problems of continuity. Quite often, distribution lines suddenly were extended to communities that were originally not supposed to be reached by them. As a result, about half of the approximately 2,000 SHS already installed by the Ministry of Energy (MOE) have to be relocated because of the unforeseen extension of distribution lines. In other words, in a chain-reaction effect, SHEP problems are creating problems for off-grid electrification per se.

In the second place, the PV projects implemented in Ghana so far have not been completely successful. In the project promoted by the Danish Agency for Development Assistance (DANIDA), SHS were ultimately transferred to local communities even though regional banks had recovered almost none of the loans they made to customers for purchase of the systems. Similarly, the RESPRO was executed with aid from the GEF and tried a new business model (fee-for-service), but had no prospects for the financing needed for O&M or additional investment upon the end of GEF involvement.

There consequently remain many problems with RE in Ghana. In this study, the Study Team therefore decided to go back to the basics and direct its energies to clarification of the issues currently confronting off-grid electrification, examination of items that must be considered in the process of drafting plans for off-grid PV electrification (e.g., collection of requisite data, method of analyzing these data, method of estimating/forecasting the demand among electrification subjects, segmentation of on- and off-grid electrification, and organizational setup for promoting off-grid PV electrification), and measures to resolve several problems requiring solution.

The preparation of a specific list of sites for PV electrification projects, meaning the drafting of an electrification program, can begin only after the resolution of the problems and issues presented in this study. At present, when they rely completely on grant aid from the initiative for Highly Indebted Poor Country (HIPC) and donors, electrification projects would have no prospects for self-supporting maintenance even if they were expanded. This is clear from the results of the PV electrification projects executed in the past and the huge accumulated debt left in the finances of the Northern Electricity Department (NED) by the extension of the grid in the northern regions.

The urgent task for the government at this time is to present a sound and workable policy for electrification. It should not attempt to expand projects with the identity of funding sources left unclear or without certain prospects for obtaining funds. It should also reconsider the execution of electrification programs that cannot continue on a self-supporting basis even if the initial investments can be made.

2. Process of master plan preparation

2.1 Basic guidelines of the study

The means of electrification that is the subject of this study is off-grid systems applying renewable energy. Such systems differ greatly from the on-grid approach promoted under the SHEP.

Unlike supply of electricity through the grid, PV systems have a low output and limited application. The typical SHS has an output of only about 100 W at most, and cannot power a refrigerator. It can provide power only for low-capacity electrical products on the order of lights, radios, and black-and-white (B&W) television (TV) sets. In addition, unlike the grid, it cannot supply power steadily 24 hours a day; the hours of availability are limited.

The off- and on-grid approaches also differ significantly in respect of the electrification principal. In on-grid electrification, the local power utility is responsible for all activities from construction to O&M. In off-grid electrification, on the other hand, principals vary. Projects may be executed by power utilities, but they may also be implemented by the local community, and promotion by an independent private enterprise is common, too.

Off-grid electrification similarly varies in the aspect of electrification cost recovery. In some projects, the principal collects fees from users in exchange for the supply of power while retaining ownership of the facilities, as in the case of on-grid electrification. In others, the principal sells the generation unit (e.g., SHS) to the user while also transferring the responsibility for subsequent maintenance to the latter.

In this way, off-grid electrification differs substantially from the on-grid type in character. For this reason, the preparation of electrification plans must be preceded by in-depth study of items such as the business model to be applied, the scheme for recovery of costs, and provision of incentives to promote electrification. With a view to constructing an electrification project model adapted to the social structure in the northern regions to this end, the Study Team set out to prepare a plan premised on sustainable operation of projects per se as well as to clearly define the basic conditions as regards electrification needs, pattern of power use, and payment capabilities.

2.2 Structure of the master plan study

The Master Plan Study consisted of examinations under the five major headings noted below, and these headings were grouped in three frameworks.

As shown in Figure 1, the fundamental work lay in identification of problems and issues experienced in past PV projects, clarification of the actual status of the socioeconomic environment on the community level in the three northern regions, and presentation of the findings as preconditions (i.e., input for preparation of the Master Plan).

Next, the Study Team examined and set forth the procedure required for formulation of the PV off-grid electrification plan based on the preconditions. In parallel with this work, it drafted standards for PV technology. The formulation of the RE plans and draft technical standards constituted the results of the technical examinations for the Master Plan (i.e., the output in the technical aspect).

In light of the results of all these examinations, the Study Team made recommendations as regards the requirements for promotion of electrification through PV off-grid systems, in the form of a concrete action plan. Naturally, this plan incorporated recommendations not only for technical arrangements but also for policy and organizational ones.

(1) Identification of problem points in past PV electrification projects

- The Study Team identified problems encountered in past PV electrification projects, and the factors that caused them. It not only dealt with the technical aspect but also shed light on tasks for the future as regards retrieval of costs and assurance of financial sustainability, which have a great bearing on project operation.

(2) Determination of the socioeconomic characteristics of rural communities in the three northern regions

- The Study Team determined the facts of life in rural communities in the three northern regions that were the subjects of the Master Plan. In so doing, it ascertained the realities as regards electrification needs, ability to assume electrification costs (payment capabilities), and electrification impact on rural society.

(3) Formulation of PV off-grid electrification plans

- Based on the problem points identified in past PV projects, the Study Team set forth the procedure for plan preparation, i.e., demand forecasting methodology, criteria for selection of districts for electrification programs, electrification methodology, and perspectives in electrification programs.

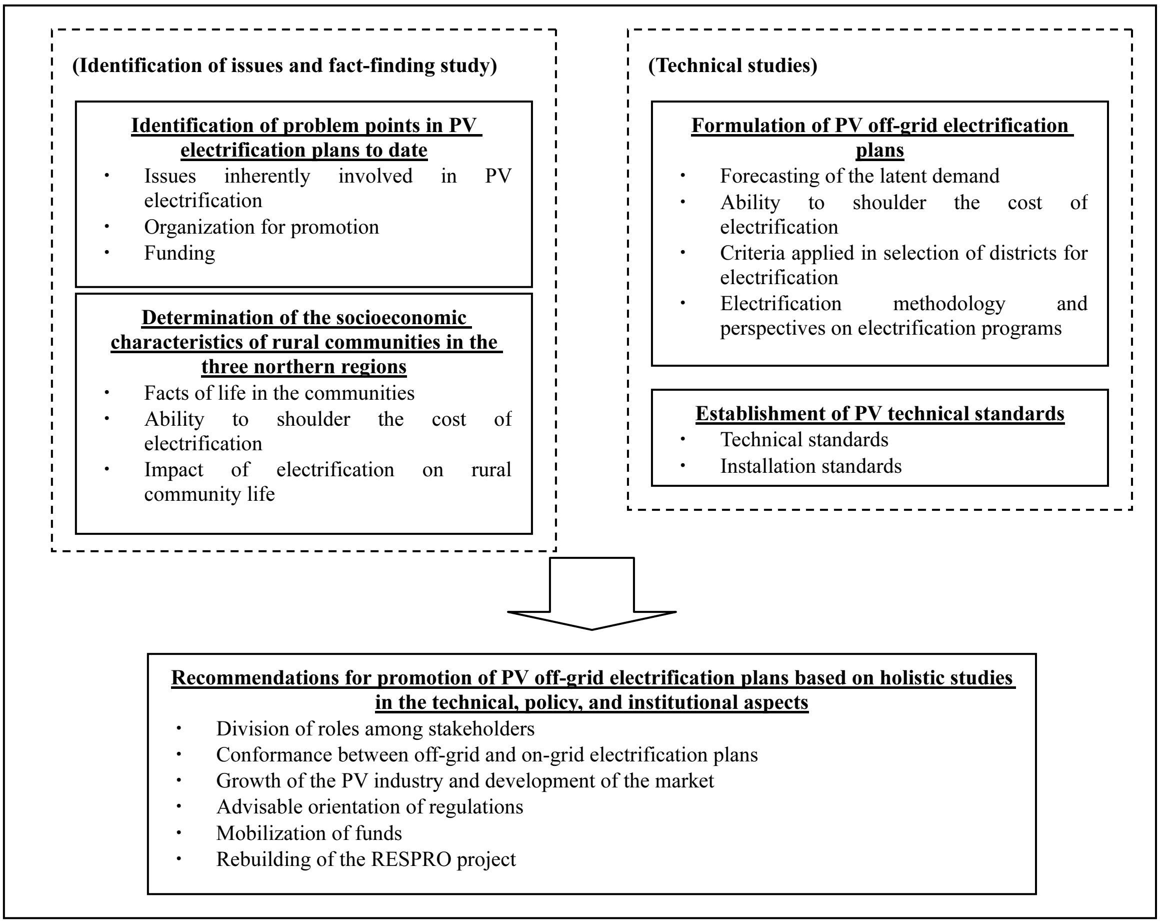
(4) Drafting of PV technical standards

- The Study Team prepared a draft for PV-related technical standards and installation standards.

(5) Recommendations for promotion of PV off-grid electrification plans (Action Plan)

- The Study Team proposed a plan for action required for successfully executing future PV off-grid projects.

- The Action Plan contained specific suggestions on matters including assurance of conformance with the on-grid electrification program (SHEP) that is the main force of RE, promotion of PV electrification by cultivating the growth of the PV industry and market, requisite orientation in regulations, and mobilization of funds.



(Source) JICA Study Team

Figure 1: Structure of the Master Plan Study

2.3 Data collection

2.3.1 Collection of basic data mainly from available documentation

To collect general basic data from existing documentation, the Study Team utilized materials including statistics and reports published by the government, and documents from power companies, i.e., the Electricity Company of Ghana (ECG), the Volta River Authority (VRA), and the NED, which is the VRA's distribution division.

For data related to PV technology in Ghana, the Study Team obtained materials mainly from the RESPRO and PV system dealers. It should be noted, however, that these data have not necessarily been generally disclosed and properly compiled in many cases. The Study Team increased the reliability of the data by repeatedly holding discussions not only with these businesses but also with concerned people at universities and polytechnic schools.

2.3.2 Field studies

Besides collection of available documentation, the Study Team made field studies to obtain information on the socioeconomic situation in communities in the three northern regions, in order to ascertain actual circumstances as regards electrification needs, the payment capabilities of beneficiaries, and prospective changes in community life due to electrification.

2.3.3 Dialogue with concerned parties through interviews

The Study Team also studied problems with the current institutional arrangements and difficulties likely to surface in the future through dialogue with concerned parties. For example, it held workshops and meetings for private interviews to collect the opinions of concerned parties on subjects including the establishment of rules and standards, the negative influence of the lifeline tariff scheme, and conceptual matters such as the gap between expectations of electricity among residents and the realities.

2.4 Method of forecasting power demand

Considering capabilities for shouldering the cost burden and need for electrification among residents, not all facilities and households in areas that are electrification subjects would be electrified.

It is not possible to determine the size of individual PV systems to be installed as well as the scale of the overall electrification plan and requisite amount of investment unless estimates are made of the number of individual facilities and households to be electrified and the level of demand at each.

A particularly important point is that, owing to the low income levels in the three northern regions, even if all households and public facilities were electrified, they quite possibly would be unable to pay for subsequent service. It is also necessary to get a good grasp of the type of electrical products that would be used in facilities and households upon electrification. For this purpose, the Study Team constructed a demand estimating/forecasting model for each customer category by adding up figures for demand constituents based on data from the village socioeconomic study.

In estimating the latent demand, the Study Team put constraints on the size of off-grid PV systems, in light of the small range of electrical products that such systems can power and the limited capacity of ordinary PV systems (50 or 100W).

2.5 Geographical segmentation of off-grid PV and on-grid electrification

It has often happened that areas which had been electrified with off-grid PV systems in past projects were reached by the grid not so long afterward. This pointed to the need for establishment of a clear guideline for segmentation of off- and on-grid electrification in this study.

The underlying idea that the role of off-grid electrification is to supplement on-grid electrification by electrifying areas that cannot be reached by the grid is still shared by the concerned parties, but there have not been any detailed studies to determine conditions for setting the dividing line between the two.

To discharge this task, the Study Team constructed a model for calculation of this line and logically compared the two in respect of economic merit.

2.6 Selection of areas to be electrification subjects

The selection of areas to be electrified by PV systems requires a clear definition of the dividing line between on- and off-grid electrification based on both policy and technical decisions, followed by an ordering of PV electrification priorities in remote rural areas given the constraints of the governmental budget.

For this task, the Study Team presented material necessary for selecting subject areas and proposed selection criteria that attached priority to medical and public facilities in electrification.

2.7 Technical standards

When PV or any other type of technology is in its infancy on the industrial level, various problems are likely to occur due to mistakes at the design stage, improper installation, and unskillful O&M. It is not unusual for these difficulties to erode consumer confidence and even impede the sound development of the market. The Study Team's aim in proposing technical standards and a code of practice was to advise the institution of technical guidelines that would prevent just such problems; it was definitely not to encourage control of PV industry activities or the market.

In line with this end, the technical standards indicate the minimum requisite performance of each component making up the system, and the code of practice, the requisite conditions to be applied in each process, i.e., design, installation, inspection, and O&M.

2.8 Study of institutional and policy issues for promotion of off-grid PV electrification

The RESPRO and other past PV projects were hampered by various problems. In light of this fact, it is clearly necessary to establish a new business model for off-grid PV electrification that is better adapted to beneficiary needs, the socioeconomic circumstances, and market environment.

The government is promoting a separate study on regulations including the establishment of standards for PV technology and issuance of licenses to PV enterprises. It must be remembered that excessive regulation may very well hinder the growth of the market. The preparation of an institutional and policy framework must be unswervingly oriented toward assisting the industry's advancement.

The projects promoted by the government even in the past for PV electrification were of great significance and undeniably furnished private-sector PV enterprises with market opportunities. The state of government finances, nevertheless, unmistakably shows that continued promotion of off-grid PV electrification solely with official funding is reaching its limits.

With an awareness of these circumstances, the Study Team attempted a clear definition of the governmental and private-sector roles with a view to the most efficient promotion of PV electrification within the financial constraints, and considered a concrete action plan needed to make arrangements for sustained promotion of electrification.

3. Master plan study results and features

As described in Section 1, the Study Team did not set out to prepare the typical list of project sites contained in past master plans for the output of this study. Instead, it complied the results of studies to clarify problem points as necessary for the formulation of a PV electrification program, present approaches required for steady pursuit of PV electrification, and identify tasks that must be tackled by the government over the coming years.

As noted at the beginning of this summary, the reason for this orientation is the problems of the most basic off-grid electrification plan, namely, the SHEP, in the areas of the continuity of the yearly plans and the geographical consistency between different projects. These problems have resulted in redundant electrification, because areas electrified with off-grid systems have ended up connected to the grid shortly afterward.

The PV projects executed so far in Ghana have not been entirely successful, and this is another major point. In particular, the RESPRO was viewed as applying an electrification model with good prospects for success, but is now finding it difficult to cover costs and has fallen into a situation that jeopardizes its continuation.

It is obvious that the promotion of new projects without a solution of these fundamental problems surrounding PV electrification will only lead to a recurrence of the same sort of difficulties.

3.1 Identification of problems in promotion of PV electrification plans to date

3.1.1 Excessive expectations of on-grid electrification and insufficient understanding of off-grid PV electrification

Political pressures are acting on the execution of the SHEP, the most fundamental RE program in Ghana, and all problems related to it stem from the lack of a setup for promotion of projects with internal conformance and consistency. In the three northern regions covered by this study, the Study Team often observed utility poles without distribution lines in some areas, where unreasonable extensions left communities waiting for electrification even though they had erected poles.

At the same time, residents generally have high expectations that their community will be connected to the grid through the SHEP, and many do not have favorable impressions of PV systems.

On-grid electrification is clearly superior to off-grid electrification as far as output and stability are concerned. Off-grid electrification is premised on a perception that it is merely an alternative means for areas that cannot be reached by the grid. Without an understanding of this factor, dissatisfaction and misunderstanding of off-grid PV electrification are liable to spread among residents. This is exemplified by the discontent among users that surfaced even in RESPRO projects, because they were paying the same tariff rates as NED customers in spite of the lower SHS output.

In other projects, systems have failed due to a lack of knowledge on the part of their users, who have refused to repay loans obtained to purchase the systems as a result.

3.1.2 Difficulty of making PV electrification projects self-funding

There are many problems in the aspect of recovery of electrification funds as well. Past PV projects were implemented with funds from donor institutions, and both project principals and beneficiaries had a low awareness of the need for reinvestment in projects, revolving funds (i.e., retrieval of investment from fees or sales revenue to fund the next investment), and assurance of O&M costs. Beneficiaries in ordinary households believed that the projects gave them the systems gratis, and were not aware of an obligation to pay service fees or O&M costs. This is a major factor hurting project continuity.

Even under the fee-for-service model applied with GEF assistance, RESPRO operation has clearly become financially difficult. Because the service is compared with tariffs for the existing distribution (on-grid) service, the lifeline tariffs were taken as the guideline. Revenue of only about 2 dollars per month, however, is not enough to cover O&M costs, let alone recover the initial investment. The batteries installed at the start of the RESPRO are already entering the phase for replacement, but this cannot be done by reinvesting funds from project income. In other words, expansion of the fee-for-service supply while adhering to the current model requires an ongoing input of funds into the RESPRO, which no longer has prospects for sustained expansion by itself.

3.2 Socioeconomic attributes of communities in the three northern regions

3.2.1 Way of life and need for electricity

This section summarizes the results of the study concerning the circumstances of community life and the needs for electricity in communities, in each demand category (i.e., households, commercial facilities, and public facilities).

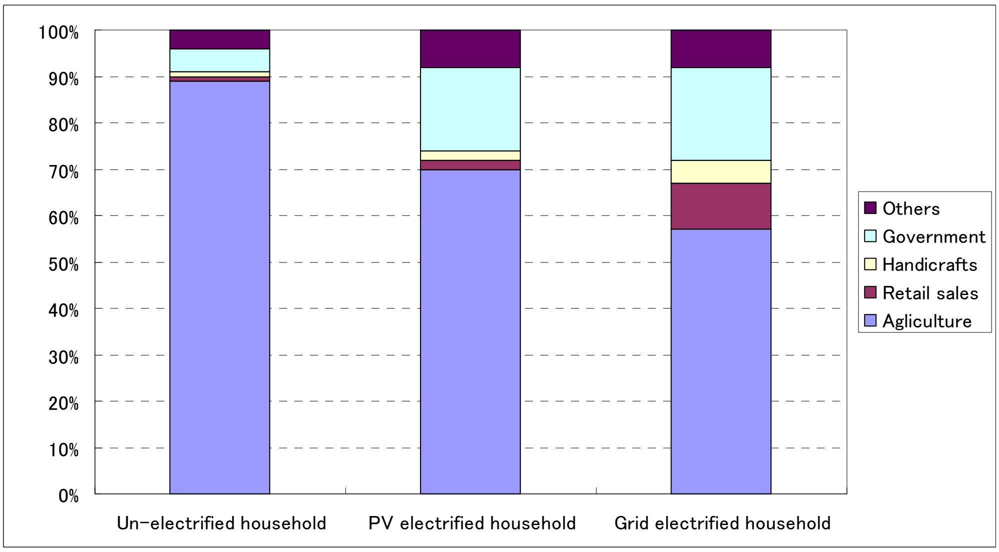
3.2.1.1 Households

Types of occupation

The majority of ordinary households are engaged in subsistence-level farming; the rate reaches 89% in unelectrified communities. This rate tends to decline as electrification progresses, and is down to 57% in communities electrified by connection to the grid (see Figure 2).

Farming households are generally poor. Agriculture in the northern regions depends almost entirely on rain for water, and has a low productivity. In some cases, it is even hard for households to produce enough food for themselves.

Some households, however, do not rely entirely on farming but instead also engage in other economic activities, such as running bars and small stores or producing cash crop items (extraction of vegetable oil). Aside from agriculture, some residents are engaged in work for the government, handicrafts, and retail sales, but they still account for only a small share of the total number. Such households are more prevalent among electrified communities than among unelectrified ones.



(Source) JICA Study Team

Figure 2: Major types of occupation in rural areas

Daily life and needs for electricity

In their daily life activity, adult males spend more time outdoors (outside homes and compounds) than adult females. Adult females engage mainly in housework and social activities in the home and compound.

The best prospective times for use of electricity, and especially lights, are early morning and night. Lights would be used for a few hours of prayer time beginning at 5:00 AM, and cooking, cleaning, eating, and other social activities at night. Electricity would also be used to listen to the radio and watch TV, but residents use batteries to power radios and very few of them own TV sets.

In contrast, there is little need for electricity during the daytime, when people are usually at work outdoors.

Judging from these circumstances, the average household would probably need electricity each day to use lights for about six hours (morning and night), radios for about six hours, and TV for about three hours.

Even among ordinary households, however, there is a large amount of variation. Those engaged in subsistence-level farming have negligible cash income, and would presumably find it difficult to pay fees for service. In contrast, households engaged in economic activities linked to a cash income may be economically prosperous and better able to purchase electrical products than those engaged solely in farming. They would also have a higher ability to pay service fees.

3.2.1.2 Commercial facilities

Small stores are generally open for 12 or 13 hours beginning about 7:00 AM. Some are open until late at night, but if use of electricity is confined to lights, the demand would last for only a few hours at night (conversely, this is not true at stores also using refrigerators and fans).

Bars have basically the same business hours as small stores, but usually have refrigerators and fans, and this increases the consumption of power for products other than lights.

3.2.1.3 Public facilities

Junior secondary schools (JSS) are usually open from 8:00 in the morning to 3:00 in the afternoon. Although some are equipped with lights, the schools do not have very strong needs for them because windows can be opened to hold classes in natural lighting. Faculty members use radios to listen to the news, but needs for other electrical products are low.

As this suggests, needs for electricity appear to be low when only the normal classes are considered, but they are higher among schools where adult education and literacy classes are held at night.

Like schools, clinics and other medical facilities are busiest around the middle of the day.

Medical facilities prefer not to open their windows for health reasons, and have stronger needs for lights even in the daytime. Lights are obviously very important for nighttime services as well as response to emergencies such as childbirth. There are also strong needs in connection with the storage of vaccine and blood, keeping of bodies, and wireless communication with institutions offering superior medical care.

3.2.2 Impact of electrification on society

Among households, electricity is viewed as a commodity with a positive effect that makes life more comfortable; generally speaking, almost no residents deny its inherent value. This is because, with proper O&M and supply, electricity benefits people.

By the same token, however, apprehensions about electrification were expressed by some residents.

In communities electrified by off-grid PV systems, there was dissatisfaction with inability to use the systems to power grain mills, refrigerators, and TV sets.

In communities electrified by connection to the grid, some residents pointed out certain negative effects, i.e., the increased financial burden of payment for electricity; the neglect of help with housework and studies by youth who are preoccupied with electric-powered entertainment provided by TV and radio, and the resultant loss of traditional community culture; and increased noise at night.

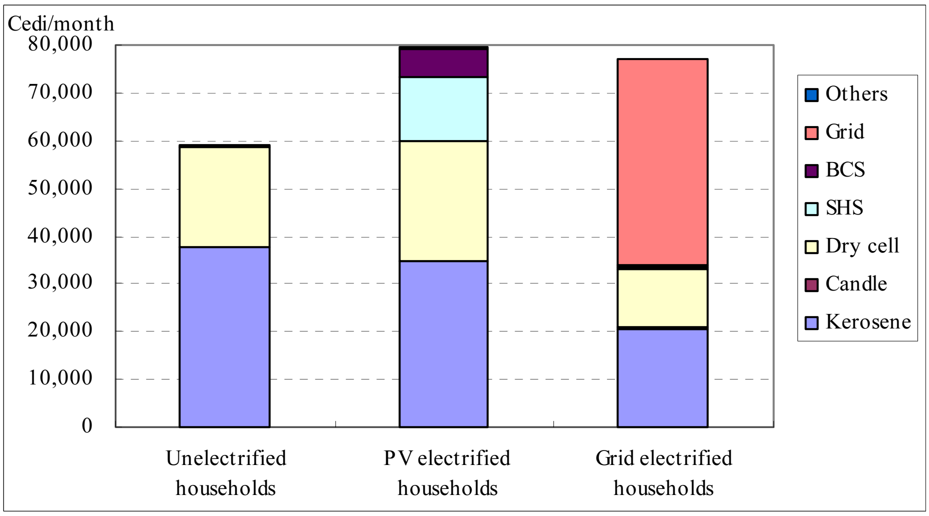
Among public facilities, and especially medical ones, electrification is given high ratings for its positive effect of facilitating services.

On the other hand, residents also pointed out negative effects deriving from electrification of commercial and public facilities. The size of electrification system capacity and the burden of fees are particularly big problems. In electrification of public facilities, it is often unclear which party (national government agency, local government agency, facility operator, or user) is responsible for O&M, and the collection of fees and performance of O&M take considerable time.

3.2.3 Ability to pay for electricity

3.2.3.1 Households

Figure 3 shows data on monthly expenditures for various type of energy, which were obtained by the questionnaire survey.



(Source) JICA Study Team

Figure 3: Monthly energy expenditures by ordinary households

Monthly energy payments come to about 59,000 cedi (6.5 dollars) in unelectrified communities, 80,000 cedi (8.8 dollars) in communities electrified with PV systems, and 77,000 cedi (8.6 dollars) in communities electrified with on-grid systems. These expenditures are made for lighting (including kerosene lamps and other articles not powered by electricity) and use of electrical products.

Expenditures for kerosene, a major type of non-electrical energy, amount to about 37,000 cedi (4.1 dollars) in unelectrified communities, 34,000 cedi (3.7 dollars) in communities electrified with off-grid PV systems, and 20,000 cedi (about 2.2 dollars) in communities electrified by on-grid systems.

Spending on batteries amounted to about 20,000 cedi (2.2 dollars) in unelectrified communities, 25,000 cedi (2.7 dollars) in communities electrified with off-grid PV systems, and 12,000 cedi (1.3 dollars) in communities electrified with on-grid systems.

Based on these data, the following are estimates of the amount that households could pay for electricity upon electrification of unelectrified communities.

- About 58,000 cedi (6.4 dollars) in the event of a switch from kerosene and batteries to electricity for all applications

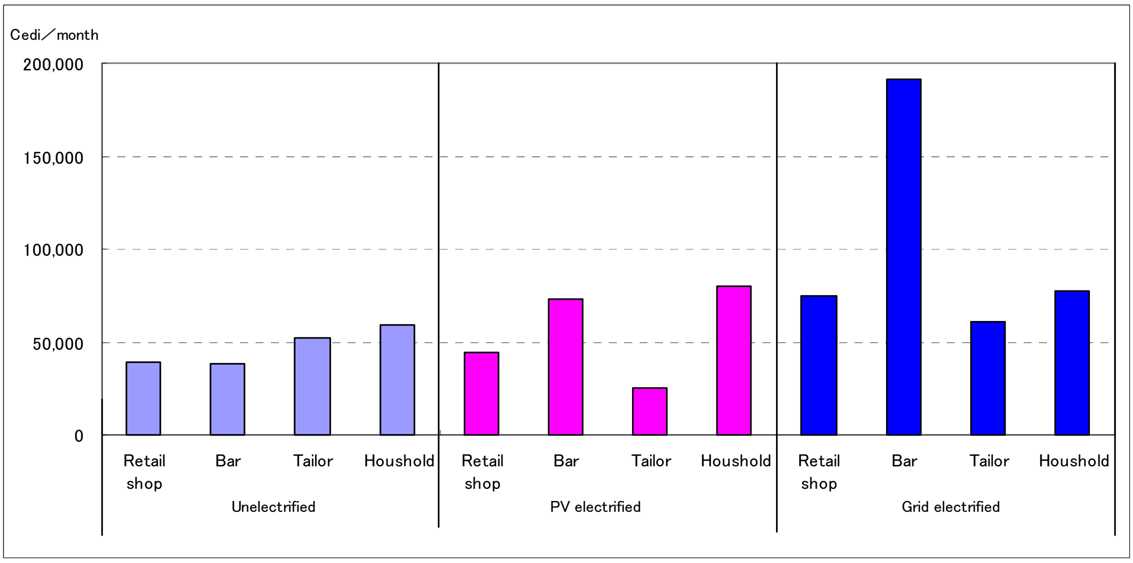
- About 29,000 cedi (3.2 dollars) in the event of diversion of about half of the current energy expenditure to electricity

- About 14,000 cedi (1.5 dollars) in the event of diversion of about one-fourth of the current energy expenditure to electricity

Even if communities are electrified, however, it is unlikely that kerosene and batteries would go completely out of use. Similarly, it can be pointed out that, in communities electrified with off-grid PV systems, spending on PV electricity accounts for only about one-fourth of the total energy expenditures. As such, the amount which people could readily spend for PV electricity would more properly be put on the level of the third estimate, i.e., about 14,000 cedi (1.5 dollars) per month.

3.2.3.2 Commercial facilities

Figure 4 shows the amount of monthly energy expenditur by type of facility.



(Source) JICA Study Team

Figure 4: Monthly energy expenditures of major commercial facilities

Monthly expenditures for energy by small stores rises along with the level of electrification; it came to about 38,000 cedi (4.2 dollars) in unelectrified communities, as compared to about 44,000 cedi (4.8 dollars) in communities electrified with PV systems and 75,000 cedi (8.2 dollars) in those electrified by on-grid systems.

As in the case of small stores, the monthly expenditures on energy by bars rose with the level of electrification; it was about 38,000 cedi (4.2 dollars) in unelectrified communities, 72,000 cedi (7.9 dollars) in communities electrified with PV systems, and 191,000 cedi (21 dollars) in communities electrified with on-grid systems.

Unlike the cases of small stores and bars, the monthly expenditures on energy by tailor shops did not rise with the level of electrification; it came to about 52,000 cedi (5.7 dollars) in unelectrified communities and dropped to about 25,000 cedi (2.7 dollars) in communities electrified with PV systems, but again rose to about 61,000 cedi (6.7 dollars) in communities electrified with on-grid systems.

In both electrified and unelectrified areas, energy expenditures of commercial facilities are below the household average.

3.2.3.3 Public facilities

Among public facilities, monthly expenditures on energy by schools averaged about 11,500 cedi (1.3 dollars) on the junior secondary level and 150,000 cedi (16.5 dollars) on the high school level. Religious facilities spent an average of about 113,000 cedi (12.4 dollars) per month for use of electric lights and small electrical products.

3.3 Forecast of the latent demand for PV electrification

3.3.1 Electrification subjects

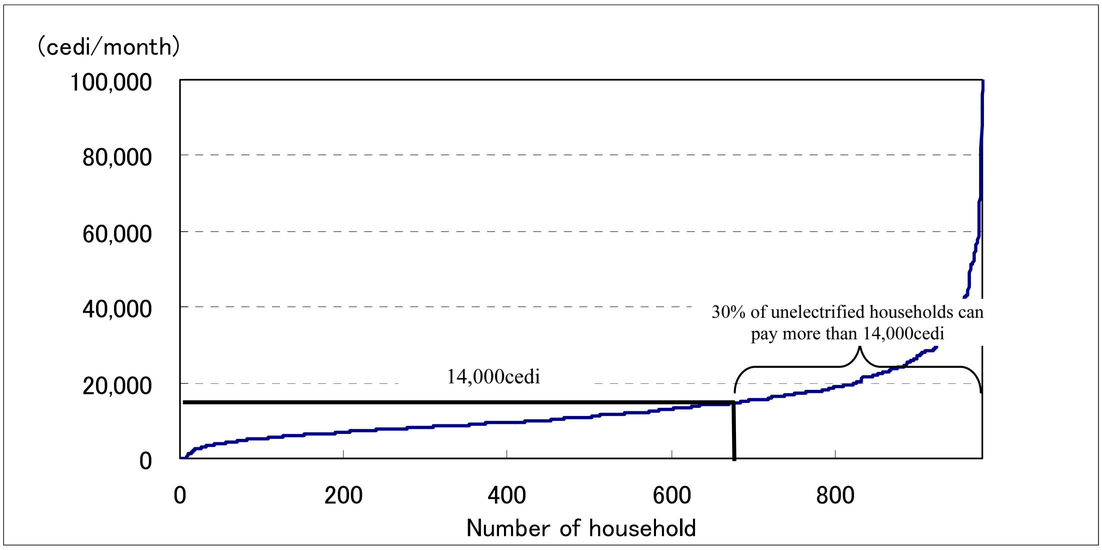
3.3.1.1 Households

Even in households electrified with PV systems, kerosene and batteries continue to be used as energy sources, and PV electricity accounts for only about one-fourth of the total energy expenditures. Application of a one-fourth share for PV to the current energy expenditures of unelectrified households yields a figure of about 14,000 cedi (1.5 dollars) as the amount they could spend for PV electrification. (The village socioeconomic study found that many residents of unelectrified communities were not willing to pay any more than at present for energy even upon electrification. Many SHS and BCS users also did not want to pay any more than at present. These findings suggest that, even with the installation of PV systems, unelectrified households would not spend much on electricity.)

A 50W SHS costs about 650 dollars (6 million cedi), and virtually no community residents could pay for one in cash.

In light of these circumstances, the Study Team considered not only SHS but also BCS as means of non-grid electrification for households. Assuming a cost of 3,000 cedi for charging a battery once a week at a BCS, this could be covered by the aforementioned figure of 14,000 cedi available for spending per month. In other words, with BCS, a sizable proportion of residents could receive the benefits of electrification.

However, unelectrified households vary in respect of the amount of energy expenditures; not all of them could pay 14,000 cedi per month for electricity. Few pay more than 14,000 cedi for electricity; those that do account for only about 30% of the total (see Figure 5).



(Source) JICA Study Team

Figure 5: Distribution of payable monthly sum among unelectrified households

As for the initial cost residents would be able to shoulder, the average is only about 120,000 cedi (13.3 dollars) among unelectrified households, but is more than twice as high at about 290,000 cedi (32.2 dollars) among households electrified with PV systems. By comparison, the car battery cost of about 50 dollars (450,000 cedi) is certainly far above the average payable burden, but there are nevertheless thought to be fairly many households that could afford to buy such batteries.

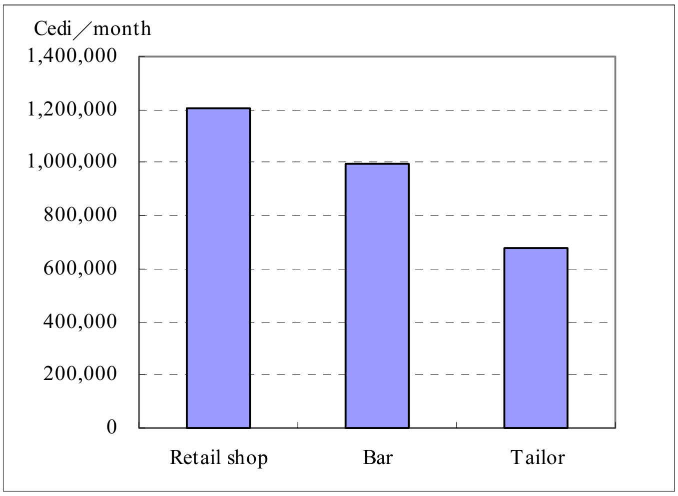
Judging from the above, if only the payable monthly sum is considered, about 30% of the households in unelectrified communities would be able to be electrified with BCS. However, the initial cost of the battery must also be considered, and it would consequently be more realistic to put the estimate for the rate of households as subjects of electrification lower, at about 20%.

3.3.1.2 Commercial facilities

As shown in Figure 4, energy expenditures by commercial facilities were below the household average in both unelectrified communities and communities electrified with PV systems.

Energy consumption in commercial facilities is fairly limited because the facilities are generally small, one-room buildings and because the proprietors return home after closing time. In addition, in the case of restaurants, the food is usually prepared in homes to the rear. For these reasons, it would probably not be appropriate to estimate the ability of commercial facilities to pay for PV electricity from their current energy expenditures.

Stores and bars in unelectrified areas have a monthly income in the range of 1.0 - 1.2 million cedi (110 - 130 dollars), and this clearly suggests a higher capability than households for purchase of PV systems (see Figure 6). If, for example, 10% of this income were directed to energy expenditures and PV electricity payments accounted for one-fourth of these expenditures, these facilities would be able to pay an estimated 25,000 - 30,000 cedi (2.8 -3.3 dollars) per month, slightly more than unelectrified households.



(Source) JICA Study Team

Figure 6: Monthly income of the major commercial facilities

The scope of electrical products used by commercial facilities electrified with PV systems is limited; it is virtually confined to lights and stereo (audio) sets.

From these observations, it is thought that about 30% of all commercial facilities would be subjects of off-grid PV electrification, and that, of this total, BCS would account for 25% points, and SHS, the remaining five.

3.3.1.3 Public facilities

Electrification of public facilities must be promoted by the government as a means of mitigating poverty through improvement of social services. Judging from the state of national finances, however, the government would find it impossible to electrify all facilities, and consequently must circumscribe the minimum requisite scope of those to be electrified.

Medical facilities

According to the results of the village socioeconomic study, almost all of the medical facilities on the order of hospital or above in the three northern regions have already been electrified. There are 199 other facilities (CHIPS compounds, clinics, and health centers) that have not been electrified.

The Ministry of Health (MOH) is pursuing the electrification of all those not yet electrified (including the small ones), and the Study Team therefore took all medical facilities as the subjects of PV electrification.

Educational facilities

In the field of educational facilities, electricity was not yet available to 481 junior secondary schools (58% of the total) and 2,894 primary schools (86%).

The Study Team excluded primary schools from the circle of electrification subjects for a number of reasons, including the limited progress of on-grid electrification, the huge expense required to electrify 2,894 facilities, and the promotion of electrification for the spread of information and communication technology (ICT) on the district level by the Ministry of Education (MOEdu). It consequently considered only junior secondary schools as the subjects of electrification with PV systems.

Other public facilities

Other public facilities that are prospective subjects of PV electrification are police stations, streetlights, and pumps for wells and bore holes. Of these, the Study Team took police stations as subjects for electrification because they are governmental facilities (although this would require agreement by the MOE and the other stakeholders).

Streetlights, however, were excluded from the circle of electrification subjects in this master plan study for a number of reasons. They require measures to protect the batteries, and this drives up costs. In addition, beneficiaries are not clearly delineated, and it would be virtually impossible to construct an O&M scheme for them.

Pumping facilities were also essentially excluded because they each would require separate design and because there have been few cases of system installation for them so far.

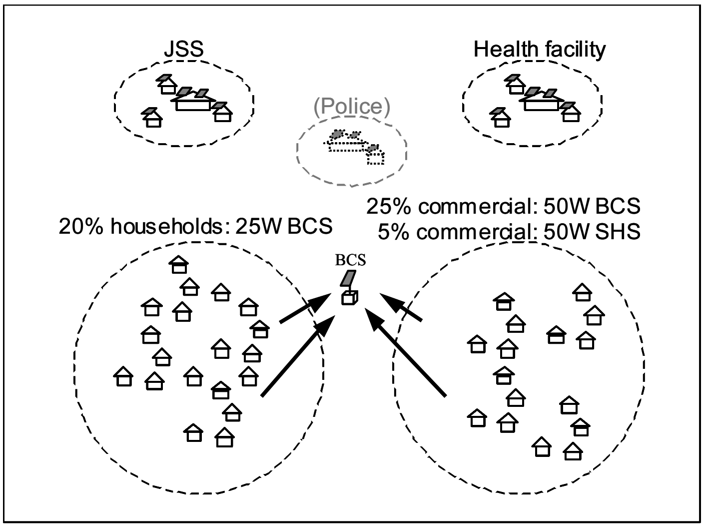
Staff houses

Besides improving services at medical and educational facilities through electrification, it is important to electrify staff houses for them to encourage personnel to accept assignments in remote communities.

The Study Team assumed installation of a 100W SHS for every three staff houses for educational facilities and health centers (and every CHIPS compound), as proposed by the MOE to furnish staff with incentive for residence in rural areas, considering that they are transferred from urban ones. It also assumed installation of a 100W SHS for each staff house for governmental facilities such as police stations.

3.3.2 PV electrification model

Figure 7 shows the PV electrification model for the three northern regions drawn on the basis of the aforementioned circle of subjects and rates of electrification. It was assumed that the public facilities would be electrified with SHS, and households and commercial facilities, with BCS.



(Source) JICA Study Team

Figure 7: PV electrification model

3.3.3 Method of estimating demand

The Study Team made estimates by two methods, one to be applied when the number of households and facilities that are subjects of electrification is known, and the other to be applied when it is not.

3.3.3.1 Method of estimation based on the number of subject households and facilities

<u>Off-grid PV electricity demand</u>

Table 1 presents perspectives on the system size for each type of electrification subject.

Table 1: Scale of PV systems to be applied

Electrification subjects	System size and comments
Households	• 25W (Use confined to the order of lighting)
Commercial facilities	• 50W (Mainly lighting, but also some use for small fans and radio-cassette players)
Public facilities	(As noted in the MOE proposal)
Clinics and health centers	• Buildings (including wireless equipment)：2×100W＝200W • Refrigerators：1×200W＝200W • Staff houses：3×100W＝300W
CHIPS compounds	• Buildings：1×100W＝100W • Staff houses：1×100W＝100W
Junior secondary schools	• Buildings：250W • Staff houses：3×100W＝300W
Police stations and govenmental buildings	• Buildings： 100W • Staff houses：1×100W＝100W

(Source) JICA Study Team

On-grid electricity demand

The village socioeconomic study found that the rate of household electrification is only 32% even in communities connected to the grid.

The main electrical products used in households are lights, radios, and radio-cassette players; other types are not in very wide diffusion. There is, however, some use of color TV sets and fans, and the average demand is estimated at 107.0W, larger than among households electrified with PV systems.

In the field of commercial facilities, estimates must take account of the demand associated with grain mills, which use 20kW of power. This is a big difference from communities electrified with PV systems. According to the study results, of the 116 grain mills in communities connected to the grid, 31 (27%) were electrified.

Among commercial facilities other than grain mills, the demand is estimated at 195.7W on the average. The on-grid electrification rate of commercial facilities excluding grain mills is 31%. Multiplication of the average demand by this factor yields the scale of the demand among the commercial facilities in the community.

As for public facilities, the Study Team assumed a demand of 110.5W for lighting and TV in junior secondary schools by applying the same reasoning as for PV systems, and 278.2W for medical facilities (and 139.1W for CHIPS compounds) in light of the actual data for them. For other public facilities, it assumed a demand of 107.0W, on a par with that in households, based on the results of the socioeconomic study.

3.3.3.2 Estimate of PV electricity demand based on population statistics

The method outlined in Section 3.3.3.1 can be used to estimate demand when the numbers of public facilities, commercial facilities, and households are known. At the stage of formulating electrification plans, however, such data are ordinarily not fully available. As an alternative method, the Study Team considered approximate estimation of the demand from population statistics. (This method is no more than a simple one to get a rough grasp of the PV electricity demand in rural areas. It must be remembered that, to promote electrification, it is necessary to determine the types of facilities in existence and their numbers.)

Based on the data confirmed by the focal discussion group (FDG) survey in the socioeconomic study, the Study Team performed statistical processing for the number of households, commercial facilities, and public facilities as percentage of population to derive the correlation with the latter.

Correlation between population and number of households

The data from the study did not reveal any significant difference among the three northern regions in respect of population and number of households. As shown below, the number of compounds can be derived by regression with a linear equation applying the coefficient of 0.09 to population.

$N_H = 0.09\ P$ (here, N_H is the number of households, and P is the community population)

Correlation between population and number of commercial facilities

There was also no significant difference among the three northern regions in respect of population and the number of commercial facilities. The number of commercial facilities can be derived by regression with a linear equation applying the coefficient of 0.025 to population.

$N_B = 0.025\ P$ (here, N_B is the number of commercial facilities, and P is the community population)

The corresponding coefficient for grain mills was 0.0021.

$N_G = 0.0021\ P$ (here, N_G is the number of grain mills, and P is the community population)

Correlation between population and number of public facilities

The Study Team estimated that communities with a population of 1,000 - 5,000 would have one junior secondary school, and those with a population of more than 5,000, two such schools.

The Study Team also estimated that there would be at least one medical facility in communities with at least 1,000 residents. The communities covered by the socioeconomic study had a low number of CHIPS compounds, and the Study Team consequently assumed that all medical facilities consist entirely of health centers and clinics.

The number of other public facilities is hard to gauge from the data obtained from the socioeconomic study, but police stations exist in district capitals and major cities, and it was estimated that there would be one in communities with a population of over 5,000.

3.3.3.3 Summary of demand forecasting methods

Tables 2 and 3 outline the two methods described above for forecasting (estimating) demand when the number of subject facilities is known and when it is not.

Table 2: Demand forecasting method (when the number of subject facilities is known)

Subject facilities	PV electrification	On-grid electrification
Households	25W x number of households x 20%	107.0W×number of households×32%
Commercial facilities	50W x number of facilities x 30% (BCS 25%, SHS 5%)	195.7W×number of facilities×31%
Grain mills	Excluded	20,000W number of grain mills×27%
Junior secondary schools	250W x number of schools	110.5W×number of facilities
Clinics and health centers	400W x number of facilities	278.2W×number of facilities
CHIPS compounds	100W x number of compounds	139.1W×number of facilities
Offices	100W x number of offices	107.0W×number of facilities
Staff houses	100W x 3 systems x number of clinics and health centers + 100W x 1 system x number of CHIPS compounds + 100W x 3 systems x number of junior secondary schools + 100W x 1 system x number of other public facilities	Excluded

(Source) JICA Study Team

Table 3: Method of estimating number of subject facilities from population (when the number is not known)

Subject facilities	Method of estimating the number
Households	N_H= 0.09 P
Commercial facilities	N_B= 0.025 P
Grain mills	N_G= 0.0021 P
Junior secondary schools	One in communities (communities) with a population of 1,000 - 5,000, two in those with a population of over 5,000
Clinics and health centers	One in communities with a population of at least 1,000
CHIPS compounds	Excluded
Staff houses	One in communities with a population of over 5,000

(Note) P: Population; NH: number of households; NB: number of facilities; NG: number of grain mills

(Source) JICA Study Team

3.3.4 Off-grid and on-grid segmentation

The cost of on-grid electrification varies greatly with the location and demand of the subject community. For this reason, careful calculations must be made of these items on the basis of actual on-grid electrification plans. However, no such plans exist at present.

For the reason mentioned above, the Study Team set up three typical community models whose population sizes are small, medium and large, and estimated electrification costs for each community model based on the results of the power demand forecast (see Table 4).

Table 4: Outline of the standard community model

	Share of the total number of communities	Off-grid PV	On-grid
Demand model 1 (P = 500)	91.74% (communities with a population of less than 1,000)	● Households (BCS) ● Commercial facilities (BCS)	● Households ● Commercial facilities
Demand model 2 (P = 2,000)	7.55% (communities with a population of 1,000 - 4,999)	● Households (BCS) ● Commercial facilities (BCS, SHS) ● Public facilities	● Households (BCS) ● Commercial facilities (including grain mills) ● Public facilities
Demand model 3 (P = 5,000)	0.71% (communities with a population of 5,000 or more)	● Households (BCS) ● Commercial facilities (BCS, SHS) ● Public facilities	● Households (BCS) ● Commercial facilities (including grain mills) ● Public facilities

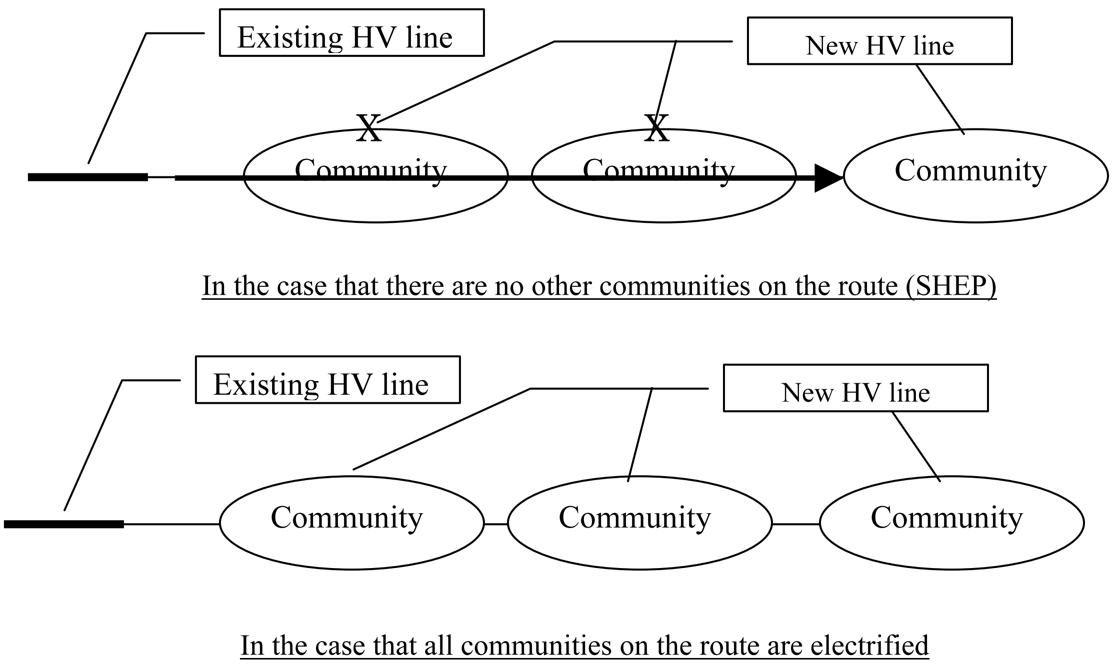
(Note) P: Number of population

(Source) JICA Study Team

3.3.4.1 Method of calculating on-grid electrification costs

Regarding on-grid electrification, the Study Team considered two model cases. One is to electrify only the target community like SHEP (i.e., other communities on the route will not be electrified); the other is to electrify all communities on the route (see Figure 8).

All communities on the route can share the costs of high-voltage (HV) distribution line equally for the latter case, while only the target community must pay all the electrification costs. Therefore it will be possible to reduce cost burden for "the case of electrifying all communities on the route" to increase beneficial lies compared to "the case of no other communities on the route".



(Source) JICA Study Team

Figure 8: On-grid electrification model

The Study Team estimated the annualized life-cycle cost by calculating the initial cost required for distribution line construction (the cost of items such as materials, transportation, and construction proper) and running cost (O&M plus transmission and distribution loss). Table 5 shows the calculation premises.

Table 5: Premises of the cost calculation (on-grid)

Service life	30 years
Maintenance cost	2% of the initial cost
Loss rate	12%
Interest rate	8%
Exchange rate	1 dollar = 9,000 cedi

(Source) JICA Study Team

3.3.4.2 Method of calculating off-grid PV electrification costs

Based on the demand model, the Study Team prepared system models on the assumption of the following subject facilities: stores, governmental offices, staff houses, clinics, junior secondary schools and households. Table 6 presents figures for the estimated electricity demand for each type of subject facility.

Table 6: Estimate of the power demand for each type of subject facility

Facility	Electrical products	Power consumption (Wh)
SHS1 (50W equivalent; commercial facilities)	Fluorescent lights (8W) x 2, B&W TV set (30W) x 1, Radio cassette player (15W) x 1	154
SHS2 (100W equivalent; staff houses)	Fluorescent lights (8W) x 5, B&W TV set (30W) x 1, Radio cassette player (15W) x 1, Small fan (55W) x 1	290
Governmental offices (100W equivalent)	Fluorescent lights (8W) x 3, B&W TV set (30W) x 1, Radio cassette player (15W) x 1, Small fan (55W) x 1	274
Clinics (400W equivalent)	Lights (8W) x 10, Vaccine refrigerator (54W) x 1, Radio communication (5.4W) x 1, Small fan (55W) x 1	1,044
Junior secondary school (250W equivalent)	Lights (faculty room 8W) x 4, Lights （class room 18W) x 6, B&W TV set (30W) x 1, , Radio cassette player (15W) x 1, Small fan (55W) x 1	760
BCS household (25W equivalent)	Fluorescent lights (8W) x 2, B&W TV set (30W) x 1	64
BCS store (50W equivalent)	Fluorescent lights (8W) x 2, B&W TV set (30W) x 1, Radio cassette player (15W) x 1	109

(Source) JICA Study Team

With a 1,000W system, BCS could charge four or five batteries per day for use in BCS stores (with a demand equivalent to 50W), and therefore meet the needs of from 20 to 25 stores. The Study Team calculated the cost of installation of the PV systems modeled under these premises[1].

3.3.4.3 Dividing line between on- and off-grid electrification

The point at which on-grid and off-grid electrification have about the same annualized cost forms the dividing line between them in the aspect of economic merit. The Study Team made assessments in terms of amount of energy (kWh) in consideration of the hours of electrical product use.

Cost comparison with on-grid electrification, however, requires an alignment of bases. The Study Team therefore considered the situation when the equipment cost is excluded for PV systems.

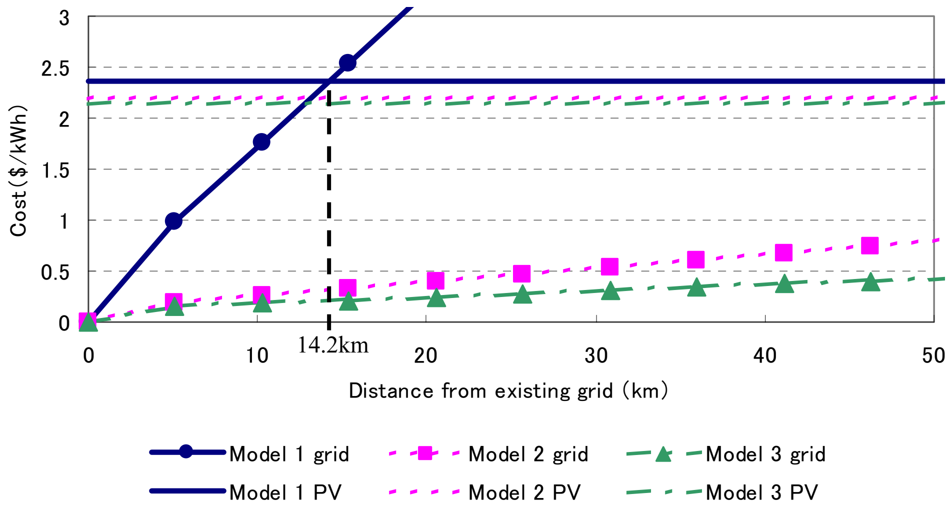
In the case that there are no other communities on the route (SHEP)

Figure 9 shows the point of division between the on- and off-grid systems for the community patterns posited here when there are no other communities on the route.

Under demand model 1, the most prevalent one in the northern regions, PV power generation would be more economical than extension of the grid as a means of electrifying communities that are more than about 14km away from the grid. Even in this case, however, the cost would exceed 2 dollars per

[1] For the installation cost per W of PV system output, the calculation yielded figures of about 12 dollars for the SHS1 50W system, 12 dollars for the SHS2 100W system, 20 dollars for the clinic system, 10 dollars for the school system, and 6 dollars for the BCS system.

kWh. On-grid electrification would be preferable for electrification of communities with demand model 2 or 3.

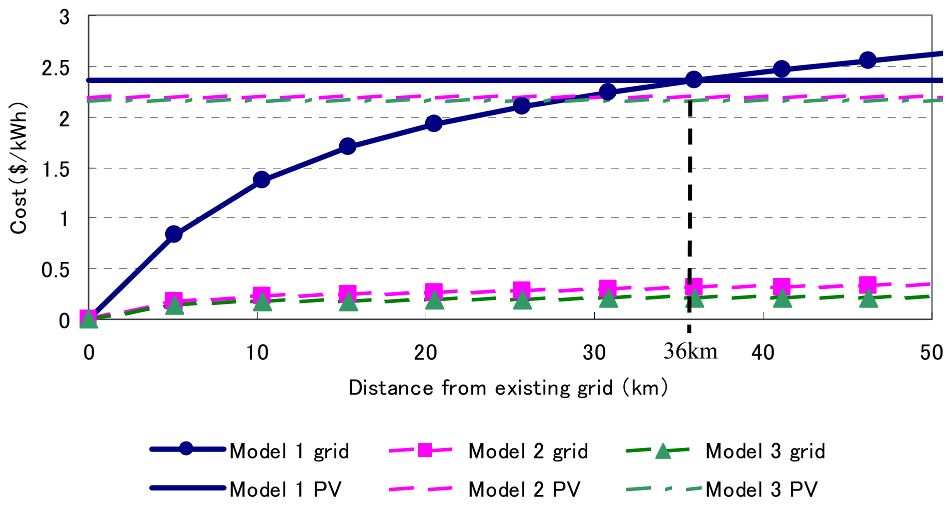


(Source) JICA Study Team

Figure 9: Cost of on- and off-grid electrification in the northern regions (In the case that there are no other communities on the route)

<u>In the case that all communities on the route are electrified</u>

Figure 10 shows the calculation results in the event of electrification of all communities on the route. It is clear that on-grid electrification is more economical for demand models 2 and 3 and would also be preferable for demand model 1 up to a distance of 36km, even if electrification cost is high.



(Source) JICA Study Team

Figure 10: Cost of on- and off-grid electrification in the northern regions (In the case that all communities on the route are electrified)

3.4 Perspectives on criteria for selection of areas for off-grid PV electrification

To establish criteria for selection of areas for off-grid PV electrification, it is first necessary to clearly distinguish them from the areas for on-grid electrification. The most important means of doing so is comparison of the costs of the two. Naturally, off-grid electrification ought to be selected for areas where it has a cost advantage relative to on-grid electrification. The continued promotion of on-grid electrification under the SHEP requires the sharing of information within the MOE and clear definition of the border between the two.

The next task is to establish an order of priority for the areas designated for electrification with PV systems in this way. Table 7 shows the items to be considered in this connection.

In ordering the areas to be electrified with PV systems in terms of priority, precedence must be accorded to the electrification of public facilities, which must be given greater weight. In the private sector, the criteria must focus on population as an indicator of the level of socioeconomic activity, and also attach commensurate weight to it.

For the purpose of illustration, Table 8 shows a sample distribution of points when a total number of 100 points is allotted for public facilities and population. In this sample, the public sector is weighted at 70%, and the private sector, at 30%.

Table 7: Items to be considered in criteria for area selection

	Items	Comments
Technical aspect	Areas that cannot be electrified by extension of the grid	・Outlying islands, etc.
	Policy/technical decisions	・Areas that cannot be reached by SHEP for at least 10 years
	Cost comparison with on-grid electrification	・Distance from distribution line
Socioeconomic aspect	Number of public facilities	・Medical facilities, educational facilities, etc. ・Weighting in correspondence with facility importance
	Population (number of households and commercial facilities)	・Population as an indicator of the level of economic activity

(Source) JICA Study Team

Table 8: Score sheet based on criteria for area selection (proposed)

Num. of Public Facilities (70)	* Health	Clinic	Health Centre	Chips Compound	
	30	30	30	15	
	Education	J.Secondary School	Primary School		
	30	30	-		
	Police Border Post	Police Border Post			
	10	10			
Num. of Population (Households) (30)	Population	Beyond 5000	2000～5000	1000～2000	～1000
	30	30	20	10	5
Total Score 100					

* Maximum 30 Points

(Source) JICA Study Team

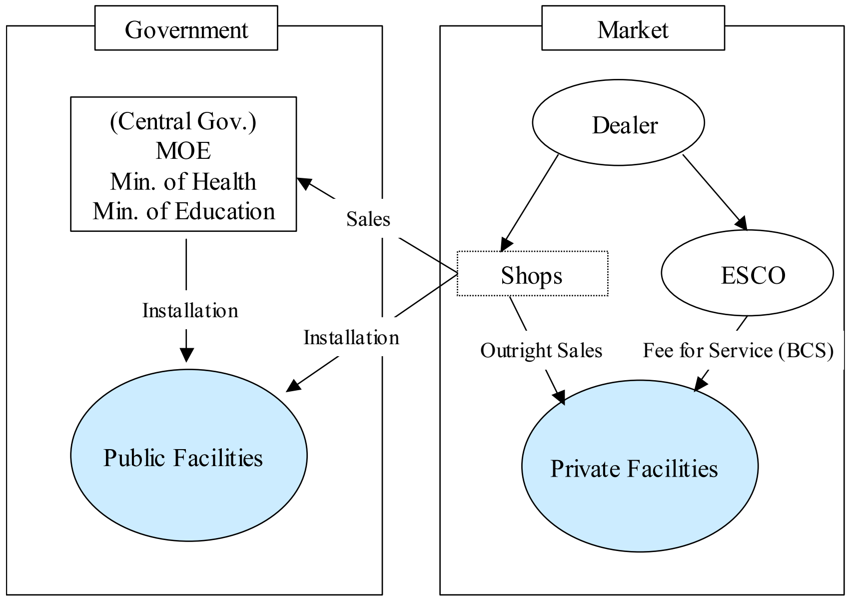
3.5 Perspectives on off-grid PV electrification

3.5.1 Sharp demarcation of electrification targets (clear separation of the public and private sectors)

To make effective use of the limited base capital in government, a clear separation must be made between the public and private sectors in the promotion of PV electrification programs. It would be advisable to promote electrification in the public sector on the responsibility of the government and to activate the market and utilize private energies in electrification of the private sector (through shops and energy service Companies (ESCO)).

At present, the government has an extremely limited capacity for assumption of financial burden, and must aspire to the most effective input of its finite resources. For this reason, the PV projects to be implemented by the government must be limited to public facilities. Similarly, expenditures for electrification of public facilities could be justified on the grounds that these facilities are part of the basic social infrastructure. Furthermore, if the agency that owns the facility can accept responsibility for payment of maintenance costs for the PV system on its own budget, performance of O&M, at least, for the PV system on a continuous basis could also be assured.

In the private sector (households and commercial facilities), on the other hand, it is doubtful that the government could aggressively promote the installation of PV systems with the currently low tax revenues. Seeing that it does not have enough financing sources to assume the cost, it has to apply the principle of imposing the cost burden on the beneficiaries. Given the deficient state of public finances, any government funding should be directed solely to the public sector for the time being.



(Source) JICA Study Team

Figure 11: Separation between the public and private sectors as electrification targets

3.5.2 Business model for PV electrification

Recovery of the cost of projects (investment and O&M costs) is a precondition for their stable continuation. As has been reiterated above several times, the RESPRO experience shows that PV electrification based on the fee-for-service model would be extremely difficult to operate because it is hard to recover funds. Under this model, it would be impossible to operate unless: 1) systems were maintained with funding from the revenue of power utilities on the grounds that PV systems are provisional measures until extension of the grid or 2) public funds are continuously furnished to the project principal.

For electrification in the private sector, it would consequently be a more realistic and sound approach for the government merely to support the activities of private enterprises and help to expand the PV market.

As compared to grid power, PV systems have a limited output, and their users would clearly be dissatisfied with them as being inferior to the former when compared in simple terms. Although past PV electrification projects installed SHS on households with grant aid from donors, in some cases, customers felt that their share of the cost burden was too high for the degree of satisfaction with the systems and stopped paying for them. This made it impossible to retrieve costs, and systems that had broken down were left unrepaired.

It is vital for beneficiaries to decide on use of PV systems at their own expense, once their ownership is solidly assured and costs are perceived as commensurate with the benefit. To this end as well, the spread of SHS in the private sector should be left to the market.

Past experience indicates that, if PV systems are installed at governmental expense without preserving this sort of orderly relationship between buyers and sellers, the result is liable to be nonpayment by the beneficiaries and disuse of systems. Even if PV systems are installed in the private sector, unless the locus of their ownership is clearly defined, there are no prospects for their maintenance and spread without continued subsidization by the government on a permanent basis.

While the method of SHS sales is essentially a matter for dealers to decide, it should be noted that, in light of past project experience, installment payments or lending directly to individuals may make it difficult to retrieve costs. As is clear from the DANIDA project, for example, it would be fairly difficult to recover loans made to individuals. As such, outright sales should be the general rule.

Another issue is the fact that the number of beneficiaries able to purchase SHS on their own resources is still limited. The results of the village socioeconomic study and demand estimate indicate that the ceiling of cost which residents are able to afford is lower than the SHS price. In addition, many residents would use electricity chiefly for lighting and radios. Considering the low ceiling on the cost burden and limited scale of electricity demand, it would be more realistic to downsize the electrification means and promote the parallel installation of BCS instead of treating SHS installation as the sole means of off-grid electrification, as has been done so far.

Like expanded installation of SHS, the operation of BCS projects ought to be pursued under the initiative of private enterprises. In the northern regions, individual PV system installation and sales businesses under the umbrella of major system dealers have commenced operations, and some parties that were employed in past governmental PV projects are attempting to start their own businesses. It is critical to make effective use, and foster the growth, of these movements in the private sector. This trend would not necessarily be confined to PV-related enterprises; enterprises selling petroleum products in communities that want to build their business in energy sales could possible purchase SHS and use them to launch BCS business.

4. Recommendations

Promotion of off-grid electrification in the three northern regions requires the resolution of the various problems and issues outlined above. Insofar as it is practically impossible to promote off-grid PV electrification solely with governmental funding, the government must stimulate the PV electrification market and work with the private sector in tackling the job.

Based on this perspective, the following are the Study Team recommendations on the study theme.

4.1 Clear definition of public- and private-sector roles

The primary role of government lies in setting forth a definite policy on off-grid electrification and drafting an electrification program based on this study.

In the second place, the government should implement PV electrification projects for the public facilities covered by the program, and foster the development of private-sector PV system dealers and installers by providing them with opportunities through the related procurement and installation.

In the third place, the government must carry out the institutional conditioning needed to nurture the growth of the PV system industry. The specific requirements to this end include establishment of technical standards and a code of practice, instatement of schemes for the training of technicians and assurance of quality, and build-up of facilities for testing equipment. It also must engage in informational activities to increase understanding and knowledge of PV systems.

The key role of the private sector, in contrast, is to expand the market for PV systems through activities coordinated with the governmental policy. Programs for PV system installation in public facilities promoted by the government continue to make up a big market. Private enterprises must take full advantage of the opportunities presented by procurement for these programs to establish a setup for local O&M services and use this network to further cultivate the private-sector market for PV systems.

As additional requirements, the private sector must cooperate with the institutional preparations by the government for advancement of the industry and collaborate with universities and polytechnic schools in the erection of frameworks for public-private collaboration on tasks such as construction of the quality assurance scheme, cultivation of technicians/engineers on the private-sector basis, and establishment of test centers.

The private enterprises are entering a phase in which they must come together as an industry to assure quality and pursue cooperation with the government.

4.2 Drafting of off-grid PV electrification program consistent with SHEP

As noted in the above remarks on the primary role of government, the MOE must draft a program for off-grid PV electrification in accordance with the criteria for area selection based on cost comparison with on-grid electrification. In the northern regions, thousands of communities are still unelectrified. To electrify all of them, the government must concentrate on inducing the maximum effect at the minimum cost.

As a major prerequisite to this end, the government must see that there is a consistency between the SHEP, which is at the core of RE, and the plan for off-grid PV electrification. The electrification unit at the MOE must manage both the yearly SHEP plans and off-grid PV electrification plans in a coherent manner. The government must also consider the prospect of revising the program for on-grid electrification itself with a view to optimizing the RE cost and alleviating the accompanying burden on electrification enterprises, even if only a little.

4.3 Rebuilding of the RESPRO

As described above, there is no cause for optimism about the future of RESPRO projects applying the fee-for-service model. The situation requires a comprehensive review of the RESPRO operations and rebuilding of the business to open up future prospects. From now on, it is advisable for the RESPRO to abandon continued application of the fee-for-service model and downsize the business.

More specifically, the RESPRO should transfer the assets (SHS) it currently owns to a third party to contract its balance sheet, and concentrate its resources in fields where it is competitive through specialization in installation and O&M on a contract basis.

The conclusion of the fee-for-service business would demand disposal of the SHS assets installed with GEF funding and provisions for the existing customers. Naturally, the party to take over these assets from the RESPRO would be responsible for dealing with the users and operating the assets. For this reason, the transferee would have to possess the financial base and organizational setup sufficient for operation of the approximately 2,000 SHS at the very least.

The potential candidates that immediately come to mind are the community assemblies and the NED (as a power distribution company).

The assemblies would appear to be the better candidates in the aspect of local operation of the facilities, but would face many problems in constructing organizational setups and raising the funds to cover the requisite O&M costs. As was learned from the DANIDA project, even if transferred to assemblies with a low organizational capability, assets are liable to be left unmaintained.

As a power distributor, the NED has a strong capability for organization including technicians and also has regional locations. There are several other benefits in transfer of the existing SHS to the NED, as follows.

First, although SHS are positioned as a supplement to grid electrification, the SHEP program to this end is saddled with problems in respect of continuity, and the disruption from them is impairing the execution of projects for SHS electrification. If the NED takes over ownership of the existing SHS from the RESPRO, it could promote PV electrification by relocating SHS facilities that were installed for the interim until grid connection to the next unelectrified communities as grid electrification progresses.

Of the approximately 2,000 SHS already installed by the RESPRO, about half will have to be moved due to the arrival of distribution lines. In addressing this task as well, the NED could make rational decisions in selecting communities for facility relocation as the SHEP program proceeds.

In the second place, if the NED becomes the SHS owner, the application of lifeline tariffs to SHS, the biggest issue in the fee-for-service model, would have proper grounds. If SHS utilization could be positioned as a provisional measure until connection to the grid as a service in power supply to customers by the NED, it would be possible to apply the same tariff scheme as for the supply by distribution lines. Although this would entail a sort of cross-subsidization within the NED tariff scheme, the issue would be the setting of the lifeline tariff itself, and ought to be resolved in the context of the overall tariff scheme.

In the third place, extension of distribution lines through the SHEP imposes a big financial burden on the NED, and is the cause of its mounting deficit. The addition of PV off-grid electrification as one of the electrification options would allow the NED to postpone plans for unreasonable extension of distribution lines, reduce its investment on RE, and put its finances on sounder footing.

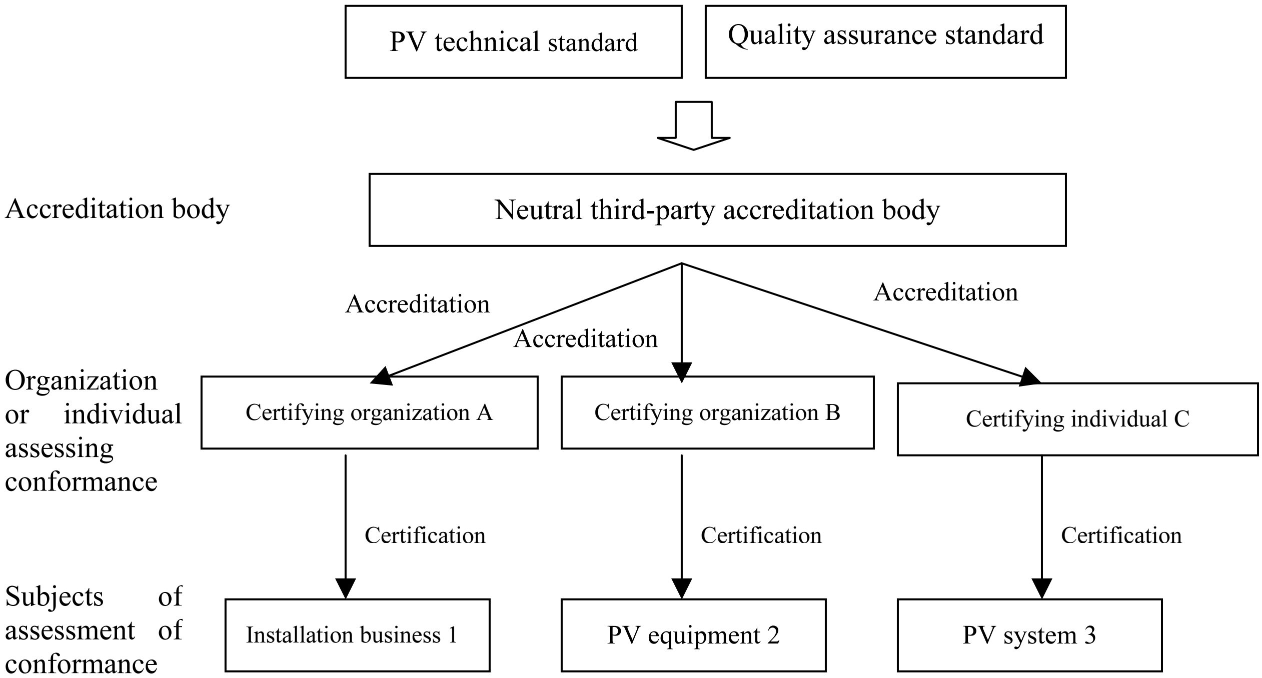
Considering the costs entailed by O&M over the coming years, there would be no incentive for the party to take over the assets unless the transfer price was extremely low. The existing RESPRO facilities were installed with GEF funding, and there consequently would be no actual debt left for the RESPRO. The transfer price would probably have to be minimal (e.g., 1 cedi) in order to offset the future O&M cost.

4.4 Cultivation of the PV industry and establishment of a scheme for quality assurance

The PV industry in Ghana is still in its infancy, and efforts must be made to build the market. Under these circumstances, the circulation of low-quality PV equipment that would destroy the confidence of consumers must be avoided on all accounts. This is also important for protecting the interest of consumers.

Perspectives on quality assurance are encompassed in standardization. Quality control and assurance ought to be implemented in accordance with the codes and standards of the country in question. In line with the concept of standardization, PV standards must be established not by the government but by an impartial third-party organization. Although it goes without saying that the membership of this third-party organization would include representatives of the competent government agencies, it would also have the participation of representatives of universities and other academic entities, private-sector firms, and consumers.

The entity accrediting organizations or individual parties that are to certify quality assurance under the scheme also must be a third party as opposed to the government. Figure 12 shows the general organization of the quality assurance scheme.



(Source) JICA Study Team

Figure 12: System of the quality assurance scheme

In Ghana, standardization is under the jurisdiction of the National Standards Board. In coordination with the Board, the MOE and the Energy Commission (EC) should set PV technical standards together with representatives of other concerned parties such as PV industries and universities or other academic institutions, and build a quality assurance scheme as soon as possible.

The institutions (organizations) or individuals issuing certificates of quality assurance would be allowed to engage in certification upon being accredited by the accrediting institution. These certifying organizations may be established by private parties; universities and other research institutions may also become involved. In addition, they could also be founded jointly by private firms and universities.

4.5 Advisable type of official regulations

The EC has already instated a provisional license scheme for the PV industry, and a number of large PV dealers have applied for licenses. The scheme was instated by the EC precisely to avoid the loss of consumer confidence in PV systems by assuring the quality of those in the market, as mentioned at the outset of this chapter.

At the same time, overly harsh regulations are liable to stunt the growth of the market. For parties that intend to launch small PV businesses on a local level, acquisition of a license is by no means an easy proposition, for reasons of expense and other factors. Among the concerned parties, there are apprehensions about excessive regulation by the government.

Viewed in a different light, the instatement of a license scheme is merely a means of regulation. In discussion of the propriety of a licensing scheme, the important question is instead how to assure the quality of firms and technicians involved in the PV industry. The answer is instatement of the quality assurance scheme in accordance with the flow of standardization, as described above. Any framework which the government superimposes on the PV industry for regulation in some form must incorporate such a scheme. Needless to say, the firms and individuals that are certified for quality assurance would be equipped with the qualifications for licensing or registration.

The worth of the scheme of PV dealer registration lies in the fact that only firms with an assured quality of work may participate in tenders for the implementation of PV projects promoted by the government. It should be noted, however, that the examination standards must be in conformance with those of the quality assurance scheme.

As one of the most fundamental requirements, responses must also be made to doubts about the propriety of supervising businesses engaged in PV system installation and O&M by means of the licensing scheme. Unlike electric utilities, PV dealers do not have exclusive authority in the market and do not apply a tariff scheme in sales of PV systems. Prices are determined solely through the mechanism of competition in the market. In this respect, PV dealers do not differ at all in character from dealers of electrical appliances or automobiles.

These observations point to a need for reconsideration of the relative merits of and features of the scheme for licensing by the government.

4.6 Development of markets through governmental projects

In Ghana, governmental funding has not been clearly set aside for PV projects, which have been implemented separately on the basis of funding from donor institutions. In addition, activities have been very limited, on the level of pilot projects. The major reason for this is the lack of a clearly defined governmental policy in favor of electrification by means of PV systems.

Financial sources for investment in PV electrification are obviously going to be limited in the future as well. Under these circumstances, the government must target public facilities as the sole subjects of PV projects undertaken with public funding. It also must adopt a definite stance of assisting the rise of the PV electrification market through procurement for these governmental PV projects.

The MOE must prepare a long-term program for PV electrification resting on this strategy. Only firms that have been certified under the quality assurance scheme should be allowed to participate in tenders for the PV projects carried out under this program. This will make it possible to give them the market for equipment procurement, installation, and O&M.

Even in public projects, arrangements must be made for post-installation O&M. In the electrification of governmental facilities by the MOE, electrification funding should be provided only for the initial cost, and the PV facilities should be transferred to the competent ministry/agency upon installation. In past pilot projects, ambiguity about the ownership after delivery (installation) led to a lack of proper O&M and neglect of unused systems.

The MOE therefore must confirm the presence of the following arrangements for O&M in the ministry/agency owning the public facility in question as a precondition for project execution.

- Assurance of O&M budget
- Conclusion of an O&M contract with installers or other certified businesses
- Appointment of a party responsible for O&M in the facility (graduate of a user training program)
- Construction of a scheme for liaison with regional institutions and the national government

4.7 Mobilization of funds

The mobilization of funds to promote PV electrification is a major task for the government. It cannot expect the electrification program to be sustainable if it relies on donor institutions for almost all of the funding, as it has done so far.

The MOE has a serious shortage of its own funding for electrification. The tax revenue collected by the Rural Electrification Fund (1.7 cedi per kWh) and the Energy Fund (5 cedi per liter of petroleum product) are not enough. The amounts to be collected were fixed about ten years ago, and the value has dropped to about 5% of its original level due to galloping inflation and the cedi's depreciation. At present, the two funds each collect 3 - 5 billion cedi per year, or only about 600,000 - 1 million dollars combined.

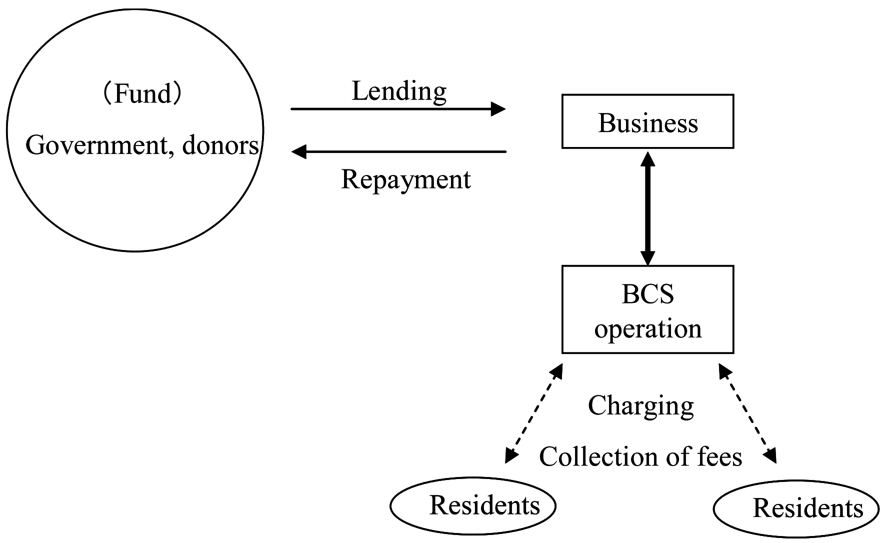
According to the MOE, the PV electrification cost for major public facilities such as schools, medical facilities, and police stations comes to about 20 million dollars. The initial cost alone for unelectrified facilities of these types in the three northern regions is estimated at about 5 million dollars.

One conceivable means of assuring these electrification funds would be to raise the amounts collected for the RE Fund and Energy Fund. These amounts have not been changed at all in spite of the ten-fold increase in power tariffs and oil prices since 1998. If they had been increased proportionately with the increase in power tariffs etc., the fund revenue would also have undergone a ten-fold increase, which would translate into income of 6 - 10 million dollars per year. Because these funds were also established for other purposes, not all of this revenue could be used for PV electrification. However, they could become key sources of funding for the PV electrification program into the long term.

It is also important to take indirect measures for funding of PV electrification in the private sector. Even so, the instatement of subsidies and provision of loans in the nature of micro credit for housing, stores, and other such private-sector facilities would not be a realistic option, in light of factors including the shortage of funding sources and the past occurrence of trouble due to the lack of a sense of ownership among customers that were "given" systems in this way.

In contrast, the option of providing financing in small amounts and at low interest rates to dealers, Non Governmental Organizations (NGOs), and other such parties deserves consideration, partly because such parties presumably have a higher creditworthiness than individuals. One available option, for example, is establishment of a revolving fund to make low-interest loans of operating funds to businesses installing BCS in rural communities, pay the money recovered over the next few years back into the fund, and use it for loans to additional businesses. In this case, loans for a single 500W system would be in range of 3,000 - 4,000 dollars.

To encourage observance of the contract terms, the government will probably also have to consider the instatement of provisions for compulsory repayment of loans in the form of the system, which would be confiscated, in the event of failure to repay loans.



(Source) JICA Study Team

Figure 13: Revolving fund concept for PV electrification

4.8 Coordination with social advancement projects to improve public services

Off-grid PV electrification is not a final end in itself; it is a means of providing basic elements of the social infrastructure, such as improved education and medical services, and safer supply of water.

In the case of medical facilities, for example, electrification is incorporated into programs along with a fuller assortment of medical equipment and the digging of wells. These programs are executed on budgets that are funded not only by the MOE but also by the MOH (with its own funds) and contributions from donors.

It is additionally possible that PV systems could be introduced in fields such as mini-irrigation. As such, the MOE (as the ministry in charge of promoting RE) must provide information on its own RE programs (both SHEP- and PV-based) at regular intervals, and ascertain the status of RE programs in other sectors for more efficient formulation of RE plans.

4.9 Preparation of a setup for information dissemination

Relative to on-grid electrification, there is a serious lack of knowledge about the objectives of PV-based electrification in rural communities. In addition, residents targeted for PV-based electrification often feel as if they have been abandoned as far as on-grid service is concerned. It is therefore necessary to actively inform them about the objectives of PV-based electrification (i.e., that it is an effective means of electrification in districts that cannot be reached by extension of the grid for at least a few years) and its benefits (i.e., that a supply of power sufficient for lighting will help to raise the level of education and medical services).

The measures that could be taken by the MOE itself on this front include the staging of demonstrations in communities that combine PV systems with TV sets, radios, and refrigerators; and promotion of educational campaigns through spots on TV and radio. Nevertheless, these would not be sufficient in themselves for widespread diffusion of information in remote communities in the north. Penetration of knowledge and information on the resident level requires community-based activities, and interaction with other principals in the social development sector would be effective to this end.

For example, correct knowledge about PV systems could be provided by having schools and medical facilities stage meetings for presentation to residents/students and displaying posters showing the benefits of PV-based electrification.

4.10 Market conditioning to be done by the private sector

In Ghana, several PV system dealers and installers have already appeared, but the PV industry is still in the formative stage. Statements reflecting the interests of only certain firms sometimes emerge at stakeholder meetings, but the industry has not yet been organized to the point that it can present unified positions.

As a first step for organization, the concerned parties should promptly establish an industrial window (association) for system-related rule-making, e.g., technical standards and a code of practice to assure system quality. Businesses are already marketing all sorts of system, and their certification as technology acknowledged by society as a whole would give them the status of de facto standards.

It should be added that the establishment of such an association is indispensable for actual operation of the arrangements for certification based on the quality assurance scheme, meaning the issuance of certificates related to design, installation, and O&M, or for equipment.

The industrial association would also have a vital role to play in the educational campaigns promoted by the government as noted above. In its publicity through mass media and posters, the government could display contact numbers for the association, so that customers could turn to it in addition to the MOE. (In Malawi, the industry instituted such an association, i.e., the Renewable Energy Industry Association in Malawi. REIAMA is partially subsidized by the government, and engages in educational activities while also participating in stakeholder meetings.)

From the standpoint of assuring PV system quality as well, it would be advisable to limit the circle of association members to those businesses that have been certified (or intend to obtain certification).

4.11 Conditioning of local markets

As is clear from the findings of the village socioeconomic study, commercial facilities and households in communities in the northern regions are physically dispersed and do not have enough money for purchase of costly PV systems (e.g., SHS) in large numbers. Furthermore, PV systems themselves have a limited output and cannot effect a dramatic improvement in the economic situation of these communities.

To induce the spread of PV systems among stores and households under these constraints, firms must curtail the costs of tariff collection and O&M to the very minimum; otherwise, the business cannot subsist.

To lower the costs of collection, for example, firms could consign the operation of BCS and SHS fee collection to local businesses such as filling stations. (For a 500W BCS installed in Pusiga, in the Upper West Region, RESPRO consigns the operation to a private business and receives a fixed monthly amount from it. The BCS is operating smoothly.) Even the largest BCS installed in remote communities would probably be fairly small (with a capacity of a few hundreds of W), and could be sited on filling station lots.

Even if a RESPRO-type fee-for-service model is applied, the business could have users bring fee payments to the filling station, from which it would later retrieve them. It would directly deal with the customer only for certain work, such as special maintenance or confiscation of systems from non-paying users. This arrangement would curtail operating costs.

Another option would be to have the community perform fee collection, but this cannot be strongly recommended, partly because ties of kinship make it difficult to collect fees from relatives in rural communities.

4.12 MOE scheme for implementation

As described in connection with the first and second recommendations, the MOE must prepare a program for PV electrification that is in conformance with the on-grid plans. It also must cooperate with the EC and private enterprises in establishing technical standards.

At present, however, the organizational setup of the MOE must be termed too weak for effective promotion of PV electrification. The Director of Renewable Energy, who has been in general charge of the RESPRO so far, is in a key position for promotion of PV electrification, but does not have any direct subordinates in the MOE head office because RESPRO personnel are all in Tamale. In addition, the Renewable Energy Unit within the MOE is under the jurisdiction of the Director of Power. The MOE therefore could be said to have two different organizations related to PV electrification. Furthermore, with a staff of only two, the Renewable Energy Unit is clearly understaffed as compared to units for on-grid electrification.

In drafting the program for future off-grid PV electrification, the MOE must pursue studies integrated with the SHEP. It also must consolidate and build up the internal organization for off-grid PV electrification.