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Japan International Cooperation Agency (JICA)
Ministry of Women, Family and Children (MOWFC)
Agency for Peace, Reconciliation and Development (APRD)
The Republic of Senegal

The Study on the Capacity Development for Disaster Risk Management in the Republic of Senegal

Main Report

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March 2007

KRC International Corp.
The Institute of Energy Economics, JAPAN

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Japan International Cooperation Agency (JICA)
Ministry of Mines, Energy and Hydraulics (MMEH)
Agency of Senegalese Rural Electrification (ASER)
The Republic of Senegal

The Study on Photovoltaic Rural Electrification Plan in the Republic of Senegal

Main Report

March 2002

KRI International Corp.
The Institute of Energy Economics, JAPAN

Currency Exchange Rate

(February 2002)

US$=¥ 133.74

US$=7.54 FF

Euro=US$ 0.87

(Euro=6.56 FF)

FF=100 CFA (FF: French francs)

CFA=¥ 0.177

PREFACE

In response to the request from the Government of the Republic of Senegal, the Government of Japan decided to conduct the Study on Photovoltaic Rural Electrification Plan in the Republic of Senegal, and the study was implemented by the Japan International Cooperation Agency (JICA).

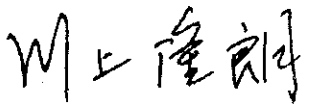
JICA sent a study team, headed by Mr. Shinichi Isoda of the KRI International Corp., to the Republic of Senegal eight (8) times from December 1999 to February 2002.

The team held discussions with the officials concerned of the Government of the Republic of Senegal, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this Report.

I hope that this Report will contrubute to promotion of rural electrification and to the enhancement of friendly relations between two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Senegal for their close cooperation throughout the study.

March 2002



Takao Kawakami
President
Japan International Cooperation Agency

Mars 2002

Monsieur Takao Kawakami
Président
Agence Japonaise de Coopératon Internationale

Lettre de Transmission

Nous sommes heureux de soumettre à vous le Rapport sur "l'Etude sur le Plan Rural Photovoltaïque d'Electrification dans la République du Sénégal". Dans le cadre du contrat avec votre organization, l'Etude a été effectuée pendant 27 mois de période à partir de décembre 1999.

En entreprenant l'Etude, l'equipe d'etude a preparé l'électrification rurale de PV en conformité avec les politiques rurales d'électrification de gouvernement et a transféré la technolotie sur la méthode de mise en place d'électrification rurale PV sous l'initiative public-privée en tenant compte de l'état actuel de demande/ approvisionnement de l'électricité, l'électrification rurale et l'économie sociale.

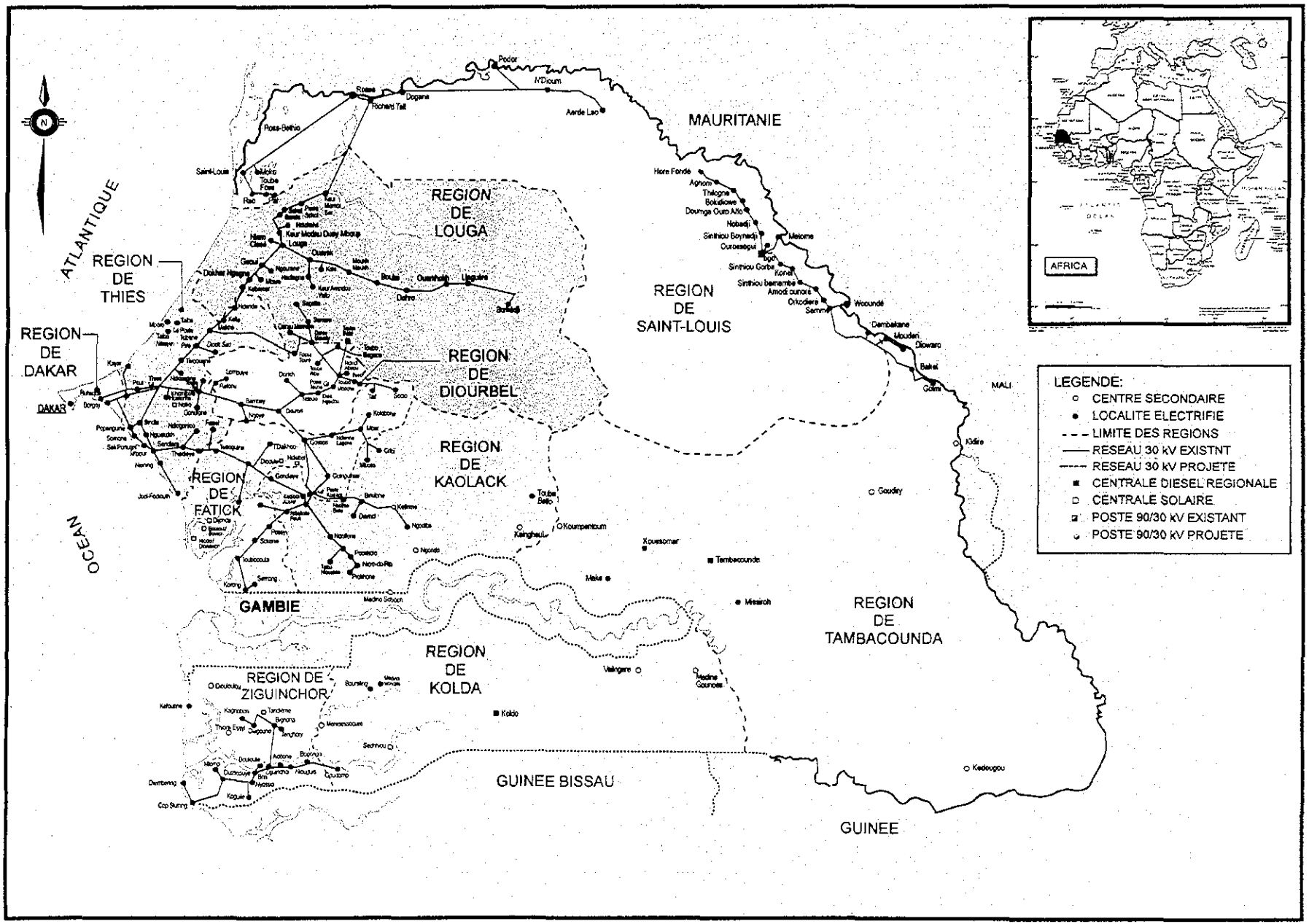
Ce Rapport s'agit du plan rural de mise en place d'électrification de PV dans la République du Sénégal. Les commentaries des fonctionnaires concernés et experts dans le demaine d'électrification sont aussi reflectés dans ce Rapport, en référant aux résultats de discussions dans le Comité de Gestion du Projet Pilote (PPMC), ateliers (workshops) et conférences tenus au Sénégal de temps en temps au cours de la période d'étude.

Nous souhaitons saisir l'occasion d'exprimer notre gratitude sincère aux fonctionnaires concernés de JICA, au Ministère d'Affaires Etrangères et au Ministère de l'Economie, Commerce et Industrie. Nous shouhaitons également exprimer notre gratitude plus profonde au Directeur de l'Energie, Ministère des Mines, Energie et Hydraulique et le Directeur Général d'ASER, l'Ambassade du Japan au Sénegal et le Bureau de JICA au Sénégal pour la collaboration étroite et l'aide étendue à nous pendant la période d'étude.

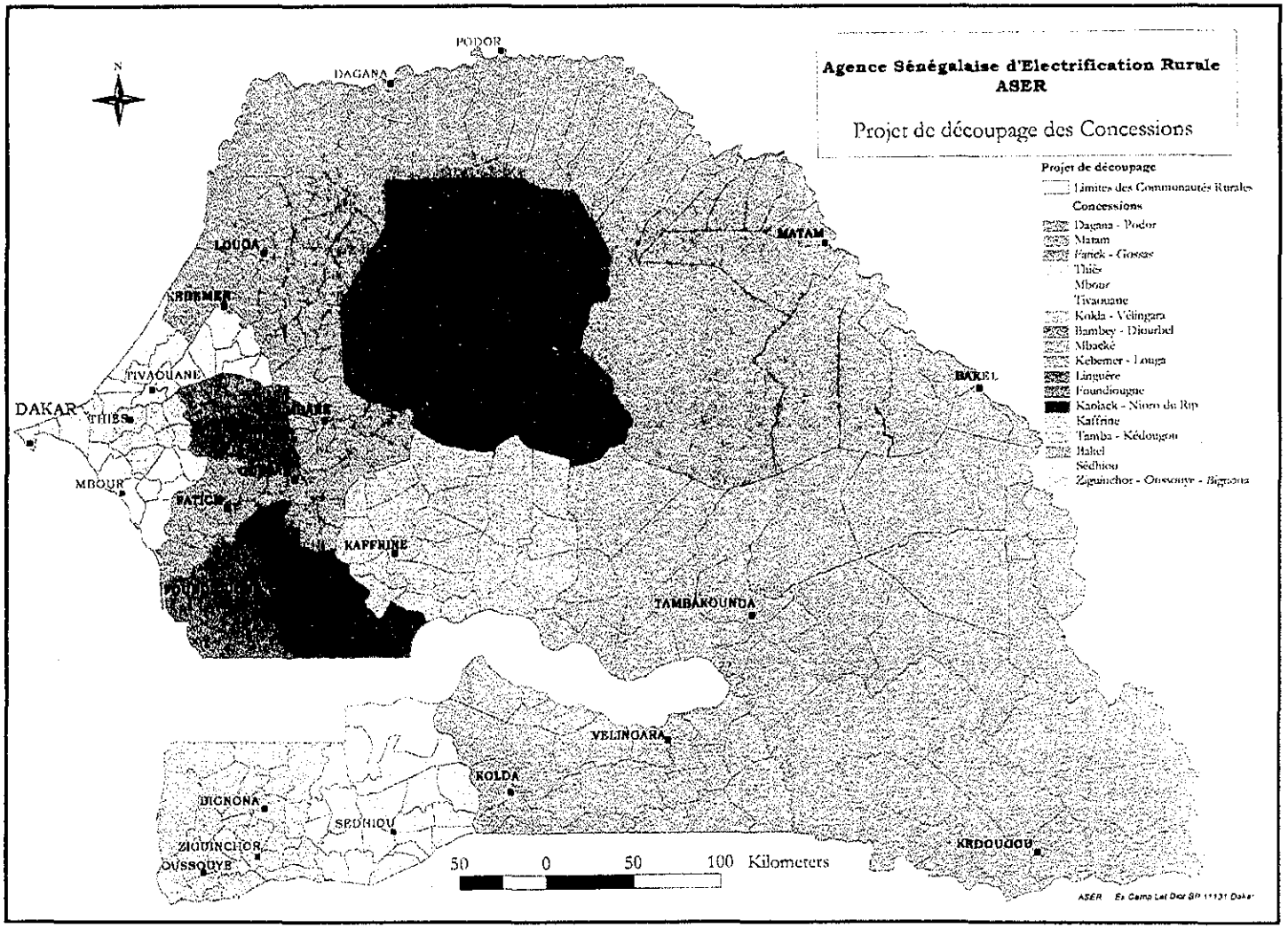
Nous vous prions d'agréer l'expression de nos salutations distinguées.

磯田真一

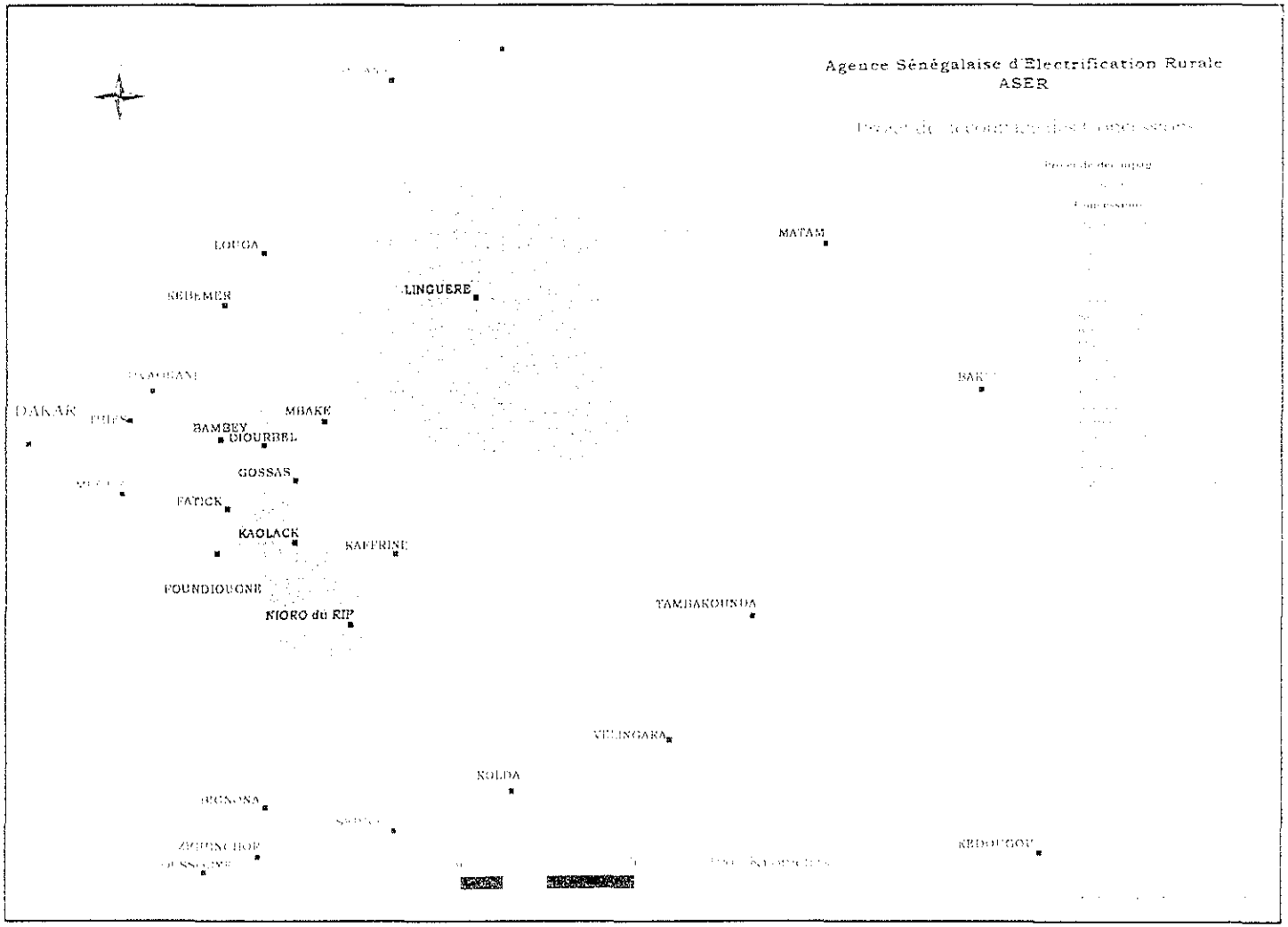
Shinichi Isoda
Chef de la Mission
L'Etude du Plan d'Electrification Rurale par Voie Photovoltaïque
en République du Sénégal



LOCATION MAP



Location of Concession



Location of Concession

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Abbreviation

AC	:	Alternative Current
ADER	:	Association Senegalaise pour le Development de l'Electrification Rurale
ASER	:	Agence Senegalaise d'Electrification Rurale
BCEAO	:	Banque Centrale des Etats de l'Afrique de l'Ouest
CERER	:	Centre d'Etudes et Recherches sur les Energies Renouvelables
		Center of Study and Research on Renewable Energy
CFL	:	Compact Fluorescent Light
CMS	:	Senegalease Mutual Credit Fund
CNCAS	:	Caisse Nationale de Credit Agricole
CNES	:	Confederation Nationale des Employeurs du Senegal
CNQP	:	Centre National de Qualification Professionelle
CR	:	Communaute Rurale
CRSE	:	Commission de Regulation du Secteur de l'Electricite
DAST	:	Scientific and Technical Affairs Delegation
DC	:	Direct Current
DFI	:	Decentralized Financing Institutions
DFS	:	Decentralized Financing Systems
D/G	:	Diesel Generator
ERIL	:	Electrification Rurale d'Initiative Locale
ESCO	:	Energy Service Company
FAO	:	Food and Agriculture Organization
FEM	:	Fonds de l'Environnement Mondial
F/L	:	Fluorescent Light
FOPEN	:	Federation des Organisations pour la promotion des Energies Nouvelles
		Federation of Organization for Promotion of New Energy
GDP	:	Gross Domestic Product
GIS	:	Geographical Information System
GPS	:	Geographical Positioning System
GTZ	:	Deutsche Gesellschaft fur Technische Zusammenarbeit GmbH
HVD	:	High Voltage Disconnection
IDA	:	International Development Agency
IEA	:	International Energy Association
IPP	:	Independent Power Producer
ISN	:	Institute of Senegal National Standard

LV	:	Low Voltage
MMEH	:	Ministere des Mines, de l'Enegie et de l'Hydraulique
NGO	:	Non Governmental Organization
ODA	:	Official Development Assistance
OJT	:	On the Job Training
O&M	:	Operation & Maintenance
PASER	:	Plan d'Action Senegalais d'Electrification Rurale
PCM	:	Project Cycle Management
PDM	:	Project Design Matrix
PLE	:	Plan Locale d'Electrification (LEP)
PPER	:	Programme Prioritaire d'Electrification Rurale
PPMC	:	Pilot Project Management Committee
PTIP	:	Programme Triennal d'Investissements
PV	:	Photovoltaic
RESCO	:	Regional Energy Service Company
ROE	:	Return on Equity
SEMIS	:	Services de l'Energie en Milieu Sahelien
SFD	:	Systemes Financiers Decentralises
SHS	:	Solar Home System
SPF	:	System Photovoltaique familial
UCAD	:	University of Dakar
UNDP	:	United nations Development Program
VUA	:	Village Users Association
WB	:	World Bank
WHO	:	World Health Organization

Unit

mm	:	millimeter
m	:	meter
km	:	kilometer
El.m	:	Elevation in meter
l/s	:	liter per second
m/s	:	meter per second
m^3/s	:	cubic meter per second
mm^2	:	square millimeter

km^2	:	square kilometer
mg	:	milligram
ton, t	:	metric ton
V	:	Volt
W	:	Watt
kW	:	kilowatt
MW	:	Megawatt
Wp	:	Watt peak
kWp	:	kilowatt peak
GWh	:	Gigawatt hour
kWh	:	Kilowatt hour
MVA	:	Megavolt ampere
KVA	:	Kilovolt ampere
Ah	:	ampere hour
Hz	:	Hertz
RPM	:	Revolution (revs) per minute
%	:	Percentage

Currency Unit

CFA	:	Senegalese Currency
US$	:	US Dollar
M.US$	:	Million US Dollar
Euro	:	European Currency
Yen	:	Japanese Currency

CHAPTER 1 INTRODUCTION

1.1 Necessity of the Study

Senegal currently has the available thermal capacities of about 300 MW, of which 271 MW is linked to the national grid generating about 1,000Gwh per year with an annual consumption of oil products of 300,000tons. SENELEC provides electricity with about 300,000 households in 260 villages. The national average electrification rate is around 25%, of which 50% of urban area is electrified while the electrification rate is just 5% in rural area. The demand grows while rural electrification by SENELEC is standstill mainly due to the aging of power facilities and high cost of transmission and distribution networks.

Under such circumstance, the government of Senegal decided to liberalize the electricity sector in 1995. The chances of entering into electricity business were given to private entrepreneurs including SENELEC. The national electric company (SENELEC) became a mere concession holder of bulk purchase, transmission and electricity sale. In accordance with the liberalization policy, the government regulations were removed so that SENELEC was allowed to purchase fuel directly from international markets.

In the background of such a trend of liberalization in the energy market, some progress has been made in encouraging private investment in the electricity industry since the beginning of the 1990s in the world. Even in the developing countries, facing the budget constraints, the power development initiated by the private sector has been made, aiming at the introduction of the fund of the private sector and the efficient corporate management. However, it is an unavoidable fact that private companies try to provide the power services with industrial area and urban area rather than to provide it with rural area, due to low risk, adequate profitability, etc.

This is also of the same with the sub-sector of rural electrification in Senegal. SENELEC continues to face such obstacles as high cost, spatially scattering situation of rural villages/consumers, and consumer demand characterized by weak electricity consumption.

Based on such fact and the process and lessons experienced in many other developing countries in the rural electrification sub-sector, the government of Senegal has formulated the rural electrification policy plan with an introduction of private

initiative-based rural electrification, which was financially supported by the World Bank. It is clearly addressed that the grid extension of the existing Senelec's distribution network will continue to play a major role while the independent diesel generator-oriented and renewable energy-oriented technologies, particularly photovoltaic technology, are also clearly addressed in the Plan.

In order to facilitate the global rural electrification, the government agency called "l'Agence Senegalaise d'Electrification Rurale"(ASER) was established in 1999. At the same time, "Commission de Regulation du Secteur de l'Electricite du Senegal"(CRSE) was also established to support the rural electrification from the institutional aspects under a strong intention that the power development under private-sector initiative is vital to the economic development in Senegal.

Nevertheless, high start-up cost is clearly the major defect that discourages private companies from providing electricity with rural areas. Moreover, there has been no comprehensive implementation plan of nationwide rural electrification using renewable energy, particularly photovoltaic technology, in Senegal. Under such circumstances, the government of Senegal requested the JICA to implement the Study on Photovoltaic Rural Electrification Plan (hereinafter, called the Study). In the Study, PV means the family photovoltaic system, otherwise called solar home system (SHS), exclusively for lighting use.

The issue of productive uses has not been addressed, but they are not being ignored in this study. We are of opinion that some local economic development will result from the initial electrification initiative. In addition, as people become more aware of the potential of the technology, we expect that there will be a demand for more systems to support local development. The organizational base for the collective action, which has been developed through the household lighting system, will make it possible to support the increased demand.

1.2 Objective of the Study

The government agency called "l'Agence Senegalaise d'Electrification Rurale"(ASER) responsible for development of the rural electrification sub-sector of Senegal, is currently involved in various preparatory works for the future rural electrification. The validation seminar was held on March 28 and 29, 2001, in which ASER formally announced its policy towards the execution of global rural electrification and addressed the ASER's objectives and approach. Participants in the Seminar came from government ministries and agencies concerned, financial institutions, energy-related suppliers, consultants, regional cooperatives, NGOs, specialists in the energy sector, etc.

Toward the execution of the rural electrification by two types of project implementation methods, as addressed in the ASER Procedure Manual, such as Program Prioritaire d'Electrification Rural:PPER and Electrification Rurale d'Initiative Local:ERIL, the PV Implementation Plan submitted in January of 2001 will be expected to be utilized at maximum with some modifications and additions.

Finally, the Study is additionally to produce a procedure guideline for the project implementation method to be used by private enterprise, rural community-based entrepreneur, etc. This procedure guideline by joint public-private initiative will be proposed, taking into account the performance of the pilot project in Mar Islands and in cope with the concept of the ASER's Procedure Manual,

1.3 Components of the Study

The Study consists broadly of the following components:

1) Implementation Plan on Photovoltaic (PV) Rural Electrification, and
2) PV System Operation Manuals

The PV Implementation Plan prepared in this Study can't be independent and separate from the global rural electrification plan, and should be a part of PASER. Principally, the selection of an appropriate method among such technologies as grid extention, diesel power generation, photovoltaic, wind power, etc. should be made by the potential operators such private enterprises, rural community, NGOs, etc., because this scheme is intended to be initiated by the private sector under the technical and financial assistance

of the government. Therefore, the approach is inevitably different from the conventional public sector-initiated rural electrification. The most significant is to construct the implementation organization responsive to the needs and demands of the market, so that the success of the project depends, to a large extent, on the capacity building of the rural community and awareness of the villagers towards the project participation.

However, the target rate for rural electrification by PV has been clearly mentioned in the above PASER, so that the active involvement by the government may be, in cases, required to meet such target. That means, the project is strongly requested to be promoted under the joint operation as one entity of public, private and rural community. In due consideration of the above-mentioned situation, the preparation of the procedure guideline for the project implementation method, in which the results of the pilot project are fully reflected, is to contribute to facilitate the rural electrification as well as to build the institutional capacity of ASER, which should be in cope with the concept of the Procedure Manuals and practical to the potential operators.

As shown in Figure 1.1, the Report mainly discusses (1) Identification of SHS Markets & PV ImplementationPlan, and (2) Business model, which will be integrated into "implementation Plan on PV Rural Electrification". In the Study, the Pilot Project is intended to provide valuable lessons and monitoring outputs with the main framework of the Study. The most important issue would be to produce the sustainable, technically and financially, mechanism of PV rural electrification, which is consolidated by the institutional and policy recommendations. The operation manual of the PV system manuals will be prepared, fully taking into account the results of the Pilot Project.

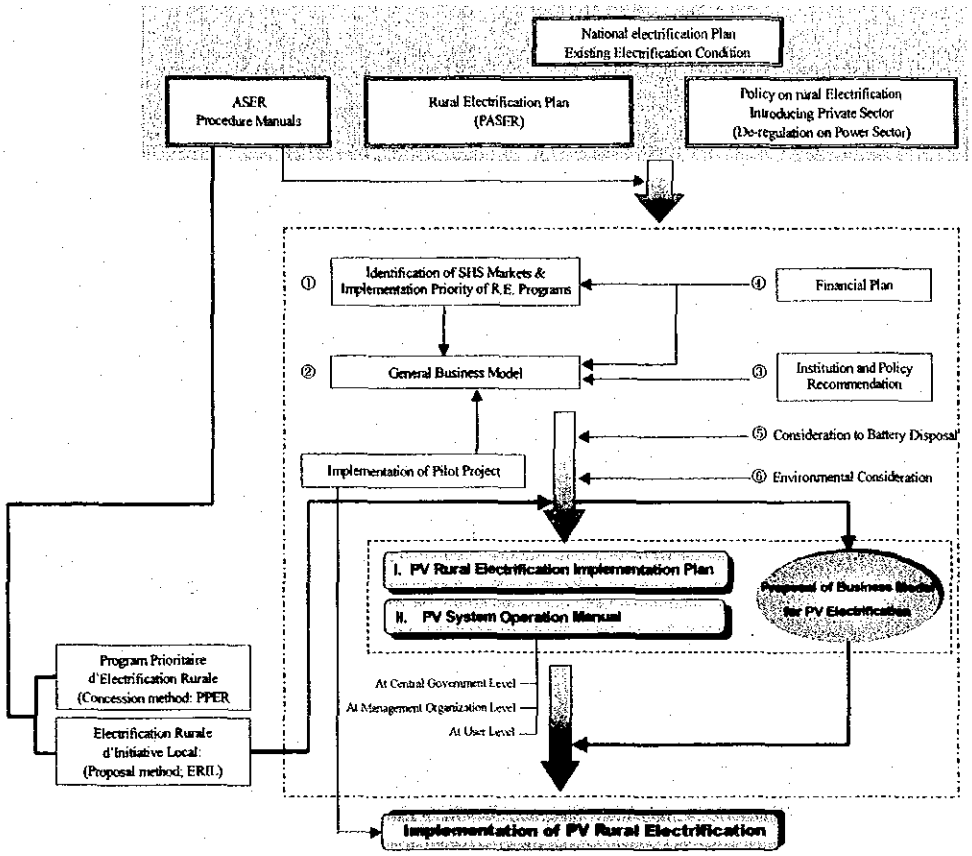

Figure 1.1 Study Flow

In addition, from the environmental aspects, the survey on disposal of used batteries generating from PV System will be executed, referring to the example of Japan in Figure 1.2. In general, the suppliers/makers need to take responsibility of the disposal of PV battery.

On the other hand, there are many cases, such as in Zimbabwe, that suppliers/makers collecting the wasted batteries and refining cadmium can not have any access to rural areas, so that large amount of used batteries are left alone. Referring to these examples as well, the most appropriate method for disposal of PV batteries in Senegal will be examined.

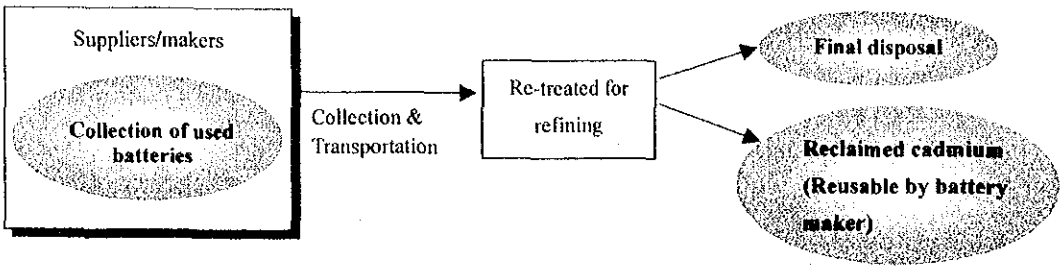

Figure 1.2 An Example of the Disposal of Used Battery in Japan

1.4 Performance of the Project

This Study commenced in December of 1999 and the field survey in Senegal was carried out six times before August of 2001. During this period, a pilot project was implemented and the PV system has been working well over a period of 12 months since the installation of 95 units being completed in December of 2000. Furthermore, fee collection has been made without significant troubles. The Study was terminated with 2nd Workshop held in Dakar in January of 2002, when the final report as listed below was submitted to MMEF/ASER and the ownership of PV equipment installed in the pilot project site was transferred to ASER. The past performance and work schedule is given in Table 1.1.

List of Reports

1. Main Report (this text)
2. Summary Report
3. PV Implementation Plan
4. PV System Manual
5. Pilot Project

Table 1.1 Summary of Past Progress of the Study

Fiscal Year	Work Stage	PV Implementation Plan	Pilot Project	Reporting
1999	Domestic Works (preparation) (Dec.22 to Jan.7)			Inception Report
	1st Field Survey (Jan.22 to Mar.21)	• Technical and economic survey on current rural electrification in Senegal • Preparation of the tender documents for the socio-economic survey and selection of the bidder	• Socio-economic survey for selection of the pilot project site • Socio-economic survey in the project site in Mar Islands • Technical survey on PV bidders and preparation of PV tender documents	Field Report
2000	2nd Field Survey (June.4 to July.23)	• Execution of the socio-economic survey (SEMIS) • Study on PV rural electrification	<u>Bidding for the PV procurement</u> • Pre-bid meeting 2000.6.30 • Closing of technical specifications (July 14) • Appraisal of TS (July 14-17) • 1st Financial bid (July 21) • 2nd Financial bid (Aug.4) • Supporting the bidding	
	1st Domestic Works (June.26 to Aug.4)	• Preparation of Progress Report	<u>Contracts of the PV procurement</u> • LOT 1 (MATFORCE) (Sep.8) • LOT 2 (AFRIWATT) (Sep.5)	Progress Report
	3rd Field Survey (Sep.24 to Oct.23)	• Study on PV implementation plan • Study on the results of the socio-economic survey • Preparation of PV implementation plan	<u>Procurement & Installation of PV</u> • Preparation of village association in Mar Islands • Selection of the pilot project operator	
	2nd Domestic Works (Oct.24 to Nov.23)	• Preparation of PV implementation plan (draft)	(JICA expert continues to stay in Senegal for installation works.)	PV Implementation Plan (draft)

Fiscal Year	Work Stage	PV Implementation Plan	Pilot Project	Reporting
	4th Field Survey (Nov.25 to Dec.24)	• Workshop at Dakar on PV implementation plan (December 12)	Completion of PV installation (December 10) Commissioning of PV system 1st Seminar (Dec.11 & 12)	
	3rd Domestic Works (Jan.5 to Jan.13) 4th Domestic Works (Mar.7 to Mr.9)	• Preparation of PV implementation plan	(PV system is in operation.)	PV Implementation Plan
	5th Field Survey (Mar.10 to Mar.19)		Monitoring of Pilot Project • Installation of data logger • 1st Maintenance of PV system	Field Report
2001	5th Domestic Works (May.25 to June.1)	• Preparation of the survey paper on potential operator		
	6th Field Survey (June.2 to July.12)	• Preparation of PV system manuals • Study on ASER Procedure Manuals • Survey on potential operators & PV Market	2nd Seminar (June.25 & 26)	
	6th Domestic Works	• Preparation of Interim Report		Interim Report
	7th Field Survey (Sep.29 to Nov.9)	• Presentation on Interim Report • Preparation of PV system manuals	3rd Seminar (October 14 & 15)	
	7th Domestic Works (July 1 to Aug.5)	• *Preparation of draft final report*		Draft Final Report
2002	8th Field Survey (Jan.19 to Feb.2)	• Presentation and discussion on draft final report	2 nd Workshop (January 29)	
	8th Domestic Works (Feb.4 to Feb.10)	• Finalization of final report		Final Report

Fiscal Year: April 1 to March 31 in Japan
Field Survey: Field Survey in Senegal
Domestic Works: Domestic Works in Japan
Technical Specifications: TS
LOT 1: Procurement and Installation of PV System
LOT 2: Procurement of Data Logger

CHAPTER 2 POWER SECTOR AND RURAL ELECTRIFICATION POLICY IN SENEGAL

2.1 Rural Electrification Sub-Sector in Transition Period

The initiation of power sector's transformation was perhaps in the mids of 1990s when the government of Senegal realized that dependence on the state-owned company (SENELEC) was no longer the appropriate policy for the farther development of power sector and rural electrification in particular. The major constraint has been the shortage of the government budget supporting expansion of electricity service provided by SENELEC. Despite of its constraint, the government financed the rural electrification (RE) sub-sector to connect 120 villages using National Energy Fund during 1994~1998.

Internal movement to liberalize power sector coincided with the global boom for privatization of infrastructure development primarily led by the World Bank. The basic strategy for the sectors transformation was traced back to "letter de politique de development de secteur de l'Energie 1996" (the energy sector policy document) in which the following three elements were clarified as the general government policy.

- disengagement of the state
- involvement of local communities
- enhancement of private initiative

The second policy followed the decentralization law (1996) addressing that local communities may award concession or leasing contract for public services to local private operators (article 317). As a part of rural infrastructure, RE facilities are possibly under the control of local communities provided that their management capacity is strengthened. The third policy does not refer to perfect privatization without the government support, but encourages private participation in operation and management of locally-based infrastructure. This primarily aims to mobilize private capital to facilitate rural infrastructural development.

In the year of 1998, the government publicized the "loi d'orientation no. 98-29" (the orientation law concerning electricity sector) where the basic structure for private-led electricity sector was legalized. The objective of the reform addressed in this law is to guarantee electricity supply at reasonable cost and to facilitate public access to

electricity service especially in rural area. The major articles addressed in this law include:

a) Operators wishing to sell electric power shall obtain a license from the Ministry of Energy. The license shall define the territory and, as the case may be, the term and obligations of public services to which the holder has agreed. (Articled 18)

b) SENELEC shall be qualified to engage in the business of bulk wholesale purchase, transmission, and the sale of electric power throughout the national territory, for a term which will be defined by a concession agreement to be signed by the Ministry of Energy. (Article 19).

c) The Ministry of Energy shall formulate and propose general policies and plans applicable to the electricity industry to the President of the Republic. The Ministry of Energy shall grant the license and concessions which shall be issued together with a license or concession agreement signed by the Minister of Energy and the holder of such license or concession. (Article 3)

d) The Regulatory Commission for the Electricity Industry shall be responsible for regulating all operations relating to generation, transmission and the sale of electricity, and pursue the objectives stated below: (Article 4)

- to ensure financial and economic viability of electric industry and maintenance necessary to sustain its viability,
- to protect interests of end-users with respect to pricing, supply and quality of electricity supply,
- to enhance competition and involvement of private sector with respect to generation, transmission, distribution and the sale of electricity supply.

e) In order to decide power rate on the initial conditions and terms, the Ministry of Energy and the Regulatory Commission shall authorize the level of revenue accrued to the concession holders in connection with normal level of profitability. Such a profitability is defined as the rate of return on capital, taking into consideration the risks to which investors are subject. Profitability shall be determined in real term, taking into account inflation index set forth applicable to the concession holder. Forecast of rate base shall be based on estimates of investment expenditures, sales of assets and agreed depreciation rates. (Article 28)

f) Agence Senegalaise d'Electrification Rurale called ASER (A Senegalese Rural Electrification Administration) is to be established and responsible for providing operators with the necessary technical and financial assistance and to organiza public tenders to grant a license or concession to bidders. (Article 30)

The so-called "fee-for-service" was implicitly embodied in the concept of the orientation law of 98-29 so that any private operators eligible for conditions and terms set forth in this law shall be allowed to undertake electricity business in the territory or concessions given by the authority. The role of the stakeholders was clarified in respect of the Ministry of Energy, the Regulatory Commission and ASER.

SENELEC was subsequently privatized and a private power company of the Canadian nationality participated in corporate management of SENELEC as one of share holders. But soon or later the Canadian capital decided to stop management of SENELEC primarily because the raise of power tariff proposed by them was not approved by the concerned authority. This would render a debatable issues to the subsequent concession-holders as to competitive market price of electricity (approximately measured by consumers' willingness to pay) versus the government-regulated price. The most serious constraint will be the lack of private actors (operators) and their fear that such a long service period as 15 to 20 years would not sustain a stable profitability as expected at the initial stage. This is directly linked to the subsidy rate the authority would guarantee. But such a debatable issue as subsidy rate has remained untouched.

In the year of 1999, the Ministry of Energy prepared the "Le secteur de l'energiè au Senegal" (the energy sector document) stating the current condition of RE, the role of stakeholders such as ASER and financial intermediaries. The first draft of "Le plan d'action Senegalais d'electrification rurale, PASER" (The Plan of Action for rural Electrification in Senegal) was presented in this document. The government goal of RE targets during three consecutive stages (Preparation 1999~2000, Lauching 2001~05, and Consolidation 2006~15) were firstly clarified by the draft plan. PV was proposed as one of electrification modes, 70,000 users as planned target up to the year of 2015. After appointment of the chairman of ASER, this agency actually commenced its operation in the mid of the year 2000 (about six months after commencement of the JICA Study). Experts of the different professional fields have been mobilized as staffs of ASER and simultaneously the chairman made a preparatory work for loan agreement with the

World Bank to finance the RE sub-sector. The most outstanding product prepared by ASER was "Procedure Manual" embodying various operation procedures for PPER and ERIL, financial mechanism. Eighteen (18) concession territories are provided throughout the national land. The business modes consist of priority Rural Electrification Plan (PPER) and Rural Electrification Project (ERIL). The former is a top-down approach to RE, giving concession to an eligible operator who manages electricity service in a given territory. The latter is called a bottom-up approach to RE, giving a project-based concession to eligible local operators or village organization.

Transitional process of RE sub-sector is illustrated in Figure 2.1

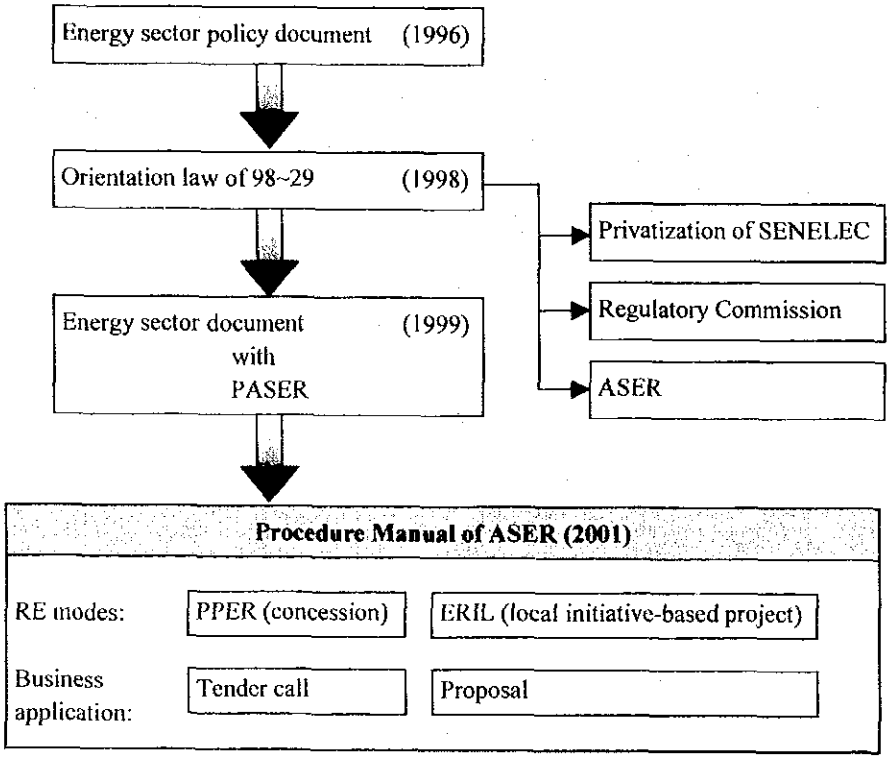

Figure 2.1 Transitional Process of RE Sub-Sector

The basic framework of operation procedures associated with two (2) RE modes was almost established thanks to the Procedure Manual. Nevertheless, there are still controversial or debatable issues which remain unsolved. The most important thing is how private entrepreneurs/investors would react to the new RE modes set forth by ASER. On March 2001, the workshop called "Validation Seminar" was held at ASER

where the concerned parties including many electrical work companies and commercial enterprises were called. The Seminar hold three (3) sessions consisting of technical, institutional and financial matters. Their reaction to the Seminar was subsequently surveyed by local consultants on behalf of KRI International Corp. The most noticeable reaction is that all participants generally acknowledge the necessity of organizations to be supported by decentralized rural operators under the responsibility of the concession-holder (PPER) or licensed operator (ERIL). Existence of rural (local) operators is also the key element for PV electrification. The other issues include interface between PPER and ERIL, subsidy rate, and intervention of SENELEC in concession area. These will be unavoidable issues to be faced by the future operators. PV electrification plan is to be carefully formulated taking into account the issues mentioned.

2.2 Likely Performance of SENELEC in RE

SENELEC that used to be the National Electricity Company but recently privatized, has been the major player of national electrification. The privatization rendered SENELEC to a profit-making organ as one of concession holders for electricity service. Under such circumstance it is unlikely that SENELEC will continue to be a driving force to facilitate rural electrification.

The current power supply of SENELEC to rural areas is marginal, heavily concentrating on urban users. As of December 1999, the number of low voltage users was reported to be 368,150 in total, of which about 12.5% or 46,000 users belong to rural area. Rural users of domestic usage (lighting, cooking, etc) turn out to be 27,961, comprising 10.8% of total domestic users (258,052) at low voltage. Electricity use of SENELEC consumers at low voltage is featured by high electricity consumption dominated by urban consumers.

Total consumption of domestic users at low voltage was 355 GWh in 1999 so that the average electricity consumption of a domestic consumer is calculated to be 1,375 kWh per year or 114 kWh per month. The number of SENELEC consumers and electricity consumption at each voltage level as of December 1999 is shown in Table 2.1

Table 2.1 SENELEC Consumers and Consumption by Voltage Level

	LV consumers			MV consumers	HV consumers	Total
	Domestic	Others	Sub-total			
Urban	230,091	92,152	322,243	870		323,117
Rural	27,961	17,946	45,907	85		45,992
Nation	258,052	110,098	368,150	955	2	369,109
Electricity Consumption	355 GWh	159.2 GWh	514.2 GWh	384.1 GWh	71.7 GWh	970.0 GWh

Source: SENELEC

High electricity consumption of a SENELEC consumer can be compared to the yearly consumption of a typical rural consumer of non-electrified village, using a Solar Home System (SHS) of 50 WP. The yearly consumption of a rural consumer is assumed to be 73 kWh (=50W × 4 hours/day × 365 days). This implies that the privatized SENELEC basically favors the area where users with high demand are collectively located, rather than the area where users with low demand are sparsely distributed.

SENELEC will be continuously constrained by generation capacity and its legal position of bulk purchaser, transmission and electricity sale. It is likely that the future electrification of SENELEC will mainly focus on improvement of service rates in the already electrified area. The conceptual flow to represent the indicative direction of the future SENELEC electrification is illustrated as follows: SENELEC would probably take interest in rural users with high electricity consumption, adjacent to existing grid in rural area.

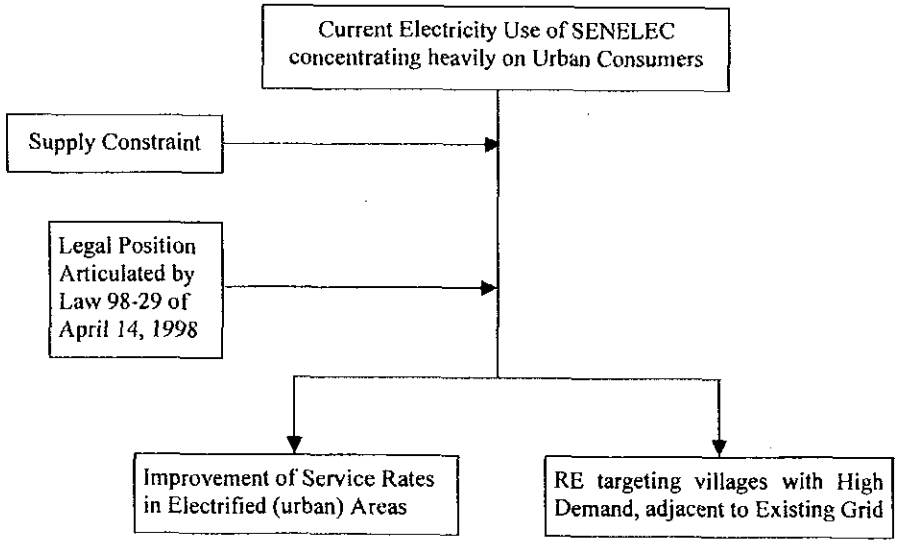

Figure 2.2 Indicative Direction of Future SENELEC Electrification

As of October 2000, the available capacity of power plants owned by SENELEC is reported to be about 300MW, consisting of diesel (102MW), steam turbine(84MW) and gas turbine(114MW). Most plants have been used for more than 20 years, and gas turbines are in particular obsolete, installed more than 30 years before. The periodical overhaul of old plants requires a careful plan of load dispatching to existing users against a growing power demand. Energy supply has been marginally sufficient to meet demand up to 1998. The following Table 2.2 shows historical records of energy supply and demand between 1991 and 2000.

Table 2.2 Historical Energy Supply and Demand

unit: Gwh

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Supply	915	1,000	988	1,020	1,080	1,154	1,241	1,300	1,322	1,044
Demand	737	809	794	865	884	922	1,006	1,074	1,369	1,063

Source: SENELEC

Senegal began to be in short of electricity in the year of 1999 onwards, as shown in Table 2.3

Table 2.3 Monthly Electricity Supply and Demand

Month	1999			2000		
	Production (MWh)	Demand (MWh)	Deficit (MWh)	Production (MWh)	Demand (MWh)	Deficit (MWh)
January	102,002	102,561	559	102,006	102,375	369
February	100,845	102,454	1,605	100,850	101,950	1,100
March	116,235	119,023	2,788	116,239	116,379	140
April	101,117	102,591	1,474	113,723	113,925	202
May	107,003	110,095	3,092	115,406	115,482	76
June	106,791	114,337	7,546	120,484	120,892	408
July	110,749	127,774	17,025	124,831	130,551	5,720
August	107,641	115,964	8,323	130,376	132,836	2,460
September	117,292	119,833	2,541	120,283	128,837	8,554
October	125,243	126,296	1,053			
November	114,814	115,981	1,167			
December	112,695	112,752	57			

Source: SENELEC

Demand surpasses supply in the year of 1999 onwards. The shortage of energy supply is adjusted by a careful plan of load shedding or supplied by an IPP doing the bulk sale of electricity to SENELEC. The shortage of power supply constrains the further development of national electrification.

The Article 19 of the Law 98-29 issued on April 1998 regulated the role of SENELEC as "exclusive bulk purchase, transmission and electricity sale". SENELEC was allowed to own generating facilities available on the effective date of this law. In other words, SENELEC will be no longer allowed to own new power plants. Energy supply to meet increasing demand will entirely depend on bulk sale of electricity from IPPs based on power purchase agreements.

The "less cost (transmission and distribution) and high return(electricity revenue)"will be undoubtedly the basic principle of future electrification. Improvement of electricity service rates in electrified areas definitely meets this principle. Perhaps rural electrification will be not prioritized in the business policy of SENELEC. Villages under the target of RE plan of SENELEC would be those with high demand, adjacent to existing grid.

2.3 Historical Performance of PV Projects

(1) Rural Electrification Plan

The PASER consists of three stages:

Preparation Stage (1999-2000)

ASER prepared for the guideline and procedures(Manual) for RE plan, institutional aspects and implementation framework of ASER-assisted rural electrification.

Launching Stage (2001-05)

The RE sub-sector will provide electricity service with 104,000 rural users consisting of new users(74,000) and existing ones(30,000).

Service Types	Existing	New	Total
Densification of electrified villages	27,000	31,000	58,000
LV distribution from generators	-	26,000	26,000
PV modules	**3,000**	**17,000**	**20,000**
Total	30,000	74,000	104,000
Rural population (2005)	5,916,000		
Rural households (2005)	696,000		
RE rate	**15%**		

The target rate of RE is expected to be nearly 15% in 2005. Out of new consumers (74,000) SENELEC's contribution will be about 42% indicating somewhat an ambitious plan of new subscribers. Those would cover 307 regional centers with the average service rates of 60%. LV distribution from generators will be implemented by private operators through tender calls, consisting of an extension of LV line from a secondary MV station (SENELEC) and autonomous generators. Both operators are regarded the distribution concession holders. Out of new PV consumers(17,000), ASER anticipates 5,000 users to be commercial customers (direct cash or credit purchase) and 12,000 users to be supplied from concession holders based on the fee-for-service or equivalent modes.

Consolidation Stage (2006-2015)

The RE sub-sector will provide electricity service with 270,000 rural consumers consisting of existing (104,000 as of 2005) and new (166,000).

Service Type	Existing	New	Total
Densification of electrified villages	58,000	22,000	80,000
LV distribution from generators	26,000	94,000	120,000
PV modules	**20,000**	**50,000**	**70,000**
Total	104,000	166,000	270,000
Rural Population (2015)	6,888,000		
Rural Household (2015)	810,350		
RE rate	**33%**		

The target rate of RE is expected to be 33% as of 2015. At this stage, the contribution of a LV distribution to RE is expected to be the biggest, 44%. The non-SENELEC service (generator + PV) would contribute to 70% of RE while the contribution of SENELEC would go down from 56% as of 2005 to 30% in 2015.

(2) Mode of Rural Electrification Implementation

ASER actually began preparing the "procedure Manual" during the preparation stage (1999-2000) and finalized it in the first quarter of the year 2001. Two (2) options are presented as the mode of RE implementation.

Priority Rural Electrification Program (PPER)

PPER means priority programs to be selected based on the Local Electrification Plan (prepared by ASER) and the National RE Plan (prepared by ASER and approved by MEH and Electricity Sector Regulatory Commission). Concessions of PPER are to be allocated into eligible concessionaires through annual tender calls. The administrative procedure to determine PPER is given below:

Procedure	Remark
Five years up-dating of National RE Plan	Rural communities to be electrified with connection (electrification) rate will be updated by referring to electrification progress and SENELEC grid extension. The interval of such an updating is 5 years, to be approved by MEH and Regulatory Commission.
Local Electrification Plan (LEP) is to be commissioned to local consultants through tender call	Though "Procedure Manual" does not define area for LEP, LEP is supposed to be prepared for area to which a concession is given. LEP must reflect the potential number of users with capacity-to-pay of them, and the number of industrial/commercial/craft-art establishments. Electricity sources (MV line, mixed generation, etc) should also be clarified.
Selection of PPER	The size of PPER to be selected based on LEP would be the number of potential users or of rural communities to be implemented within two or three years. Accordingly a PPER implicitly indicates a group of 2 to 3 rural communities.
Allocation of PPER concessions to successful bidders	Bidders are evaluated from both technical and financial aspects. The provisional successful bidder is invited to negotiate with ASER about the draft financing arrangement. A PPER concession is finally given to the successful bidder with approval of the Regulatory Commission.

Rural Electrification Project (ERIL: Electrification Rurale d'Initiative Local)

ERIL is considered the bottom-up or local initiative-based project to be implemented by local communities, users' association, local operators or NGOs. Unlike service companies doing electricity services of PPER, local bidders of ERIL projects are supposed to be lack of technical and financial knowledges about projects. Administrative procedure of ERIL presented in the "Procedure Manual" is shown below:

Procedure	Remark
Notification of project proposal	Any bidders taking interest in ERIL are free to submit technical proposals to ASER. The submission of proposals is twice in a year, the first between June 1 and 30, the second between December 1 and 30.
Technical assistance of ASER to preparation of proposals (The duration of assistance would not exceed one year from notification)	A wide coverage of technical assistance can be expected from ASER. It covers demand analysis, promising technical option, financial analysis and proposal (loan, subsidy), document writing for license or concession, operation and management system.
Selection of proposal and preparation of TOR for planning of selected ERIL project	Upon selection of proposals, ASER is ready to prepare TOR for planning of ERIL projects selected. Local consultants make contract with ASER to undertake the detailed Local Electrification Plan (LEP).
Submission of project financing	Based on the detailed LEP, project promoter (bidder) request project financing to ASER.
Final selection of ERIL projects	ASER evaluates technical and financial aspects of ERIL projects proposed, financial proposal in particular.
Financial agreements	ASER then shifts to the detailed negotiation of financing convention with bidders, covering loan, subsidy, banking system.
Allocation of ERIL concessions	The successful bidder submits an application of ERIL concession to MEH and get the full right for ERIL project upon approval of MEH and Regulatory Commission.

(3) Concessions

The final version of "Procedure Manual" proposes area and size (in terms of potential users) of concessions. The number of concession turns out to be twenty (20) in total. A concession area is basically equivalent to a department while a few concession cover two (2) or three (3) departments, depending on the number of potential users. The ASER makes rough estimation of connection rtes to estimate potential users in the future RE market. The connection rates are estimated by population range of a village as follows:

Connection Rates (1)

Population size	P>1,000	500<P<1,000	250<P< 500	P< 50
Connection rates (%)	40	30	20	10

Connection Rates (2)

Population size		P>1,000	500<P< 1,000	250< P<500	P<250
Base connection	(%)	30	20	10	5
Maximum connection	(%)	60	40	30	25
Economic activity	(%)	+15	+10	+10	+10
External resources	(%)	+5	+5	+10	+10
Proximity to urban	(%)	+10	+5	+0	+0

The connection rates (1) simply assumes those by size of village population. The connection rates (2) adds a few criteria to (1) in order to estimate the maximum connection rates. Criteria consists of economic activity, external resources and proximity to urban area.

Based on the connection rates of (1) and (2), the "Manual" estimates potential users by concession area as of the year 2011. Potential users in 2011 are estimated to be 156 thousands and 202 thousands respectively. The RE rate in the case of maximum connection rates is estimated to be 29 percent as of 2011. The average number of potential users per concession area is calculated to be about 10,000, which appears to be large enough for a private company to do business of electricity supply service.

Table 2.4 Number of Potential Users by Concession Area (As of 2011)

No.	Region	Department	Nos of users in connection rate of (1)	Nos of users in connection rate of (2)
1	Ziguinchor	Bigona-Oussouye-Ziguinchor	7,844	9,575
2	Diourbel	Diourbel-Banbay	7,329	10,852
3	Diourbel	Mbacke	13,808	18,698
4	St Louis	Dagana-Podor	9,169	9,160
5	St Louis	Matam	9,735	11,201
6	Tambacounda	Tambacounda-Kedougou	6,109	9,082
7	Tambacounda	Bakel	5,310	6,296
8	Kaolack	Kaolack-Nioro du Rip	9,390	13,317
9	Kaolack	Kaffrine	9,580	13,865
10	Thies	Tivoouane	8,768	10,006
11	Thies	Thies	8,938	11,357
12	Thies	Mbour	9,684	9,802
13	Louga	Kebemer-Louga	5,016	6,163
14	Louga	Linguere	7,146	10,162
15	Fatick	Gossas-Fatick	10,339	14,152
16	Fatick	Foundiougne	5,142	6,094
17	Kolda	Sedhiou	8,815	12,602
18	Kolda	Kolda-Velingara	6,224	9,537
	Total		148,346	191,921
		RE Rates (%)	22	29

The provisional plan of RE implementation expressed by concession areas is given below.

1st	2001	Dagana-Podor, Mbour, Kolda-Velingara
2nd	02	Foundiougne, Kaolack-Nioro du Rip, Sedhiou
3rd	03	Matam, Bakel, Ziguinchor
4th	04	Tivaouane, Kebemer-Louga, diourbel-bambey
5th	05	Tambacounda, Kaffrine-gossas, Fatick
6th	06	Linguere, Mback, Thies, Kedougou

ASER starts with the bidding for Local Electrification Plan of Dagana-Podor, Mbour, Kolda-Velingara in the first tranche in order to select concessionaires in the year of 2001. The reasons for selection of these concession areas first are i) concentration of villages whose population is more than 1,000, ii) distribution of relatively high income users, and iii) potential area for LV network. Kolda-Velingara would be the target area of French ODA. The allocation of concessions to successful bidders is expected to end in the year of 2006.

2.4 Market Arrangement toward the Public-Private Initiative Rural Electrification

The following is a basic policy of ASER for the rural electrification.

ASER's objectives

The stake in electrifying rural areas can be expressed economically, socially and in terms of land adjustment. Over-population of some of our towns and particularly Dakar, is a trend that urges a progressive inflection to be generated by a global rural development strategy, in which rural electrification will be one of the main vectors for irrigation development, education, health, fishing, tourism etc., and a restoration of an optimized balance between towns and rural areas.

Regarding the weakness of the electrification rate in rural areas (8%), the Senegalese government has undertaken a new dynamic in order to achieve ambitious objectives by setting up a new organizational device in which the Senegalese Agency for Rural Electrification (ASER) is a very important component. Its mission is to promote rural electrification by sustaining local initiatives and carrying out electrification projects

based on the Senegalese Rural Electrification Action Plan (PASER) adopted by the Government in 1999.

The implementation of this action plan was scheduled in three phases :

- a preparation phase 1999 – 2000, corresponding to setting up of the structure and the preparation of the launching phase,
- a launching phase 2001 – 2005, in which the main objective will be to reach an electrification rate of 15% that represents access to electricity for 100 000 new rural households,
- a consolidation phase 2006 – 2015, in which the main objective will consist of intensifying the rhythm of the realizations achieved during the launching period. This will help us to achieve a minimum rate of 30% by year 2015, meaning electricity for 270 000 rural households that represent 70% of Senegalese Rural Communities.

ASER's approach

Division of the country into rural **electrification** concessions and involvement of private sector

The organisational scheme adopted to implement rural electrification projects is based on the division of the country into 18 rural electrification concessions, with around 10 000 potential customers per concession. ASER will launch three invitations to tenderers each year, to select one private operator for each concession, who will be in charge of implementing priority rural electrification projects of the Government, based on a contract with ASER which precise a clear rural electrification development rhythm in the concession. ASER will be in charge of controlling the proper execution of the contract with the operator.

At the level of the village, the private operator will be relieved by a local operator for the exploitation of local low voltage grid. This approach present the advantage to reduce considerably the cost of managing customers.

Priority and local initiative rural electrification projects

In the ASER approach, two types of rural electrification projects are considered: The priority rural electrification projects (PPER) decided by the Government, under the delegate project ownership of ASER, and also rural electrification projects from local initiative (ERIL, from NGOs, local associations or local communitie) The ERIL projects can benefit from the technical and financial assistance of ASER.

Financial assistance from ASER

Important subsidies and credit from ASER are indispensable to attract the private operators' equity participation in the rural electrification, which has been regarded as social development.

Adaptation of grid technical standards

Oversized technical standards represent an important brake to rural electrification expansion in Senegal, because of the corresponding high cost of investments. New sizing and design of grids through a linging up to the low levels of electricity demand in rural areas strongly reduce the cost of investments for rural electrification. But this operation must take in account the furure increase in the electricity demand levels.

A strong communication component

The actors targetted through the communication component are various:

- Households,
- Local communities,
- Potential private operators,
- NGOs and local associations,
- Bankers and donors,
- Decision makers

This justify a multimedia strategy of communication, based on:

- Meetings with rural community leaders,
- Radio animation in local languages,
- Brochures and audio-visual documentaries and reports,

- Quaterly connection bulletin between local communities, customers associations, investors, public administration and other partners for development,
- TV mass addresses and debates towards populations and deciders,
- Local training workshops (for rural counselors and local associations and NGOs),
- A WEB site,
- Annual activities reports.

Concessions approach, involvement of private sector, financial assistance to PPER operators, financial and technical assistance to ERIL projects, adaptation of technical standards, strong information and communication campains, should together lead ASER to reach the senegalese rural electrification objectives.

The ASER rural electrification program is one of the main national strategy to fight against poverty.

The significant aspect common in the two models such PPER and ERIL addressed in the Procedure Manuals, is that the locally-based entrepreneur be positively involved in the project. The local initiative approach, is quite recommendable not limited to the "Local Initiative Rural Electrification"(ERIL), but also to facilitation of the rural development itself. The major economic entity in the rural community is considered to be represented by local NGOs, local cooperatives, local owner of the small business such as boutique owner of PV equipment, etc..

In the stage when business activities initiated by rural community are very poor, access to business information is difficult due to no linkage between urban-based business group and local community. Therefore, the development process should be well considered, from several aspects such as time factor, business linkage between urban and rural inclusive of information, community empowerment..

In such an initial stage, as a project promoter, the existing business entities, particularly interested in the energy and electrical and electrical industry, is expected to play a major role.

2.5 Past Lessons and Future Tasks of the Rural Electrification

Under the right conditions, SHS can offer lighting and other services to large numbers of households that are poorly served by existing energy sources or have no service at all. PV systems are an effective complement to grid-based power, which is often too costly for sparsely settled and remote areas. For such rural conditions, fuel-independent, modular solar home systems (SHS) can offer the most economical means to provide lighting and power for small appliances.

As a renewable energy source, PV systems are also environmentally friendly, contributing to reduction in environmental performance and reduce reliance on expensive imported fuels.

In spite of these appealing features, solar home systems do not yet have broad market acceptance and face significant barriers to widespread diffusion. The main obstacle is their initial purchase price, which puts them out of the reach of all but upper-income houscholds. Opportunities exist to reduce the cost of solar home systems over the near future. These include the outlook for steady decline in PV module prices on the international market, and the economies of scale in procurement, sales and servicing that an enlarged customer base can provide. However, even with these cost reductions, unless adequate financing arrangements, geared to low- and middle-income households, are in place, solar home systems cannot play a significant role in rural electrification.

Many early solar home system programs in the 1970s and 1980s failed, due to a variety of factors. These included 1) unreliable technical performance, 2) poor system design, 3) lack of sustainable and proper technical support, 4) implementing agency shortcomings, 5) poor attention to cost recovery, and 6) unrealized user expectations and consequent dissatisfaction. As a result, thanks to the lessons learned from these experiences and from technological improvements, solar home systems now show a robust potential for long-term sustainability. In spite of wide recognition of PV systems, the need to overcome the first cost barrier is recognized to be prerequisite in any country context.

Among others, several key findings which are critical to broad diffusion of PV system in rural areas, emphasize the need to:

- Overcome the first cost barrier,
- Establish responsive and sustainable infrastructure to deliver PV services, and
- Provide quality products and services.

(1) Overcoming the First Cost Barrier

Affordable Payment Schemes Affordable and accessible financing is a major consideration in the design of any PV program due to the high initial costs of solar home systems. Affordability can be increased by providing households with term credit through local dealers or the banking system or by leasing or energy service company (ESCO) arrangements.

Here in Senegal, the latter scheme of "fee for services", corresponding to energy service company (ESCO) arrangements, is planned to be introduced for promotion of the rural electrification. This scheme will be initiated and facilitated by ASER, which has been created as an agency responsible for rural electrification. Its principal purpose will be to promote rural electrification and, to this end, to provide technical assistance and financial support required to carry out rural electrification projects represented by PPER and ERIL. Such judicious use of subsidies and concessionaire loan as financial support, could help implement household PV programs. To assure sùstainable programs, such assistance should be also used to build market infrastructure through planning, promotion, training, feasibility studies, quality assurance, and similar activities, or limited equity to reduce the capital costs of a project.

In addition to that, Governments should rationalize duty and tax structures, if these discriminate against PV development. Relatively high import duties (particularly on PV modules) and other taxes such as VAT, can severely limit the potential for commercially viable, market-driven solar home system programs. Tax incentives such as exemption of corporate tax and/or introduction of one-year's depreciation, may be advised to be adopted for facilitation of PV diffusion.

(2) Establishing Responsive and Sustainable Infrastructure

Institutional Structure and Identification of Potential Operators No single institutional arrangement is appropriate for every country. Looking at the socio-economic situation of Senegal, Fee for Servicemodel may be the most recommendable, being well in cope with the principle policy of ASER. It can allow for the most affordable payment schemes, and can thus reach a larger customer base than other credit delivery schemes such as leasing arrangements and cash or credit sales to consumers. With a large customers' base, the potential operators can obtain economies of scale in procurement and in the delivery of support services, make product standardization and quality assurance easier, and facilitate battery recycling. While the fee for service model is an attractive concept, its long-term viability requires business management skills and technical capabilities that may be limited in rural areas. Furthermore, the fee for service model also carries greater commercial risk due to the longer cost-recovery period represented by concession period. Therefore, the business management skills and technical capabilities are vital to the sustainable development of PV systems so that the training and the creation of potential local electric operators should be envisaged as a major technical assistance provided by ASER.

Financial Sustainability. PV programs must be operated as businesses. They should generate revenues sufficient to recover capital investment, service debt, pay for administrative and support services, cover payment defaults and, in the case of for-profit operations, provide satisfactory returns for investors. To ensure sustainability, PV programs should:

- set prices to allow for full cost recovery;
- select only consumers with a willingness and ability to pay;
- ensure that consumer expectations are in line with the energy services to be provided;
- maintain high product quality and responsive services;
- establish effective fee collection methods and enforce regulations to shut off service for nonpayment;
- adopt simplified administrative procedures; and
- choose and retain quality staff.

Effective Management and Support Services A successful PV program needs well-qualified managers and technicians. In this scheme, managers will be selected, preferably recruited locally, by the operator. Technicians, who will be locally selected from the villages, are supposed to be employed and trained by the operator. Adequate salaries are also required to retain qualified managers in rural areas. In addition, technicians must be trained in order to assure responsive repair and maintenance services, seemingly an often under-emphasized aspect of PV programs. In due consideration of global rural electrification, the potential operator, which will play a vital role in the project formulation, should be surveyed and identified based on the criteria for eligibility by ASER.

(3) Providing Quality Products and Services

Technical Quality The long-term sustainability of a PV program depends on well-designed products (including proper assembly and installation procedures) that meet consumers' expectations and capacity to pay. Low-capacity and high-quality products should be offered to those potential customers with only a limited ability to pay. Costs should never be reduced by compromising system quality or by decreasing support services. Where low-cost systems must be used, customers need to be fully aware of and accept a limited level of service.

Consumer Awareness User education is essential for PV program success. Information and training in simple maintenance and safe operating procedures should be targeted to those persons in the households who will have primary responsibility for the system. Users need to understand that good operating practices minimize recurring costs and enhance battery life.

(4) The Role of Government and Donor

Grid-based electricity has only been the mainstay of rural electrification efforts. However, the increasingly high cost of serving isolated and remote communities burdens government budgets. A large proportion of rural needs for household lighting and small power requirements can be met by solar home systems at a lower economic cost than grid service. Consumers are reluctant to purchase what is perceived to be only a short-term solution. Instead, explicit government support of solar home system programs for isolated, or remote villages, or non-served portions of electrified communities can help PV meet low load demands and prevent uneconomic extension of the rural electrification grid.

The key role of government is to guarantee an appropriate institutional and regulatory environment. Governments should rationalize duty and tax structures as well as incentive or subsidy programs to reduce market distortions and facilitate access to credit. Other governmental functions include the setting of technical standards, monitoring and disseminating information on PV technology and the performance of solar home systems. By investing directly in PV equipment as part of education, health, and other social programs, governments represented by Direction of Energy can also play an important role in establishing the infrastructure needed to sustain PV systems.

Finally, the electricity use of PV should cover lighting as well as productive use such as water pumping, refrigerator and craft industry. Nevertheless, considering that lighting is the most important purpose of rural electrification, it has been mutually agreed between JICA Study Team and MEH at the beginning stage of the Study that primal use of PV is the lighting including electric apparatus of household and public facilities (i.e. school, health post, etc.)