Japan International Cooperation Agency (JICA)

Ministry of Water, Hydraulic and Rural Equipment (MHEHR)

Agency of Transport and Rural Infrastructures (AATR)

The Republic of Senegal

The Study on Urban Water Supply Development Plan in the Republic of Senegal

Summary

March 2002

Nippon Koei Co., Ltd.
The Institute of Energy Economics, Japan

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

Summary

March 2002

KRI International Corp.
The Institute of Energy Economics, JAPAN

Currency Exchange Rate

(February 2002)

US$＝¥ 133.74

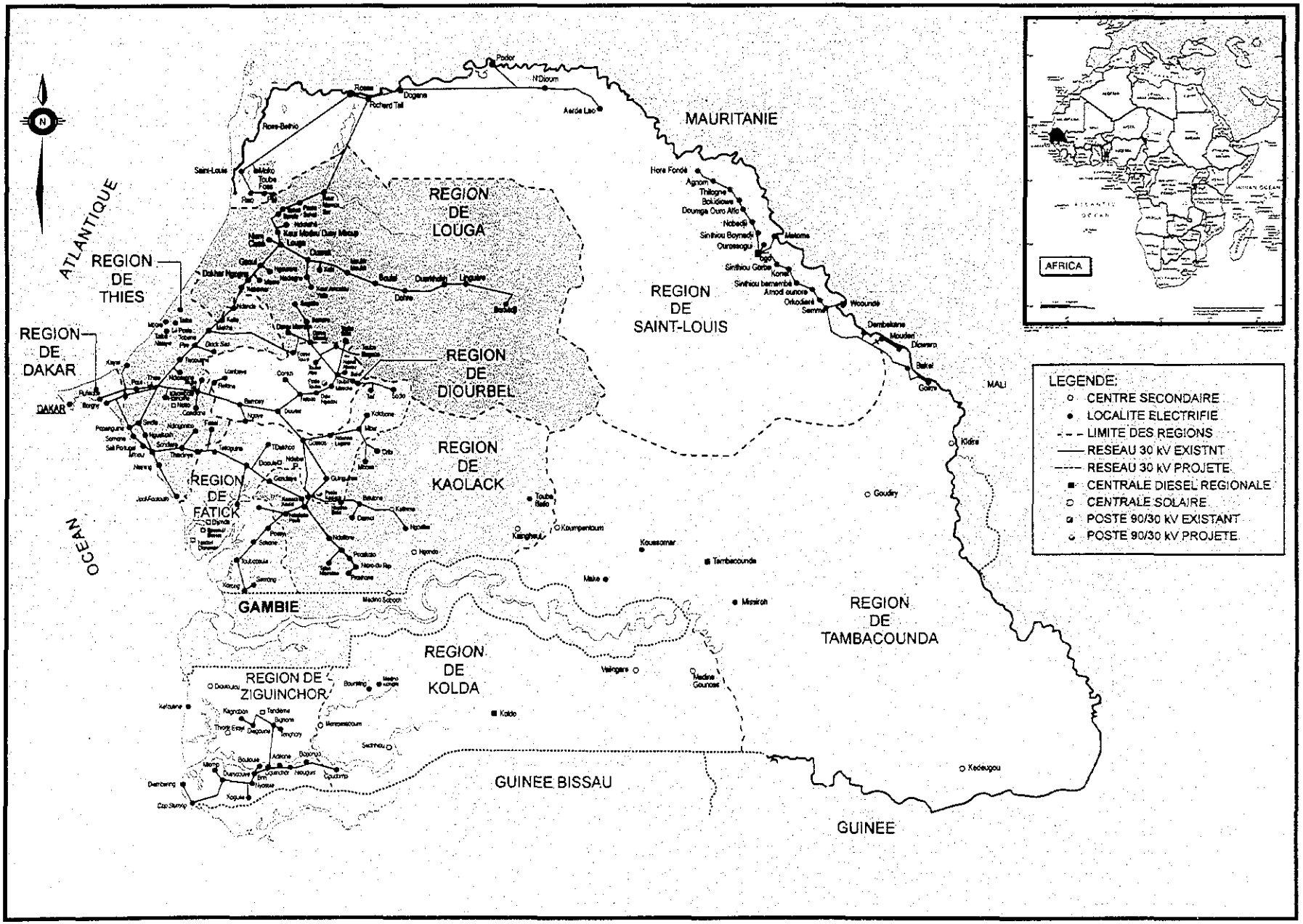
US$＝7.54 FF

Euro＝US$ 0.87

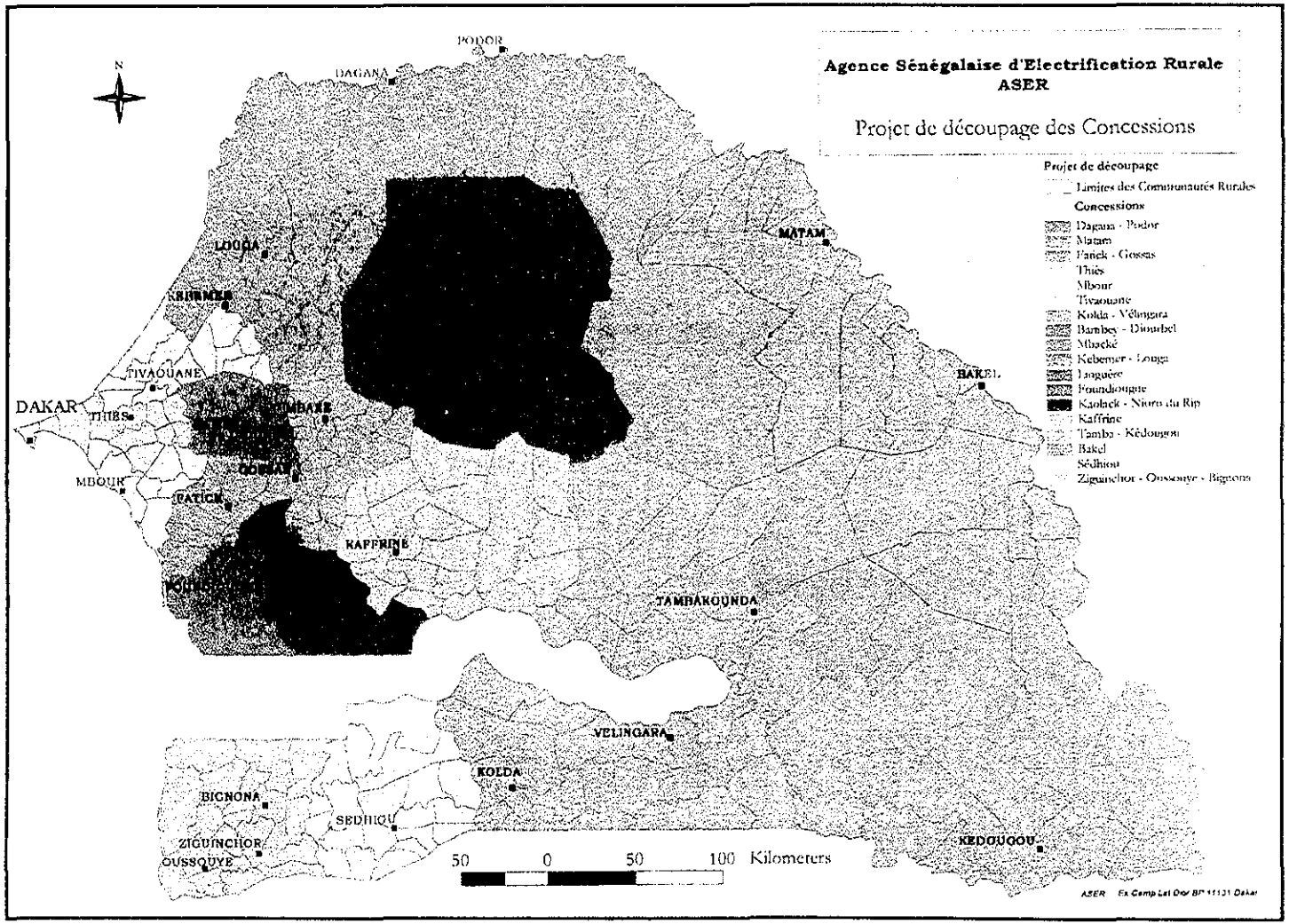
(Euro＝6.56 FF)

FF＝100 CFA (FF: French francs)

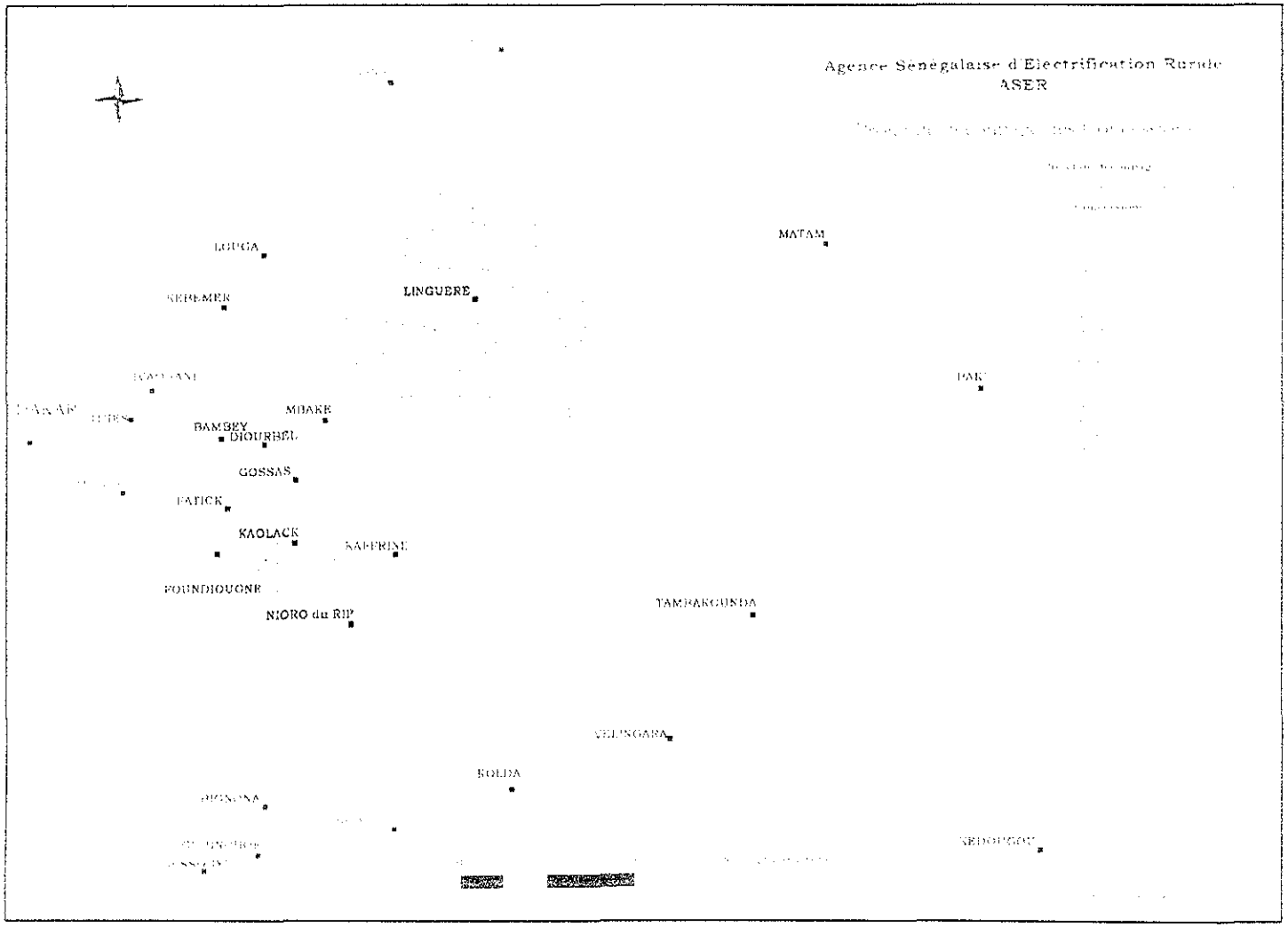
CFA＝¥ 0.177



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 and Objective 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 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.

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.

The government agency called "l'Agence Senegalaise d'Electrification Rurale"(ASER) responsible for development of the rural electrification sub-sector of Senegal. Toward the execution of the rural electrification, two types of project implementation methods, such as Program Prioritaire d'Electrification Rural:PPER and Electrification Rurale d'Initiative Local:ERIL, have been proposed, the latter of which will be applied to the PV rural electrification.

The Study consists of 1) Implementation Plan on Photovoltaic (PV) Rural Electrification, 2) PV System Operation Manuals and 3) Business Model as a part of the market arrangement for the public-private initiative rural electrification.

1.2 Approach of the Study

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 as 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 Implementation Plan, 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 has been prepared, taking into account the performance of the Pilot Project.

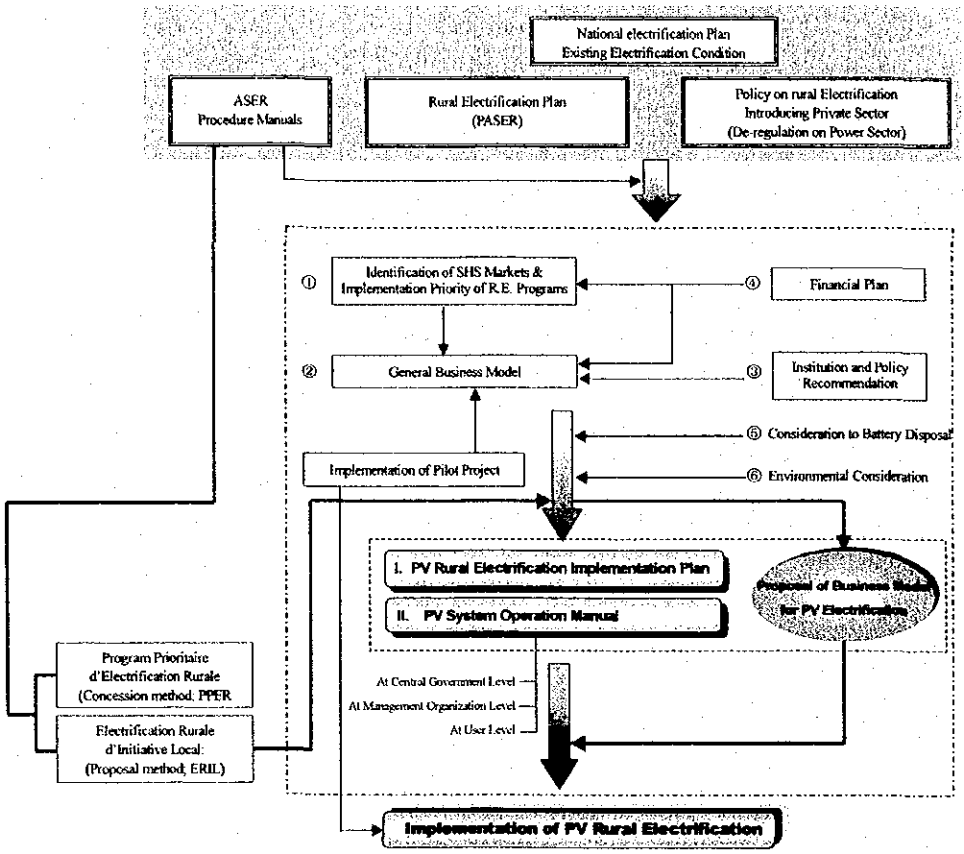


Figure 1.1 Study Flow

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 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. In relation to the shortage of the government budget as major constraint for supporting an expansion of electricity service in the rural area, 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:

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 law stipulates that the Ministry of Mines, Energy, and Hydraulics, the Regulatory Commission and ASER will play the major role in this sub-sector of the rural electrification.

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 Mines, Energy and Hydraulics (MMEH) prepared the "Le secteur de l'energiè au Senegal" (the energy sector document) stating the current condition of the rural electrification. 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 Stage 1999~2000, Lauching Stage 2001~05, and Consolidation Stage 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. 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 and/or village organization.

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

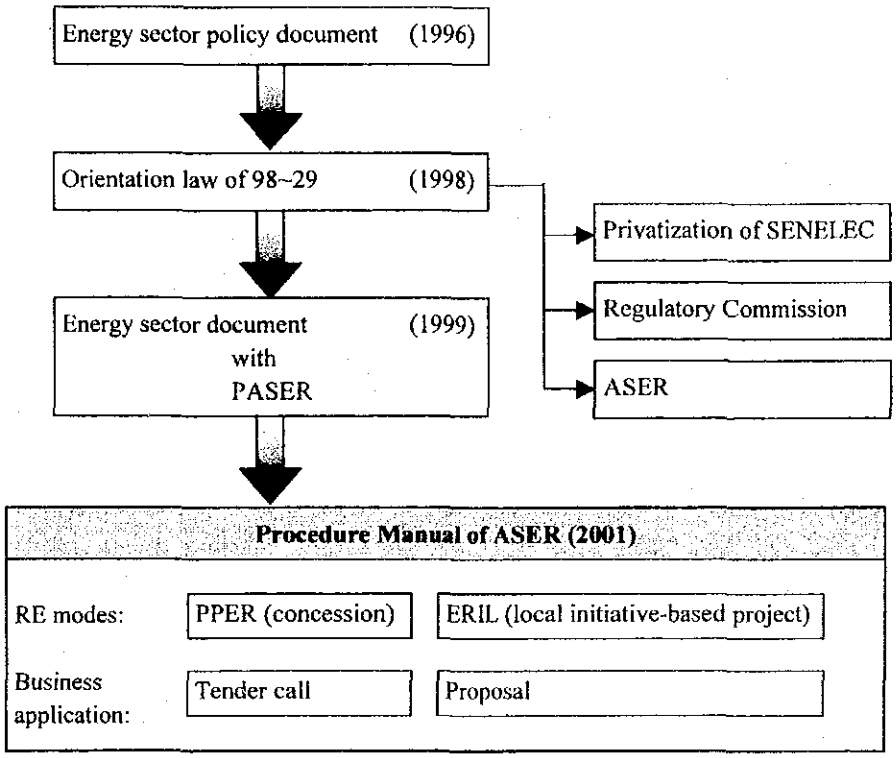


Figure 2.1 Transitional Process of RE Sub-Sector

2.2 Current Power Supply of SENELEC

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 number of SENELEC consumers and electricity consumption at each voltage level as of December 1999 is shown below.

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.

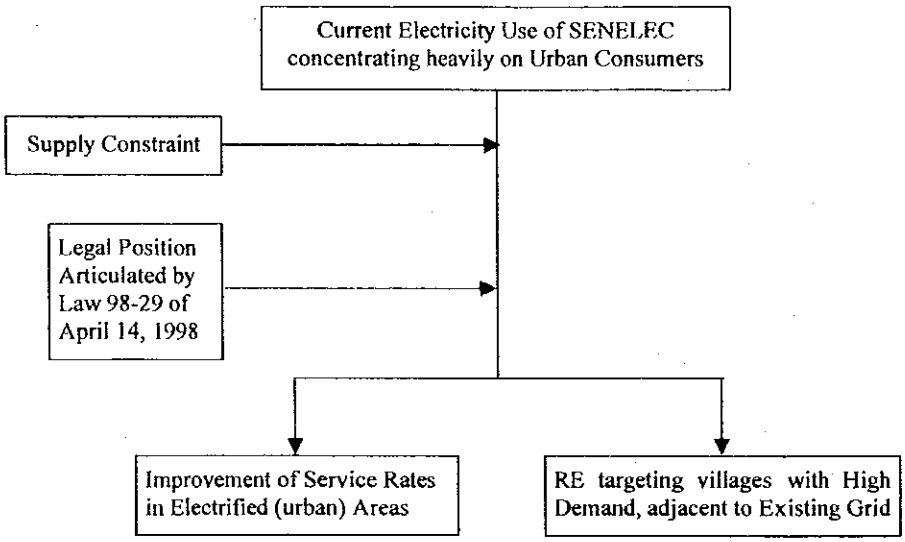


Figure 2.2 Indicative Direction of Future SENELEC Electrification

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 following table shows historical records of energy supply and demand between 1991 and 2000.

Table 2.1 Historical Power 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

2.3 Rural Electrification in Senegal and Basic Policy

(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	30,000	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) ASER's Rural Electrification Plan

The potential demand in the respective concession area is assumed as below.

Table 2.2 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 Basic Strategy toward PV 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 households. 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.

CHAPTER 3 PV RURAL ELECTRIFICATION PLAN

3.1 Identification of PV Market and Potential Demand

(1) Market Characteristics of SHS

As a type of electricity supply, PV is classified into solar power station, hybrid solar power station, and a family photovoltaic system (solar home system, SHS). The types of solar power and hybrid system consisting of generators and distribution line are defined as the closed network whose service coverage is restricted, supplying one or two villages. Such a closed network can be connected to grids of SENELEC or other networks. SHS is, on the other hand, an independent unit, easily installed at users' dwelling properties. SHS does not require a collective demand as a project of LV distribution needs.

Rural electrification in developing countries is generally characterized by low electricity consumption of end-users concentrating on the middle to high income classes dwelling in villages or isolated areas. Electricity use is largely restricted to lighting, say, five (5) to ten (10) kWh per month. Lighting is implicitly regarded as the basic electricity use in SHS-based rural electrification.

The market characteristics of SHS are summarized as follows:

a) End-users are presumed to be extensively diffused in villages scattered nationwide. Such an individual demand might be identified in villages having smaller middle scale of population.

b) End-users are those who can afford to purchase a fairly expensive unit or to pay the constant service fee periodically. They are thus presumed to belong to the middle to high income classes.

c) The economic nitch for SHS usually covers remote or isolated areas where load or load density is low. The market nitch for SHS is to be determined by size of household demand for electrification and the distance from existing grid.

(2) Basic Conditions

A demand for SHS is defined as a household being willing to install a SHS unit. The market study is to identify spatial distribution of villages having potential demand for SHS and to make the quantitative analysis of such demand by locality or region. Potential demand for SHS is to be estimated with the following conditions:

a) The market segmentation complies with twenty (20) concession areas proposed in "Procedure Manual" of ASER.

b) There are the different types of SHS according to power output. This study primarily focuses on the standard type of 50 wp to be presumed to be extensively diffused in all Senegal.

c) The basic data such as population and family size at present (the year of 2000) is estimated based on those of the previous census year (1988) owing to no successive census data.

d) The target year of demand forecast is that of 2015 in accordance with PASER.

(3) Methodology

The identification of SHS market starts with potential demand for electrification at the level of village. Potential connection rates by size of village population is hypothesized in the Procedure Manual. These hypothetical connection rates are used to estimate potential demand for electrification for all the non-electrified villages.

Next, the costs per kWh are compared among three technical options (grid extension, diesel generator, and SHS) in order to find out cost effective area for SHS in relation to the distance from existing grid and household demand for electrification. The more household demand is, the less electrification cost is. The cost per kWh diminishes as household demand becomes larger.

Finally, the market study ends up with identification of villages where SHS is to be introduced and potential demand for SHS by concession area. The methodology for SHS market analysis is conceptually illustrated below.

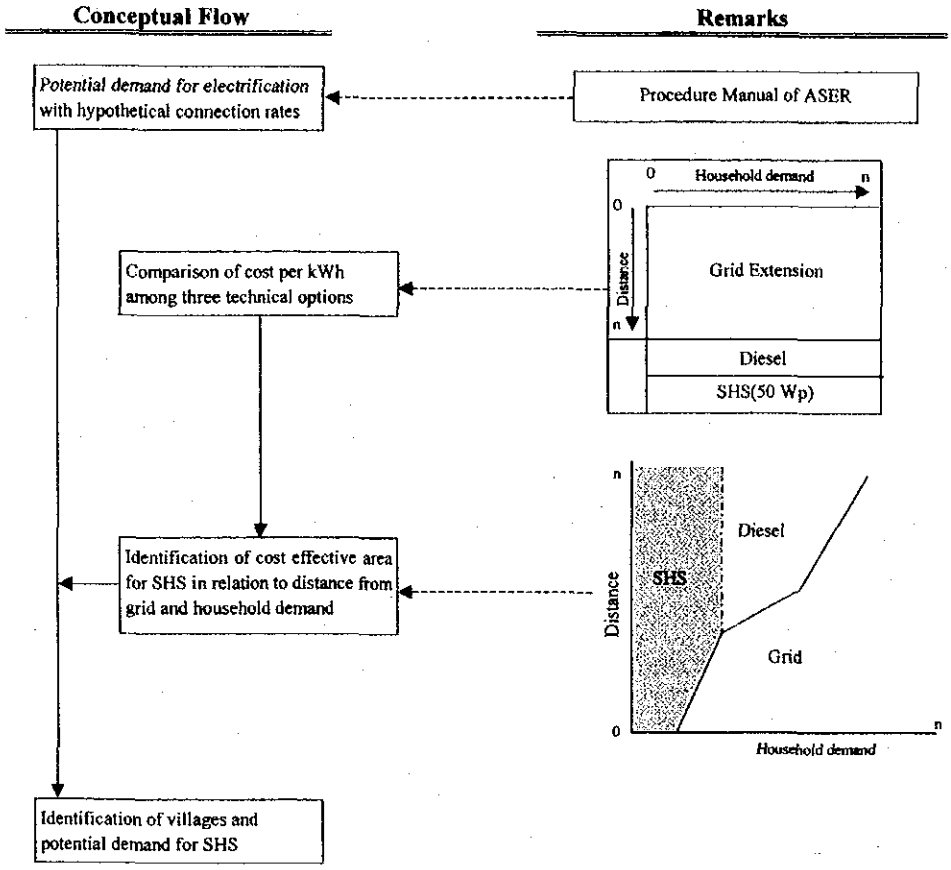


Figure 3.1 Conceptual Flow for Estimation of Potential Demand for SHS

Estimation of potential demand for electrification at present is simple, referring to the village population of the year 2000 (estimate) and hypothetical connection rates quoted from Procedure Manual. Electrification cost of grid extension takes the form of matrix with respect to household demand and distance from grid. Extension cost increases in proportion to distance from grid, whereas that diminishes as demand grows. Electrification cost of diesel diminishes as demand grows, while that of SHS seems to be constant in little relation to size of demand. The shaded area corresponds to cost effective area for SHS, resulted from comparison of cost per kWh among three technical options. Finally, the number of village including demand for SHS in SHS area is to be estimated by concession area.

(4) SHS Demand and Village Distribution of SHS Area

The cost effective area for SHS, indicating the number of villages is shown in Figure 3.2 and summarized as follows:

a) The number of non-electrified villages in SHS area turns out to be 11,222. The majority of non-electrified villages is thus identified to be those for SHS-based rural electrification.

b) Out of 11,222 villages, the majority of them is identified in SHS area where the distance is over 0.6km, and demand is in the range from 1 to 30 households. The number of villages in this block is estimated to be 6,695.

c) The second largest block of village distribution is the area where the distance is more than 0.6km and demand in the range from 30 to 60. The number of villages in the second block is estimated to be 4,004.

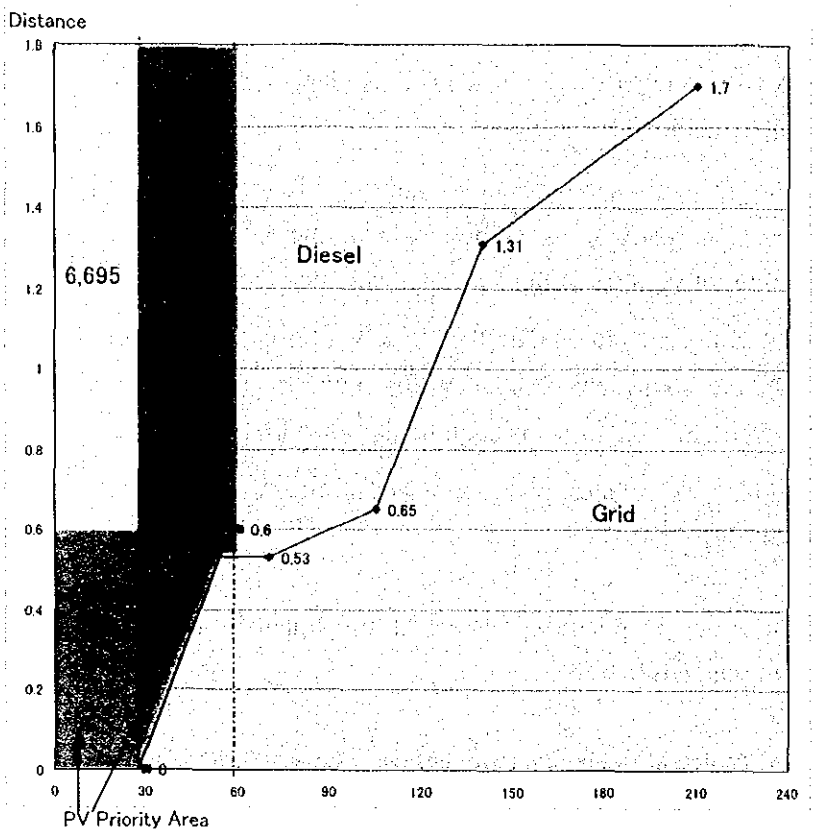
d) The number of villages in the third and fourth blocks is estimated to be 299 and 224, respectively.

The regional distribution of potential demand is illustrated by histograms as shown in Figure 3.3 and summarized in Table 3.1.

Table 3.1 Regional Distribution of Potential Demand

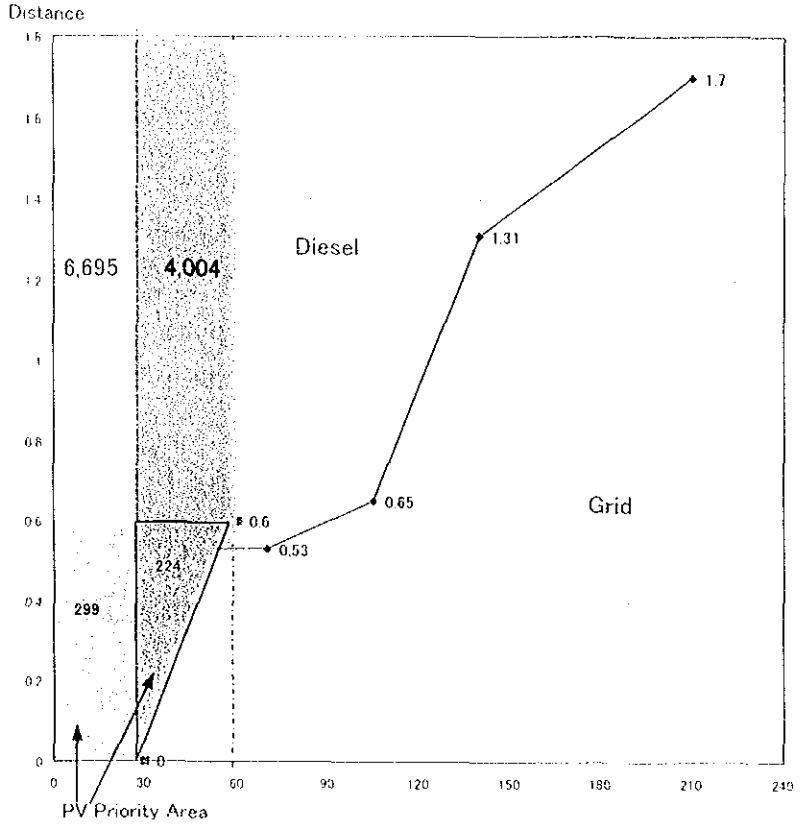
Region	Demand	Region	Demand
Dakar	115	Louga	7,243
Diourbel	9,364	Saint louis	7,247
Fatick	9,235	Tambacounda	7,640
Kaolack	14,321	Thies	12,130
Kolda	10,240	Ziguinchor	4,998
		Grand total	82,533

Potential demand is estimated to be 82,573 in all regions. The market has a big potential demand for SHS at present. Looking at regional distribution of potential demand, Kaolack is the top region, accounting for 14,321 units while Ziguinchor demands the least units (4,998), except for non-electrified commune area of Pakar.



	Demand ≤ 30 households, Distance more than 0.6km	6,695 Villages	57,790 Households
	Demand ≤ 30 households, Distance less than 0.6km	299 Villages	2,580 Households
	30 < Demand ≤ 60, Distance more than 0.6km	4,004 Villages	20,990 Households
	30 < Demand ≤ 60, Distance less than 0.6km	224 Villages	1,173 Households
		11,222 Villages	82,533 Households

Figure 3.2 Distribution of Villages in SHS Area



	Demand ≤ 30 households, Distance more than 0.6km	6,695 Villages	57,790 Households
	Demand ≤ 30 households, Distance less than 0.6km	299 Villages	2,580 Households
	30 < Demand ≤ 60, Distance more than 0.6km	4,004 Villages	20,990 Households
	30 < Demand ≤ 60, Distance less than 0.6km	224 Villages	1,173 Households
		11,222 Villages	82,533 Households

Figure 3.2 Distribution of Villages in SHS Area

Potential Demand for SHS by Department

Region	Dept	Nos of CRs	Villages	Demand
Dakar	Rufisque	1	10	115
Diourbel	Bambay	13	401	4,435
	Diourbel	11	340	2,792
	Mbacke	11	282	2,137
Fatick	Fatick	14	185	3,044
	Foundiougne	9	307	3,097
	Gossas	12	282	3,094
Kaolack	Kaffrine	21	847	7,313
	Kaolack	9	429	3,168
	Nioro du Rip	11	456	3,840
Kolda	Kolda	13	677	2,748
	Sedhiou	20	573	5,536
	Velingara	10	422	1,956
Louga	Kebemer	16	796	1,957
	Linguere	17	664	2,924
	Louga	15	776	2,362
Saint Louis	Dagana	6	261	2,100
	Matam	12	254	3,128
	Podor	10	148	2,019
Tamba	Bakel	10	400	2,102
	Kedougou	10	221	1,746
	Tamba	13	737	3,792
Thies	Mbour	8	123	2,844
	Thies	9	348	4,103
	Tivaouane	15	859	5,183
Ziguinchor	Bignona	15	279	3,094
	Oussouye	4	68	1,002
	Ziguinchor	5	74	902
	Total	320	11,219	82,533

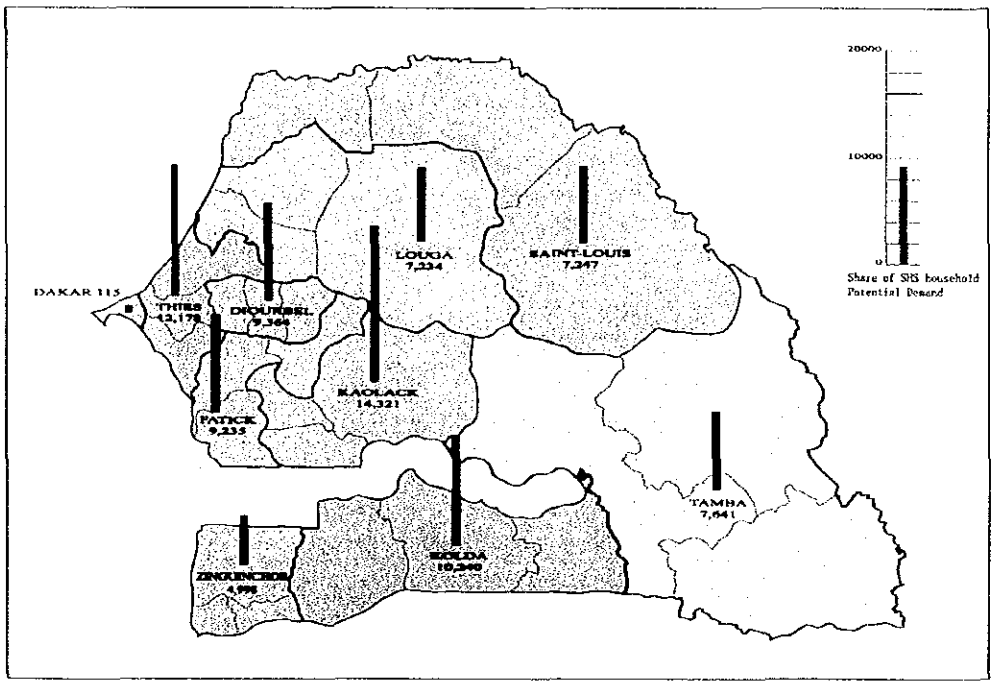
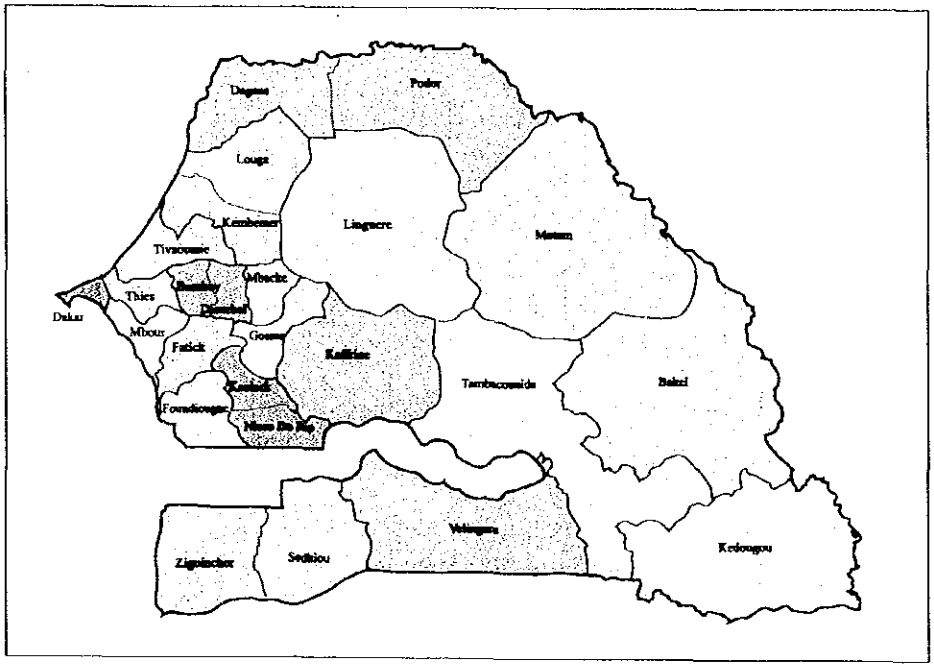


Figure 3.3 Regional Distribution of Potential Demand for SHS

Demand Projection

Number	Concession Area	2000	2005	2010	2015
1	Zinguinchor	4,706	4,911	5,459	5,355
2	Diourbel-Bambay	7,112	7,576	7,947	8,340
3	Mbacke	1,820	2,625	3,225	3,961
4	Dagana-Podor	4,119	4,140	4,173	4,217
5	Matam	2,681	2,953	3,794	3,582
6	Tambacounda-Kedougou	5,099	5,449	6,409	6,413
7	Bakel	1,869	2,049	2,527	2,464
8	Kaolack-Nioro du Rip	6,549	7,704	8,475	9,325
9	Kaffrine	6,857	8,062	8,888	9,799
10	Tivaouane	5,012	5,529	5,898	6,291
11	Thies	3,644	4,561	5,071	5,637
12	Mbour	2,566	3,131	3,446	3,794
13	Kebemher-Louga	4,319	3,528	2,882	2,355
14	Linguere	2,753	3,329	3,791	4,316
15	Gossas-Fatick	6,079	6,321	6,510	6,708
16	Foundiougne	2,751	3,429	3,797	4,205
17	Sedhiou	5,138	5,662	6,722	6,875
18	Kolda-Velingara	4,591	5,059	5,713	6,142
Total		77,665	86,018	94,727	99,779

Note) The current household demand (77,665) for SHS is expected to increase to around 100,000 in the year of 2015. The average growth rate of household demand is estimated to be 1.7 percent.



Potential Demand for SHS by Concession Area

3.2 *Basic Concept of Business Strategy for PV Rural Electrification*

Among others, the following items are critical to diffusion of PV system particularly in the initial stage;

A. Overcome the high initial cost barrier: The obstacle of the high initial cost of obtaining energy needs to be removed. Credit mechanisms and/or subsidy provision, lower-cost equipment, and lower service (not lower quality service) standards could all contribute to achieve this objective. (Financial Model)

B. Encourage local participation: Participation of local communities, investors, and consumers/beneficiaries (rural population) in the design and delivery of energy services is essential. Decentralized approaches need to be a part of the solution, but they require capacity building of local community. (Project Formation)

C. A demand-oriented approach: Based on the belief that solutions to local problems are likely to be more sustainable to the extent that the target communities are able to participate in designing and implementing those solutions. Accordingly, the projects which support implementation of the program's objectives will deliberately reflect needs and requirements as identified by grass-roots communities themselves in close partnership with project promoters, of course requiring an assistance of the government. (Reliable Relationship among the parties concerned)

Taking into account the above matters, the basic concept of PV rural electrification has been established for this Study.

1. The plan on PV rural electrification for this Study is lighting-oriented scheme as defined below;

   "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 that primal use of PV is the lighting including electric apparatus of household and public facilities (i.e. school, health post, etc.)"

   Throughout this discussion 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. Through the training programs, credit mechanisms, and increased government awareness and social acceptance of these technologies, these programs will expand into the direct economic development arena. Once it is established that rural communities can take part in the formal economic structure, with an understanding and acceptance of credit options, the goal of community empowerment will be achieved.

2. Among the target area for PV rural electrification, there are some locations which may be regarded as transitory stage until they are electrified by other permanent or semi-permanent competitive alternatives such as grid extension, diesel generator grid, etc., which are able to provide sufficient power for value-added income generation as well. In that case, there is high possibility that the PV equipment installed will be transferred to other un-electrified locations in the future.

3. The target household for PV installation is for those with high annual income, say the upper 20-25% village population. That is, the initial target for PV installation is for those being capable to pay for electricity services. This approach characterizes the study and will be applied for selection of PV priority area. The first priority has been placed on the project sustainability. This development concept is critical to materialization of the rural electrification policy of Senegal, which requires improvement of rural electrification service rate and introduction of private sector initiative.

   To meet such requirements, the methodology has been here proposed.

   The materialization of "lowering of financial burden on users" and "satisfaction of electricity needs of users" will require both supply-side contribution and demand-side contribution.

   The respective contribution is represented by the following:

   Supply-side "Provision of good quality services"

Demand-side "Financial contribution, called as the initial payment of users being equal to 10% of the initial investment cost" and "Monthly payment" to make the project sustainable.

It should be noted that the risk of fee collection for electricity services is structured to be finally imposed on the Project Operator (the global entrepreneur). That is why most of the financial and technical supports from the government should be directed to the global entrepreneurs, that is, project operators, in the initial stage.

4. The electrification by PV is regarded as lighting-oriented, so that it will not contribute to income generation at the outset. This situation will continue to be only in the initial stage, but the electrification by PV will be expected to be expanded within the village in problem (densification) in a later stage. In parallel with such densification, the income generating activities will be also promoted by introduction of other alternative electrification, but all depending on the business activities of the global entrepreneur in close consultation and collaboration with village community.

As to the financing activities in the regional community. Fund Circulation Mechanisms, should be vitalized and deepened in the rural community. This is a part of the roles played by ASER to create the rural electrification environment/market attractive to the global entrepreneur as well as to the rural population.

The above-mentioned good combination of income generating and financing activities assisted by global entrepreneurs will be expected to proceed in the best case to sustainable rural development.

To materialize such scheme, locally-based entrepreneurs familiar with local socio-economy, local culture and customs, local language, etc., represented by local NGO, PV experts, etc. are expected to play a very important role. The role could be characterized by "Coordinator", which only constructs the reliable relationship among the global entrepreneurs, the rural community, and the rural population.

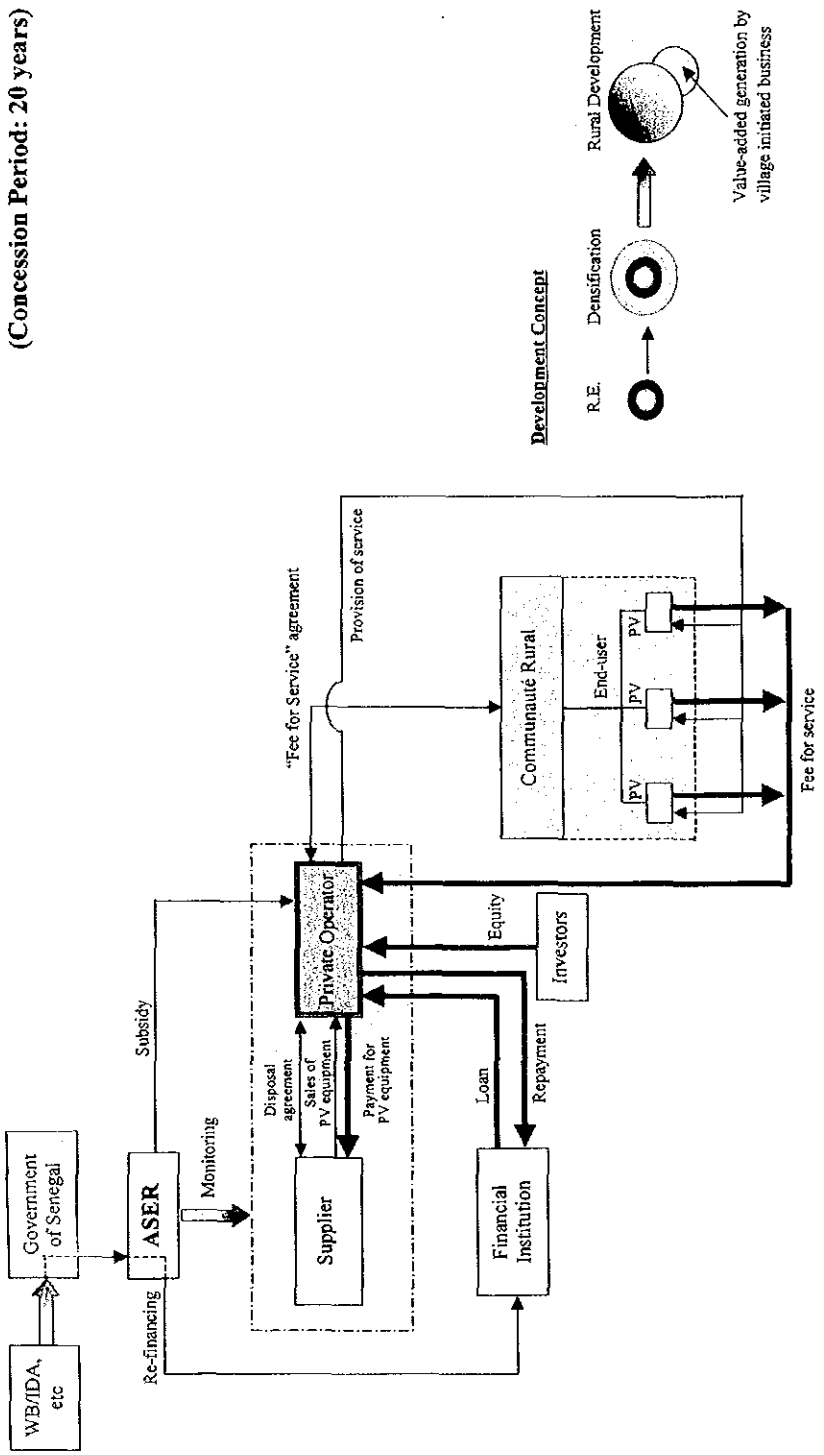


Figure 3.4 Business Model (PPER/ERIL)

Total Management by Private Operator under Local Community Initiative

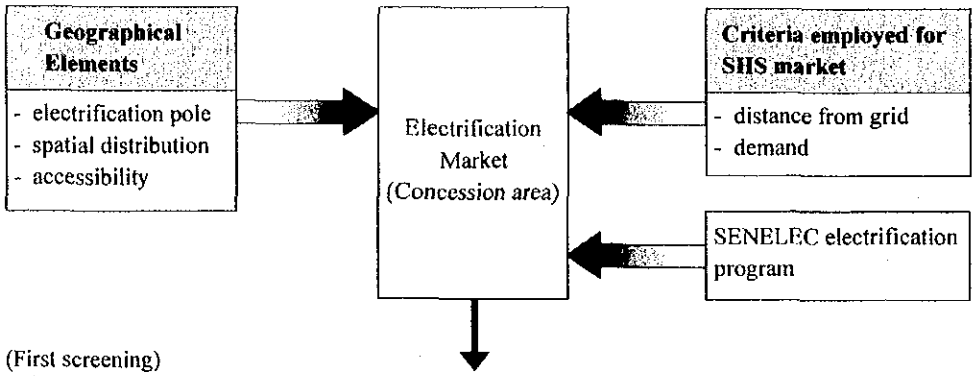
3.3 Rural Electrification Programs for PV (SHS)

(1) Premises for SHS Market

The theoretical approach to identification of villages having potential demand for SHS is demonstrated in Figure 3.2. Potential market (the distribution of villagers) is presented in terms of I) distance from existing grid and (ii) demand (household). The approach would be fundamentally appropriate for the scheduled Local Electrification Plan of 3 concession areas (Dagana-Podor, Mbour, Kolda-Velingara) in the first tranche where electrification market for technical options (extension of MV line, LV network, PV) is to be clarified. Nevertheless, the market for respective option would be determined taking into consideration the following criteria given below:

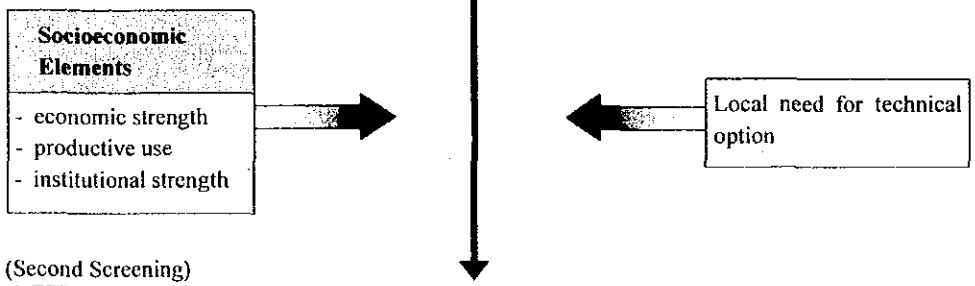
Criteria	Criteria Conditions
a) Electrification center	• Distribution of community rurals' center • Potential demand for electrification at centers of CRs
b) Spatial distribution of villages	• Distribution of satellite villages around centers of CRs • Distribution of villages along existing grid line
c) Accessibility	• Roads' network with road surface conditions • Accessibility to centers of Departments
d) Economic strength of villages	• Fertile condition of farm land • Share of non-agricultural income sources
e) Productive use of electricity	• Size of harvested area by crop • Production possibility of agricultural-processed products
f) Institutional strength of villages	• Existence of local entrepreneur or NGOs • Invalvement of village organization in water supply, primary health care and social activities • Involvement of women in existing social activities

The criteria is largely classified into two elements; namely I) geographical element covering from a) to c) and ii) socioeconomic element covering from d) to f). The point is how to use criteria in order to identify potential market for respective technical option. Perhaps the survey is firstly to be made for geographical element in order to have a rough idea of villages to be electrified and technical captions for them. Secondly socioeconomic element is taken into account in order to determine villages with the appropriate options to be electrified. The concep0tual flow of market screening for technical options is as follows:



(First screening)

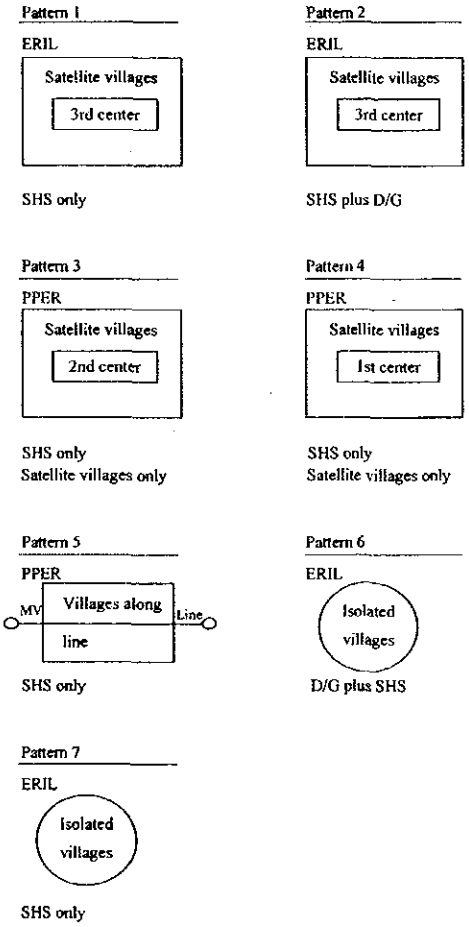
Potential Market	Options
1) First category of community rural centers	MV extension with LV network
2) Second category of community rural centers	D/G based mini grid
3) Third category of community rural centers	D/G or SHS or a combination of them
4) Satellite villages around community rural centers of the first category	LV extension
5) Satellite village around community rural centers of the second and third categories	SHS
6) villages along existing grid line	LV extension or SHS
7) Isolated villages	SHS



(Second Screening)

Group	Market	Options	Modes
1	First category of CR centers	MN extension with LV	SENELEC
2	- ditto -	- ditto -	PPER
3	Second category of CR centers	D/G-based mini grid	PPER or ERIL
4	Third category of CR centers	D/G-based mini grid	PPER or ERIL
5	- ditto -	SHS	ERIL
6	- ditto -	D/G with SHS	ERIL
7	Satellite villages around the first category of CR centers	LV extension	PPER
8	- ditto -	SHS	PPER
9	Satellite villages around the 2nd and 3rd categories of CR centers	SHS	ERIL or PPER
10	Villages along existing grid	LV extension	PPER
11	- ditto -	SHS	PPER
12	Isoalted villages	D/G with SHS	ERIL
13	- ditto -	SHS	ERIL

1st Screening	2nd Screening	Main Criteria Employed
1st category of CR centers	Group 1	• Potential users (more than 60) with high income
	Group 2	• The above criteria but outside of SENELEC plan
3rd category of CR centers	Group 4	• High possibility of productive use of electricity • Existence of local entrepreneur or NGOs • Relatively high economic strength of villages
	Group 5	• Existence of local entrepreneur or NGOs • Experience of village organization in social activities
	Group 6	• Relatively high possibility of productive use of electricity • Existence of local entrepreneur • Experience of village organizations in social activities
Satellite villages Around 1st center	Group 7	• Potential users (more than 30) plus local preference
	Group 8	• Potential users (less than 30)
Villages along existing line	Group 10	• Potential users (more than 30) plus local preference
	Group 11	• Potential users (less than 30)
Isolated villages	Group 12	• The same as Group 6
	Group 13	• The same as Group 5



(2) Application of SHS Market Concept

The preliminary survey of Kaffrine indicates the potential number of rural households to be electrified by SHS in accordance with RE modes (PPER or ERIL).

Community Rural	Mode	SHS Users According to Patterns								
		1	2	3	4	5	6	7	Max	Min
MBOS	PPER				300-400				400	300
GNIBI	PPER				300-400				400	300
BOULEL	PPER/ ERIL		200-250	200-300					550	400
KAHI	PPER					100-150			150	100
DIANKE SOUF	ERIL	150-200							200	150
M. HODDARr	PPER				300-400				400	300
N. GUENT	ERIL		200-250						250	200
D. MINAM	ERIL		200-250					30-50	300	230
Total									2,650	1,980

The term "potential users" means potential households to be electrified by SHS. They are estimated to be 2,650 at maximum and 1,980 at minimum in the survey area. The future SHS-based RE would be probably implemented on the basis of community rural. Perhaps a community rural might be the least unit to formulate a SHS project. The average scale of SHS users per project (or per community rural) in the survey area is estimated to be 330 at maximum and 250 at minimum. Perhaps such a range of project scale is assumed to be under annual capacity of a concession-holder of PPER or ERIL. In this study, the average scale of a project is assumed to be 300 on the average.

(3) Rural Electrification Programs of SHS

All Senegal is divided into 18 concession areas. The implicit order of tender call for concession areas is supposed to be:

No comprehensive explanation is made in the Manual as to how such a schedule is strategically formulated. In fact, the capacity-to-pay of users for electricity service is the most determinant factor for successful implementation of a concession-based RE. This is why the area of Dagana-Podor, endowed with rich users-to-be, was scheduled for the first tender call. Velingara-Kolda is to be under the scheme of French development assistance. The implementation order of tender call for concession would depend on socio-economic or external factors.

(4) PV Rural Electrification Plan up to 2015

The number of households to be electrified by SHS is estimated to be about 60,000 as of the year 2015, which corresponds to about 59% of potential demand (99,800) as of the year 2015. Electrification of 59,500 households will be les than the target (70,000) of PV RE proposed by the PASER. The number of CRs to be electrified turns out to be 199, which corresponds to 62% of the whole CRs.

Table 3.2 SHS Rural Electrification Programs

Concession	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	
1				300	→	→	→	→	→	→	→	→	→	→	→	3,600
2					300	→	→	→	→	→	→	→	→	→	→	3,300
3							300	→	→	→	→	→	→	→	→	2,700
4		300	→	→	→	→	→	→	→	→	→	→	→	→	→	4,200
5				300	→	→	→	→	→	→	→	→	→	→	→	3,600
6						300	→	→	→	→	→	→	→	→	→	3,000
7				240	→	→	→	→	→	→	→	→	→	→	→	2,880
8			300	→	→	→	→	→	→	→	→	→	→	→	→	3,900
9						300	→	→	→	→	→	→	→	→	→	3,000
10					300	→	→	→	→	→	→	→	→	→	→	3,300
11							300	→	→	→	→	→	→	→	→	2,700
12		270	→	→	→	→	→	→	→	→	→	→	→	→	→	3,780
13					214	→	→	→	→	→	→	→	→	→	→	2,355
14							300	→	→	→	→	→	→	→	→	2,700
15						300	→	→	→	→	→	→	→	→	→	3,000
16			300	→	→	→	→	→	→	→	→	→	→	→	→	3,900
17			300	→	→	→	→	→	→	→	→	→	→	→	→	3,900
18		300	→	→	→	→	→	→	→	→	→	→	→	→	→	4,200
		870	1,770	2,610	3,424	4,324	5,224	→	→	→	→	→	→	→	→	60,015

3.4 Financial Plan

The objectives of financial analysis are clearly different, depending on the role of stakeholders involved in implementation of RE. A concessionaire (private operator) would take interest in return of equity (ROE), and financial institutions definitely secure certaintly that both principal and interest are to be repaid as scheduled, given loan conditions. ASER as the government organ to give permission of RE business to concessionaires, will be responsible for selection of them and have to determine subsidy amount based on financial proposal, with an approval of the proposed pricing for "fee for services".

(1) Basic Conditions of Financial Analysis

The basic concept of the project formulation has been proposed in the previous section, which is based on and in accordance with the principle policy of ASER.

Referring to the role of the respective stakeholder, the basic conditions for financial analysis are as follows;

1) System Unit Cost

The majority of household demand for SHS is identified to be 55Wp. Financial analysis focuses on a unit of 55Wp, the cost of which is 450,000 FCFA.

2) Capacity to Pay

The monthly payment corresponding to "capacity to pay" depending on the average monthly expenditures for electricity-related appliances can be estimated by referring to the Nationwide Socio Economic Survey as a component of the JICA Study. Expenditures of energy items consumed by non-electrified village households (1,483 samples) are presented below. The whole samples (1,483) are divided into those by income class whose classification is the same as that employed to identify share of SHS users in income distribution. Yearly and monthly expenditures indicate the average figures of respective income class.

Table 3.3 Expenditures of Energy Items (Sample Survey)

Annual income category (,000FCFA)	Non-electrified village households		Cumulative (%) of income distribution	Annual expenditures of energy items (FCFA)	Monthly expenditures (FCFA)
< 300	488	(32.9)	32.9	24,989	2,082
300 to 600	96	(6.5)	39.4	29,066	2,422
600 to 800	425	(28.6)	68.0	37,907	3,158
800 to 1,000	155	(10.5)	78.5	49,310	4,109
1,000 to 2,000	126	(8.5)	87.0	63,702	5,308
2,000 to 3,000	156	(10.5)	97.5	66,922	5,576
3000 <	37	(2.5)	100.0	85,248	7,104
	1,483	(100.0)			

Source: Sample data of the Nationwide Socio Economic Survey (JICA)

Suppose that the share of SHS users-to-be in the upper income classes ranges 20 to 25%, they would belong to income brackets ranging from (1,000,000 to 2,000,000 FCFA) to (> 3,000,000 FCFA). The number of sample households covering these

income categories is 319, sharing about 22% of the whole samples. The monthly average expenditure of energy items of 319 samples is estimated to range between 5,000 CFA and 6,000 FCFA. The result indicates that the willingness-to-pay is averagely estimated to be around 5,700 FCFA nationwide. The willingness-to-pay is, of course, different by area, depending on energy expenditures and share of SHS users-to-be in income distribution. In this financial analysis, the range of monthly payment is assumed to be from 5,000 to 6,000 FCFA.

3) Scale of subscribers per project

The number of subscribers (installation units) covered by one project mostly ranges from 100 to 500, depending on size of population in community rurals. The scale of subscribers per project is assumed to be 300 for analysis.

4) Annual O&M expenses

Operation and maintenance cost per unit is assumed to diminish as the scale of subscribers increases. Annual O&M cost as % of initial investment cost by scale of subscribers is given below:

100 units	:	4.6%
300 units	:	3.8%
500 units	:	3.4%

5) Users' Contribution

Financial contribution	:	10% of the initial cost, called as "Initial Payment"
Institutional set-up	:	Establishment of village users association, called as VUA, under the initiative of the village community
Payment method	:	Monthly Payment shall be fixed by the operator subject to ASER's approval

6) Operator's Proposal

Operator's equity	:	15~20% at minimum, more than the users' contribution
Loan portion	:	Concessionaire loan from local financial institution financially supported by ASER

Subsidy proposal	:	Proposed as % of the initial investment cost with socio-economic analysis results for the target villages, referring to willingness to pay and capacity to pay
Structuring of VUA		Training schedule of technician of village community Method of bill collection and fee for technicians Maintenance supporting system
Cash-flow management		Secure the amount to be required for renewal of all equipment during the concession period of 20 years (tentative)

7) Role of ASER

Assessment of the proposal to be submitted by the operator

Selection criteria	ROE which be ranged between 15 and 20% (Provisional)

The pricing for "Fee for Services", such as initial payment and monthly payment, may be proposed under the following conditions;

1. Equity portion as % of the initial cost
2. Users' contribution as % of the initial cost
3. Loan amount and loan conditions such as interest, repayment period and grace period
4. Subsidy portion of % of the initial cost
5. Project management structure

(2) Financial Analysis

The financial analysis has been carried out based on the pre-conditions as shown on Table 3.4 and the summary results on Table 3.5. The calculation format is shown on annex A, in which the income statements, the cash-flow statements, and the balance sheets are presented over a concession period of 20 years.

The monthly payment, which corresponds to "Capacity to pay" depending on the average monthly expenditures for electricity-related appliances, shall be determined in due consideration of socio-economic conditions in the target village. On the other hand, the initial payment corresponding to 10% of the investment cost, is regarded as a pre-condition for initiation of this scheme.

Table 3.4 Pre-Conditions for Financial Analysis

1	Initial Investment Cost	135	Million CFA
2	Users' Financial Contribution (equal to Initial Payment)	10%	of 2. Initial Investment Cost
3	Operator's Equity	20%	of 2. Initial Investment Cost
4	Annual O & M expenses		
	100 Units	6.1%	of 2. Initial Investment Cost
	300 Units	4.6%	of 2. Initial Investment Cost
	500 Units	4.0%	of 2. Initial Investment Cost
5	Replacement Period		
	PV Module	20	years
	Charge Controller	10	years
	Battery	4	years
6	Interest Rate of Bank Loan	7%	
7	Interest Rate for Saving Deposit	4.25%	

(3) *Financial Plan*

ASER will be financially required to support implementation of SHS RE during 2001 – 2015. Here, to meet the policy target of ASER, the total PV units to be installed until the year of 2015 is estimated to be about 70,000. The financial requirement are estimated under the following assumptions;

1.	Capacity of SHS PV system	55	Wp
2.	Present unit price of SHS PV system	450,000	CFA
3.	Exchange rate (against US$)	750	CFA/US$
4.	Capital structure		
	Operator's equity	20	%
	User's contribution	10	%
	ASER's financial support	70	%
	Subsidy	(50	%)
	Loan	(20	%)
5.	Devaluation growth of CFA	Case I	0% p.a.
	(No change of exchange rate is applied for the years after 2011)	Case II	3% p.a.
		Case III	5% p.a.

In this analysis, the capacity of SHS PV system is assumed to be 55 wp, which is recognized to be rather popular in the developing countries and as well in Senegal.

The outputs are presented as total amount required to support the diffusion of SHS PV system over a period of 200-2015 and meet the policy target of ASER (Annex A, chart A-3).

The summary results of the financial plan are presented as below:

	Case I	Case II	Case III
Devaluation value	0% p.a.	3% p.a.	5% p.a.
Total amount (Million CFA)	26,460	33,795	39,726
Total amount (Thousand US$)	35,280	35,280	35,280

In the case III for the annual growth, 5% of currency devaluation, the accumulated financial support of ASER, including the technical support supposed to be equal to 20% of the financial support, has been estimated at about 39.7 million CFA, in which the exchange rate is 750 CFA/US$ and 1,222 CFA/US$ for 2000 and 2010, respectively.

As shown on the above results, the total amount required to meet the policy target of ASER will be influenced greatly by the exchange rate of CFA against US$, the former of which is rigidly linked to the French francs, eventually to the currency of Euro.

As discussed in the subsequent section the PV market in Senegal is very susceptible to the external economic and technology development. The management of currency exchange rate is beyond the power of ASER, even the government of Senegal. Therefore, it should be noted that the PV rural electrification is not a domestic matter and the implementation will be significantly affected by the external economic development, particularly the change in currency valuation.

Table 3.5 Pre-Conditions for Financial Analysis

Subsidy Rate	Fee for 5 years	ROE	Cash Position After 20 years	Fee After 5 years	Fee increase %	ROE	Cash Position After 20 years
50%	4,650	10.1%	-53.7 Million CFA	5,441	17%	16.9%	0.9 Million CFA
50%	4,890	15.0%	-29.5 Million CFA	5,379	10%	18.9%	4.2 Million CFA
50%	5,130	20.0%	-5.3 Million CFA	5,233	2%	20.8%	1.8 Million CFA

ROE: the internal rate of return on equity, is determined as the discount rate that equalizes the present value of the streams of financial costs represented by investor's equity, say "cash outflow" and profits represented by net income after tax plus (depreciation + amortization), say "cash outflow" in the international accounting standards, over a period of the project life.

Annex A

General Business Model

Chart A-1 Business Model (Draft) Total Management by Private Operator under Local Community Initiative
(PPER: Program Prioritaire d'Electrification Rurale)
(ERIL: Electrification Rurale d'Initiative Local)

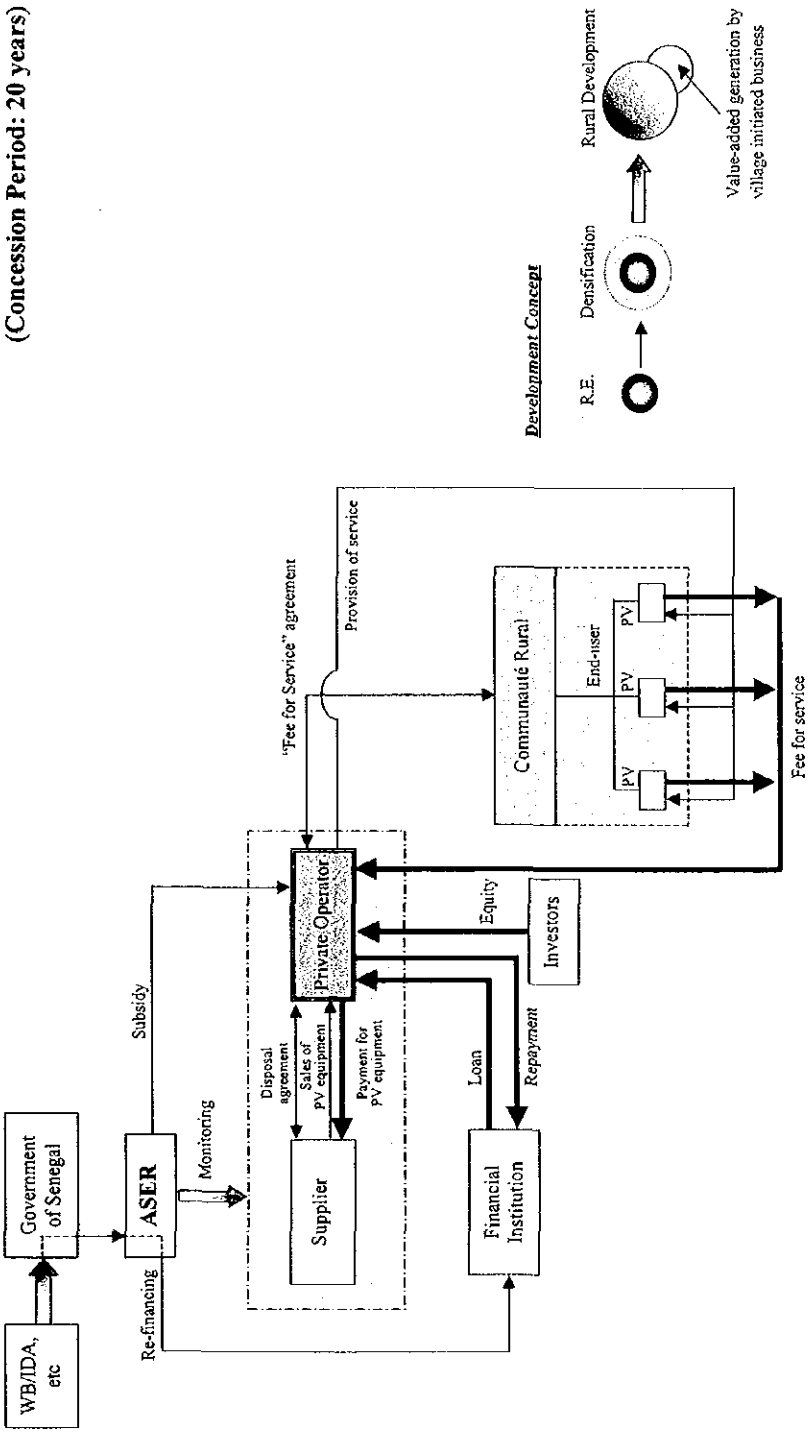


Chart A-2 (1) General Business Model : Summary of Financial Analysis

Chart Summary Table Operation & Management by the Operator over a Concession Period of 20 years

General Pre-Conditions		
System Unit (55 Wp)	300	Units
System Unit Cost	450,000	CFA
Replacement Cost	135.0	Million CFA after 20 years' operation

Fee for Service			
Period (Year)	Up to 5	6 to 10	11 to 20
Tariff (CFA/month)	5,130	5,233	5,233
		2%	2%

Initial Payment	
45,000	CFA/Unit

Replacement cost secured after 20 years

Case Study		Cash Position		Fee for Service (CFA/month)		
Subsidy Rate	ROE	After 20 years		Up to 5	5 to 10	10 to 20
50%	20.8%	1.8	Million CFA	5,130	5,233	5,233

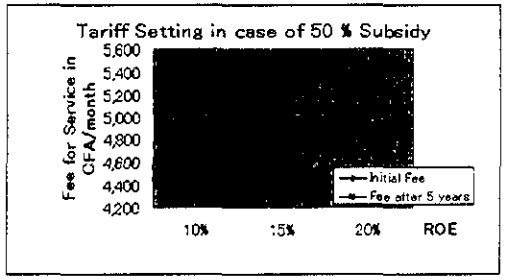
Subsidy Rate	Fee	ROE	Cash Position after 20 years		Fee after 5 years	%	ROE	Cash Position after 20 years	
50%	4,650	10.1%	−53.7	Million CFA	5,441	17%	16.9%	0.9	Million CFA
50%	4,890	15.0%	−29.5	Million CFA	5,379	10%	18.9%	4.2	Million CFA
50%	5,130	20.0%	−5.3	Million CFA	5,233	2%	20.8%	1.8	Million CFA
30%	5,920	20.1%	6.6	Million CFA	5,802	−2%	19.1%	0.4	Million CFA
30%	5,670	15.0%	−16.6	Million CFA	5,954	5%	17.3%	2.9	Million CFA

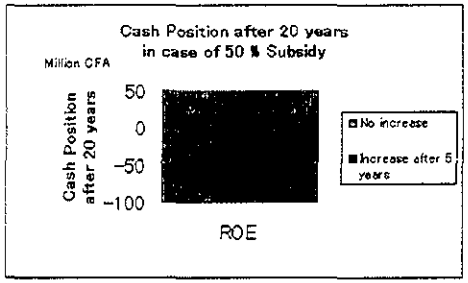
Tariff setting for 50% subsidy		
	Initial Fee	Fee after 5 years
10%	4,650	5,441
15%	4,890	5,379
20%	5,130	5,233

Cash Position after 20 years		
	No increase	Increase after 5 years
10%	−53.7	0.9
15%	−29.5	4.2
20%	−5.3	1.8

Subsidy = 50%
ROE = 20%
Cash Position on the positive side after 20 years

	Fee for Service		Cash position
	0 to 5	6 to 20	after 20 years
100	5,600	5,655	0.6
300	5,130	5,233	1.8
500	5,000	5,150	4.5





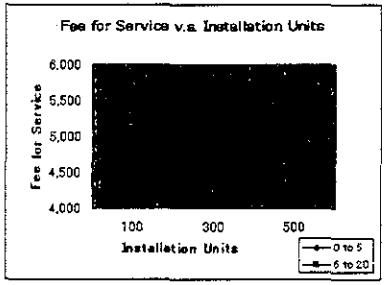


Chart A-2(2) General Business Model: Financial Analysis

Financial Model for PV Rural Electrification

1 English, 0 French (In case of liquidation)

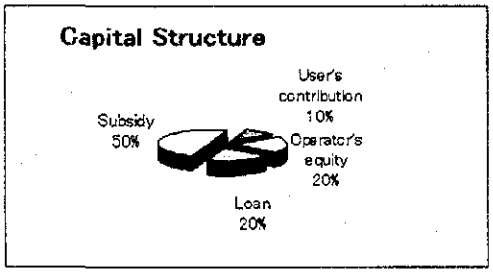
Pre-Conditions

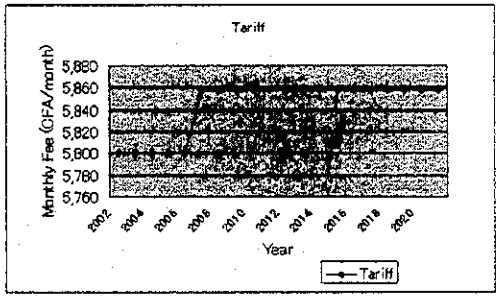
1 System Unit Cost (55 Wp) 450 (1,000 FCFA)

2 O & M Cost for Private Operator See "O & M and Renewal"

3 Capital Structure

Initial Investment Cost	135,000	0.21	US$ million
User's contribution	10%	13,500	
Operator's equity	20%	27,000	
Loan	20%	27,000	
Interest	7.0%		
Repayment	5,400	x 1,000 CFA/year	
Grace period	5	years	
Repayment period	10	years	





Subsidy 50% 67,500 ROE = 13.9% over a period of 10 years for the operator's profitability 94,500 Amount (= Subsidy + Loan) 15,000 Profit at sales

4 Others ROE = 17.7% over a period of 20 years for the operator's profitability without liquidation

Depreciation method A straight-line method

Income tax rate 0%

5 Tariff

up to 2006	up to 2011	after 2012	Tariff setting after 10 years
0%	1%	1%	← Increase in tariff after 10 years
5,800	5,858	5,858	

45,000 FCFA For the initial payment which may be regarded as 'User's Contribution'

OK 5,800 FCFA/Unit/month For the monthly payment

741,000 (Total amount of user's payment for 10 years)

5,924	Minimum Accu. Cashflow
5,924	Cash Position after 10 years
-43,980	For equity liquidation

4,787	Minimum Acc. Cashflow
4,787	Cash Position after 20 year

6 No. of Subscribers 300 Units

,where the amount required for replacement be secured, say, 135.0 Million CFA after reduction of the replacement cost 139.8

18,177 to secure the cash position on the plus side over a period of 20 years

7 Depreciation (US$ = 650 FCFA)

		FCFA/System	Life	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
														1	1	1	1	1	1	1
PV Module (Wp)	55	180,000	20	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Charge controller (A)	8	40,000	10	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Battery (Ah)	100	83,000	4	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750	20,750
Lamps	4	52,000	5	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400	10,400
Pole, Cable, etc.	1	60,000	20	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Installation, Transport	1	35,000	20	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
Sub-total	1	450,000		48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900
Difference		0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		450,000		48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900	48,900
		Depreciation		14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670

Chart A-2 (3) General Business Model: Financial Analysis

I.L 8	**Projection of Income**																		
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
	Fee Collection Ratio		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Revenue		18,468	18,468	18,468	18,468	18,468	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837
	Expenses Direct cost		5,112	5,112	5,112	3,600	3,600	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024
	Gross Profit	0	13,356	13,356	13,356	14,868	14,868	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813
	Depreciation		14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670
	Interest	0	1,890	1,890	1,890	1,890	1,890	1,890	1,512	1,134	756	378	0	0	0	0	0	0	0
	Net Profit	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	1,143	1,143	1,143	1,143	1,143	1,143	1,143
	Income tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Minimum income tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Net Income	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	1,143	1,143	1,143	1,143	1,143	1,143	1,143
	Accumulated Profit	0	-3,204	-6,408	-9,612	-11,304	-12,996	-13,743	-14,111	-14,102	-13,715	-12,949	-11,806	-10,662	-9,519	-8,376	-7,232	-6,089	-1,516
J	**Debt Financing**	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	20
	Loan at beg		27,000	27,000	27,000	27,000	27,000	27,000	21,600	16,200	10,800	5,400	0	0	0	0	0	0	0
	Repayment							5,400	5,400	5,400	5,400	5,400							
	Interest	0	1,890	1,890	1,890	1,890	1,890	1,890	1,512	1,134	756	378	0	0	0	0	0	0	0
	Loan at end	27,000	27,000	27,000	27,000	27,000	27,000	21,600	16,200	10,800	5,400	0							
H	**Cash-Flow Stream**	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
	Net income	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	1,143	1,143	1,143	1,143	1,143	1,143	1,143
plus	Depreciation	*0*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*	*14,670*
plus	User's contribution	13,500																	
plus	Equity	27,000										0							
plus	Additional equity (Work	0										0			0				
plus	Loan	27,000																	
plus	Subsidy	67,500																	
minus	Repayment	0	0	0	0	0	0	5,400	5,400	5,400	5,400	5,400	0	0	0	0	0	0	0
minus	Initial Investment	135,000										100%							
minus	**Replacement**		0	0	0	24,900	15,600	0	0	24,900	0	27,600	0	24,900	0	0	15,600	24,900	0
O	PV Module (Wp)	180,000																	54,000
	Charge controller (A)	40,000										12,000							12,000
	Battery (Ah)	83,000				24,900				24,900				24,900				24,900	24,900
	Lamps	52,000					15,600					15,600					15,600		15,600
	Pole, Cable, etc.	60,000																	18,000
	Installation, Transport	35,000																	10,500
	Profit for Supplier	0																	

Chart A-2 (4) General Business Model: Financial Analysis

			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
			450,000																	
H	Net Cashflow		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
			0	11,466	11,466	11,466	-11,922	-2,622	8,523	8,901	-15,621	9,657	-17,565	15,813	-9,087	15,813	15,813	213	-9,087	15,813
	Accu. Cashflow		0	11,466	22,932	34,398	22,476	19,854	28,377	37,279	21,658	31,315	13,751	29,564	20,478	36,291	52,104	52,318	43,231	106,484
	Deposit bank rate	4.25%		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	136,790
	% of the outstanding amount	80%			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
			-27,000	11,466	11,466	11,466	-11,922	-2,622	8,523	8,901	-15,621	9,657	-17,565	15,813	-9,087	15,813	15,813	213	-9,087	15,813
	Equity Portion		-27,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80%	Bank deposit effect for 80% of the outstandings			0	390	793	1,210	846	785	1,102	1,442	960	1,321	768	1,332	1,068	1,642	2,236	2,319	3,978
	at the beg. of the year Real Cash-Flow		-27,000	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	19,791
	Operator's ROE =	20.8%		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	136,790

			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
O	Profitability	5.0%	-27,000																	
		Profit at sale	0																	
	Operator ROE =		-27,000	0	0	0	0	0	0	0	0	0	0							
	(for 10 years)																			
	Equity owner		-40,500	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	19,791
	(for 20 years)	Accu. Cashflow		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	136,790

Liquidation of the operator's equity = 0

Cash outstandings after the liquidation = 22,598 27,000

	Balance Sheets	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
H.1	Loan	27,000	27,000	27,000	27,000	27,000	27,000	21,600	16,200	10,800	5,400	0	0	0	0	0	0	0	0
	User's contribution	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500
	Additional equity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Equity	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
	Retained earnings	0	-3,204	-6,018	-8,429	-8,911	-9,758	-9,719	-8,986	-7,535	-6,188	-4,102	-2,191	285	2,497	5,282	8,662	12,124	28,790
	Subsidy	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500
	Liabilities & Equity	135,000	131,796	128,982	126,571	126,089	125,242	119,881	115,214	111,265	107,212	103,898	105,809	108,285	110,497	113,282	116,662	120,124	136,790
	Cash	0	11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	136,790
	Assets	135,000	120,330	105,660	90,990	101,220	102,150	87,480	72,810	83,040	68,370	81,300	66,630	76,860	62,190	47,520	48,450	58,680	0
	Assets	135,000	131,796	128,982	126,571	126,089	125,242	119,881	115,214	111,265	107,212	103,898	105,809	108,285	110,497	113,282	116,662	120,124	136,790
												0	0	0	0	0	0	0	0

Chart A-2 (5) General Business Model: Financial Analysis

Cashflow Stream & Cash Position (Case 2)		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
(In case of no liquidation)	Cashflow	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	19,791
	Accu. Cashflow	11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	136,790

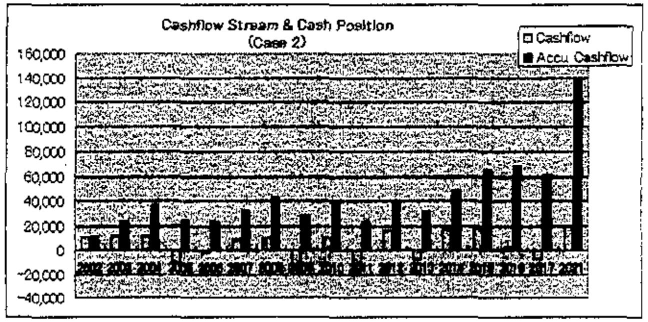


Chart A-3 General Business Model: Financial Analysis

Annex B — Pre-conditions

1 **Financial Plan for PV Rural Electrification** **Case III** — No. of total installation units : 70,000

1 English, 0 French — Subsidy rate : 50%

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Installation Units	(55 Wp)	1,000	2,000	2,000	2,500	2,500	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	70,000
Price of PV System in US$	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Exchange rate US$=	750	788	827	868	912	957	1,005	1,055	1,108	1,163	1,222	1,222	1,222	1,222	1,222	1,222	
Price of PV system in CFA	450,000	472,500	496,125	520,931	546,978	574,327	603,043	633,195	664,855	698,098	733,003	733,003	733,003	733,003	733,003	733,003	
Subsidy	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
Annual reduction in subsidy %	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Loan	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	
(Subsidy + Loan) (%)		70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	
Total Amount of Financial Support from ASER (A)	(Million CFA)	331	695	729	957	1,005	2,533	2,659	2,792	2,932	3,079	3,079	3,079	3,079	3,079	3,079	33,105
Total Amount of Technical Support from ASER (B)	(Million CFA)	66	139	146	191	201	507	532	558	586	616	616	616	616	616	616	6,621
(B)/(A) =	20%																
Total Amount	(Million CFA)	397	833	875	1,149	1,206	3,039	3,191	3,351	3,518	3,694	3,694	3,694	3,694	3,694	3,694	39,726
Exchange Rate US$ =	750	788	827	868	912	957	1,005	1,055	1,108	1,163	1,222	1,222	1,222	1,222	1,222	1,222	
Devaluation growth of CFA =	5.0%																
Total Amount	(Million US$)	0.50	1.01	1.01	1.26	1.26	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	35.3
Accumulated Amount	(Million US$)	0.5	1.5	2.5	3.8	5.0	8.1	11.1	14.1	17.1	20.2	23.2	26.2	29.2	32.3	35.3	

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Total Amount (Million CFA)	397	833	875	1,149	1,206	3,039	3,191	3,351	3,518	3,694	3,694	3,694	3,694	3,694	3,694	39,726
Total Amount (Thousand US$)	504	1,008	1,008	1,260	1,260	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	35.280
Installation Units	1,000	2,000	2,000	2,500	2,500	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	70,000
Accumulated Units	1,000	3,000	5,000	7,500	10,000	16,000	22,000	28,000	34,000	40,000	46,000	52,000	58,000	64,000	70,000	

Major parameters

Devaluation growth of CFA = 5.0% — 0.0% 3.0% 5.0% (No change of exchange rate is applied for the years after 2010)

Case Study		Devaluation growth of CFA	0%	3%	5%
5.0%		Total Amount (Million CFA)	26,460	33,795	39,726
39,726		Total Amount (Thousand US$)	35,280	35,280	35,280
35,280