CHAPTER 3 MANUAL FOR PROJECT OPERATOR

3.1 Manual of Planning for Rural Electrification by SHS

(1) The Beginning

This manual is focusing to provide a PV rural electrification project in ERIL type by a private operator in a remote area of Senegal.

In the manual of ASER has provided, when project promoter of ERIL project wanted to submit proposal, they can ask to support of expert for providing complete proposal.
The support of expert is providing for the items below:

- analysis of the solvable electricity demand and optimisation of the choice of concession areas
- selection of the electrification technical options
- identification of private operators
- fixing and negotiation of tariffs conditions to be included in the schedule of conditions attached to the license or concession
- preparation of the commercial scheme of the operator
- evaluation of the financial needs of the project
- definition of the clauses of the contract between the various actors involved in the project: contract between operator and users, convention between operator and local community, etc
- preparation of the application documents for ERIL licence and/or concession
- preparation of request application for ASER financing,
- preparation of promotion/advertisement campaigns or operations to attract new subscribers
- administrative procedures, namely in tax and costume services.

The cost of providing proposal by expert is subsidized by ASER as 70% maximum, but this subsidy has to refund after project is implemented.

But in general, project promoter or project operator will be better to provide the proposal by themselves to understand the situation of their project and this manual is not only for ERIL type project but also for the PV electrification in PPER concession applicable.

1) Use of PV Systems

The investigation of the It Power Ltd. (UK research company) shows demand is expected for 12GW in future 10 years concerning the market of the PV system in developing country. Demand for domestic electrification is expected to be the largest, next is education, then application to the pump.

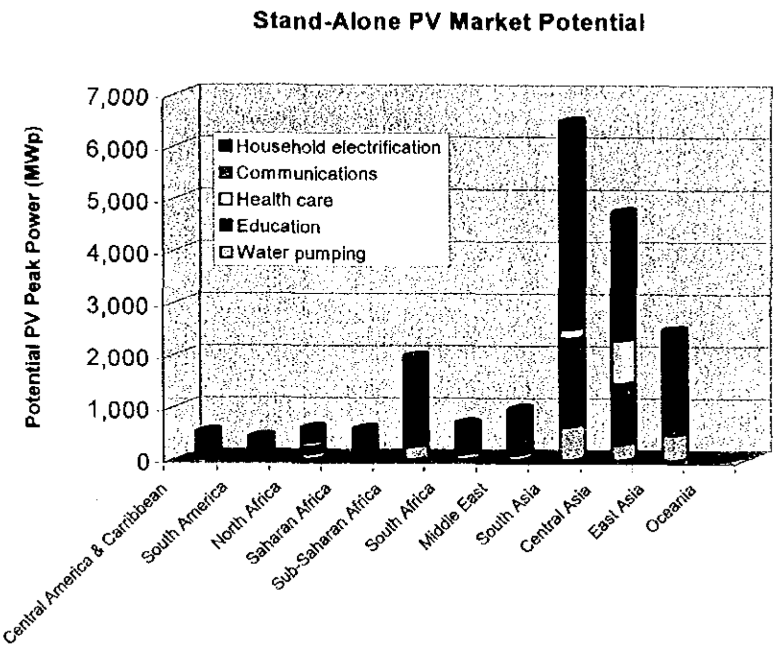

Figure 3.1 The Market of PV (It-Power)

2) Concrete Uses of the PV System in Developing Country

There are several items as concrete uses of the PV system in developing country as shown on Table 1.1. (Solar Photovoltaics for Sustainable Agriculture and Rural Development FAO 2000)

Among those, the direct objective of the rural electrification is the electrification for households. But when private companies try to implement PV electrification, they will spread their business in other market not only for the household electrification.

Table 3.1 Concrete Uses of the PV System in Developing Country

Agriculture	• water pumping • *electric fencing for livestock and range management*
Community	• water pumping, desalination and purification systems • lighting for schools and other community buildings
Domestic	• lighting, enabling studying, reading, income-producing activities and general increase in living standards • TV, radio, and other small appliances • water pumping
Healthcare	• *lighting for wards, operating theatre and staff quarters* • medical equipment • refrigeration for vaccines • communications (telephone, radio communications systems) • water pumping • security lighting
Small enterprises	• lighting systems, to extend business hours and increase productivity • power for small equipment, such as sewing machines, freezers, grain grinders, battery charging • lighting and radio in restaurants, stores and other facilities

Source: Solar Photovoltaics for Sustainable Agriculture and Rural Development FAO 2000

3) Measures of Utilization of PV System

To utilize PV system for rural electrification, there are several types of utilization system such as concentrating type (centralized type), independent type (stand alone type), battery charge station and hybrid type.

a) Concentrating type

Centralized generation of electricity system, it installs PV module and battery collectively to one place and distribute electricity by mini-grid in village(s).

It converts DC electricity to AC electricity and supplies each customer through lines at the same voltage as the electricity of the grid supplies then to be used it as usual electricity from the grid. As for size of system is from several kW to several hundreds kW, and as for number of connected users to the service network to be 10 - hundreds households.

The usual home electric appliances can utilize and machinery or equipment for small-sized business or pumping is possible to use.

b) Independent type

It installs PV module and battery for each individual households or facilities.

The generation and consumption of electricity are done by each system independently.

The size of system is to be from several dozen W to several hundreds W.

Electricity is supplied as DC 12V usually, but in some cases for larger capacities electricity is converted to AC by using inverter and can use common electric appliances.

It will be installed in household, schools, dispensaries, sales stores or restaurant.

The equipments to be utilized are light, audio-visual equipment such as radio, radio-cassette and TV or small refrigerator.

c) Battery charge station (BCS)

It installs PV module collectively and charge batteries that users bring into and after charging users bring back to their households and use electricity charged in the battery.

The voltage of battery is usually 6V or12V.

The size of system is to be from several hundreds W to around 10kW, it is decided by number of customers to join the project.

The capacity of batteries is several dozen Ah to 200Ah, it is limited by the battery weight that could be carried from households to BCS.

The available appliances are light, small audio-visual equipments.

The frequency of recharging is around once per one or two weeks according to the consumption of customer. It is recommendable that user connect battery to discharge controller for keeping the life of battery long.

d) Hybrid type

A PV generation is combined to a diesel generation, wind generation or micro hydro generation.

There are types of systems with battery and without battery and supplied electricity in DC or AC. The grid connected system is also one model of hybrid system.

The size of system is to be several hundreds W to several hundreds kW and both of concentrated or individual types are considerable.

The appliances to be used are according to the capacity of supplied electricity for each user that from only lamps available to usual home electric appliances available.

Selection of the type of the system is decided according to the electric utilization equipment of the user expecting, the electricity consumption quantity, possible amount of the payment and type of available energy of the area.

4) Estimation of customer

The number of expected customers will be disclosed in the LEP (the Local Electrification Plan) that the ASER will prepare for the area to be executed the electrification preferentially.

The items to be disclosed in LEP are:

1) Classification of the rural towns of the concerned area, namely on the basis of the following criterions:
   - number of town having more than 1000 inhabitants;
   - number of town having more than 1000 inhabitants located less than 2 km from the MV grid, or less than 2 km from a town having more than 1000 inhabitants and located less than 2 km from the MV grid;
   - number and population of town fitted with motorized borehole,
   - number of towns with less than 250 inhabitants, located more than 2 km from the MV grid or from a town of 1000 inhabitants;
   - dominant economic activities.

2) Detail map (1/50 000) of the area concerned by the LEP using the SIG data base of ASER, indicating the towns, its respective populations (number of inhabitants, of households and houses, growth rate), the access roads (roads, tracks), existing facilities or to be provided, liable to be electrified (boreholes, public buildings, health centres, etc.), the MV grid (existing or planed), existing generators and possible LV grids;

3) Survey capacity and willingness to pay electricity among sample households in each one of the towns having more than 1000 inhabitants and in ten other towns, to determine in a concise manner: (i) the current solutions (source of energy and appliances) used for lighting, audiovisual, refrigeration, freezing, air conditioning as well as the related expenditures (energy, maintenance, renewal cost); and (ii) the expectations of households, in terms of electricity service, depending on their financial capacities;

4) Evaluation of the community and productive needs: trade, craft art, agricultural yield and products processing, livestock, public buildings (administration, health facilities, schools, etc.);

5) A 1/5000 scale map of each one of all the towns having more than 1000 inhabitants, coming with a location using GPS of all possible public and private delivery points and if necessary draw LV grid;

6) Identification of possible environmental constrains that are typical to the concerned area: nature reserve, protected forest, vulnerability of water resources (surface and underground), protected built patrimony, etc;

7) Statistical analysis and set up of model electricity consumption referring the electrified towns in the same region or if not available referring to similar context, to result in realistic unit consumption hypothesis for households and community and/or productive users;

8) Identification and collection of information about ongoing and future rural electrification projects in the neighbouring areas, that might affect the development of electrification in the target area: MV grid extension, possible synergies, etc.)

9) Selection of least cost electrification options, brief designing of electrification systems to be installed to achieve (at minimum) the objectives of PASER in the area, while indicating namely:

- the number of towns that can be electrified by MV grid extension, and the characteristics (length, specifications) of the MV antennas and LV lines;
- number and characteristics (length, installed power and specifications) of small LV grid supplied from local generators while indicating the location of already existing motorized boreholes;
- number of towns that can be electrified by solar option, etc;

10) Evaluation of investment costs and operation of the various selected electrification systems, assessment of marginal kWh cost for each system and for the entire area and classification of the systems according to their implementation priority.

The number of estimated users of PV electrification will be clarified in clause nine (9) as the number of towns that can be electrified by solar option.

5) Flow of a Process to Provide a Project of PV Rural Electrification

The process of a private operator is going to implement an electrification project by SHS of a certain area is shown in Fig.3.2.

In the case of ERIL type project, the project promoter will be the project operator by themselves or select some another entity such as PV system supplier, expert, consultant or NGO as the project operator.

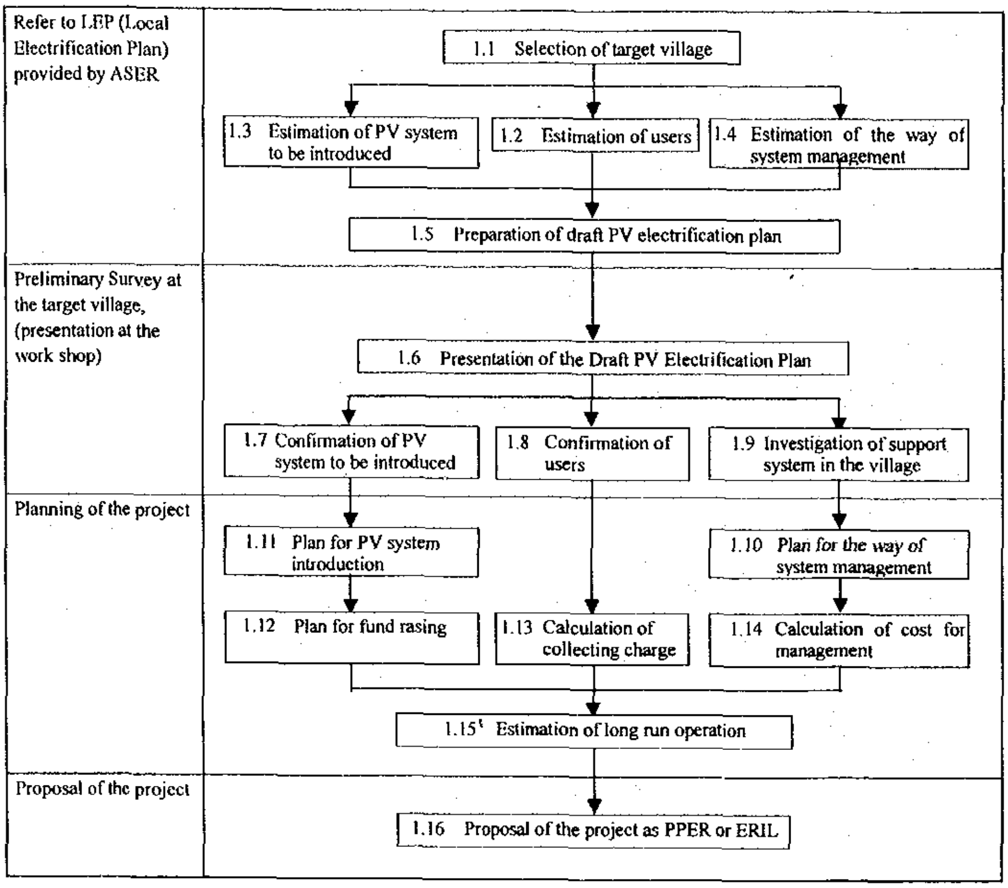

Figure 3.2 The process Flow of Planning Electrification by SHS

(2) Selection of an Objective Area (Villages)

In the case of ERIL type project, the proposed community will be the objective area and in the case of PPER concession, analyze the data of LEP (Local Electrification Plan) surveyed by ASER and select an area or villages to be electrified by SHS.

In LEP, villages that apart two km from existing grid and less than 250 in number of inhabitants are the objective village of SHS electrification. But by the study of JICA team, they presented the report "The study on PV Rural Electrification Plan in the Republic of Senegal, Implementation plan on PV Rural Electrification in January 2001" it assumed that the average consumption of electricity in household is 200Wh/day, the village apart from 0.6 km from existing grid and number of customer is less than 60 is supposed to be the objective village of SHS electrification.

It is preferable to implement PV electrification effectively that customers are concentrated in an area where the local technician can visit at least once in two months all customers for maintenance of the system and the number of customer for one local technician can maintain will be around hundred (100) in such area.

In general, if considers as the latent customer is a household who wants to use electricity, almost all of households of non-electrified villages are to be latent customers, but considering as the electrification is a business of private organization, the customer should be possible to purchase PV system or able to pay for electricity charges.

From the economic point of view, the target area or village should be positive in economic activity and comparatively rich in larger income families.

(3) Estimation of Customers

Method to estimate the number of latent customer in an area is explained in the report mentioned above, it is estimated by data of :

- Cost of grid extension, cost of diesel generation and cost of PV generation
- Number of households in the village
- Distance from existing grid
- Distribution of income in the area
- Distribution of excess income
- Daily consumption of electricity

By the report, it supposed the cost of 30W SHS system is 350,000FCFA and 50W SHS system is 450,000FCFA, the latent customer who can pay the 10% of the system cost as initial payment is estimated in each regions. The estimated number of latent customer is shown on Table 3.2.

But this table only shows the estimated number of latent customer in regions and not for each villages or limited areas.

It is difficult to estimate the number of latent customer in each villages, it will be done to listen or collect information from the local community offices or key persons who are well informed in the situation of areas or villages.

Table 3.2 Estimation of Latent Customer in Regions

Region	Department	No. of CRs	No. of Village	No. of Customer	Total in Region	30W	50W
Dakar	Rufisque	1	7	164	164	5	159
Diourbel	Bambay	12	413	3,696	7,607	447	7,160
	Diourbel	10	341	2,254			
	Mbacke	11	275	1,657			
Fatick	Fatick	14	203	3,941	10,912	377	10,535
	Foundiougne	9	302	3,534			
	Gosas	12	273	3,437			
Kaolack	Kaffrine	21	842	9,770	19,273	1205	18,068
	Kaolack	9	405	4,122			
	Nioro du Rip	11	453	5,381			
Kolda	Kolda	13	679	2,835	9,370	986	8,384
	Sedhiou	20	574	4,585			
	Velingara	10	424	1,950			
Louga	Kebemer	16	777	3,549	11,801	1574	10,227
	Linguere	17	653	4,414			
	Louga	15	741	3,838			
Saint Louis	Dagana	6	261	1,777	6,649	782	5,867
	Matam	12	276	3,071			
	Podor	10	158	1,801			
Tambacounda	Bakel	10	402	1,983	7,305	769	6,536
	Kedougou	10	222	1,461			
	Tambacounda	13	739	3,861			
Thies	Mbour	8	150	2,091	8,400	600	7,800
	Thies	9	356	2,703			
	Tivaouane	14	849	3,606			
Ziguinchor	Bignona	15	280	3,374	5,182	451	4,731
	Oussouye	4	65	898			
	Ziguinchor	5	67	910			
Total		317	11187	86,663	86,663	7,196	79,467

Source: Implementation plan on PV Rural Electrification January 2001 (JICA study team)
30W: Number of potential customer who can purchase PV system capacity 30W
50W: Number of potential customer who can purchase PV system capacity 50W
From this survey result, there are 87,000 potential customers for 30W to 50W system and in that number 80,000 are possible to purchase 50W system

(4) Estimation of the PV System to be Introduced

1) Estimation of Electricity Consumption

Electricity consumption is estimated from an estimation of appliances to be used and hours to be utilized them.

The appliances to be used are supposed as lamps, radio, radio-cassette, TV, refrigerator, washing machine, fan and pump, but for SHS, objective appliances might be limited as lamps, radio, radio-cassette and TV.

JICA study team implemented the socio-economic survey of 1,670 households in whole Senegal by entrusting to a local consultant in 2000. From the survey we can find several factors for rural electrification, such as :

a) Number of lamps

Distribution of number of lamps in households is shown on Table 3.3. The average number of lamps per household is around four, but the households that have two or three lamps are main parts in the distribution.

Table 3.3 Number of Lamps in households

No of	No. of Lamps														
Room	1	2	3	4	5	6	7	8	9	10	11-15	16-20	>20	N.A.	Total
1	16	2			1				1					6	26
2	55	76	13	1							2			11	158
3	28	92	109	17	4	1		1						18	270
4	14	52	93	104	16	3	2					1		11	296
5	8	35	58	46	60	7	2	3			2			11	232
6	9	25	22	39	22	53	4	3	1					11	189
7	4	6	11	20	26	5	26	4	2					4	108
8	2	7	12	12	19	9	7	15	3		3			3	92
9		2	4	13	5	2	3	6	6					6	47
10		5	5	7	4	7	6	3	1	7			1	5	51
11-15	1	2	6	11	12	13	7	6	4	11	18	2		5	98
16-20		1	3	2	4	4	2	3	1	1	5	4	1	7	38
>20			2	1	1	2	1			3	5	2	7		24
N.A.	3	13	7	6	2	2	1	1			1	1		5	42
Total	140	318	345	279	176	108	61	45	19	22	36	10	9	103	1,671

Source: Socio-economic survey by JICA study team in 2000

b) Possession of electric appliances

Possession of electric appliances classified by region is shown on Table 3.4.

By this table, most of all households have radio or radio-cassette and even the number of them in each households is more than one, for radio the average number for each households is 1.6 and radio-cassette is 1.8.

The ratio of possession TV is different according to the region but willingness to have TV is high, the ratio in future will increase rapidly.

Table 3.4 Possession of Electric Appliances (%)

Region	Refrigerator	Fan	Radio casset	Radio	Stereo system	Color TV	B/W TV	Others	No of HH
Diourbel	0.5	0.0	31.7	61.1	0.5	0.5	1.8	0.0	221
Fatick	0.0	0.6	21.1	39.4	1.1	1.1	2.2	0.0	180
Kaolack	0.5	0.0	34.3	51.2	0.0	1.0	0.5	1.0	201
Kolda	4.1	2.1	71.3	40.5	3.1	4.6	9.2	0.0	195
Louga	1.1	0.6	81.1	64.6	0.6	10.3	18.3	0.6	175
Saint Louis	1.4	1.4	73.3	53.4	1.4	8.2	13.7	1.4	146
Tambacounda	7.3	0.9	67.5	50.0	2.6	10.7	11.5	3.8	234
Thies	0.5	0.0	36.2	49.7	0.0	0.5	3.0	1.0	199
Ziguinchor	0.8	0.0	35.8	65.0	0.8	4.2	3.3	4.2	120
Whole country	2.0	0.6	50.1	52.2	1.1	4.5	6.9	1.3	1,671

Source: Socio-economic survey by JICA study team in 2000

c) Using hour of appliances

Hour of using kerosene lamps is surveyed and numbers of lamps that are used per day less than four hours and more than four hours are nearly equal, and the hour of using gas lamp is nearly four hours, then consider the average using hour for lamp is to be four hours.

Using hour of TV, radio and radio-cassette is not clear in this time, we will suppose it as four hours per day.

In case to substitute candles, we recommend to use LED (Laser Emission Diode) lamp that it is very low electricity consumption

d) Example of electricity consumption

The examples of electricity consumption type are estimated as below:

Type 1 : Five lamps, color TV, radio, radio-cassette

Type 2 : Three Lamps, B/W TV, radio-cassette

Type 3 : Two lamps, four LED lamps, B/W TV, radio-cassette

Type 4 : Two lamps, B/W TV

Electricity consumption of each type is calculated on Table 3.5.

Table 3.5 Example of Electricity Consumption

Appliances	Consumption	Using Hour (Hr)			
	(W)	Type 1	Type 2	Type 3	Type 4
FL lamp 8W	8	4	4	4	4
FL lamp 8W	8	4	2	2	2
FL lamp 8W	8	4	2		
FL lamp 8W	8	2			
FL lamp 8W	8	2			
LED lamp	0.7			8	
LED lamp	0.7			8	
LED lamp	0.7			8	
LED lamp	0.7			8	
TV color	30	4			
TV B/W	12		4	4	4
Radio-cassette	10	4	4	4	
Radio	5	4			
Total consumption	Wh/day	308	152	158.4	96

2) Decision of System Sizing

Basic system sizing is designed from the irradiation of the site, capacity of PV module for generation of electricity and capacity of battery for storage of the generated electricity.

a) Irradiation

The irradiation is varied by the season and site, the PV system should supply enough electricity even in the worst month of the irradiation.

The irradiation also change by the tilt angle of PV module that receives irradiation. The irradiation that PV module receives is maximized when the tilt angle is equal to the latitude of the site of PV module is installed, both in total annual irradiation and in the lowest month. Some example irradiation of location in Senegal are shown on Table 3.6.

Table 3.6 Irradiation in Senegal (Horizontal and 15° Declined)

Location	Tilt	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kaolack	0	4.87	5.73	6.07	6.55	6.32	5.71	5.18	5.39	5.50	5.45	4.89	4.43
	15	5.76	6.46	6.48	6.63	6.16	5.50	5.05	5.41	5.73	6.01	5.61	5.30
St.Louis	0	4.14	4.95	5.90	6.41	5.98	5.59	5.43	5.28	5.38	5.10	4.60	3.75
	15	4.91	5.61	6.34	6.53	5.88	5.43	5.32	5.31	5.65	5.66	5.41	4.50
Kedougou	0	5.28	5.95	6.11	6.50	5.94	5.59	5.31	5.08	5.43	5.52	5.19	4.89
	15	6.22	6.68	6.50	6.56	5.78	5.37	5.16	5.09	5.64	6.07	6.03	5.84
Dakar	0	4.67	5.36	6.23	6.69	6.24	5.87	5.29	4.87	5.36	5.33	5.11	4.28
	15	5.54	6.06	6.67	6.79	6.10	5.67	5.17	4.91	5.61	5.90	6.00	5.14

Data: by Siemens

From this table, the lowest irradiation of tilted surface in Senegal is in December at St. Louis, it is 4.5kWh/m^2/day.

b) Capacity of PV module

Capacity of PV module =Consumption of electricity/(Irradiation x Total efficiency)

Total efficiency = Efficiency decrease by PV module temperature (0.9) x Charging efficiency to battery (0.8) x Loss of cable and others (0.9) = 0.65

c) Capacity of battery

Capacity of battery = Electricity consumption x Non-sunshine day/(Efficiency of battery discharge x Depth of discharge)

Efficiency of battery discharge = Loss of charge controller (5%) + Loss of wiring (5%) =0.9,

Non sunshine day = assumed as three days,

Depth of discharge (DOD): Solar type battery = 80%, Automotive type battery = 50%

Calculated capacities of PV module and battery for consumption types mentioned above Table 3.6 is shown on Table 3.7, supposing the lowest irradiation as 4.5kWh/m2/day and depth of discharge (DOD) 50%.

Table 3.7 Capacities of PV Module and Battery

		Type 1	Type 2	Type 3	Type 4
Consumption of electricity	Wh	308	152	158.4	96
Capacity of PV module	W	105	52	54	33
Capacity of battery	Ah	171	84	88	53
Recommended capacity of PV module	W	100 or 55 x 2	50 or 55	50 or 55	30 or 36
Recommended capacity of battery	Ah	200	100	100	50 or 60

There will be many combinations of capacities for PV module and capacity of battery.

The project will provide a several kind of systems to apply the demand of customer.

Customer will select the system by considering their electricity consumption and their ability of payment.

3) Estimation of Payable Amount of Customer

It is an important condition to design system to know the payable amount of customer for SHS.

In the case of estimation the number of potential customer in Table 3.2, premises for customer is who can pay 10% of system cost as initial payment or down payment from their excess income. For monthly payment, it will be covered by the expense of kerosene and dry batteries for lamp and radio or radio-cassette. They will be substituted by electricity generated from introduced PV system.

In LEP the expense for kerosene and dry batteries will be surveyed, but JICA study team had surveyed in socio-economic survey mentioned above. The data is shown on Table 3.8.

Table 3.8 Expense for Lighting and Dry Batteries Classified by Annual Income and Number of People in Household

People in H.H	Annual income (1,000FCFA)							
	<300	300−600	600−800	800−1,000	1,000−2,000	2,000−3,000	>3,000	Average
Sumple	495	490	160	130	195	66	71	
<6	26,650	30,715	28,062	99,920	47,294	50,300		31,492
6−10	33,708	41,224	49,712	51,281	99,727	75,722	97,686	46,590
11−15	38,681	46,978	54,445	60,003	66,188	43,607	79,067	48,990
16−20	42,834	45,830	82,037	74,519	97,982	98,554	101,443	66,023
21−25	42,051	62,093	126,236	99,982	95,762	95,469	136,307	88,499
26−30	77,185	80,964	34,560	214,200	84,043	143,200	186,825	115,896
31−35	153,360	92,400	163,980	178,800	251,000	60,600	101,810	148,347
36−40		154,200	95,700	122,400	62,700	220,733	201,283	165,263
>41	65,580	251,980			368,500	128,344	207,507	184,572
Average	34,848	45,880	65,392	74,749	91,973	93,392	141,549	57,437

Source: Socio-economic survey by JICA study team in 2000
Mainly they are expenses of kerosene for lamps and dry batteries for radio and radio-cassette.
The expense increases as annual income increase and number of people in household increase.
It can be estimate the expense for lighting and dry batteries is more than 7,000 FCFA per month for the households that regarded as the potential customer of SHS electrification (annual income is more than 1,000,000FCFA).

(5) Consideration of the Method of the Management of SHS Electrification

There are several methods to introduce PV systems in rural areas. It will be separated in four methods, as cash and credit sales, leasing and fee for service styles.

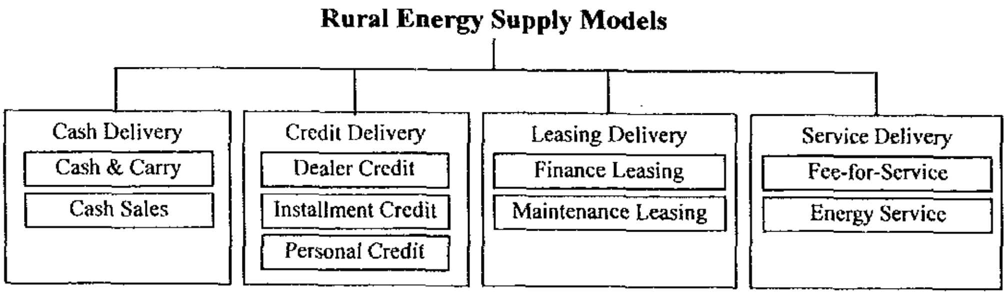

Fig. 3.3 Rural Energy Supply Model by ISES Fraunfofer Institut Solare Energie Systeme

a) Cash delivery: Sell PV system by cash. Method of installation and maintenance is decided by negotiation of seller and buyer.

b) Credit system: Sell by credit. There are different systems who provides credit, installation and maintenance during credit term will be negotiated with seller and buyer.

c) Leasing delivery: Lease PV system for a long term with leasing fee, installation and maintenance during term of leasing made by leasing company. The obligation of renewal of system parts is decided in the contract.

d) ESCO delivery: PV system is installed at customer's house, but it belongs to the service company. Service Company does maintenance and renewal of system parts. Customer pays installation fee and monthly fee for energy service he enjoys (electricity).

It is compared the sell delivery and ESCO delivery of PV system. It is concluded that the ESCO delivery will be better than sell delivery for PV system introduction.

Table 3.9 shows the reason of why ESCO method is recommended as the management system for PV electrification.

Table 3.9 Comparison of Selling Delivery and ESCO Method for Implementation of Rural Electrification by PV System

Problem by Selling Delivery	Solution by Introduction of ESCO Delivery
Customer will be limited in the wealthier people who can afford high price of PV system or installment of credit in two or three years term.	ESCO can provide low interest loan and offer relatively low monthly service fee for electricity service. The system cost of PV system is expected to decrease by scale merit of purchasing of ESCO than individual purchase.
Transaction costs are high. Because the market for selling PV systems is a small segment of the rural population and widespread in an area.	Transaction cost can decrease as latent customer increase by affordable service fee in a limited area and can find enough customer to introduce ESCO system
Preferable preventive maintenance is difficult to expect as people not tend to pay for maintenance after purchase. Without prefer maintenance, a life of battery will be shortened.	In ESCO system, a local technician will maintain batteries periodically as preventive maintenance and keep the system condition better.
In sales delivery, people tend to buy cheaper system that will be consisted from smaller size of PV module, battery and low quality components.	In ESCO delivery system, PV system will be designed to reduce total life cost considering the size of PV module and battery and the quality of system components.
In sales delivery, people tend to purchase cheaper and low quality system components when they have to renewal and it will reduce the life of the PV system.	In ESCO system, components for renewal are standardized and stocked. It will be renewed in short period after request of renewal.
People will abuse the system that they own. When they own the system no one constrain them to abuse the system	In ESCO system, ESCO can confiscate the system when people abuse or alter the system without permission of ESCO and local technician is watching as he visiting customers for maintenance.
People will hesitate to purchase the system as they expect the grid will extend in near future then the PV system they bought turns to useless	When grid extended, ESCO will collect systems and stop collecting fee then re-install them for other un-electrified area.

Credit delivery is nearly same as cash delivery when credit term is short, leasing delivery is similar with ESCO delivery during the term of leasing except repurchase of system when the term of lease has been over.

When ESCO system is established in the area and people well understand the PV system, it is possible to introduce cash delivery system if people wants and ESCO will accept a request of maintenance with fee.

(6) Draft proposal of PV Electrification Project in the Area

1) Estimation of Customer

As for the project, it is necessary to implement with certain number of customer in the area.

It is recommended around 300 customers will be a proper number as implementing a project, they can spread in a few villages in the area but will be covered by one local operator and three or four local technicians.

One local operator will manage three to four local technicians and each local technician will maintain for 70 to 120 PV systems in villages they cover.

2) Design of PV System

Design of PV system to be introduced is started by selecting system components considering the conditions of area or villages. System components are PV module, PV module support, charge controller, battery, lamps and others.

Detail specifications are decided in the section 1.11 system introduction plan referring to the ASER Manual Vol-II "the Technical Minima".

a) PV module

PV modules are categorized according to their materials and structures. They can be broadly categorized into the silicon group, which is based on silicon materials, and the compound group, which is based on compound semiconductor materials. It is shown on Fig 3.1.6-1.

Categories of Solar Cells

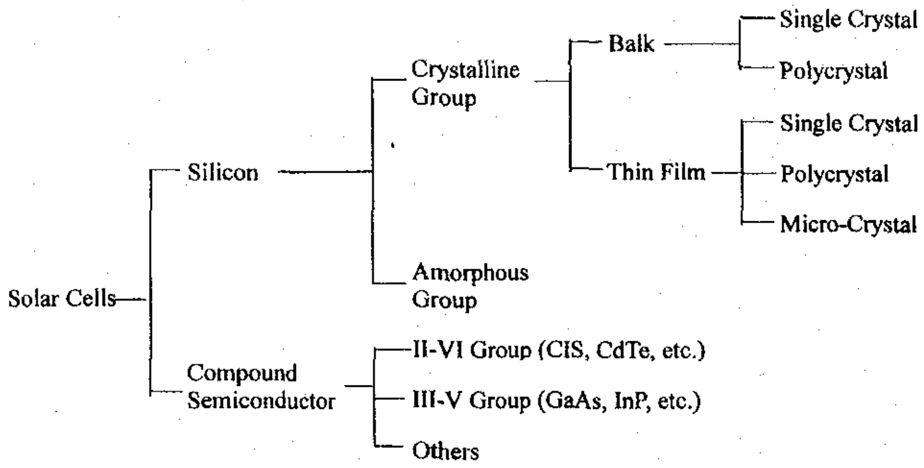

Figure 3.4 Categories of Solar Cells

The silicon group is sub divided into the crystalline and amorphous group, and the compound group into the II-VIgroup (CIS, CdTe, etc.), theIII- V group (GaAs, InP, etc.), etc.

The commercial PV module is mainly based on silicon group, such as: single crystalline, multi crystalline and amorphous ones, the size of PV module is normally 50 to 200W/module.

Amorphous silicon module is for smaller capacity 20 to 30W/module

Typical module efficiency is:

Single crystalline:12 to 15%, multi crystalline: 11 to 14% and amorphous: 5 to 7% and manufacturers are guarantee its efficiency for 10 to 15 years.

b) PV module support

There are several types of PV module mounting methods such as: set on a roof type, pole mount type, set on the ground type and wall support type.

The method will be decided by the situation of houses the PV system to be installed.

Structure of roof or wall is tough then roof top mount and wall support mount is available and if they are not tough enough adopt pole mount or set on ground type.

c) Charge controller

To maintain battery for its expectable life, charge controller should be installed in the system to prevent over charge and over discharge of battery.

There are two types of charge controllers, the semiconductor and mechanical relay type.

Semiconductor type uses power MOS transistor to control switching action and some models use a microprocessor to control advanced functions such as correcting temperature deviation.

Most of this type shorts a PV module during HVD (High Voltage Disconnection). This is called the shunt type and produce heat during HVD. Therefore, it is necessary to assemble with heat sink to radiate the generated heat.

Mechanical relay type uses relay to control switching action in shunt and series types. Its functions are simple and it is relatively strong against surge voltage caused by lightening.

Recently, Pulse Width Modulation (PWM) technology is introduced to control charge current by varying pulse width and time. When the battery is discharged, the pulse width is practically fully on all the time. As the battery voltage rises, the pulse width is decreased, slowly reducing the magnitude of the charge current.

This PWM type can be applied to either shunt or series type control. Greater control over exactly how the battery approaches full charge is possible, and less heat is generated as well.

Recently, a new type of controller is introduced that the pre-payment system is added to charge controller and it regulate the supply of electricity to loads by checking the inserted pre-paid card or medal is effective or not. The pre-paid card or medal is provided at retail shops or KIOSK in villages near customer and customer can purchase medal or renew pre-paid card by paying some money when they want to use electricity. The supplier of system collects money from retail shops or KIOSK, it will be easier to collect fees than collect from each customer.

d) Battery

There are several types of battery and their characteristics are shown on Table 3.10 and11.

Battery is very important component in the PV system. It is required deep discharge level, long life and easy maintenance. The solar battery and sealed (gelled) type battery are developed for use in the PV system.

The selection of solar type or sealed type battery is according to the situation of the project. If there are local technicians who can maintain systems periodically, then open type solar battery is preferable. But systems that without local technician and customers maintain them-selves, it is better to take the sealed battery of maintenance free.

Table 3.10 Characteristics of Batteries

Type of Battery	Use	Characteristics
Automotive battery	Starting cars and lorries	Optimized discharge large current in short time and recharge soon after then
Traction battery	Electric vehicles	Designed to deep cycle discharge and tend to lose water at a faster rate
Stationary battery	Emergency system, telecommunications, etc	Low self discharge rate and long cycle life with shallow cycle discharge
Solar battery	PV system	High cycle life for deep discharge. Distilled water consumption is low and self discharge rate is low
Sealed or gelled battery	PV system	Reduce the gassing(electrolysis of water) to a minimum that omits the process to top up by water. No spillage of battery liquid when turn over it. No maintenance battery

Source: Rural Lighting A guide for development workers Intermediate Technology Publication

Table 3.11 Life and Approx Cost of Batteries

Type of Battery	Self Discharge	Depth of Discharge	Cycle Life	Calendar life	Approx Cost (<100Ah)	(>100Ah)
	%/month	%	Number	years	US$/kWh	US$/kWh
Automotive battery	30	20 80	300-600 20	1-3	100-150	80
Traction battery	5-7	80	1500	4-6	200-400	200
Stationary battery	3	50 80	3000 1200	5-10	300-400	250
Solar battery Low antimony	1-3 3	50 80	3000 1200	5-10	250-350	200
Sealed or gelled battery	2-6	20 50	400-1500 400-1000	4-8	150-500	200

Source: Rural Lighting A guide for development workers Intermediate Technology Publication

e) Lamps

Lamps for PV system are usually fluorescent lamps or compact fluorescent lamps (CFL). CFL works in the same way as standard fluorescent tubes, the main difference being that CFL tubes are smaller and tubes are folded over and sometimes mounted in pairs.

Two main CFL types exist:

Integral type: ballast built into the base of lamp

Modular type: ballast is separated with lamp tubes

Characteristics of fluorescent lamps and CFL are shown on Table 3.1.2.

Table 3.12 Characteristics of Fluorescent Lamps and CFL

Items	Fluorescent Lamps	CFL	Incandescent Lamps
Luminous efficiency	35 to 78 lm/W	48 to 80 lm/W	8 to18 lm/W
Power range	4 to 125 W	9 to 23W for integral type 5 to55w for modular type	0.75 to 1000 W
Life	5000 to 8000 h	8000 to 10000h	15 to 1000h
Power requirement	AC from 100V upwards DC from 3V upwards with inverter/transformer	AC from 100V upwards DC from 12V upwards with inverter/transformer	AC or DC, from 1.5V upwards
others	Not good for short duration lighting	Not good for short duration lighting	Light for very short period

Source: Rural Lighting A guide for development workers Intermediate Technology Publication

f) Cables and others

Sizes of cables in system should be considered to limit a voltage loss in a specific range and choose insulating and coating materials for indoor and outdoor use.

Battery box with lock is sometimes adopted for safety of customers and prevention of direct connection to batteries.

Switches, outlets and junction boxes are sub components for wiring.

3) Estimation of PV System Cost

System cost is estimated by accumulation of system component cost and transport/installation cost.

Components cost varies according to specification and purchase conditions. Specification will be considered not only initial payment but also life-time cost of the system.

Graphs show a distribution of prices of main system components in Senegal in 1999

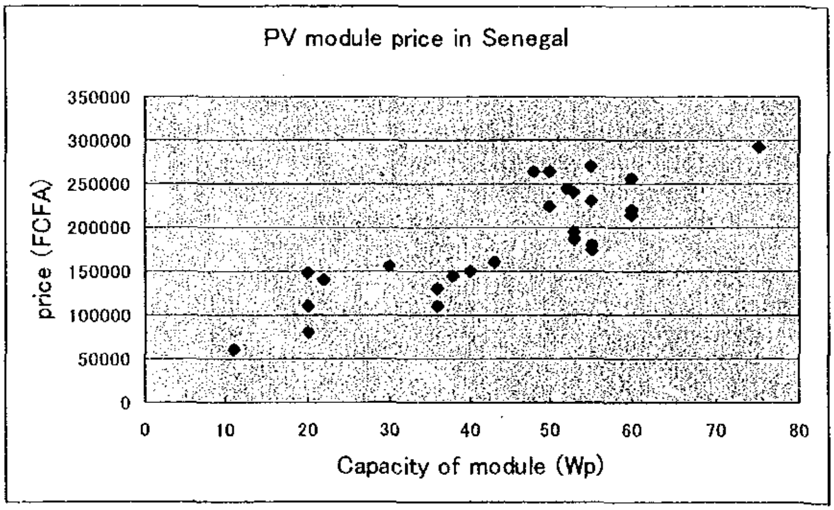

Figure 3.5 Distribution of Prices of PV Module in 1999 JICA (Provisional Survey)

Price of PV module is proportionate with its capacity. Unit price for Wp of PV module, at 30Wp class is about 8US$/Wp and at 50 to 60Wp class is 5 to 7 US$/Wp.

The delivery price at manufacturing factory is estimated about 4 US$/Wp then a margin for PV module will be 1 to 3 US$/Wp. The ex-factory price in 2005 and 2010 is expected as 3 US$/Wp and 2 US$/Wp respectively, then price in Senegal will be 4 to 5 US$/Wp in 2005 and 3 to 4 US$/Wp in 2010 respectively.

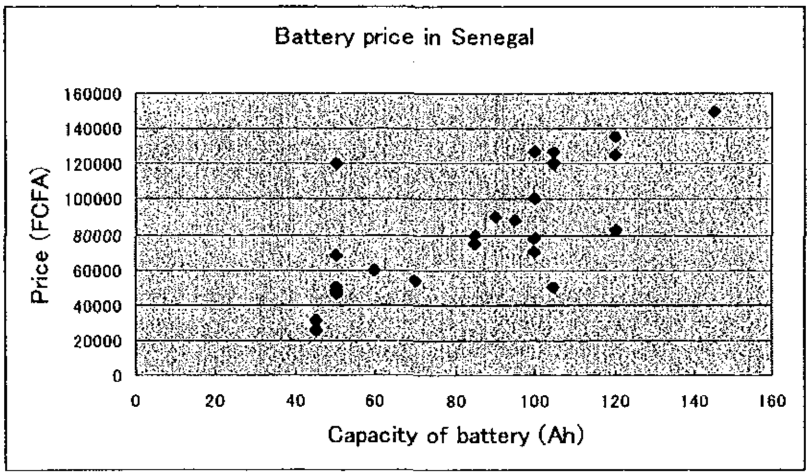

Figure 3.6 Price Distribution of Battery in 1999 JICA (Provisional Survey)

Price of battery is also proportionate with its capacity, but they differ in same capacity by their types such as, automotive type is cheaper than solar type and closed gel type is more expensive than open wet type.

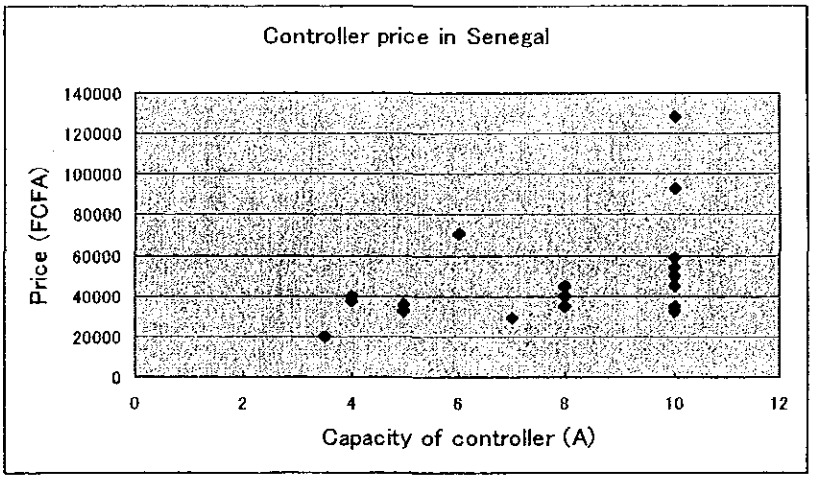

Figure 3.7 Price Distribution of Charge Controller in 1999 JICA (Provisional Survey)

Price of charge controller is not clear to proportionate with its capacity. The deviation of price in same capacity is large according to their specification and brand name. Charge controller is an important component to decide the performance of the system, it is recommended to choose well adopted one in PV market.

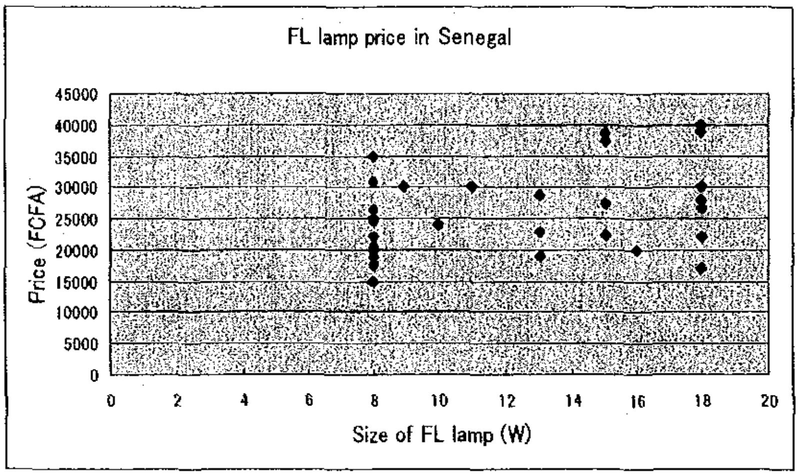

Figure 3.8 Price Distribution of Fluorescent Lamp in 1999 JICA (Provisional Survey)

Distribution of price of fluorescent lamp is not proportionate with its size. The price difference between same sizes will be caused the type of lamps such as ordinal type and compact type. In case of ESCO, the cost for renewal of lamps is covered by customer then cheaper ordinal type is adopted usually.

The other components of PV system are support of PV module, cable for wiring, switches and outlet for appliances are also available in domestic market.

4) Estimation of Management Cost

Estimate a management cost of ESCO system. It is preferable to manage PV ESCO project independently, but in the early stage, it seems difficult in private company to manage only one or two projects independently. Except local technicians the other persons are counted as part-time engagement for the project and add 20% of direct personnel cost as expenses for executing the management.

The example of management cost for 300 PV systems is shown on Table 3.13.

Table 3.13 Example of Management Cost

Personnel	Number	Engaged for PV (%)	Unit Cost (FCFA/month)	Annual Cost (FCFA)
Manager	1	20	500,000	1,200,000
Accountant	1	20	200,000	480,000
PV Engineer	1	50	200,000	1,200,000
Assistant	1	50	100,000	600,000
Local Technician	3	100	50,000	1,800,000
Total				5,280,000
Expenses Cost	20% of personnel cost			1,056,000
Grand Total				6,336,000
Per one system				21,120

Table 3.14 Personnel in Management Organization and Their Job Description

Personnel	Job Description
Manager	Planning of the project, Explanation at the site, Implementation and management of the project, Negotiation with ASER/VUA
Accountant	Purchase of material, collection of fee, Payment of expense, Control of budget, Management of deposit (Fund for renewal)
PV engineer	Decision of system specification, Support of purchasing, Check of material, Check of installation work, Treatment of system trouble, Training of local technician, Education of customer, Renewal of system components, Confiscation the system from un-paid customer
Assistant	Assistant for PV engineer, Management of reserved material, Book keeping for system, Book keeping for local technician
Local technician	Maintenance of PV system, Check of customer's way of utilization, Collection of user's comment

5) Rough Estimation of Collecting Fee

A collecting fee is roughly estimated from management cost estimated on Table 3.1.3 and annual depreciation cost on Table 3.15.

As an example of annual depreciation cost, 50W PV system, the system cost is estimated as 450,000FCFA. It is itemized and supposed life of duration is shown on Table 3.1.5.

Table 3.15 Example of Annual Depreciation Cost

System Components	Cost (FCFA)	Durable Years	Annual Depreciation Cost
PV Module (Wp)	180,000	20	9,000
Charge controller (A)	35,000	10	3,500
Battery (Ah)	73,000	4	18,000
Four Lamps	52,000	10 (Inverter)	5,200
Pole, Cable, etc.	65,000	20	3,250
Installation, Transport	45,000	20	2,250
Total	450,000		41,200

Sum of depreciation cost and management cost is 62,320FCFA, then monthly cost is 5,200FCFA. Calculate a long-term trial balance based on this amount as a monthly fee, considering a raising method of initial investment fund and amount of future re-investment and rate of returns then decide monthly fee to be collected.

Durable years of this table are one assumption for calculation and will be determined by the project operator with their quality and way of maintenance.

(7) Explanation of the Plan of Electrification by PV System

Visiting object villages or an area and explain the plan of electrification by PV system and method of management of operation. Survey the candidate of customer and their expectation for PV electrification. Items of explanation are:

1) What is Photovoltaic Generation and Reason to be Introduced in Objective Villages

The principle of PV generation, merit of PV such as it does not need to supply fuel as the energy source is sun, clean and safety, easy to installation, and demerit of PV such as the limitation of supply energy and less or no generation on cloudy or rainy days.

The reason to introduce PV system in this area, explain the grid extension or diesel electrification will be not expected in near future and better to enjoy the electrified life as early as possible.

2) Explanation of the PV System to be Introduced

If there is no PV system has introduced in the village or near area, people could not imagine what is a PV system. It is better to provide the model system to be introduced this area and show them what is the PV system and how work it especially the brightness and convenience of lamps is important to realize.

3) Explanation of Management System

In case of introduction of ESCO system, the difference from sell out system should be explained as the system will installed in customer's household but its belongs to the ESCO company, renewal of components is carried out by ESCO, regular maintenance is done by local technician hired by ESCO and customer use electricity from PV system with a little care for the system and pay monthly fee.

4) Explanation about Expected Fee to be Paid by Customer

Customer will be asked to pay initial payment to install PV system and after utilization of PV system regular monthly fee should be paid in regular terms. The amount of payment in this stage is to be a temporary and when project is decided to implement by agreement of ASER then contract with operator and customer conclude with final amount of payment.

5) Others

Explanation to select candidates of local technicians from the village or near areas

(8) Clarification of PV System Design

Clarify the system design to be introduced by considering the request from discussion at site.

Select the request that receivable and not.

(9) Clarification of Candidate Customer

Grasp a number of households who want to be customer of PV electrification. (register temporally)

(10) Survey of Support System at Village

Survey existing group or organization that will be possible to support an introduction or management of PV system at site. Or examine the possibility to organize candidate of customers to support themselves.

(11) Consideration for Structure of Management System

1) Structural Requirements for a RESCO (Rural Energy Service Company)

a) *Subsidies should not be provided for anything but capitalization. All operating and maintenance costs need to be covered by user fees.*

Virtually all rural electrification, whether grid based or independent, requires an initial capital subsidy. However, a continuing operational subsidy creates a dependency which has proven very difficult to break and can defer rather than encourage further economic development.

b) *Management needs to be professional and there must be readily available training for technicians at all levels.*

All businesses have this basic requirement but it is particularly critical for service oriented businesses. For trading businesses, profit or loss in the trade is immediately evident, in the service business profitability is determined only over the long term and requires better quality planning and control. A key issue also is the continuing availability of technical personnel to handle installation, maintenance and repair. The institution must be able to provide technical training to new personnel as growth and staff turnover occurs.

c) *There have to be enough customers to absorb the cost of the RESCO institution.*

Because of the need for professional management and qualified technical staff no matter what size the RESCO, the cost of establishing a RESCO to serve 100 households is not much lower than that to form a RESCO to serve 500. The per household cost seems to level out rapidly above 500 households (depending largely on customer density) and above 1000 customers, the per customer cost usually changes little. So the minimum successful size of an RESCO seems to be around 500 customers with larger numbers needed for long term profitability.

d) *Disconnects for non-payment of service fees MUST be enforced.*

Without enforcement, customers soon learn that they really do not have to pay in order to get service and many cease paying making the business unprofitable.

e) *Reventive maintenance is essential to cost effective operation. For solar RESCOs, a local technician which visits each site at least bimonthly is necessary.*

Solar PV systems are deceptive in their apparent simplicity. With only three basic components, the expectation is that little effort is needed for the operation and maintenance of a solar system. The reality, however, is not so simple. While it is correct that if quality components are provided, rarely do the panel or controller give problems even without preventive maintenance, the battery is not so forgiving. Since battery problems are usually the accumulation of many small problems occurring over a long time, when the battery is damaged enough to display obvious symptoms of trouble it is usually too late to do much other than replace the battery. Preventive maintenance is essential for maximum battery life and obtaining the lowest life cycle cost and highest system reliability.

f) *All components of generation and distribution must be owned and maintained by the institution with no user responsibility for other than proper use of the generated power.*

The RESCO must have an incentive to provide competent and frequent maintenance. If the RESCO will have to pay for the replacement of failed batteries, that incentive is there. If the user has ownership and is responsible for replacement, there is little incentive for the RESCO to provide the onerous and costly preventive maintenance which is required for long battery life.

g) *Some form of feedback directly from users to the institution is required in order to insure customer satisfaction and that the local technician is doing an adequate job of preventive maintenance.*

While a local resident technician is necessary to provide low cost maintenance services, supervision is difficult and expensive unless customers help insure that the local technician is indeed making the necessary visits and performing the appropriate maintenance. Relying on customer complaints has not been adequate, a formal mechanism for customer feedback ¾ such as a user's committee ¾ is necessary.

h) *There must be a sufficient geographic density of customers to allow a local technician to properly and cost effectively service at least 75 households.*

The only way low cost preventive maintenance can be provided is through the clustering of users so that visits can be made at low cost. In general, it is not cost effective for a local technician to have fewer than 50 systems to service and if the customer base is dense, one technician can handle as many as 150 systems per month.

2) Consideration Upon the Management

a) Employment of local operator or external PV engineer

Incase of the project site is far from the main office of the project operator, employ a local operator or an external PV engineer who has experiences on PV system operation and lives near the site. Entrust them a part of the management and operation of the project like repair of system trouble and training of local technician or fee collection.

b) Storage of spare parts

It is important to stock spare parts at near the site to shorten the time for repair the system trouble. Spare parts will be stock in the house of local technician or deposit them to retail shop in the site same as a fluorescent tube for replacement.

c) Storage of used battery

Used batteries are collected by project operator and treat them as neutralize the acid and stock them to prevent the contamination of water and soil

(12) System Introduction Plan

Redesign the PV system to be introduced for the project by detail design of each system components based on the recommended specification by the ASER manual Vol-II "Technical Minima" and collect cost estimations from PV system suppliers.

Calculate the true amount of initial investment value.

As for example, estimated cost of 50W system of 150 system in year 2000 is shown on Table 3.16

Table 3.16 Example of Estimation of System Cost

50W 150 System (year 2000)

Items	Specs	Price (FCFA)		
		A	B	C
PV module	50W	170,000	250,000	165,000
Support	Steel, Wall Support	30,000	20,000	25,000
Battery	100Ah/12V	75,000	100,000	72,000
Charge Controller	5A	35,500	24,000	29,500
Three Lamps,	8W FL	45,000	59,000	39,000
Miscellaneous	Cable, etc.	93,000	81,300	80,000
Installation		70,000	43,700	40,000
Transportation		6,000	2,000	2,300
Total		524,500	580,000	452,800

In case of JICA pilot project, final capacity of PV module was 55W and added another components such as LED lamps and battery case.

(13) Plan for Raising Fund for Initial Investment

An amount of initial investment is calculated from a unit cost of PV system multiply by a number of customers and add some reserves for additional expense. Project operator should provide initial investment and operational cost.

a) Equity : Project operator should provide a some part of initial investment by himself. The lower limit of equity is described in the manual of ASER. It recommends around 30% including initial payment of customer.

b) Initial payment of customer : To ask customer for initial payment is effective to increase their mind for participation to the project and confirmation of their financial pay ability.

In case of the grid connection utility company usually ask to pay connection fee for customer and customer should pay in-house wiring cost. In case of PV electrification, in-house wiring cost is included in the initial investment cost.

c) Subsidy : For proceeding rural electrification, the charge for customer would be lower the better, the loan and the equity of project operator would be less are desirable, to realize them ASER provides subsidy for initial investment. The upper limit of subsidy is described in the manual of ASER (35%).

d) Loan : Shortage of investment amount from equity, initial payment and subsidy will be covered by loans. Lenders will be commercial bank or domestic financial systems. But for the implementation of rural electrification, ASER will arrange loans in advantageous conditions of long term and low interest rate.

e) Others : Fund from international cooperation organization is expected as a support for initial investment.

(14) Calculation of System Management Cost

Calculate management cost of system management, it will consist from personnel cost of people in project operator, local operator and local technicians and expenses for operation and management.

Expenses are transportation and communication cost to the site and office, purchase, stock and renewal of system components, distilled water and grease for battery and so on.
In addition to above, indirect cost such as cost of office maintenance and distribution of administration cost would be assigned.

(15) Calculation of Collecting Fee

Calculate a long-term trial balance as centered on the rough estimated value of collecting fee mentioned in 3.1.6-(5) repeatedly and find final proper fee that can maintain system sustainable and payable by customer.

(16) Calculation of a Long-term Trial Balance

a) Calculation of initial investment : System cost x Number of introduced system

b) Decision of distribution for initial investment : Equity, initial payment of customer, subsidy, loan and conditions of loan(interest rate, term of pay-back and grace period)

c) Calculation of income : Monthly fee x 12 x Number of customer

d) Calculation of expense (Management cost) : Personnel x Engaged number x Unit labor cost x 12 + Expenses for O&M

e) Expense for renewal components : Cost of components at end of durable year x Number of customer(Cost is different by the year of purchase as expecting reduction of cost)

f) Depreciation : Initial purchased cost/durable years + renewal components purchased cost/durable years

g) Calculation of the balance of loan : Loan – Repayment
Repayment : Grace period = 0, after grace period = Loan/(Pay-back years – grace period)

h) Calculation of interest : Balance of loan x Interest rate

i) Gross Profit(Before depreciation) = (3)Income - (4) Expense(Management cost)

j) Net Profit = (9)Gross profit - (6)Depreciation - (8)Interest

k) Net Cash Flow = (10)Net profit + (6)Depreciation + Initial payment + Equity + Loan + Subsidy + Working Capital – Initial investment – Repayment - (5) Expense(Renewal)

l) Return on Equity (ROE) = The discount rate when the total summation of present value of equity and (11)Net Cash Flow becomes zero.

m) Financial Internal Rate of Return (FIRR) = The discount rate when the total summation of present value of outflow of cash ((1)Initial investment + (5)

Expense(Renewal)) and inflow of cash (Initial payment of customer + Subsidy + (9)Gloss profit) becomes zero

In this calculation of trial balance, try to find proper values for sustainable project by changing collection fee and ratio of Initial payment of customer, subsidy and equity.

The recommended rough target of ROE will be around 25% and FIRR will be 8 to 10%.

The example of calculation sheet of trial balance is attached.

3.2 Manual for Implementation Stage of the Project

(1) At the Beginning

This manual is provided for the case of an implementation of an ESCO style PV electrification in rural area of Senegal after the project operator had getting a license or concession of the project.

The manual based on the experiment that JICA pilot project has been implemented.
The outline of steps are shown on Fig.3.2-1

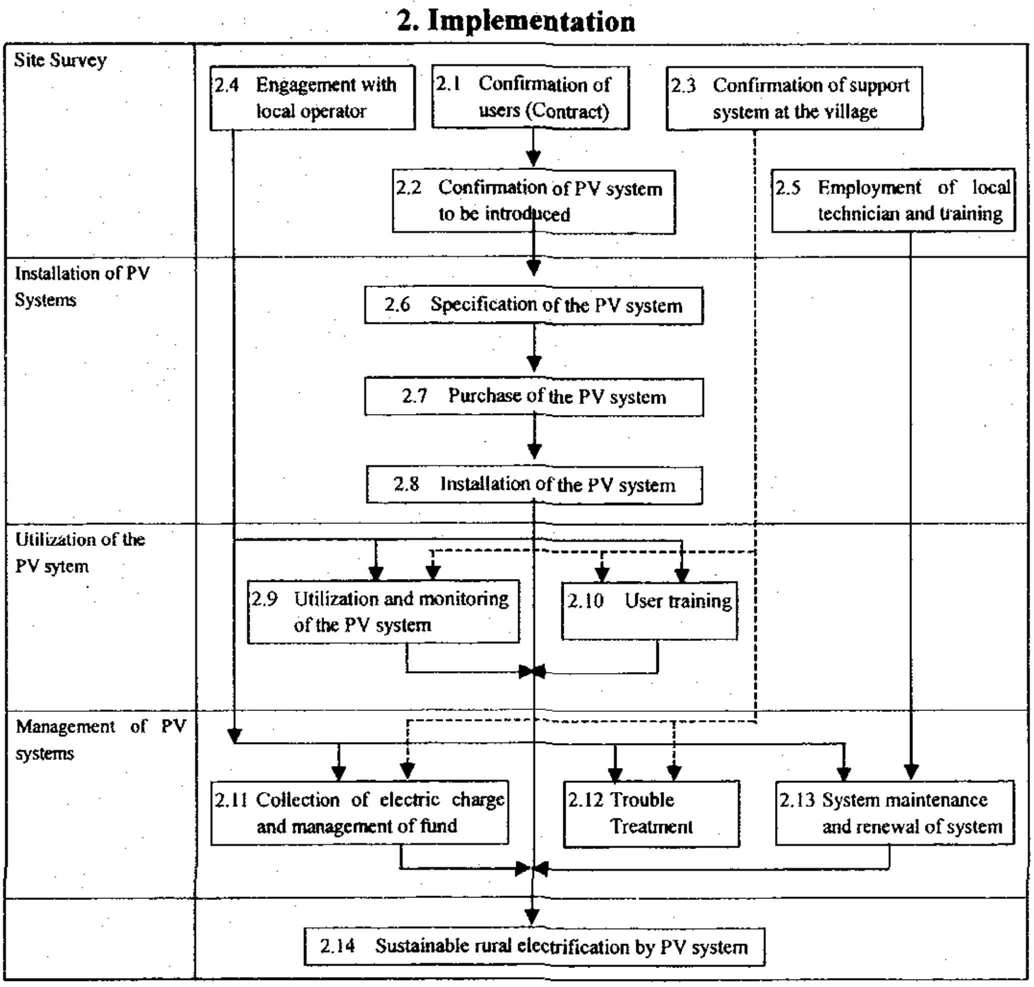

Figure 3.9 Outline Flow of Implementation Stage

(2) Confirmation of Customer

As the first step, confirm a number of customers to join the project with conclusion of contract.

1) Call for Customer

Call for customers who want to be supplied electricity by SHS in target villages or area of to be implemented the project. Before the calling, provide a contract paper based on the concept of the project then explain the project and the contract to customers with presence of leaders of the village and make the contract. If there are several types of PV system, explain the difference of types to customers as they can understand and choose of them.

2) Contract with Customer

To proof a capability of payment after installation of PV system, operator requests customers to provide initial payment and collect it at the signing of the contract.

It is necessary some terms for customer to provide the initial payment, the project operator may ask customer to provide a part of initial payment at the time of contract and later collect the rest.

This is an example of the contract of JICA pilot project had provided. The contract mentions about:

a) Name of the persons concerned
b) Outlines of the business of the contract
c) Description of system composition to supply service of contract
d) Object of the contract
e) Description of the concerned partners
f) Validity
g) Settlement of contentions
h) Penalty
i) Maintenance and repairs

j) Replacement of PV system components

k) Fee collection

l) Initial payment

m) Monthly payment

n) Notification of the repairing demand

o) Exclusion

p) Cancellation of the contract

q) Case of force majeure

r) Insurance

s) Accessibility

Attachment-1 (Contract on the PV Electrification in Mar Island)

(3) Confirmation of PV System to be Installed

Confirm the types and numbers of PV system to be installed.

In case of JICA pilot project, the result of customers' selection for three types of JICA offered is shown on Table 3.17.

Table 3.17 Offered Systems in JICA Pilot Project

Load	Electricity consumption (W)	Estimated use hours (Hr)		
		Type 1	Type 2	Type 3
Fluorescent lamp	8	3	3	3
Fluorescent lamp	8	3	2	3
Fluorescent lamp	8	3	2	
Fluorescent lamp	8	3		
Fluorescent lamp	8	3		
LED lamp	0.7			8
LED lamp	0.7			8
LED lamp	0.7			8
LED lamp	0.7			8
TV B/W	12		4	3
Radio	5	2	3	4
Total consumption	Wh/day	130	119	104
Number of customer		44	0	51

These types are based on the minimum irradiation in Senegal is assumed 5kWh/m^2/day and a calculated capacity of PV module in system is around 50W.

In the meeting of explanation at site, JICA team used an illustration to show what equipment can use how many hours per day in each types of the system.

It is better to show the system by model that a brightness of lamps is difficult to imagine by paper explanation.

The choice of customers concentrated on type 1 and type 3 that include many lamps in the system, as indicating that they want many lamps to light in the night because most of their household in pilot site are consist from many looms.

(4) Confirmation of Management Supporting System at Site

It is recommendable to organize customers group at site when number of customers in site over 20 or 30. Select leaders in the group and ask them to take care of the group such likes as an intermediary of operator and customer.

Roughly speaking the leaders of village are used to be a richer class and will be expected to become customers of PV electrification, they might be considered as liaison persons to inform a system trouble to the operator or check a working condition of local technician to the operator.

In the case to ask cooperation with responsibility, operator may have to provide some rewards for their cooperation

In the case of JICA project, it organized two associations i.e.VUA (Village Users Association) at the site of the project.

Expected cooperation works for them are:

a) Collect monthly fee from customers
b) Guide customers to pay monthly fee
c) Enlightenment and monitoring of customer for use of PV electricity in a monthly meeting

d) Watching of working conditions of local technician

e) Gather the requests or complains from users and inform them to the project operator.

(5) Engagement of local operator

In case of the office of the operator is far from the project site, it will be expensive to dispatch member of the operator so often. Then if there is a proper person or organization who have a lot of experiences in PV technology near the site, the company may engage those person or organization as a local operator to entrust a part of the management of the project.

There is a group of PV experienced work shops in Senegal called FOPEN-SOLAIRE dispersed in rural area of Senegal. They will be a candidate of a local operator.

Name of workshops of FOPEN and their location is shown on Table 3.18.

Table 3.18 Name of Work Shops of FOPEN-SOLAIRE and Their Location

Name of workshop	Place
AMICALE DES GROUPMENTS DU SECTUR DE FOUNDIOUGNE(AGSF)	Quartier Thiamene (Foundiougne)
ASSOCIATION REGIONALE DES AGRICULTEURS DE FATIK(ARAF)	Quartier Diakhao-Gossas (Fatik)
CULTURE FOR AFRICAN DEVELOPMENT (CAD)	Guediawaye (Dakar)
CENTRE CAYOR ENERGIE SOLAIRE (CCES)	Quartier Netti gouyes (Pekesse)
CENTRE DE PROMOTION ET DE DIFFUSION DES ENERGIES RENOUVELABLES (CPDER)	Croisement Ndiosmone (Tattaguine)
CENTRE DE PROMOTION ET DE DIFFUSION DES ENERGIES RENOUVELABLES DE KAOLACK (CPDERK)	Boulel (Kaffrine)
FRERES UNIS DE DIOULE (FUD)	Diakhao (Fatik)
GROUPMENT D'ASSISTANCE AGRO-PASTORALE (GAAP)	(Mbour)
UNION REGIONALE DES ASSOCIATIONS PAYSANNES DE DIOURBEL (URAPD)	(Bambey)
GROUPMENT DES JEUNES ARTISANS DE POUT (GJAP)	Pout (Thies)
UNION POUR LA SOLIDARITE ET L'ENTRAID (USE)	Nganda (Kaffrine)
G.I.E. REBUSSOISE D'EXPLOITATION (REBEXE	Medina (Dakar)

There are also several PV technicians in Senegal who have been trained and have a good experiences on PV /SHS , practiced in the study of GTZ or others.

They also will be a candidate of a local operator.

In case of JICA pilot project, the project operator engaged a local operator to entrust a part of the job of the project operator in pilot site.

The contract between the project operator and local operator is attached.

(Attachement-2 Contract between the project operator and local operator)

(6) Engagement and Training of Local Technician

A local technician is an important person to bring ESCO method in success. When a project is decided to go on, engage local technicians and train them with basic technology of PV system before installation starts then join them into the installation works of PV systems.

There are two cases to train local technician, one is train by operator themselves or train them in independent training facilities.

As a case of a PV system supplier comes to be an operator of PV electrification project, they have their own PV experts and it is possible to train local technicians in the company. There are two independent training centers in Dakar, one is CNQP and other is CFPT.

A comparison of these two institutions, CNQP is a basic technical training course and CFPT is higher technical and theoretical training of PV system, curriculum of CNQP seems enough for the training of local technicians to learn the basic knowledge about what SHS is.

A five days curriculum of CNQP for PV technician is shown on Table 3.19.

Table 3.19 Curriculum of Training for Primary Course of PV Technician

	Morning	Afternoon
Day 1	Basic knowledge about electricity	Handling of multi-meter
Day 2	Explanation of SHS	Explanation of illumination
Day 3	Renewal of SHS components	Installation of SHS
Day 4	Installation of SHS	Installation of SHS
Day 5	Maintenance of SHS	Maintenance of SHS

The contract between the project operator and local technician is attached.
(Attachement-3 Contract between the project operator and local technician)

(7) Specification of PV System Design

This is an example of system design for SHS. Components of system are shown on Table 3.20.

This system supplies services described in 2.2, the basic combination of capacities for PV module and battery is 50W class and 100Ah/12V

Specifications of system components are decided by referring to domestic and international standards and recommendations of experts in Senegal.

These specifications should be provided in the application form to be submitted to ASER for the permission of the concession of the project and ASER provided a reference manual to check the specifications as "Technical Minima" in their manual Vol-II.

Table 3.20 PV System Components

Components		Type 1	Type 3
PV module	Crystalline 55Wp	1	1
Support	Wall support	1	1
Battery	100Ah/C20	1	1
Battery box		1	1
Charge controller	PWM 10A	1	1
Fluorescent light	8W	5	2
LED lamp	0.7W		4
Outlet for radio	6V/9V	1	1
Outlet for TV	12V		1
Cable A	4.0mm^2 10m	1	1
Cable B	2.5mm^2 80m	1	1
Installation		1	1

1) Technical Specifications of Photovoltaic Module

Most of all former studies on rural electrification by SHS in Senegal have used a photovoltaic module of 50 Wp to improve a life style in remote area.

Recently technical innovation brought increasment of power for a unit of PV cell and the difference in price between 50 Wp module and 55 Wp module become small.

Therefore, 55Wp PV module would become major for 50Wp class of SHS in near future. The study team chose a photovoltaic module of 55 Wp.

The technical specification of PV Module has been specified in order to be sure that suppliers offer the PV modules in good quality. The specifications of a PV module have mainly specified type of cell, peak watt, performance at high temperature condition and outdoor exposure resistance.

The amorphous type module is omitted as it has not enough actual results of long time durability and its surface area is wider than crystal cells that the support should be tougher than crystal cells.

2) Support Structure of PV Module

As for support, there are several types such as, set on a roof type, pole mount type, set on the ground type and wall support type.

At pilot site, most of households have square walls and easy to hold a wall support to extend its top to over the roof then decided to adopt wall support type in pilot.

Because of Mar Island is surrounded by the sea, the support structure should have corrosion resistance.

The specification indicated the component to be used for the support structure, that is, rustproof steel, stainless steel and anodized aluminum.

In addition, support structure made by wood and plastics is generally available for SHS, though, this kind of support structure were excluded in this tender because the study team took into account of its reliability.

3) Technical Specifications of Battery

To select the type of battery, the open type of battery is chosen as the project is maintained by local technician periodically. Closed type battery (gel-type) is regarded as a maintenance free type but still expensive and life is shorter than well-maintained open type battery.

As a result of sizing battery, the study team requested 100 Ah of battery, of which capacity varies according to the discharge rate. The proposed SHS was adopted a battery rated at 20-hour rate of discharge for a maximum discharging ampere of proposed SHS was approximately estimated 5 A. 5A corresponds to 20-hour discharge rate of 100 Ah battery.

The technical specifications of battery have been defined from the aspect to make sure that the battery for the proposed system should have enough lifetimes under use of a deep cycle charge and discharge.

Besides, because batteries are sometimes placed within the reach of user's hands, there exist some risks like unauthorized change of system by users, an electric shock and other accidents.

The study team requested to prepare special battery box.

In the specification, the battery characteristics like voltage, capacity, density and volume of electrolyte, self-discharge rate are defined.

4) Technical Specifications of Charge Controller

Nowadays, a computer programmed Charge Controller is most reliable to prevent batteries from overcharging and over discharging. For the Pilot Project a computer programmed charge controller is also requested. The technical requirement of Charge Controller is defined concerning nominal current, operation current, voltage of cutting off charge and discharge, voltage of reconnection, temperature compensation of voltage criteria, polarity protection and exposure resistance.

5) Technical Specifications of Lamps, Ballasts and Fixtures

To make lamps work as long as possible, the quality of ballast inverter of fluorescent lamp is the most important factor.

From this point of view, the technical specifications are defined concerning voltage, nominal power, luminous efficiency, ballast wave shape, frequency of ballast, ballast efficiency and exposure resistance.

For LED lamp, nominal power and luminous efficiency are defined.

The fluorescent lamp is most weak point in the PV system that easy to failure, it is common case to use separate type of fluorescent tube and inverter ballast as the replacement of fluorescent tube paid by customer. The low quality of inverter ballast shorten the life of fluorescent tube and customer replace tube in short period, that make customer unsatisfied for the PV system.

Therefore, it is important to select the specification of fluorescent lamp in high quality.

6) Technical Specifications of Power Outlets

The power outlet for AC use and that for DC use are compatible, though, the polarity indication of outlet is necessary for DC use outlet.

Besides, the study team requested DC/DC converter, which converts the system voltage from 12V to 6V or 9V, for radio outlet for the purpose of aid for managing energy consumption of radio and radio cassette.

7) Technical Specifications of Cable and Accessories

The main point of cable specifications is to give suggestions to bidders to minimize voltage drop between tip to end.

Namely, the length and section area of cable is the main factor to be defined.

8) Datalogger System

In general, datalogger is not necessary for rural electrification but this pilot project set three dataloggers to survey the condition of electricity consumption of households.

Datalogger system is required to collect meteorological data and power generation/consumption data.

Only one of three sets of datalogger system measures and records meteorological data like irradiation and ambient temperature.

All datalogger systems installed to record the voltage of PV array and battery, and the current to the battery and loads.

The specification of datalogger system was referred to the specification of a world-famous datalogger.

The isolation amplifier had not included in the original specification but after installation of them, it found necessary to insert in the circuit of datalogger and we added later.
(Attachment - 4 Technical Specifications of SHS)

(8) Purchase of System

Purchase of system will be done according to the rule of the organization of providing the project.

Purchase will not be limited only from domestic market but can purchase from overseas.

In the case of supplier is a project provider some components will be supplied from their related organizations.

Here describes general flow of purchasing PV system.

1) Preparation of Purchase Specification

It includes not only technical specification but also terms of contract such as: method of bidding, timing, payment condition, quality assurance, after sales service and etc. too.

2) Open Bid or Bid by Nomination

Selection of the method of bidding. For JICA pilot project, adopted bid by nomination

3) Selection of Nominated Company (Organization)

Preparation of list of nominated company and send invitation for bidding

4) Explanation of Bidding

Explanation of specification and terms of contract

5) Bidding

Separation of technical bidding and price bidding

6) Evaluation of Bidding

Check technical bidding for every item to fit the specification or not.

Ask price bidding to companies who pass the technical bidding

7) Contract/order

Contract with a company who submit the lowest value

8) Delivery/inspection

Check quantity of delivered materials and inspect quality of them as they pass the specification.

In case of JICA pilot project, the inspection of qualities for PV module, battery, charge controller and ballast of fluorescent light were tested in the laboratory of CERER.

It is necessary to provide enough time to check the quality of components if confirm them by the test at laboratory.

In case of pilot project, the test results reported after installation completed and the quality of fluorescent lamp is not satisfied the specification in order.

After a few months of operation, failures of fluorescent lamp occurred in many systems and the life of fluorescent tube were very short and customers had to replace many fluorescent tubes by their own expense.

PPMC decided to replace all fluorescent lamp to new ones that satisfy the specification and supplier (=operator) agreed to replace them.

9) Installation

There are cases that a contract includes installation of systems or separately provide a contract for installation systems.

In case of JICA pilot project, it included installation of systems in the contract with components supplier.

Detailed instruction for installation is described in section 2.8.

10) Completion inspection

After completion of installation, check all systems and point out defects in installation if there are.

Systems pass the inspection after corrections of defects.

11) Receipt

Receipt all systems that pass completion of inspection

12) Guarantee

After delivery of system, during the terms described in contract, the supplier guarantee the quality of components and if the system downs by the fault of components the supplier will repair or replace the damaged component without additional payment.

(9) Installation of PV System

1) Decision of Arrangement of System in Household

For arrangement of system such as location of holding PV module, setting of battery and controller and location of fitting lamps are decided by discussion with each customer house by house.

Example of arrangement of system in household are attached
(Attachment-5 Plan Sommaire)

2) Installation of PV Module

Secure PV module support to the wall avoiding shades from building or trees and fix PV module then adjusts direction to face South correctly. The tilt angle is fixed by the support itself.

Introduce cable through wall to the position of charge controller is setting.

3) Setting of Charge Controller

Charge controller is set on the column or wall where customers are easy to watch and not too far from battery (less than 2m is recommended)

4) Setting of Battery

Battery is set at well ventilated and not disturbs a life activity of people in households, and adding to above, easy for maintenance of local technician is desirable.

5) Wiring of In-house

Connect controller to lamps, switches and outlets by wiring, it is better to extend wire horizontal and vertical correctly and fix it in regular intervals.

6) Connection Cable and Wire to Charge Controller

Connect cables from PV module, battery, wire from lamps and outlet to charge controller. Follow the sequence of connection to the direction that provided by manufacturer of charge controller.

7) Check the Installation Work

Check the installation work according to the check sheet as if the installation work is carried out by the direction of specification and if there are defects, point out and order to correct them.

Check the restoration of holes on the wall made by insertion of the cable of PV module into a room.

Confirm the collection of empty bottles used to carry an electrolyte for batteries to prevent a contact of children to a residue of acid.
(Attachment - 6 Acceptance Check List for installation)

8) Initial Charge of Batteries

When fill an electrolyte to battery, if battery dry-charged before shipping, it will indicate about 70% state of charge (SOC). It is recommended to charge battery in full SOC before connect to loads.

In Senegal, charge a 100Ah battery with 50W PV module from 70% to full SOC, it requires three to four fine days in series if connecting to charge controller.

In case of PV engineer stays at site, it is possible to shorten times to initial charge by connecting PV module to battery directly and check SOC of battery by measuring a voltage of battery terminals and specific gravity of electrolyte. (The procedure is described in technical specification of attachment-4)

9) Utilization of PV Electricity

Confirm the initial charge is completed, loads are connected and start to use electricity.

Details of using electricity are described in the user manual.

It explains customers that appliances to use and hours of using are limited and in rainy season, the generation will decrease and users may have days that they cannot use electricity.

(10) Monitoring of Utilization

It is necessary to know how customers use electricity for the management of electrification.

The local technician visits customers and maintains the PV system periodically, he may ask customers how they use electricity and what they feel for PV electricity and he reports them to the project operator.

In JICA pilot project, it installed three dataloggers in three customers PV systems. They can inform how PV systems work and how customers use electricity

(Attachment-7 Example of system working condition (Interim Data Collection))

(11) Customer Training

A project operator should enlighten customers how to use limited electricity supplied by PV system.

In the beginning, customers are difficult to understand how much electricity they can use actually.

They use much more electricity than PV system can supply and charge controller cut the supply of electricity or they too much suppress the consumption of electricity and they may waste a capacity of PV systems.

After repeated explanation of user's guide by operator and local technician or self-studying of customers they will become to use well of electricity from PV system.

The instruction of using PV system is provided by a project operator (See User's manual) and explained to customers how to keep PV system work well. Important items are provided as illustrations and put up it by a charge controller.

(12) Collection of Fee and Management of Fund

Collection of fee from customer is an important condition to sustain management of rural electrification.

1) Timing of Fee Collection

As timings of fee collection are considered as every month, every two months, every three months, half-yearly and yearly.

In same villages, the timing that customer can provide cash might be different and want to pay in different timings, operator will provide a different fee collection schedule for customers.

In case of JICA pilot project, it provides every month, every two months and half-yearly as fee collection schedule.

2) Collector of Fee

As for fee collector, there will be many cases such as: project operator dispatches its employee, local operator acts for project operator, local technician collects fee when he visits customers for maintenance, village supporting group collects fee and financing institution executes as an agency of fee collection.

A person who collect fee is expected to have some authority to force payment when customer tend to deny a payment.

In case of JICA pilot project, at first an accountant of project operator comes and collects fees but it needs a lot of expense to collect fees and changed to VUA collect fees and handed it to local operator, then local operator informs to accountant to come and get fees.

3) Increase Efficiency of Fee Collection

Notice the date of fee collection prior several days to customer can provide cash and some member of family should stay in house.

4) Action for Un-paid Customer

It is described on the contract that the operator would confiscate the PV system when customer un-paid in certain terms and the time limit of operator informs.

To success ESCO management electrification, it is important to minimize un-paid customer and for achieving this to show an enforcement of confiscation as a warning for other customers.

But effort to increase fee collection such as cooperation of village supporting group that they persuade un-paid customer to pay will be necessary too.

5) Management of Collected Fee

Collected fee will be used for daily management cost and fund for future renewal system components, the later should be managed separately to deposit in an account that operated with an interest.

As a management cost, it will be classified in items as:

a) Cost for local technician

b) Cost for local operator

c) Cost for project operator (transportation, communication, consumption goods, personnel expense, others)

For renewal:

a) Cost of renewal components

b) Cost for works of renewal

(13) Treatment of System Trouble

Objective of ESCO method is to supply good service and failure of electricity supply should minimize as possible and recover it as soon as possible.

In case of JICA pilot project, the light trouble should be fixed within three days and tougher trouble that PV expert has to treat it should be fixed within seven days from noticed by customer to operator are targeted.

To realize it, it is necessary to train local technician who can diagnose causes of trouble and technology to treat them and preparation of proper quantity of stocks for system components to replace.

As another case of trouble, customer has modified the system or adds another appliances without a permission of operator. Local technician has to insist restoration or confiscation of the system.

(14) Maintenance of PV System and Renewal of System Components

Local technician who stays in or near the site does routine maintenance of PV system periodically. In case of troubles that local technician cannot treat, PV engineer of operator will come and repair for them.

Daily maintenance is a checking of PV system periodically and try to find any troubles in the system and if find a trouble local technician try to treat it and when trouble cannot treat by local technician, he should inform it to PV engineer of operator.

Main job of daily maintenance is check of a battery condition. Levels of electrolyte in battery cells should be checked carefully and add distilled water to top up a normal level of electrolyte.

Maintenance done by PV engineer of operator is usually repair a down of the system caused by failure of system components and replace of system components will be the most effective action to treat a problem so operator has to keep proper quantities of stock of system components at or near the site.

When time is passed, system components aged and reach their durable years and increase a number of component to be renewal. A life of each system components is different by its condition of utilize and their original quality, then there will be distribution in their life as short and long.

To make exchange work simple and effective, renewal of components will be done in one time for certain components even if there still remains life in some of them.

(Attachment-8 Point for daily maintenance and check sheet Note on Maintenance)

(15) Completion of Sustainable Rural Electrification with PV System

Conditions to be satisfied for implementation of rural electrification with PV system

a) Customers satisfy to service offered and pay their fees

b) PV systems are well maintained by local technician and PV engineer of operator

c) Operator can manage its organization and renewal of system components within fees from customer

d) Operator can hold re-investment fund when concession terms completed

e) Operator enjoys enough return on its investment

f) Operator has willingness to invest same electrification project

g) There are customers who expect to receive SHS electricity and can pay fee for electricity.

CHAPTER 4 OPERATION MANUAL FOR THE GOVERNMENT INSTITUTIONS CONCERNED

In preparation of the manual for the government institutions concerned, the rural electrification is planned to implement by two options such as "Concession" method, called PPER and "proposal" method called as ERIL, under the initiative of ASER as an executing agency of the Ministry of Mines, Energy and Hydolaulics.

Our study is focused on PV electrification and PV electrification is expected as to be introduced mainly by ERIL scheme. Then in this chapter, the evaluation method for the project proposal of the ERIL scheme in the preparatory stage and the investigation and monitoring method for the implementation stage have been discussed to formulate the operation manual for the government institutions, mainly ASER concerned.

Reminder on ASER Procedures Relating to the Implementation of ERIL Projects

ERIL projects are projects initiated by grass root communities and contrary to PPER project, it corresponds to a bottom-up approach without any prior geographical planning.

For the implementation of ERIL projects, ASER will periodically launch tenders calls. The objectives of the tender will be :

- To promote local initiatives as far as rural electrification is concerned;
- To provide necessary support to those initiatives so that the latter could result in concrete and viable Rural Electrification Projects, that could later benefit from appropriate financing.

ERIL Projects will Concern

- Any kind of Rural Electrification Project outside the concession area of SENELEC and PPER projects;
- Any Rural Electrification technical options in cope with the technical minima set by PASER

Selection Criteria

For an application for assistance to set up of an ERIL project to be selected, it has to :

- Be in cope with the fields covered by the tender call;
- Be submitted by a Project promoter officially recognized and showing enough guarantees of solvency;
- Show evidences of real support from target local communities and populations;
- Show evidence of the commitment made by the Project Promoter as far as co-financing the requested support using his own funds.

4.1 Preparatory stage [Evaluation of the proposal]

- A first part describing the content of the application document for licence and/or ERIL concession: preliminary studies; the output of the awareness campaigns, of consultations; the application document;
- A second part describing the modes of evaluation of the information provided in the application document.

(1) Items and Documents in the Proposal to ASER

The application document will include the following elements:

- The output of the LEP, the information and awareness campaign ;
- The outlines of the project and the features of the Project Promoter;
- A feasibility study and a financial planning allowing the Project Promoter to apply for fund provision from ASER or other donors.

1) The Project Area

- The objective area of the project
- Justification of the selected target area

2) Project Promoter/Operator

- Name and corporate name of the project promoter
- Background
- Legal form, main members, partners and/or shareholders

- Immediate and long-term objectives
- Type of activities
- Available management capacities
- Name and corporate name of the potential operator(s) if different from project promoter
- Type of activities carried out by the operator
- Available management competences
- Available technical operation capacities
- Target objectives for personnel training
- Experiences of the operator as far as installation and maintenance of PV equipment and concerned.

3) Result of LEP Survey

- A set of 1/50,000 scale maps of target area or summary map in case of an isolated village. That summary map should make it possible to access the area of urbanization from target village.
- Socio-economic characteristics of the target area showing the various categories of household as distributed into homogeneous strata, in the target areas: type of habitat/income/equipment;
- Estimation of the number of users and predictions on the future evolution of the number;
- Type of organization existing in the target area (village);
- The main characteristics of the PV systems to be utilized.
- A classification of energy demand into homogeneous socio-economic group;
- A description of the electricity services liable to be supplied
- A description of the photovoltaic equipment;
- A proposal for tariff policy;

4) Information, Awareness and Consultation Campaign for the Beneficiaries

The objectives of the information and awareness campaign will be :

- To ensure the acceptation of the project by the target populations;
- To involve the target population in the selection of the main technical, financial and organizational options;
- To evaluate and integrate collaboration with the associations following a bottom up approach.

The target population needs to be sensitised on the proposed electricity service and mainly on its limits.

A model contract form to be signed by the operator and the users further to a prior agreement among them will be attached to the application document.

5) Proposed Products and Services

The proposed products and services will have to be in cope with the outlines of the LEP

- Target level of energy demand
  The demand level will have to take into account the solvent demand among the various socio-economic categories as defined in the LEP;
- Proposed ranges of system capacity
  Various ranges of capacities can be offered depending on the level of the identified demand. However there should not be more than three levels of capacity.
- Justification of the proposed ranges of system capacities
  The proposed capacity ranges will be justified on both technical and economic scales.

  The Project promoter will have to show evidence that the proposed capacity ranges are in cope with both the needs of the target users and their payment capacity for the services provided with the various capacity ranges.
- Technical characteristics of the proposed PV equipments
  The components of the electrification systems to be installed within the scope of ERIL projects must be in conformity with the standards commonly accepted (technical minima of volume II of ASER procedure manual)

The Project Promoter shall attach the application document for concession, the related information to the specifications of the proposed photovoltaic equipment.

The typical technical specification sheets are attached as attachment-9

6) Impact of the Proposed PV Systems on Environment

The installed equipment shall not represent any threat on environment. The Project promoter will make some proposal regarding the collection system of the components liable to affect environmental equilibrium: batteries; electronic components etc…

7) Proposed Implementation Plan

- Selection of dissemination procedure
- Justification of selected dissemination procedure
- *Time schedule of project implementation*
- Procedure of purchasing, installation, operation, maintenance and fee collection of project.

As regards the implementation of the project, the Project Promoter will propose:

A planning for the procurement of the equipment.

The project promoter will submit a proposal on the procedure for the procurement of the equipment if the operator is not same as the supplier.

He will make proposal relating to the procedure for acceptance in the warehouse of the supplier.

A planning for the installation of the equipment.

The Project promoter will submit a plan for the installation of the equipment, the organization system for the installations as well as the personnel to be dispatched for the installations.

He will submit a quality plan so that to enable keeping records on the installation works.

A planning for provisional acceptance

The provisional acceptance that will be carried out further to the putting into *service of the equipment must allow* :

- Verifying the conformity of the operational scheme proposed by the Project promoter;
- Verifying the conformity to the characteristics of the proposed services;
- Verifying the conformity of the equipment;
- Verifying the conformity to the standards and the rule book.

The Project Promoter will submit a provisional acceptance plan.

Acceptance will be carried out by a research consultancy proposed by ASER.

The procedures for maintenance intervention

Maintenance refer to all the actions aiming at:

- Repairing of breakdowns during routine operation of the equipment;
- Avoiding fast degradation of the equipment so that it could be used over its designed life span.
- The operations for the maintenance of the systems correspond to electrical works, non-electrical works, interventions, measuring operations, testing operations and verification operations.
- The Project Promoter will submit the operation mode he is planning to implement so that to ensure normal operation of the equipment.
- The Project Promoter will submit the features of the personnel who will carry out the maintenance of the equipment as well as the quality plan enabling keeping records of those operations (maintenance sheet)

The systems for fee collection and fund management

Those systems should include:

- The fee collection methods;
- The personnel in charge of fee collection;

- The management system for the collected fees;
- The mode of securing of the collected fees;
- The Justification of the costs relating to fee collection and fund management.

8) Feasibility Studies

- Tariff setting

  The tariffs for electricity service by means of photovoltaic equipment must allow ensuring:

  - Renewal of equipment;
  - Management of the equipment;
  - Maintenance of the equipment.

  In the calculation of the renewal cost, the following needs to be taken into account:

  - The investment cost for the equipment;
  - The life spans of the various components of the photovoltaic system reasonably estimated.

  The costs for system management must allow covering:

  - The users management fees;
  - The invoicing and fee collection fees.
  - The cost of raising the investment fund
  - The administration cost for the organization

  Maintenance cost must include:

  - The salaries for the local technicians;
  - The salaries for the external technicians (in case of hiring external technicians);
  - The possible fees for an engineer;
  - The cost for spare parts

- Calculation of long term cash flow

- Guarantee to keep sustainability of the project

9) Financial Plan

- Financial plan to implement the project
  Describe provided equity, user's contribution, expected subsidy and bank loan
- Justification of the amount of the requested subsidy

  The subsidy is provided in the idea of:

  - Alleviating the initial investment cost of the operator;
  - To facilitate for users access to electricity services;
  - To adapt the tariff systems to the payment capacity of users;

  The proposed level of subsidy should take into account:

  - The maximum tariff that target users can afford;
  - The optimal profitability parameter (Internal Rate of Return; Net Present Value of the operation) allowing to keep the fee for the proposed service over the requested concession period

  The Project Promoter will make some suggestions on the different forms of requested subsidies so that the proposed project could be profitable. He will propose the mode of subsidy payment

(2) Evaluation of Project Proposal Documents

1) The Project Area

- Suitability of the area for ERIL project

  Check the proposed area is not included in concessions of SENELEC and already proposed program of PPER concession.

2) Project Promoter/Operator

- Project promoters can be an administrative entity, a local community, a rural electrification operator, a development project and a donor. Project operator can be PV system supplier, PV expert and NGO.
- Institutional system of project promoter/project operator

Organizational chart or composition of organization is examined that the organization is eligible to implement the project

- Main activities of organization

  History of organization and main activities of them are examined as the organization is eligible to implement the project

- Experiences of project promoter/project operator

  Experiences of organization on PV electrification project or another projects for rural development are preferable.

- Experience of project manager

  It is better that project manager or key person in project has an experience of PV rural electrification

- Plan for training and enlightenment

  Plan for training of the member of organization and customer enlightenment will be described in the proposal.

3) Result of LEP

- Explanation of the reason that PV system to be introduced this area should be described
- Relation with other projects

  Any relation with other developing project will be described
- Those information will be confirmed by the information in GIS data base of ASER.
- The demand and equipment described in this plan will be evaluated by taking into account the criteria of PV systems

4) Information, Awareness and Consultation Campaign for the Beneficiaries

- The records of the awareness campaign will be confirmed if necessary though a mission dispatched by ASER.
- The engagements taken by Users and those taken by the operator have to be in conformity with the outlines of the schedule of conditions drawn by ASER.

- Cooperation plan with community

  Negotiation result with rural community for cooperation on the project and future development will be described in the proposal

- Consultations with beneficiaries/rural population

  Estimation of customer

  Check the method for estimation or selection of customers

5) Proposed products and services

- Evaluation of system capacity

  Check the method of demand estimation and calculation of suitable PV module and battery capacity,

  Premises for capacity setting are:

Efficiency of PV module:	95%
Efficiency of battery :	80%
Efficiency of charge controller :	90%
Autonomy:	maximum three days
Depth of battery discharge:	40 to 50%
Irradiation:	5.5kWh/m^2/day

  For reference, the following levels of demand could be considered:

  Calculated capacity of PV module/Capacity of battery are:

For 2 to 3 lamps:	100Wh/Day: 30Wc/50Ah
For 4 to 5 lamps with/without radio tape and B/W TV:	170Wh/Day: 50Wc/85Ah
For 4 to 5 lamps with radio tape and colour TV:	250Wh/Day: 70Wc/125Ah

- Evaluation of quality of system components

  Check the specification of proposed PV system components based on "technical minima" of ASER manual Vol-II

  Evaluation of the results of the quality control on PV system components are attached as Attachment-10

- Evaluation of purchasing

  Check the prices of system components and suppliers of them and ASER should survey the normal price range of PV system components in Senegal and international market for the reference

- Evaluation of renewal process for system components

  Check the plan of renewal process of system components and supply method of them

6) Impact of the Proposed PV Systems on Environment

- Evaluation of environmental effect

  Check the environmental effect prevention procedure based on "Regles environnementales" of ASER manual Vol-II.

  Procedure of recycle or collection of used battery is to be checked carefully.

7) Program of project implementation

- Schedule of each main point of project should be arranged reasonably
- Organization for project implementation

  Who or what organizations are in charge of supply components, installation, maintenance, operation, fee collection and so on will be described clearly

  The proposed procedures for provisional acceptance must be conducted in conformity with the sheets of annex 3 to 7 in Attachment-11

8) Feasibility Studies

In this manual, the proposal is assumed as the project is based on the ESCO scheme and fee is collected from users.

- Premises for "Fee" calculation

  The "Fee" for electric service must allow guarantying:

  - The renewal of equipment
  - The management cost of system
  - The maintenance cost of PV system and

- The reasonable return for its investment by project promoter

  Check the premises of "Fee" calculation, such as; initial investment cost, cost of renewal components, life term of system components, cost of operation and maintenance, term of concession, interest rate for discount, rate of inflation, return on investment (ROI), interest rate for loan, etc.

  The reasonable and proper value of them will be discussed later.

- Process of "Fee" calculation

  There are several standard methods to calculate the proper fee to be collected and we recommended one example of calculation method in operation manual for operator (3.1.16)

  The fees will be subjected to the capacity of the users to pay for the proposed services and will include:

  - The investment cost ;
  - The maintenance cost;
  - The management cost;
  - The provisions for renewal of equipment. To calculate those provisions, the following life spans will be considered:

· PV Module	20 years
· Charge Controller	10 years
· Battery	4 years
· Installation accessories	10 years

  Consumables will be under the charge of the user (lamp tubes, fuses etc.)

  The monthly fee for a 55 Wp PV system (assumed initial cost as 450,000CFAF) of a project consist of around 300 users will be comprised between 4,500 and 6,000 CFAF.

  The tariff level proposed by ASER will be subsequently submitted to the appreciation of the Commission de Régulation du Secteur Electrique (CRSE)

- Comparison with other project

  The amount of "fee" should not be much different by the projects of providing nearly equal services by the PV system.

- Long term cash flow of the project

Long term cash flow should be shown and prove the project is feasible and sustainable

- Sustainability of the project

Evaluate the project by assuming even in the pessimistic case such as the collection rate of fees down as 80%, the project can sustain its operation.

- Fee collection method and fund management method

Method of fee collection

Method of fee collection will be varying by projects and the least cost *method is recommendable.*

The penalty for un-paid users

The penalty for un-paid users should be described (such as confiscation of PV system) in the procedure to maintain high fee collection rate.

Way of management for collected fee

Collected fee should be managed properly to reserve a part of it for future expense of renewal components

The proposed fee collection method and management system will be the one inducing the smaller cost.

- A locally based fee collection system and fund management will be prioritised;
- If possible, the collected fees will be deposited in a local financial institution;
- A separate account will be open to secure the funds for the renewal of the equipment;
- The statements showing the deposited funds will be periodically submitted to ASER;
- An annual financial statement will be appended to the annual report of the operator then will submit to ASER.

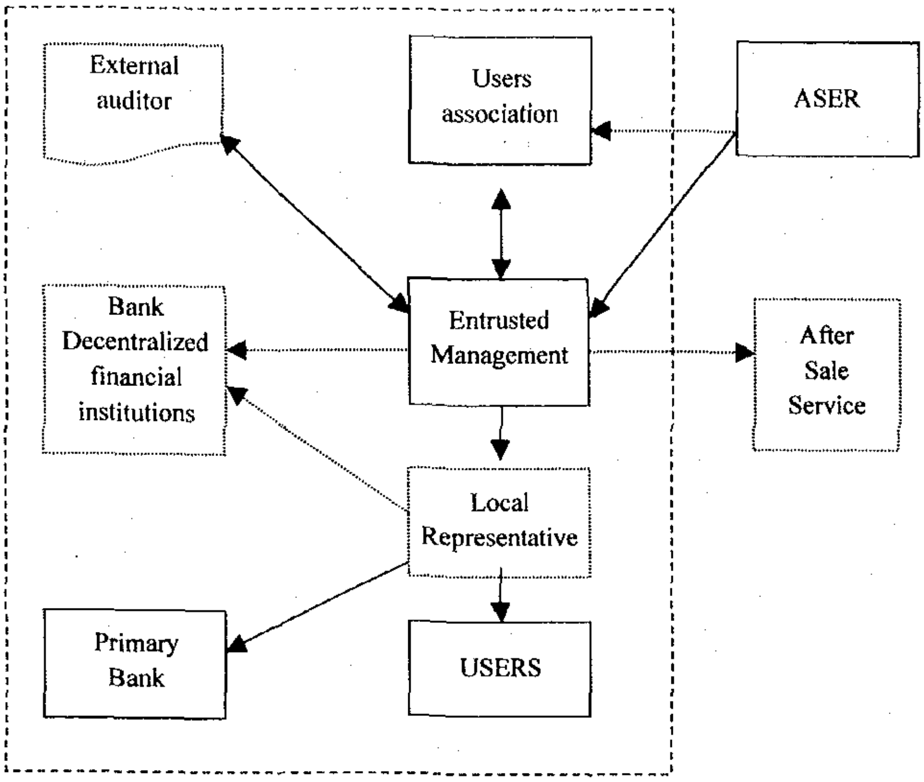

Figure 4.1 The Model of Fee Collection and Fund Management Systems

9) Financial Plan

- Justification of requested subsidy

Objective cost for subsidy

Subsidy should be awarded only for the initial investment and not for the operation cost.

Initial payment may include transportation and installation cost.

Criterion for operators to be eligible for subsidies

The eligibility criterion for subsidies will follow the principles below:

- The principle of minimum subsidy will be prioritised;
- The level of subsidy corresponding to the level of minimum profitability parameter for the operator;
- The operator' s internal rate of return will be determined taking into account the applied interest rate coming with the appropriate risk rate;

- The level of subsidy, correlated to a given profitability parameter for the operator will take into account the income level of the target users;
- The allocation of subsidy will be based uniquely on performance indicators considered for the reference period of the project implementation.

The amount and ratio of subsidy in initial investment

There are several opinions about the amount or ratio of subsidy, such as;

- Uniform amount of subsidy for each PV systems installed not regarding to their capacity
- Fixed ratio for the initial investment cost
- Variable ratio for the initial investment cost according to the objective area as an incentive for the project promoter to stimulate the project development in less developing area, such as higher subsidy rate for villages of small number of household than for villages of large number of household.
- Variable ratio according to the year of implementation, such as early start project can get higher rate of subsidy.
- Variable ratio according to the method of electrification, such as higher subsidy ratio for PV electrification than grid extension.

This is very complicate matter and was discussed in ASER manual Volume III.

The maximum percentage of subsidy is recommended to limit below 35% of initial investment.

- Timing of payment of subsidy

  Project promoters will expect the payment of subsidy as early as possible considering for their cash flow, but to clear the outlay of subsidy, it is better to pay when ASER confirm the installation of systems has been completed.

  In case of multi-annual project, the subsidy will be paid at the end of each fiscal year according to the offer from project promoter with the confirmation of acceptance by the investigator (Control entity).

- Evaluation of financing plan

  Equity of project promoter, contribution of users, subsidy by ASER, loans from banks and other financing sources will be described, 20 to 30% will be covered by equity of project promoter and users contribution, 30 to 35% covered by subsidy and rest will be covered by bank loan and conditions of loan have to be checked.

4.2 Implementation Stage [Investigation and Monitoring of the Project]

(1) Investigation of the Quality of Purchased Materials

1) Method of Quality Checking

The ASER manual recommends to check the quality of materials and work of installation by the third party engaged with ASER called "bureau de control" or "control entity". They execute the works of quality check of purchased materials and installation work.

The materials should be checked at the warehouse of consignee in Senegal and confirm the quality then transport to the project site.

2) *Quality Documents Attached on Purchased Components*

Suppliers have to attach quality documents for their products that prove them conforming to the specification in order document. The investigator confirms the document data that satisfy the specification data of order document.

3) Quality Check in Senegal

Some samples of system components are submitted to check their quality in the testing laboratory in Senegal (CERER) and the results of test should be regarded as final data to the supplier and project operator.

The international quality approval system is under preparation, after realization of the system, components with approved label will be accepted without test and components without label should be checked their quality.

(2) Investigation of Installation Work

1) Method of Checking the Installation Work

The control entity will investigate the installation work with project operator.

2) Items to be Checked in Installation Work

The objectives of checking the installation work are:

- Verifying the conformity of the operational scheme proposed by the Project promoter;
- Verifying the conformity to the characteristics of the proposed services;
- Verifying the conformity of the equipment;
- Verifying the conformity to the standards and the rule book.

The items to be checked in the investigation of installation work are described in the manual for operator.

Refer to attachment-6 and attachment -11

3) Point Out the Items to be Corrected

If there finds any items to be corrected, the control entity point out them and submit a record to the project operator to correct defects or faults of installation works.

4) Acceptation of Installation Work

After confirmation of the completion of correction work of indicated defects and faults, the control entity agrees to accept the installation of systems.

5) In Case of Multi Annual Project

In the case of PV rural electrification project, there may be the case that the installation of PV systems will be done through several years.

The control entity will join each case of installation to investigate the work of installation. The case of project in remote areas, investigation will be done by periodical visit of the control entity.

(3) Monitoring of System Operation

The objectives of the monitoring of the operation and management of the equipment are:

- To confirm the project subsidized by ASER is operating and managing normally;
- To optimise the experience resulting from the operation of the equipment;
- To monitor the main indicators of the management of the equipment;
- To monitor the performance of the equipment;
- To monitor the reliability of the equipment;
- To allow ASER ensuring the feedback of experience necessary to the designing and operation of the equipment to be installed future projects;

1) Method of Monitoring

Project operator provides the periodical report of project operation and management and submits it to ASER.

ASER or entrusted entity by ASER may visit the project site to monitor the management and operation of the project.

2) Timing of Monitoring

Project operator provides the annual report in the end of every fiscal year and submits it to ASER and ASER renew their PV rural electrification data-base of each ERIL projects by the report.

3) Items to be Written on the Report

i) Situation of system operation

- How many systems are working:
  How many systems are installed and are in operation or had failed, if there are systems of different capacities, report by each capacities of systems.
- Situation of maintenance work
  Number of local technicians, frequency of their visit to users and their works of the maintenance will be reported. This will provide the estimation of the number of user that local technicians can manage.
- Number of renewed system component
  Number of system components and their operating years by each

components renewed during the year will be reported. This will provide the estimation of provable life of each component.

- Use of electric appliances
  Report the number of used appliances and average hours of usage from sample users in the project by hearing. This will provide the estimation of available appliances and usage hours by different PV systems.

- Training of local technicians
  Report the contents of training for local technicians. This will provide items that ASER could support for project promoter/operator.

- Education of users
  Report the contents of education or enlightenment of users done by project promoter/operator. This will provide the idea to apply the prospective PV project.

ii) Main causes of system failure and counter-measures of repair for them

Report the main failures of systems classified by their causes and repair method for them and preventive method for recurrence. This will reduce the failure of PV system and shorten the time of repair the system for the prospective PV project.

iii) Persons to be engaged the project

Report the persons who engaged the operation and management of the project by term of percentage of work share to the project, such as work only for the project means 100%, work for two projects and shared same hours means 50%. This will provide the estimation of necessary man power for the PV project.

iv) Financial situation of the project

- Income

  Report the amount of collected fee and initial contribution if there were new registration. Compare the amount of expected at the start of the year.

  If there remains an un-collected fee, describe the method to enhance the collection.

- Expenses

  Report by the items of:

  - Renewal cost: Cost of renewal component, Cost of stock, Expense for renewal of the components
  - Management cost: Cost of user management, Cost of fee collection, Cost of raising fund, etc.
  - Maintenance cost: Cost of local technician, Cost of external technician, Cost of engineers, Cost of reserves, etc.

- Funding

  Report the situation of funding for renewal of components or initial contributions.

  ASER can estimate the project is managing well or not by analyzing these figures and can provide an adequate budget scheme of a PV project.

  If ASER finds the situation of the project is coming worse, ASER can advice to the project promoter/operator to correct the management to prevent the corruption of the project.

iv) Comment or request from users

Collect user's request or comment on PV system and system operation.

Report the reply of project promoter/operator for the comment and request from users.

ASER will provide more adequate feature of PV rural electrification by considering those comments and requests from users.

The sample of reporting format is attached as Attachment-12

4) Penalty for Un-submission of the Report

The submission of the report is one of the conditions to approve the subsidy.

If the project promoter/operator ignored the submission of the report without proper reason, ASER can penalize them. Penalty for the case will be discussed later.