Part 2　MASTER PLAN

PART 2 MASTER PLAN

Chapter 1 PV Rural Electrification Programme for State Governments

1.1 Common Issues for All State Governments

In Nigeria, on-grid rural electrification programmes are in progress with the own funding of state or local governments in parallel with the rural electrification programme of the FMPS. While some state governments, such as the Sokoto State Government, have introduced PV pumps, PV systems have never been used by any state government as a tool for off-grid rural electrification.

In order for state governments and the PHCN to be able to strategically proceed with rural electrification in the coming years, the following work must urgently commence to obtain information on on-grid electrification and to formulate suitable rural electrification projects.

(1) Confirmation of the Present State of the 33/11 kV Distribution Lines

Any distribution line extension work in Nigeria is conducted under a rural electrification programme formulated by either the FMPS or a state government. Once newly constructed facilities have passed the acceptance inspection by the PHCN, the ownership is transferred to the PHCN. In reality, however, the facilities transferred to the PHCN are not listed on the distribution grid diagramme of the PHCN and the latest state of the live distribution lines cannot be confirmed by either a state government or the PHCN. For this reason, it is essential that the PHCN gathers the basic information listed below on distribution lines under a study entrusted to local consultants.

1) Sections of completed distribution lines
2) Total length
3) Classification of distribution lines by type and size of cable used
4) Location and capacity of each distribution transformer installed

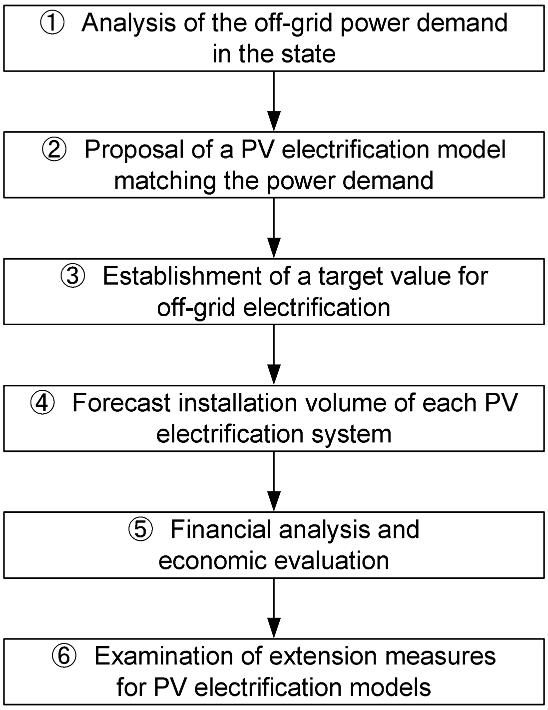
As part of the Study, a distribution grid diagramme (for Ondo State; only the locations of the on-grid electrified villages are shown) prepared based on data gathered from the Electrification Bureau of each state government and the PHCN has been prepared as a reference material for future surveying and field work by the Nigerian side.

(2) Clarification of the Target Areas for On-Grid Electrification Projects

In regard to on-grid rural electrification through the extension of the existing grid, the target areas of the Rural Electrification Programme of the FMPS and those of state government projects will be clarified and these will be overlaid on the distribution grid map prepared in (1) above to formulate a medium to long-term distribution line extension plan. This will avoid a situation where the existing grid is extended immediately after the installation of PV systems and the installation of PV systems to serve potential PV users will be facilitated without giving local residents a sense of expectation in regard to “the extension of the grid in the near future”.

(3) Formulation of PV Rural Electrification Projects

Assuming that the preparatory work described in (1) and (2) above is conducted by the Nigerian side, the method for the state governments of Jigawa, Ondo, Imo and the Federal Capital Territory (FCT) to formulate PV rural electrification projects is finalised in the rest of this chapter in accordance with the steps shown in Fig. 1-1. As the concrete selection method for the target areas for PV electrification is described in detail in Part 2, Chapter 2, the subject matters here are the proposed of a PV electrification model for each state, the establishment of targets for the introduction of PV systems and the financial analysis method.



Source: The Study Team

Fig. 1-1 Formulation of PV Rural Electrification Projects by State Governments

The four target states of the M/P are geographically dispersed and the potential to use solar energy varies from one state to another. Moreover, as the power demand per capita and the electrification rate greatly vary from one state to another as shown in Table 1-1, the uniform application of a single PV electrification model to all states is irrational. For this reason, the optimal PV electrification model is proposed for each state as described in the following sections.

Table 1-1 Outline of the Power Demand in the Four Target States

State	Load allocation recorded in 2003 (MW) (1)	Population by 1991 Census (2)	Load per population (W/ person) (1)/(2)	% of Households with Electricity (1997)
Jigawa	22.40	2,875,525	7.8	12
Imo	22.10	2,485,635	8.9	61
Ondo	29.00	2,249,548	12.9	72
Abuja	121.60	371,674	327.2	71

Source: PHCN materials and the General Household Survey 1997/98

Such matters as the establishment of local maintenance and extension measures to achieve PV rural electrification projects are comprehensively described in Chapter 4 – Maintenance System for the Implementation of the Master Plan and Chapter 5 – Action Plan for Education on and the Extension of Solar Energy Use of the Main Report. The measures to be employed by such stakeholders as the federal government, state governments are private companies are described there.

1.2 Jigawa State

1.2.1 Analysis of the Power Demand

Among Nigeria's states, Jigawa State enjoys high solar energy use potential as the state's annual mean quantity of solar radiation is as high as 5.66 KWh/m^2/day (compared to the national average of 5.50 KWh/m^2/day). Meanwhile, the state's household electrification rate of 12%[1)] is low because of the fact that the extension of the 33/11 kV distribution lines has mainly focused on LGHQs and important towns, suggesting relatively high potential for the introduction of PV systems for rural electrification.

Fig. 1-3 shows the 33 kV distribution diagramme for Jigawa State. Under the present system, the entire demand is met by four 33 kV distribution lines which extend from the Hadejia Secondary Substation (2 x 132/33 kV, 15 MVA) located some 150 km from Dutse, the state capital. A maximum power demand of some 29.6 MW was recorded in 2005. Assuming an average power factor of 0.85, the transformers at the above substation are already over-loaded (15 x 2 x 0.85 = 25.5 < 29.6) and the PHCN plans to establish a new substation (2 x 40 MVA) in Dutse by the end of 2006.

Table 1-2 and Table 1-3 show the historical changes of the number of users and the maximum demand respectively in Jigawa State, indicating a high annual growth rate of 6 – 8% for the number of users and 9 – 20% for the maximum demand.

Table 1-2 Number of Users in Jigawa State

(Unit: users)

	2003	2004	2005
Household Users	26,364	28,431	30,196
Commercial Users	169	171	175
Total	26,533	28,602	30,371

Source: PHCN

1) General Household Survey 1997/98

Table 1-3 Maximum Demand in Jigawa State

(Unit: MW)

	2000	2001	2002	2003	2004	2005
Maximum Demand	13.1	19.5	21.5	26.5	28.8	29.6

Source: PHCN

Jigawa State is one of the states in Nigeria which suffers from frequent power cuts and the power supply reliability based on on-grid electrification is extremely low. Table 1-4 shows accident statistics involving the 33 kV distribution lines in Jigawa State. According to data of the PHCN, the average duration of a power cut is more than six hours while a planned power cut due to the insufficient capacity of the generating, transmission and transformation facilities lasts much longer. In general, on-grid electrification enjoys a higher level of user satisfaction than off-grid electrification as it permits the longer use of large capacity electrical appliances. The results of a village socioeconomic survey indicate that the level of user satisfaction is low in on-grid electrified villages in Nigeria because of the long duration and high frequency of power cuts. In contrast, the level of user satisfaction in areas subject to off-grid rural electrification is relatively high.

Table 1-4 Frequency of Accidents Involving 33 kV Distribution Lines in Jigawa State

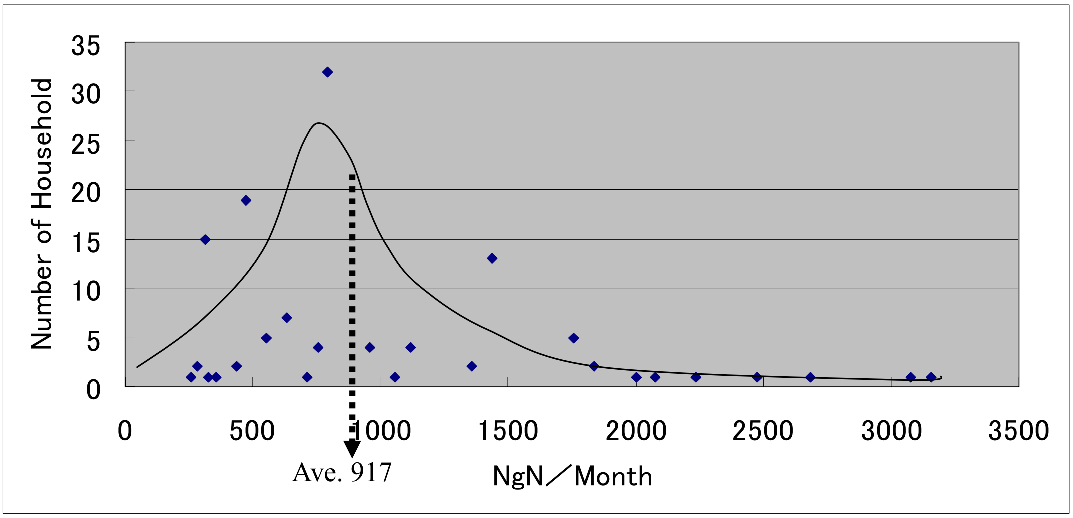
(Unit: times/month)

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
2004	9	20	9	18	22	14	14	9	17	8	9	8	13.1
2005	5	8	7	10	12	14	11	10	9	10	9	9	9.5

Source: PHCN

1.2.2 Proposal of PV Electrification Models

Jigawa State is the poorest state among the four target states of the Study. The village socioeconomic survey results establish the distribution of the energy expenditure (i.e. the total expenditure for kerosene, diesel oil and dry cells) in unelectrified villages as shown in Fig. 1-2 with an average expenditure of 917 NgN/month. It is, therefore, essential to propose a PV model (s) which matches the low payment ability of rural residents for electricity supply. Monitoring for the pilot project confirmed that the installation of PV pumps is in progress by the state government or the FMST (ECN) in northern states in Nigeria and that there is a strong need for street lighting and the supply of electricity to mosques.



Source : Village socioeconomic survey results

Fig. 1-2 Distribution of Energy Expenditure (Kerosene and Diesel Oil) in Unelectrified Villages (Jigawa State, N = 128)

In view of the present situation in Jigawa State, the gradual introduction of BCSs, the initial cost of which as a household PV electrification system is the lowest of all PV systems, is proposed, starting with the villages which are the remotest from the grid, in addition to the introduction of PV systems for public facilities because of the highly beneficial effect on all villagers, including the poorest.

From 2010 to 2020 when it is assumed that PV systems will be widespread with the cost of equipment falling due to the mass production effect, that the service network for PV companies will have expanded and that the payment ability of rural residents will have increased, it may well be possible to introduce SHSs in addition to BCSs for those users whose payment ability is higher than others.

In short, the following PV electrification models are proposed for short-term and medium to long-term PV rural electrification in Jigawa State.

- BCSs and public facilities (short-term: up to 2010)
- BCSs and SHSs (medium to long-term: 2010 – 2020)

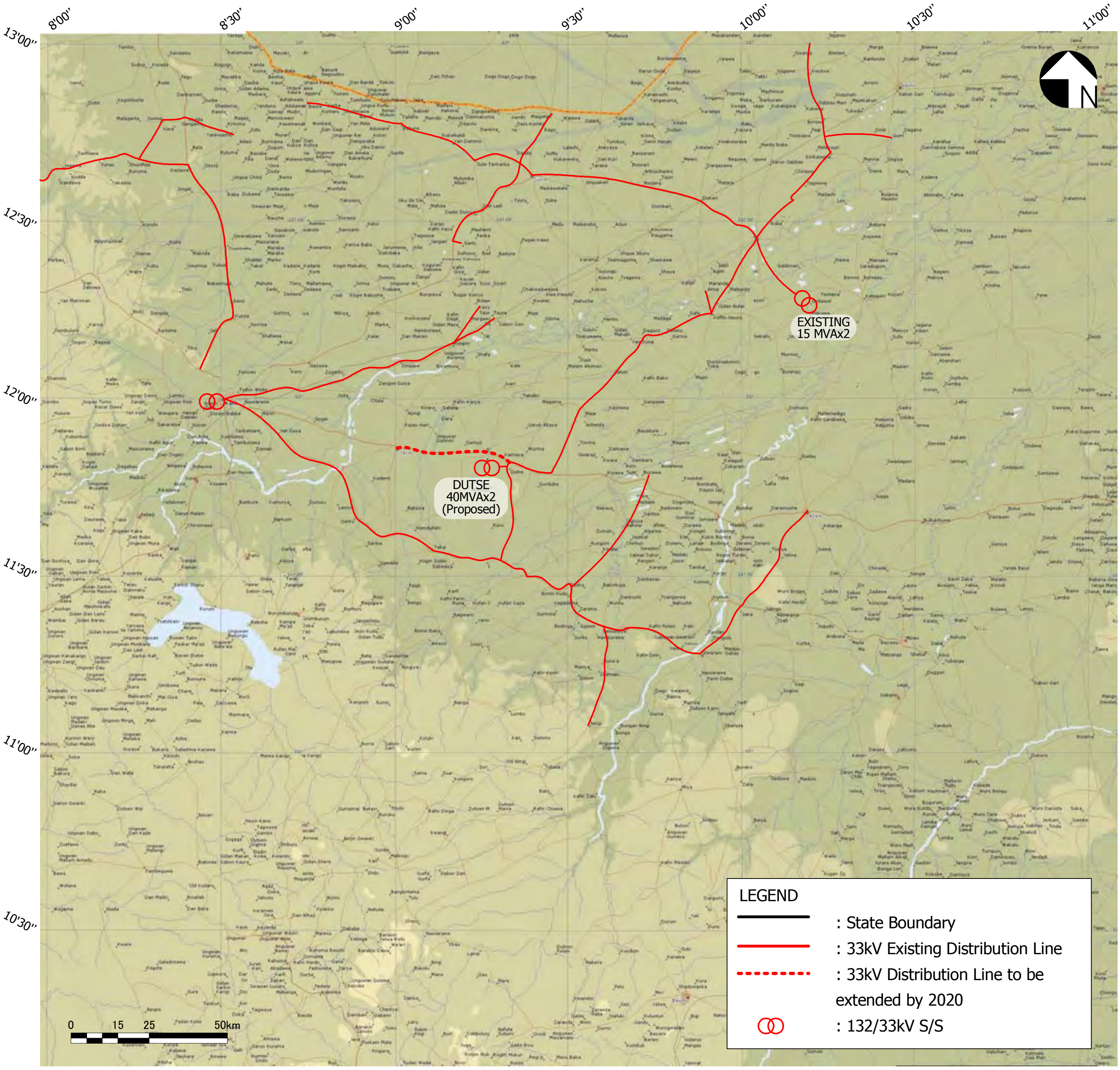
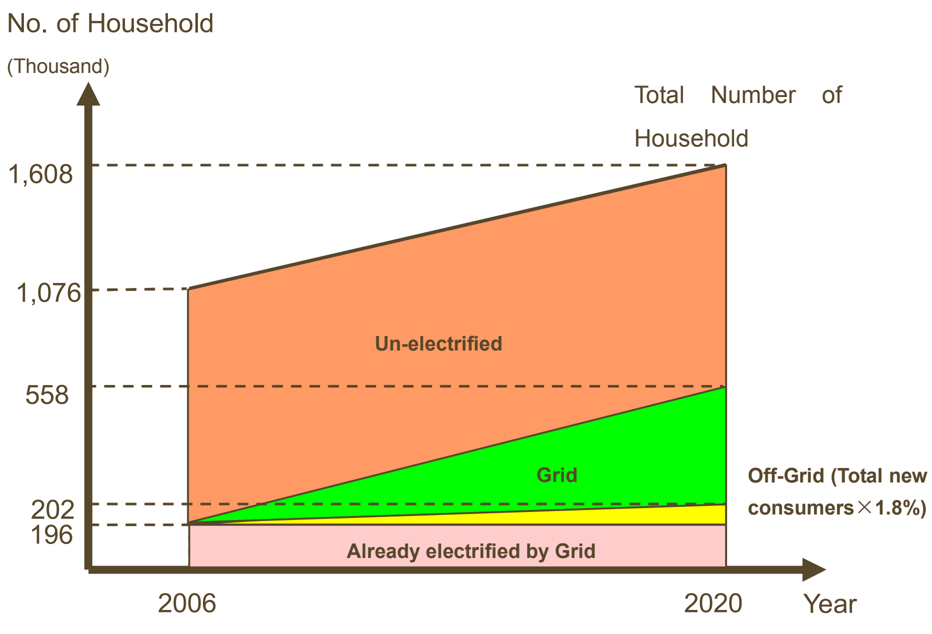


Fig. 1-3 33 kV Distribution Diagramme for Jigawa State

1.2.3 Off-Grid Electrification Targets

Next, it is necessary to establish short-term as well as medium to long-term targets for off-grid electrification. The National Energy Policy of Nigeria plans the supply of electricity (including electricity generated by renewable energies) to 75% of the total population in 2020. Accordingly the target electrification rate for Jigawa State to achieve the national target is set at 22% in 2010 and 35% in 2020.[2] Using the population ratio by state based on the results of the 1991 National Census, the total number of households in Jigawa State in 2006 is estimated to be approximately 1.08 million. Meanwhile, the National and State Population Projections[3] predict an increase of the number of households in Jigawa State to approximately 1.61 million by 2020. This means that electricity supply to 560,000 households (1,610,000 x 0.35) will be required in 2020. As of 2006, some 200,000 households receive electricity through on-grid electrification, making new supply (either by on-grid or off-grid) to some 360,000 households (560,000 – 200,000) necessary to achieve the 2020 target. As the Rural Electrification Policy and the Renewable Energy Action Programme of Nigeria intend the use of PV generation to supply electricity to some 1.8% of new users in the coming years, the supply of electricity to some 6,400 households by means of off-grid PV rural electrification will be necessary. Fig. 1-4 shows the planned scheme to supply electricity to new users in Jigawa State.



Source: The Study Team

Fig. 1-4 Planned Number of Electrified Households up to 2020 (Jigawa State)

Based on the above analysis, Table 1-5 lists the PV systems of which the introduction in Jigawa State is planned by 2010 and 2020. Here, private RESCO (Rural Energy Supply Company) or communities are assumed to act as the principal implementing organizations except for public

2) Refer to 2.6 – Formulation of the National PV Electrification Programme for further details
3) Conducted by the National Population Commission and the United Nations Population Fund

facilities in accordance with the REA's policy of facilitating the entry of private companies as much as possible. In regard to SHSs, however, market penetration based on the model of direct sale by PV companies to wealthy users is planned and it is assumed that 10% of the newly introduced SHSs will come from such direct sales.

Table 1-5 PV Systems of Which the Introduction is Assumed in Jigawa State by 2010 and 2020

Year	～ 2010		～ 2020			
System	BCS	Public Facilities	BCS	SHS		Public Facilities
Implementing organization	1.RESCO 2.Community 3.Gov / ODA	Gov / ODA	1.RESCO 2.Community	1.RESCO 2.Community	Direct Sales	Gov / ODA
No. of PV systems	60	1	95	4,000	400	1

Source: The Study Team

1.2.4 Financial Analysis and Economic Evaluation

(1) Financial Analysis of BCS Projects

In regard to the introduction of BCSs in Jigawa State, as 60 systems (serving 1,200 households) are to be introduced in the four year period from 2007 to 2010 in accordance with the schedule shown in Table 1-5, it is assumed that 15 systems (serving 300 households) will be installed each year. In the seven year period from 2011 to 2017, it is assumed that PV electrification based on BCSs will be conducted at a rate of approximately five new systems (serving some 100 households) a year.

Table 1-6 Annually Required Equipment Investment for BCSs in Jigawa State

(Unit: NgN)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Investment cost per system	2,304,000	2,200,615	2,097,231	1,993,846	1,890,462	1,787,077	1,683,692
Number of BCS systems to be installed	15	15	15	15	5	5	5
Investment cost	34,560,000	33,009,231	31,458,462	29,907,692	9,452,308	8,935,385	8,418,462
Necessary subsidy for 50% initial cost	17,280,000	16,504,615	15,729,231	14,953,846	4,726,154	4,467,692	4,209,231
Installation year	2014	2015	2016	2017	2018	2019	2020
Investment cost per system	1,580,308	1,476,923	1,373,538	1,270,154	1,166,769	1,063,385	960,000
Number of BCS systems to be installed	5	5	5	5	0	0	0
Investment cost	7,901,538	7,384,615	6,867,692	6,350,769	0	0	0
Necessary subsidy for 50% initial cost	3,950,769	3,692,308	3,433,846	3,175,385	0	0	0

Source: The Study Team

A BCS-based electrification project involving some 100 households (20 households/system x 5 systems) as examined in 3.3 can be regarded as the typical model for the wider extension of this system. BCSs are suitable for the electrification of remote and not so affluent villages and should preferably be implemented as a community-led electrification project led by a village electrification association rather than as an electrification effort led by a private RESCO. As an organization, a village electrification association does not seek a profit as in the case of a private stock company and it will be sufficient for such an association to pursue business management which does not incur a deficit in its cash flow while ensuring the benefits of electrification for villagers. As described in 3.3, there is no point in calculating the FIRR or FNPV of a village electrification association given its organizational character. The significance of this type of organization lies with the need to examine the marginal level of its charge so that the organization can operate without a cash flow deficit throughout the project life.

Based on the presupposition that the price of PV systems will steadily decline with the passing of time due to the technological innovation of such systems and expansion of the market, it is assumed here that the initial investment cost per household will gradually decline with the passing of time. Another assumption is that 50% of the initial investment cost will be provided by a subsidy while 30% and 20% will come from soft loans and cash respectively. The conditions described in 3.3 are also applied here for other detailed presuppositions. The expected size of the initial payment per household, the monthly charge and the battery charging fee are shown in the tables below.

Table 1-7 Initial Amount of Cash to be Paid by Each Household for the Installation of a BCS

(Unit: NgN)

Installation year	2007	2008	2009	2010	2011	2012	2013
Initial payment per household	23,040	22,006	20,972	19,938	18,905	17,871	16,837
Installation year	2014	2015	2016	2017	2018	2019	2020
Initial payment per household	15,803	14,769	13,735	12,702	11,668	10,634	9,600

Source: The Study Team

Table 1-8 Monthly Charge and Single Battery Recharging Fee After Installation of a BCS

(Unit: NgN)

Installation year	2007	2008	2009	2010	2011	2012	2013
Monthly charge (1-5 year)	621	593	565	537	510	482	454
Battery recharging fee (1-20 year)	66	64	61	59	57	54	52
Installation year	2014	2015	2016	2017	2018	2019	2020
Monthly charge (1-5 year)	426	398	370	342	314	287	259
Battery recharging fee (1-20 year)	50	47	45	43	40	38	36

Source: The Study Team

(2) Financial Analysis of SHS Projects

In regard to the introduction of SHSs in Jigawa State, the presupposition is the installation of a number of SHSs to serve 400 households a year, totalling 4,000 households in the 10 year period from 2011 to 2020 (no SHSs will be introduced up to 2010). As the installation of SHSs for the off-grid electrification of poor villages in Jigawa State of which the poverty level is higher than that of other states is planned, it is assumed that only 55 W SHSs will be installed throughout the planned period from 2011 to 2020.

Table 1-9 Annually Required Equipment Investment for SHSs in Jigawa State

(Unit: NgN)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Investment cost per system	144,000	137,538	131,077	124,615	118,154	111,692	105,231
Number of 55W SHS systems to be installed	0	0	0	0	300	300	300
Investment cost	0	0	0	0	35,446,154	33,507,692	31,569,231
Necessary subsidy for 50% initial cost	0	0	0	0	17,723,077	16,753,846	15,784,615
Installation year	2014	2015	2016	2017	2018	2019	2020
Investment cost per system	98,769	92,308	85,846	79,385	72,923	66,462	60,000
Number of 55W SHS systems to be installed	300	300	600	600	600	300	400
Investment cost	29,630,769	27,692,308	51,507,692	47,630,769	43,753,846	19,938,462	24,000,000
Necessary subsidy for 50% initial cost	14,815,385	13,846,154	25,753,846	17,861,538	10,938,462	2,492,308	0

Source: The Study Team

A 55 W SHS-based electrification project involving some 150 households as examined in 3.3 can be regarded as the typical model for the wider extension of this system. 55 W SHSs are suitable for the electrification of remote and not so affluent villages and this type of project should preferably be implemented as a community-led electrification project led by a village electrification association. As in the case of BCS-based electrification projects described earlier, it is assumed that it will be sufficient for such an association to pursue business management which does not incur a cash flow deficit throughout the project life. Accordingly, a marginal level of electricity charge which is designed not to incur a deficit is examined. The expected size of the initial payment per household and monthly charge are shown in Table 1-10.

Table 1-10 Required Initial Cash Payment by Each Household for the Installation of a 55 W SHS and the Monthly Charge Thereafter

(Unit: NgN)

Installation year	2007	2008	2009	2010	2011	2012	2013
Initial payment	28,800	27,508	26,215	24,923	23,631	22,338	21,046
Monthly charge (1-5 year)	1,210	1,160	1,110	1,050	1,000	950	900
Monthly charge (6-20 year)	620	590	570	550	530	500	470
Installation year	2014	2015	2016	2017	2018	2019	2020
Initial payment	19,754	18,462	17,169	15,877	14,585	13,292	12,000
Monthly charge (1-5 year)	850	800	750	700	650	600	550
Monthly charge (6-20 year)	450	420	400	370	350	320	290

Source: The Study Team

(3) Purchase of SHSs by Individual Users

It is assumed that some 2,500 SHS will be purchased by individual users from PV dealers in the 10 year period from 2011 to 2020. As this represents voluntary purchase by wealthy individuals, these systems are not included in the scope of the present analysis.

(4) Public Facilities

As only a few public facilities exist, these facilities are not included in the scope of the present analysis.

(5) Economic Evaluation of PV Projects in Jigawa State

Economic evaluation of BCS and 55 W SHS projects described above using the method employed in 3.5 (where the economic evaluation of PV electrification projects nationwide is conducted) produces the following results.

Table 1-11 Economic Evaluation of PV Electrification Projects in Jigawa State

	Combined	Only SHSs	Only BCSs
EIRR	36.2%	38.1%	32.7%
ENPV	NgN 1,137,011,470	NgN 890,230,557	NgN 246,780,913
B/C Ratio	2.76	2.89	2.42

Source: The Study Team

1.3 Ondo State

1.3.1 Analysis of the Power Demand

Although the annual mean quantity of solar radiation of 5.60 $KWh/m^2/day$ is high (compared to the national average of 5.50 $KWh/m^2/day$), the decline of the mean quantity of solar radiation to 3.50 $KWh/m^2/day$ in August during the rainy season means that the scope of application of solar energy is limited compared to Jigawa and other northern states. The electrified household ratio of Ondo State of 72%[4]) is much higher than the national average (44%) because of the geographical spread of the existing 33/11 kV distribution lines, mainly along trunk roads, to reach not only LGHQ areas and important towns but also many rural areas.

Prior to 1976 when the old Ondo State was established, only some 26 towns were electrified. However, a further 125 towns were electrified from 1976 to 2004 under the electrification programme of the state government. As of 2006, some 170 towns and villages are still not electrified. Because of the absence of a 33 kV distribution diagramme for Ondo State, the locations of the electrified towns through extension of the grid are shown in Fig. 1-6.

Improvement of the reliability of the power supply to electrified towns and villages in Ondo State is a major challenge in addition on the on-grid electrification of unelectrified towns and villages. While the FMPS once planned the construction of four new 132/33 kV substations at Ondo, Ikare, Okitipupa and Ado-Ekiti in the period from 1982 to 1990, only one substation was constructed at Ondo in 1985. The two existing substations (Akure and Ondo) are already over-loaded and the State Electrification Board of Ondo plans to construct two 132/33 kV substations at Ado-Ekiti and Ikare Akoko or Okitipupa. Both the 33 kV distribution lines and distribution transformers (33/0.415 kV) in the state are showing signs of deterioration and their systematic replacement is desirable.

Table 1-12 and Table 1-13 show the historical changes of the number of users and the maximum power demand in Ondo State respectively. These tables show that the maximum power demand dropped by approximately 5 MW in the period from 2002 to 2005 even though the number of users increased by some 46,000 in the same period, indicating that the supply capacity lags behind the actual power demand.

Table 1-12 Number of Users in Ondo State

(Unit: users)

	2002	2003	2004	2005
Household Users	105,163	113,236	122,967	144,318
Commercial Users	24,115	26,544	27,899	30,134
Industrial Users	305	616	786	909
Others	215	396	26	50
Total	129,798	140,792	151,678	175,411

Source: PHCN

4) General Household Survey 1997/98

Table 1-13 Maximum Power Demand in Ondo State

(Unit: MW)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2002	52.0	51.4	51.7	52.5	54.5	54.5	52.5	54.5	54.8	52.5	54.5	54.8
2003	54.6	54.3	54.4	54.6	54.3	54.4	54.6	54.3	54.4	54.8	54.6	54.4
2004	57.8	55.0	57.3	50.5	54.0	53.0	54.0	47.5	50.5	54.0	51.0	46.5
2005	45.5	49.5	50.0	45.0	44.5	45.0	44.0	41.0	48.0	50.0	45.0	40.5

Source: PHCN

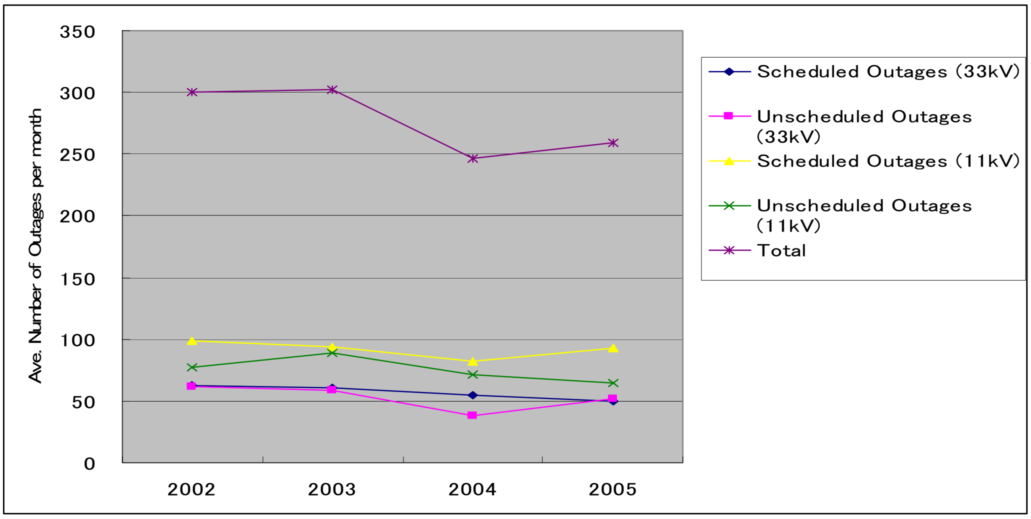
Ondo State is one of those states where the frequency of power cuts is particularly high and the reliability of power supply from the grid is extremely low. Table 1-14 and Fig. 1-5 show failure statistics for the 33 kV distribution lines in Ondo State. These indicate that even though the number of outages involving a distribution line is declining, incidents of outage (power cut) still frequently occur, particularly with the 11 kV distribution lines in urban areas. In general, while on-grid electrification enjoys a higher level of user satisfaction as it allows the longer use of high capacity electrical appliances, the village socioeconomic survey results suggest that the level of user satisfaction in on-grid electrified villages in Nigeria is rather low because of the length and frequency of power cuts. Accordingly, the level is user satisfaction is relatively high in electrified areas using off-grid PV systems.

Table 1-14 Number of Outages Involving 33 kV Distribution Lines in Ondo State

(Unit: times/month)

Month			1	2	3	4	5	6	7	8	9	10	11	12	Average
2002	33kV	Scheduled	48	82	77	62	64	48	60	57	42	74	64	72	62.5
		Unscheduled	62	46	57	49	62	64	72	68	88	47	55	68	61.5
	11kV	Scheduled	113	92	86	107	92	112	78	104	64	92	118	125	98.58
		Unscheduled	88	71	84	97	66	77	105	64	99	58	72	45	77.17
2003	33kV	Scheduled	62	49	58	59	67	59	64	52	72	44	82	64	61
		Unscheduled	48	42	36	72	65	58	72	66	68	57	49	72	58.75
	11kV	Scheduled	124	88	110	62	86	52	80	66	132	105	88	128	93.42
		Unscheduled	81	74	68	84	67	101	133	84	112	76	72	120	89.33
2004	33kV	Scheduled	48	55	64	41	46	38	44	74	62	59	47	80	54.83
		Unscheduled	24	34	34	33	26	66	46	33	43	40	32	51	38.5
	11kV	Scheduled	121	110	134	63	61	54	66	40	21	110	102	102	82
		Unscheduled	55	58	64	102	89	82	106	67	68	64	45	51	70.92
2005	33kV	Scheduled	61	72	39	40	18	42	71	42	46	45	54	63	49.42
		Unscheduled	39	53	94	46	54	41	56	45	62	50	38	40	51.5
	11kV	Scheduled	84	91	78	36	117	121	94	105	88	86	116	102	93.17
		Unscheduled	66	45	62	119	63	30	45	72	58	61	72	86	64.92

Source: PHCN



Source: PHCN

Fig. 1-5 Historical Changes of Outages Involving Distribution Lines

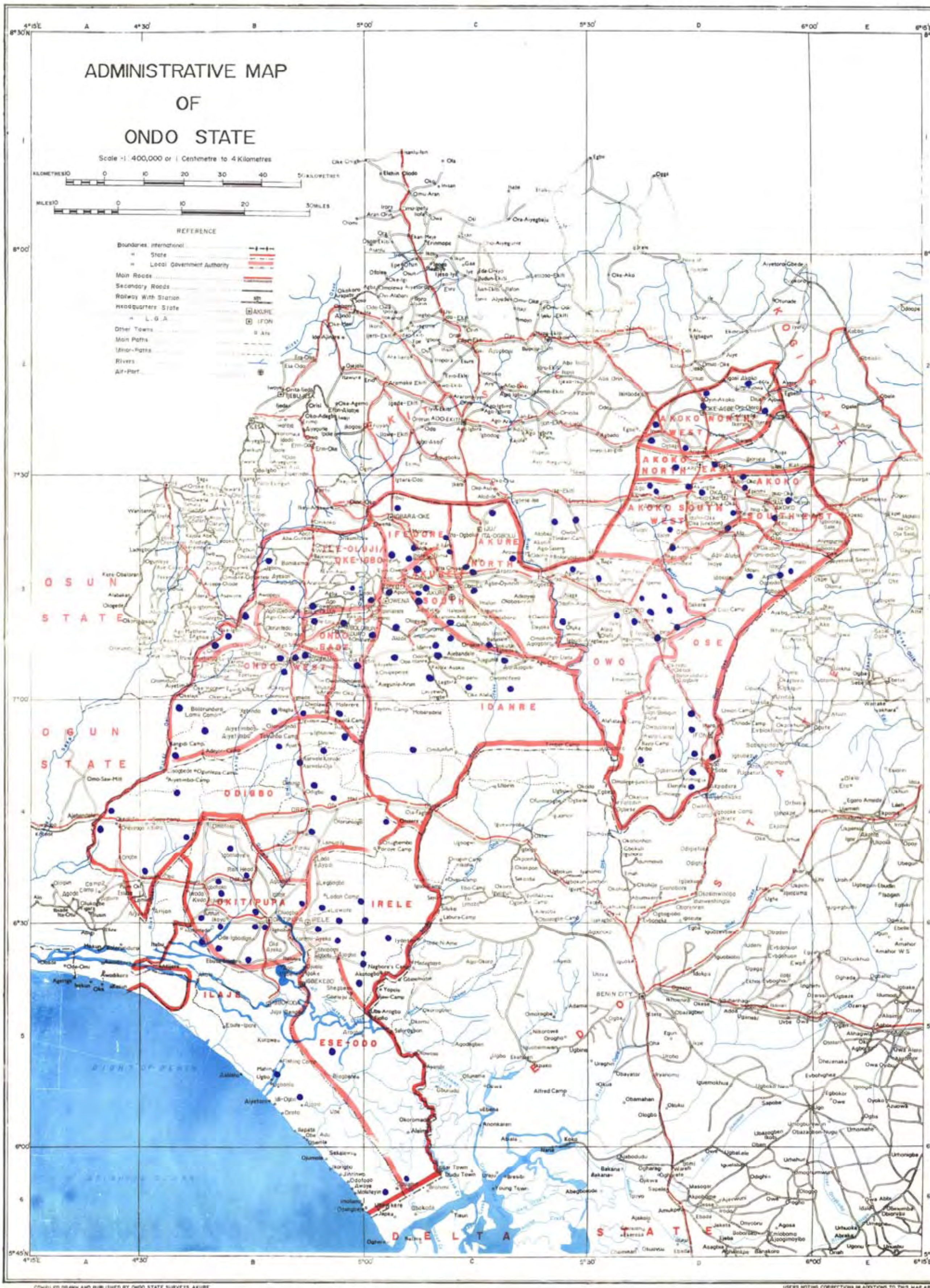
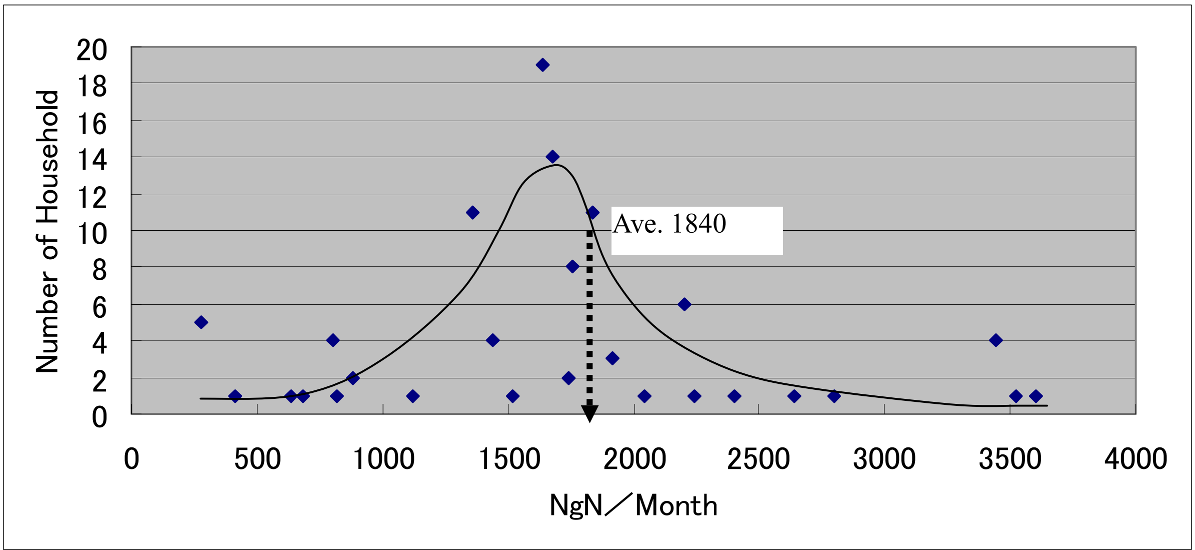


Fig. 1-6 Locations of On-Grid Electrified Towns/Villages

1.3.2 Proposal of PV Electrification Models

The village socioeconomic survey results have established the distribution of the energy expenditure (i.e. the total expenditure for kerosene, diesel oil and dry cells) in unelectrified villages as shown in Fig. 1-7 with an average expenditure as high as NgN 1,840/month. Given the fact that no household wants the introduction of a BCS because of restrictions on the capacity of the electrical appliances which can be used and also on the hours of use, the proposal of a PV electrification mode with high specifications despite a high monthly charge is necessary. Moreover, as the existing grid spreads over a wide area along the major trunk roads, the distance for grid extension to unelectrified villages is short, making the life cycle cost per KWh, including the grid extension cost, relatively low. For this reason, PV systems in Ondo State are considered to be tentative measures until the realisation of on-grid electrification and the introduction of a mini-grid system which can be easily relocated once on-grid electrification is realised in the near future is proposed as a short-term as well as medium to long-term PV electrification model.



Source: Village socioeconomic survey results

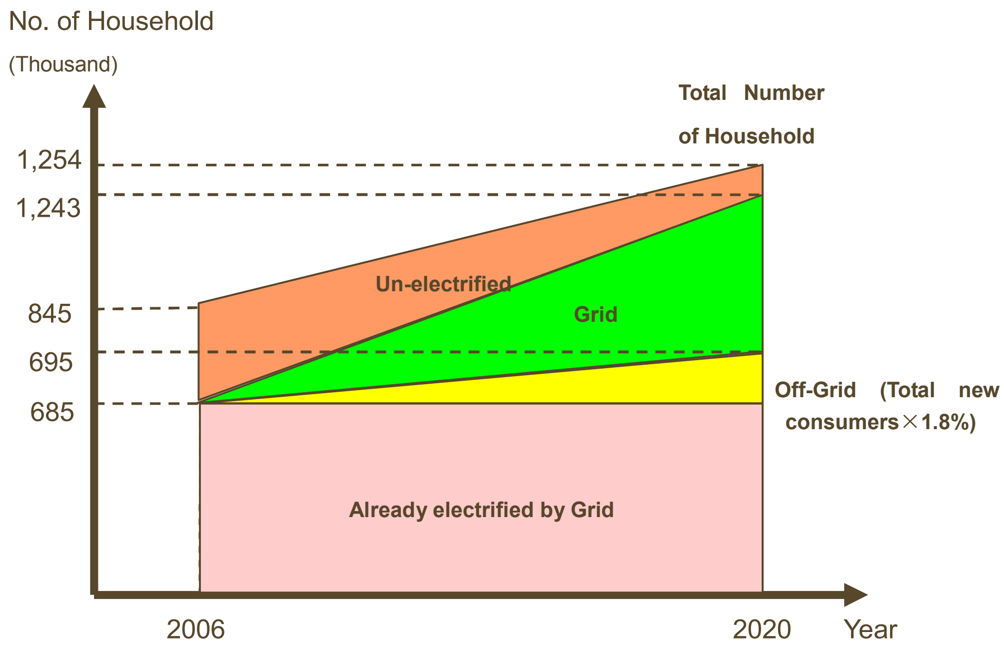
Fig. 1-7 Distribution of Energy Expenditure (Kerosene and Diesel Oil) in Unelectrified Villages (Ondo State, N = 110)

1.3.3 Off-Grid Electrification Targets

The establishment of short-term as well as medium to long-term targets for off-grid electrification in Ondo State is necessary. The National Energy Policy of Nigeria plans the supply of electricity (including electricity generated by renewable energies) to 75% of the total population in 2020. Accordingly, the target electrification rate for Ondo State to achieve the national target is set at 86% in 2010 and 99% in 2020.[5] Using the population ratio by state based on the results of the 1991 National Census, the total number of households in Ondo State in 2006 is estimated to be approximately 840,000. Meanwhile, the National and State Population Projections[6] predict an

5) Refer to 2.6 – Formulation of the National PV Electrification Programme for further details
6) Conducted by the National Population Commission and the United Nations Population Fund

increase of the number of households in Ondo State to approximately 1.25 million by 2020. This means that electricity supply to 1.24 million households (1.25 million x 0.99) will be required in 2020. As of 2006, some 680,000 households receive electricity through on-grid electrification, making the new supply (either on-grid or off-grid) to some 560,000 households (1.24 million – 0.68 million) necessary to achieve the 2020 target. As the Rural Electrification Policy and the Renewable Energy Action Programme of Nigeria intend the use of PV generation to supply electricity to some 1.8% of new users in the coming years, the supply of electricity to some 9,900 households by means of off-grid PV rural electrification will be necessary. Fig. 1-8 shows the planned scheme to supply electricity to new users in Ondo State. The planned quantity of off-grid PV systems to be introduced in Ondo State in the coming years is larger than that for Jigawa State because of the high target electrification rate of 72% even though the user increase rate is set as being small.



Source: The Study Team

Fig. 1-8 Planned Number of Electrified Households up to 2020 (Ondo State)

Based on the above analysis, Table 1-15 lists the PV systems of which the introduction in Ondo State is planned by 2010 and 2020. Here, it is assumed that a private RESCO will act as the principal project implementing organization in accordance with the REA's policy of facilitating the entry of private companies as much as possible. The operation and maintenance of a mini-grid system by a village electrification association is not considered because the maintenance of a mini-grid system involves regular patrolling and checking by a PV engineer.

Table 1-15 PV Systems of Which the Introduction is Assumed in Ondo State by 2010 and 2020

Year	～ 2010	～ 2020
System	Mini Grid	Mini Grid
Implementing organization	1.RESCO 2.Gov / ODA	RESCO
No. of PV systems	110	495

Source: The Study Team

1.3.4 Financial Analysis and Economic Evaluation

(1) Financial Analysis of Mini-Grid Projects

For the implementation of mini-grid based electrification projects in Ondo State, implementation by a RESCO is assumed instead of the village-based participatory approach for BCS or SHS projects. The pace of project implementation will correspond to the planned schedule shown in Table 1-15. The year of 2007 will be considered the preparatory year to establish a RESCO, followed by the installation of 110 systems serving 2,200 households (20 households/system x 110 systems) in the three year period from 2008 to 2010 (30 systems in 2008 and some 40 systems each in 2009 and 2010). In the 10 year period from 2011 to 2020, a further 385 systems will be installed to serve 7,700 households (20 households/system x 385 systems) at an annual rate of 38 systems in the first five years and 39 systems in the second five years.

Table 1-16 Annually Required Equipment Investment for Mini-Grid Systems in Ondo State

(Unit: NgN million)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Price of mini-grid system	0	3.55	3.39	3.22	3.05	2.89	2.72
Number of mini-grid systems to be installed	0	30	40	40	38	38	38
Investment cost	0	107	135	129	116	110	103
Necessary subsidy for 50% initial cost	0	53	68	64	58	55	52
Installation year	2014	2015	2016	2017	2018	2019	2020
Price of mini-grid system	2.55	2.38	2.22	2.05	1.88	1.72	1.55
Number of mini-grid systems to be installed	38	38	39	39	39	39	39
Investment cost	97	91	86	80	73	67	60
Necessary subsidy for 50% initial cost	48	45	43	30	18	8	0

Source: The Study Team

As it is assumed that mini-grid based electrification in Ondo State will be conducted by a private RESCO, the FIRR and NPV of this company are calculated here. The preconditions are the same as those for the financial analysis of mini-grid electrification projects in 3.3. As shown in the table below, the FIRR and the financial NPV are 17.9% and some NgN 350 million.

FIRR (Financial Internal Rate of Return)	17.9%
Financial NPV (Net Present Value)	NgN 351,085,700

In regard to sensitivity analysis, two cases where the income (collected electricity charge) is 15% and 30% below the expected level are analysed. Two further cases where the investment cost is 15% and 30% above the expected level (meaning that the PV equipment cost and the installation cost do not fall below the expected levels) are also analysed.

Table 1-17 Sensitivity Analysis

Case	FIRR (%)	NPV (NgN)
Base Case	17.9	351,085,700
Case 2 (Income: 15% down from the expected level)	14.4	207,673,442
Case 3 (Income: 30% down from the expected level)	10.9	61,168,248
Case 4 (Investment cost: 15% up from the expected level)	15.7	287,399,929
Case 5 (Investment cost: 30% up from the expected level)	13.8	223,537,826

Source: The Study Team

(2) Economic Evaluation of Mini-Grid Projects

The economic evaluation of the mini-grid projects described above using the same method employed in 3.5 (where the economic evaluation of PV electrification projects nationwide is conducted) produces the following results.

Table 1-18 Economic Evaluation of PV Electrification Projects in Ondo State

Item	Numerical Value
EIRR	48.4%
Economic NPV	NgN 2,652,914,458
B/C Ratio	3.54

Source: The Study Team

1.4 Imo State

1.4.1 Analysis of the Power Demand

The annual mean quantity of solar radiation in Imo State is low at 4.67 KWh/m^2/day (compared to the national average of 5.50 KWh/m^2/day) which drops to 3.73 KWh/m^2/day in August during the rainy season. Consequently, the scope of application of solar energy is limited compared to Jigawa and other northern states. The electrified household ratio of 61%[7)] is higher than the national average (44%) and the average distance from the grid to the target villages of the Pre-F/S is comparatively shorter at approximately 8 km compared to other states, indicating the geographical spread of the existing 33/11 kV distribution lines, mainly along the major trunk roads, to reach not only LGHQ areas and important towns but also many rural areas.

As in the case of other southern states, the total power demand in Imo State is not met because of the insufficient generating, transmission and transformation capacity. While the maximum demand

7) General Household Survey 1997/98

in this state, including the suppressed demand[8)], is estimated to be 120 MW, the available supply capacity is only 60 MW, meaning that only some 50% of the maximum demand is met. It is planned to construct and expand 132/33 kV distribution substations and switchyards but the increase of the number of users and maximum demand at an annual rate of 6.7% and 5.9% respectively indicate the urgent need for facility expansion.

Table 1-19 Number of Users in Imo State

(Unit: users)

	2000	2001	2002	2003	2004	2005
Total Number of Users	124,756	134,283	143,810	153,337	162,864	172,391

Source: PHCN

Table 1-20 Maximum Demand in Imo State

(Unit: MW)

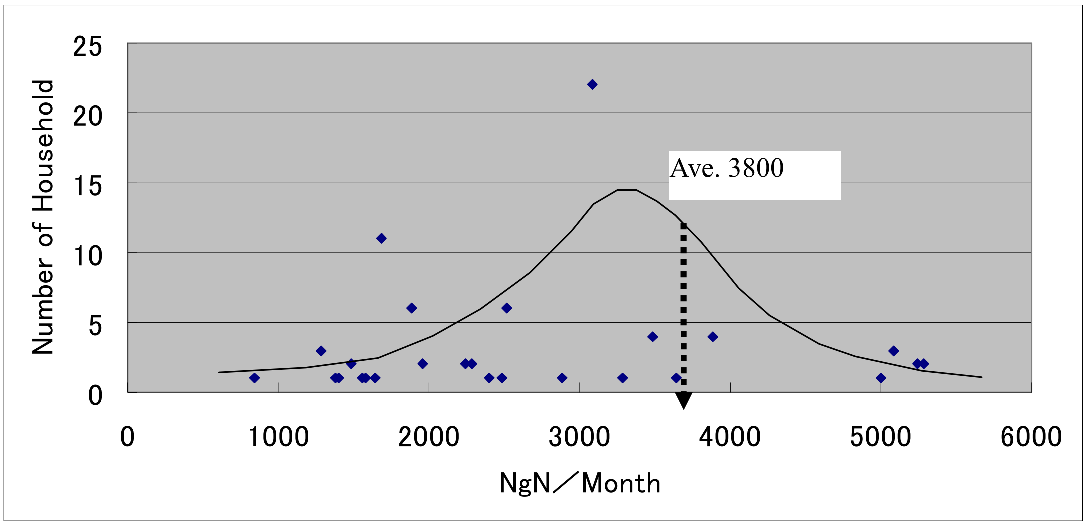
	2000	2001	2002	2003	2004	2005
Maximum Demand	90	95	100	110	115	120

Note: Estimated value, including the suppressed demand.

Source: PHCN

1.4.2 Proposal of PV Electrification Models

The village socioeconomic survey results have established the distribution of the energy expenditure (i.e. the total expenditure for kerosene, diesel oil and dry cells) in unelectrified villages as shown in Fig. 1-10 with an average expenditure of NgN 3,800/month which is the highest among the target states of the Study. As a portable independent generator is owned by approximately one in 10 households, the potential power demand in unelectrified villages is assumed to be quite large.



Source: Village socioeconomic survey results

Fig. 1-9 Distribution of Energy Expenditure (Kerosene and Diesel Oil) in Unelectrified Villages (Imo State, N = 88)

8) The suppressed demand means the quantity of voluntarily suppressed power consumption because of insufficient supply.

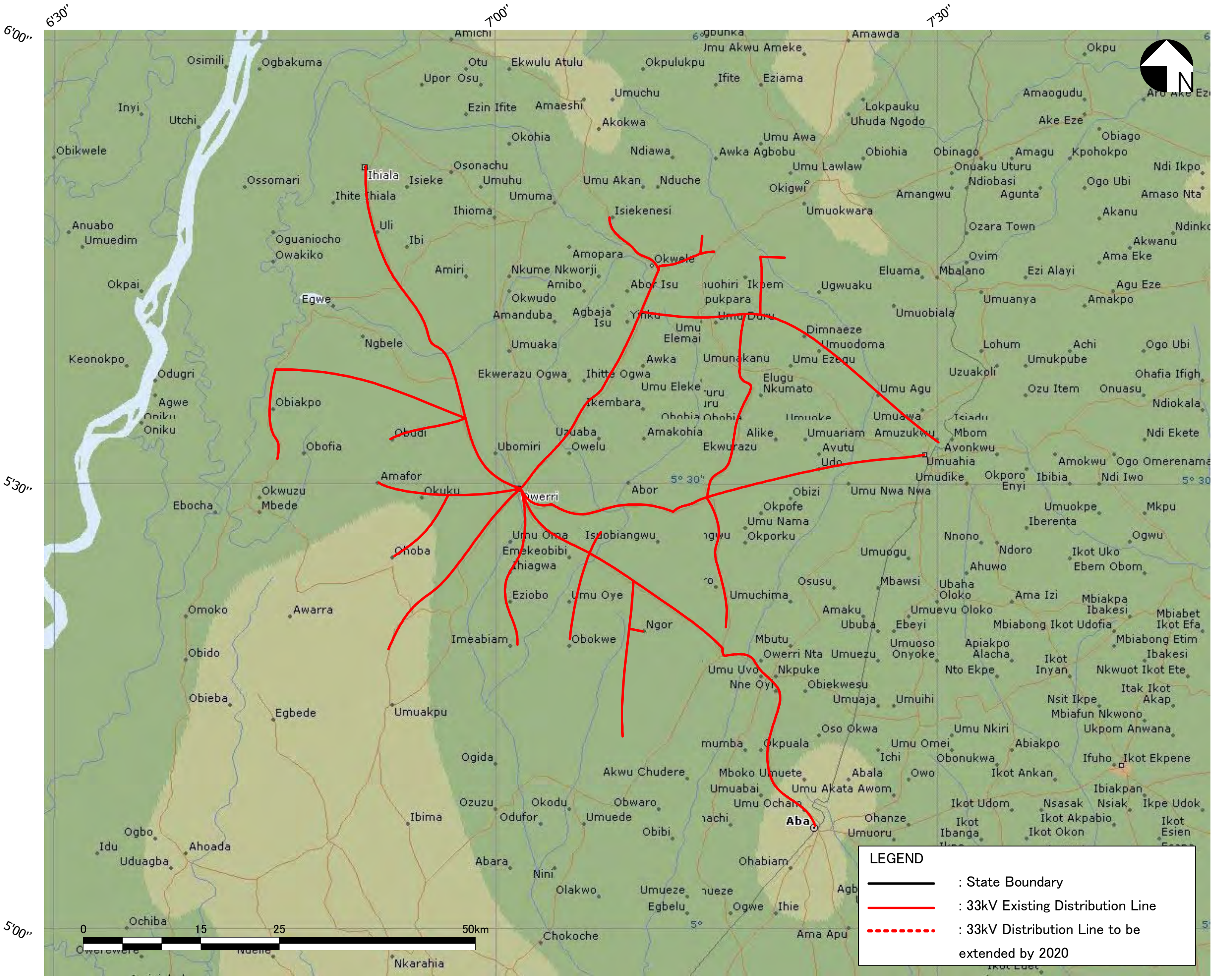


Fig. 1-10 33 kV Distribution Diagramme for Imo State

Based on the above analysis, the proposal of a PV electrification model(s) which can raise the level of user satisfaction in Imo State despite a high monthly charge as in the case of Ondo State is necessary. However, as the electrification rate in Imo State is lower than that in the FCT (71%) and Ondo State (72%), the inclusion of medium size villages which are located far from the existing grid in the target villages for PV electrification is highly feasible. Therefore, the use of a private RESCO to install individual SHSs as a short-term measure, starting from those villages with a large power demand but which are far from the existing grid compared to other unelectrified villages, is proposed. In the medium to long-term from 2010 to 2020 when the mass production effect on the equipment price and expansion of the service network of PV companies as a result of the wide use of PV systems are expected to take place, the required length of grid extension to the remaining unelectrified villages will be shorter, making the life cycle cost per KWh, including the grid extension cost, relatively low. For this reason, PV systems in Imo State are considered to be tentative measures until the realisation of on-grid electrification and the introduction of a mini-grid system which can be easily relocated once on-grid electrification is realised in the near future is proposed as a short-term as well as medium to long-term PV electrification model.

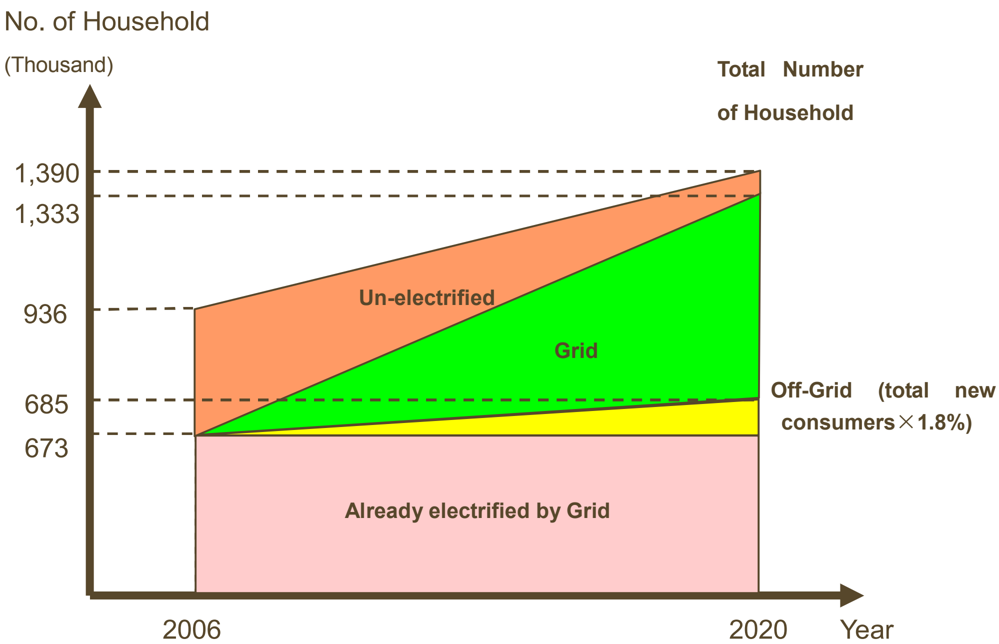
In short, the following PV electrification models are proposed for Imo State as short-term and medium to long-term models.

- SHS (short-term: up to 2010)
- Mini-grid system (medium to long-term: 2010 – 2020)

1.4.3 Off-Grid Electrification Targets

The establishment of short-term as well as medium to long-term targets for off-grid electrification in Imo State is necessary. The National Energy Policy of Nigeria plans the supply of electricity (including electricity generated by renewable energies) to 75% of the total population in 2020. Accordingly, the target electrification rate for Imo State to achieve the national target is set at 78% in 2010 and 96% in 2020.[9)] Using the population ratio by state based on the results of the 1991 National Census, the total number of households in Imo State in 2006 is estimated to be approximately 940,000. Meanwhile, the National and State Population Projections[10)] predict an increase of the number of households in Imo State to approximately 1.39 million by 2020. This means that electricity supply to 1.33 million households (1.39 million x 0.96) will be required in 2020. As of 2006, some 670,000 households receive electricity through on-grid electrification, making the new supply (either on-grid or off-grid) to some 660,000 households (1.33 million – 0.67 million) necessary to achieve the 2020 target. As the Rural Electrification Policy and the Renewable Energy Action Programme of Nigeria intend the use of PV generation to supply electricity to some 1.8% of new users in the coming years, the supply of electricity to some 11,700 households by means of off-grid PV rural electrification will be necessary. Fig. 1-11 shows the planned scheme to supply electricity to new users in Imo State. The targets for both on-grid and off-grid electrification in Imo State are set high as it is necessary to substantially increase the electrification rate in the state to achieve the national electrification rate of 75%.

9) Refer to 2.6 – Formulation of the National PV Electrification Programme for further details
10) Conducted by the National Population Commission and the United Nations Population Fund



Source: The Study Team

Fig. 1-11 Planned Number of Electrified Households up to 2020 (Imo State)

Based on the above analysis, Table 1-21 lists the PV systems of which the introduction in Imo State is planned by 2010 and 2020. Here, it is assumed that a private RESCO will act as the principal project implementing organization in accordance with the REA's policy of facilitating the entry of private companies as much as possible. In the case of SHSs, however, it is predicted that some systems will be directly sold by PV companies to wealthy users and it is estimated here that 10% of the total number of SHS units will be installed through such direct sale in the market. The operation and maintenance of a mini-grid system by a village electrification association is not considered because the maintenance of a mini-grid system involves regular patrolling and checking by a PV engineer.

Table 1-21 PV Systems of Which the Introduction is Assumed in Imo State by 2010 and 2020

Year	～ 2010		～ 2020		
System	SHS		SHS		Mini Grid
Implementing organization	1.RESCO 2.Community	Direct Sales	1.RESCO 2.Community	Direct Sales	RESCO
No. of PV systems	2,340	260	2,340	260	455

Source: The Study Team

1.4.4 Financial Analysis and Economic Evaluation

(1) Financial Analysis of Mini-Grid Projects

For the implementation of mini-grid based electrification projects in Imo State, implementation by an RESCO(s) is also assumed instead of the village-based participatory approach for BCS or SHS projects. The pace of project implementation will correspond to the planned schedule shown in Table 1-21. The period from 2007 to 2010 will be considered the preparatory period to establish a RESCO(s), followed by the installation of 225 systems serving 4,500 households (20 households/system x 225 systems) in the five year period from 2011 to 2015. In other words, some 45 systems (serving some 900 households: 20 households/system x 45 systems) will be installed. In the following five year period from 2016 to 2020, 230 systems serving 4,600 households (20 households/system x 230 systems) or at a pace of some 46 systems serving some 230 households will be installed each year.

Table 1-22 Annually Required Equipment Investment for Mini-Grid Systems in Imo State

(Unit: NgN million)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Price of mini-grid system	0	3.55	3.39	3.22	3.05	2.89	2.72
Number of mini-grid systems to be installed	0	0	0	0	45	45	45
Investment cost	0	0	0	0	137	130	122
Necessary subsidy for 50% initial cost	0	0	0	0	69	65	61
Installation year	2014	2015	2016	2017	2018	2019	2020
Price of mini-grid system	2.55	2.38	2.22	2.05	1.88	1.72	1.55
Number of mini-grid systems to be installed	45	45	46	46	46	46	46
Investment cost	115	107	102	94	87	79	71
Necessary subsidy for 50% initial cost	57	54	51	35	22	10	0

Source: The Study Team

Here, it is assumed that a private RESCO will conduct the installation of 455 PV mini-grid systems (each system serving 20 households) in Imo State in the 10 year period from 2011 to 2020. The FIRR and the financial internal NPV (FINPV) of the said RESCO are calculated based on the assumption that 45 PV mini-grid systems (serving 900 households) will be installed each year in the five year period from 2011 to 2015, followed by the installation of 46 systems (serving 920 households) each year in the next five year period from 2016 to 2020. The other preconditions are the same as those for the financial analysis of the mini-grid electrification projects in 3.3. As shown in the table below, the resulting FIRR and FINPV is 16.6% and some NgN 270 million respectively.

FIRR (Financial Internal Rate of Return)	16.6%
Financial NPV (Net Present Value)	NgN 268,517,917

In regard to sensitivity analysis, two cases where the income (collected electricity charge) is 15% and 30% below the expected level are analysed. Two further cases where the investment cost is 15% and

30% above the expected level (meaning that the PV equipment cost and the installation cost do not fall below the expected levels) are also analysed.

Table 1-23 Sensitivity Analysis

Case	FIRR (%)	NPV (NgN)
Base Case	16.6	268,517,917
Case 2 (Income: 15% down from the expected level)	13.7	154,571,731
Case 3 (Income: 30% down from the expected level)	10.5	39,469,020
Case 4 (Investment cost: 15% up from the expected level)	15.0	223,503,256
Case 5 (Investment cost: 30% up from the expected level)	13.6	178,488,596

Source: The Study Team

(2) Financial Analysis of SHS Projects

In the case of SHSs, it is assumed that 2,340 households in Imo State will have been electrified by SHSs in the four year period from 2007 to 2010. As clearly shown by the village socioeconomic survey results, the socioeconomic situation in Imo State is quite different from that in Jigawa State in that the poverty level is relatively low and the level of the demand for electrification is high. Accordingly, it is inferred that even in areas outside the scope of on-grid electrification in the near future, there are people who cannot be satisfied with the 55 W type SHS which is to be introduced in Jigawa State but which only provides electricity for lighting. It is, therefore, assumed that 110 W and 165 W type high specification SHSs will also be installed in Imo State to allow users to listen to the radio and watch television. In short, SHS-based off-grid electrification involving three types of SHSs will be introduced in Imo State using the model examined in 3.3 to serve villages with 330 households (55 W for 180 households (60%), 110 W for 90 households (30%) and 165 W for 30 households (10%)). The planned pace is the installation of a SHS at 540 households (55 W for 324 households, 110 W for 162 households and 165 W for 54 households) in 2007, followed by installation at 600 households (55 W for 360 households, 110 W for 180 households and 165 W for 60 households) each year in the period from 2008 to 2010.

Table 1-24 Annually Required Equipment Investment in SHS Projects in Imo State

(Unit: NgN)

55W	Installation year	2,007	2,008	2,009	2,010
	Investment cost per system	144,000	137,538	131,077	124,615
	Number of 55W SHS systems to be installed	324	360	360	360
	Investment cost	46,656,000	49,513,846	47,187,692	44,861,538
	Necessary subsidy for 50% initial cost	23,328,000	24,756,923	23,593,846	22,430,769
110W	Installation year	2007	2008	2009	2010
	Investment cost per system	194,400	185,677	176,954	168,231
	Number of 110W SHS systems to be installed	162	180	180	180
	Investment cost	31,492,800	33,421,846	31,851,692	30,281,538
	Necessary subsidy for 50% initial cost	15,746,400	16,710,923	15,925,846	15,140,769
165W	Installation year	2007	2008	2009	2010
	Investment cost per system	324,000	309,462	294,923	280,385
	Number of 110W SHS systems to be installed	54	60	60	60
	Investment cost	17,496,000	18,567,692	17,695,385	16,823,077
	Necessary subsidy for 50% initial cost	8,748,000	9,283,846	8,847,692	8,411,538
	Total investment cost	95,644,800	101,503,385	96,734,769	91,966,154
	Total necessary subsidy	47,822,400	50,751,692	48,367,385	45,983,077

Source: The Study Team

As the implementation of the above-mentioned multi-type SHS projects on a village by village basis is necessary because of the long distance of these villages from urban areas, community-led implementation is the most appropriate. Accordingly, these projects will be implemented as community-led electrification projects involving village electrification associations. It is assumed here that it will be sufficient for these village electrification associations to prevent their operation from incurring a cash flow deficit. As such, a marginal charge level which allows operation without a cash flow deficit throughout the project life is examined here. The expected size of the initial payment per household and the monthly charge are shown in Table 1-25.

Table 1-25 Required Initial Cash Payment by Each Household for the Installation of a SHS and the Monthly Charge Thereafter

(Unit: NgN)

Installation year		2007	2008	2009	2010
55W	Initial payment per household	28,800	27,508	26,215	24,923
	Monthly charge (1-5 year)	1,200	1,140	1,090	1,040
	Monthly charge (6-20 year)	600	580	550	530
110W	Initial payment per household	38,880	37,135	35,391	33,646
	Monthly charge (1-5 year)	1,620	1,539	1,472	1,404
	Monthly charge (6-20 year)	810	783	743	716
165W	Initial payment per household	64,800	61,892	58,985	56,077
	Monthly charge (1-5 year)	2,700	2,565	2,453	2,340
	Monthly charge (6-20 year)	1,350	1,305	1,238	1,193

Source: The Study Team

(3) Purchase of SHSs by Individual Users

It is assumed that 260 SHSs will be purchased by individual users from PV dealers in the four year period from 2007 to 2010. As this represents voluntary purchase by wealthy individuals, these systems are not included in the scope of the present financial analysis.

(4) Economic Evaluation of PV Electrification Projects in Imo State

The economic evaluation of the mini-grid projects and various SHS projects described above using the method employed in 3.5 (where economic evaluation of PV electrification projects nationwide is conducted) produces the following results.

Table 1-26 Economic Evaluation of PV Electrification Projects in Imo State

	Combined	Only Mini-Grids	Only SHSs
EIRR	37.7%	56.3%	25.5%
ENPV	NgN 2,524,245,416	NgN 2,222,756,370	NGN 301,489,046
B/C Ratio	2.91	3.91	1.54

Source: The Study Team

1.5 FCT (Abuja Federal Capital Territory: FCT)

1.5.1 Analysis of the Power Demand

As the Meteorological Agency does not have any meteorological data for the FCT, data for the nearby city of Minna in Niger State is used for reference purposes. Although the annual mean quantity of solar radiation of 6.01 KWh/m^2/day is high (compared to the national average of 5.50 KWh/m^2/day), the figure drops to as low as 3.86 KWh/m^2/day in August during the rainy season. Consequently, the scope of application of solar energy is limited compared to Jigawa and other northern states. The electrified household ratio in the FCT of 71%[11)] is substantially higher than the national average (44%), indicating the geographical spread of the existing 33/11 kV distribution lines, mainly along the major trunk roads, to reach not only LGHQ areas and important towns but also many rural areas.

Fig. 1-12 shows the distribution diagramme for the FCT. Despite of the fact that it is the capital area, the 33 kV distribution lines are radially extended, causing a low level of reliability of the power supply. For this reason, reconfiguration of the distribution system is necessary to create a loop system supported by constantly open load break-switches so that switching of the power supply route can be conducted to counter a power failure.

Table 1-27 and Table 1-28 show the historical changes of the number of users and the maximum demand respectively in the FCT. The annual increase rate of the number of users is as high as 12 – 27%. In the case of the maximum demand, although the annual increase rate of 39% in 2005 is extremely high, it varies from one year to another. The main cause of the increased demand is inferred to be population inflow from neighbouring states. The insufficient transmission and distribution capacity in the FCT mean that scheduled outages in turn are a permanent feature of the power supply, suggesting a much larger potential power demand.

11) General Household Survey 1997/98

Table 1-27 Number of Users in the FCT

	2001	2002	2003	2004	2005
Total Number of Users	178,909	228,045	259,782	302,129	337,675
Annual Increase Rate (%)	N/A	27	14	16	12

Source: PHCN

Table 1-28 Maximum Demand in the FCT

(Unit: MW)

	2000	2001	2002	2003	2004	2005
Maximum Demand	100	104	N/A	180	201	270

Source: PHCN

The FCT is an area which is blighted by frequent power cuts caused by deteriorated distribution equipment and the reliability of the power supply through on-grid electrification is extremely low. Table 1-29 shows accident statistics involving the 33/11 kV distribution lines in the FCT. These figures indicate an increasing trend of accidents involving both the 33 kV and 11 kV transmission lines in recent years, suggesting the deterioration of such equipment as transformers, cables and switches. It is, therefore, highly desirable to secure the necessary budget to systematically repair or renew this equipment.

In general, on-grid electrification enjoys a higher level of user satisfaction than off-grid electrification as it permits the longer use of large capacity electrical appliances. The village socioeconomic survey results, however, indicate that the level of user satisfaction is low in on-grid electrified villages because of the long duration and high frequency of power cuts. In contrast, the level of user satisfaction in areas subject to PV off-grid electrification is relatively high. As the FCT has many more commercial facilities, such as stores and hotels, and federal government-related public facilities than other states, the introduction of PV systems linked to the grid is hoped for to supplement the on-grid electrification with a low power supply reliability. One condition to achieve this is the development of the domestic market for PV systems through the advancement of the off-grid PV electrification of rural areas.

Table 1-29 Frequency of Accidents Involving 33/11 kV Distribution Lines in the FCT

(Unit: times/year)

	2000	2001	2002	2003	2004	2005
33 kV Distribution Lines	234	N/A	204	424	474	621
11 kV Distribution Lines	257	N/A	267	816	525	823

Source: PHCN

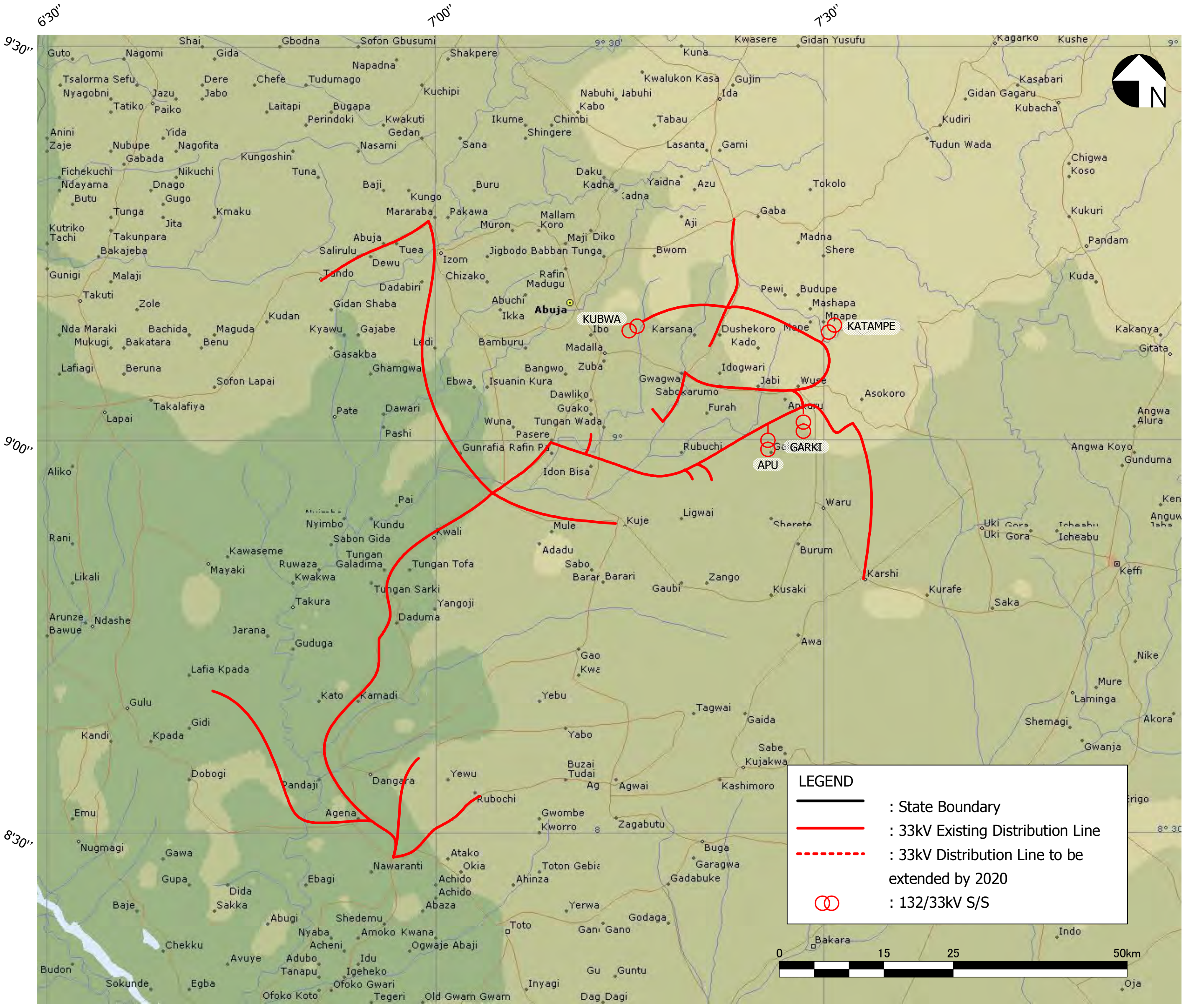
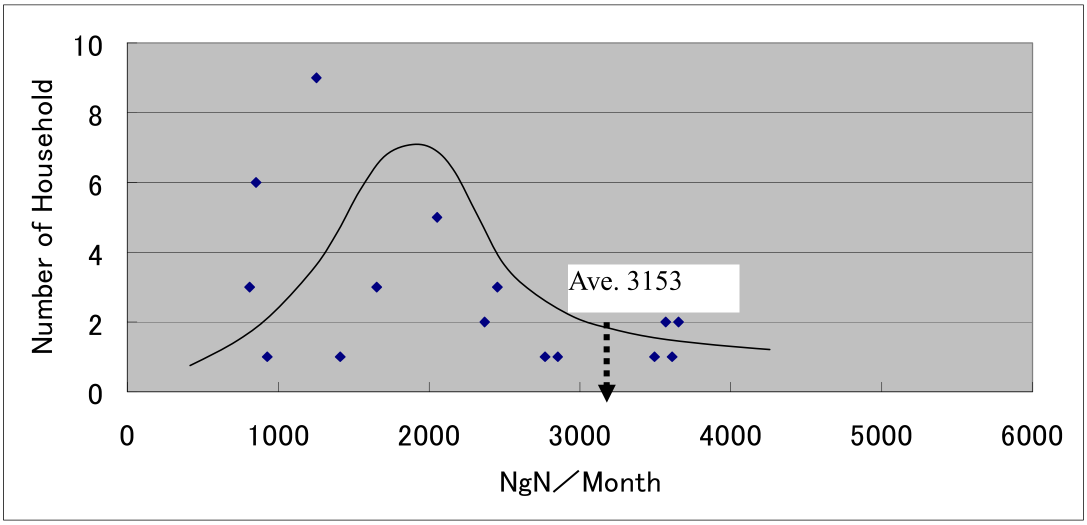


Fig. 1-12 33 kV Distribution Diagramme for the FCT

1.5.2 Proposal of AV Electrification Models

The village socioeconomic survey results indicate that the average monthly expenditure (i.e. the total expenditure for kerosene, diesel oil and dry cells) in unelectrified villages in the FCT is fairly high at NGN 3,153 as shown in Fig. 1-13. As no local household wants the introduction of a BCS because of restrictions on the capacity of the electrical appliances which can be used and also on the hours of use, the proposal of a PV electrification mode with high specifications despite a highly monthly charge is necessary. Moreover, as the existing grid spreads over a wide area along the main trunk roads, the distance for grid extension to unelectrified villages is short, making the life cycle cost per KWh, including the grid extension cost, relatively low. For this reason, PV system in the FCT are considered to be tentative measures until the realisation of on-grid electrification and the introduction of a mini-grid system which can be easily relocated once on-grid electrification is realised in the near future is proposed as a short-term as well as medium to long-term PV electrification model (the same PV electrification model adopted for Ondo State).



Source: Village socioeconomic survey results

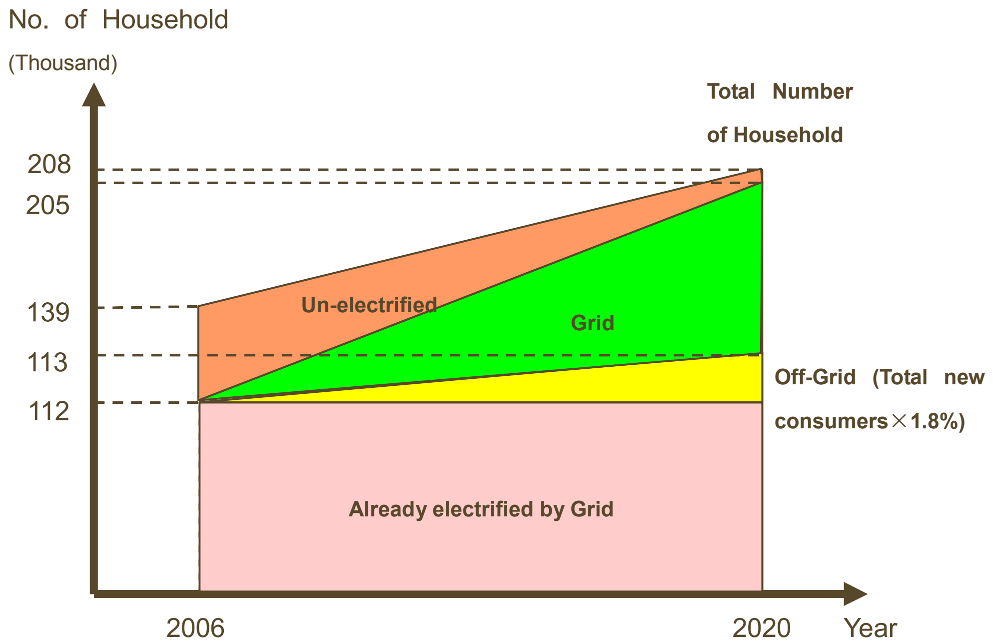
Fig. 1-13 Distribution of Energy Expenditure (Kerosene and Diesel Oil) in Unelectrified Villages (FCT, N = 42)

1.5.3 Off-Grid Electrification Targets

The establishment of short-term as well as medium to long-term targets for off-grid electrification in the FCT is necessary. The National Energy Policy of Nigeria plans the supply of electricity (including electricity generated by renewable energies) to 75% of the total population in 2020. Accordingly, the target electrification rate for the FCT to achieve the national target is set at 85% in 2010 and 99% in 2020.[12)] Using the population ratio by state based on the results of the 1991 National Census, the total number of households in the FCT in 2006 is estimated to be approximately 140,000. Meanwhile, the National and State Population Projections[13)] predict an increase of the number of households in the FCT to approximately 210,000 by 2020. This means

12) Refer to 2.6 – Formulation of the National PV Electrification Programme for further details
13) Conducted by the National Population Commission and the United Nations Population Fund

that electricity supply to 200,000 households (210, 000 x 0.99) will be required in 2020. As of 2006, some 110,000 households receive electricity through on-grid electrification, making the new supply (either on-grid or off-grid) to some 90,000 households (200,000 – 110,000) necessary to achieve the 2020 target. As the Rural Electrification Policy and the Renewable Energy Action Programme of Nigeria intend the use of PV generation to supply electricity to some 1.8% of new users in the coming years, the supply of electricity to some 1,700 households by means of off-grid PV rural electrification will be necessary. Fig. 1-14 shows the planned scheme to supply electricity to new users in the FCT. The planned quantity of off-grid PV systems to be introduced in the FCT in the coming years is small because of the high current electrification rate of 71% in 2006 and the small estimated population in 2020.



Source: The Study Team

Fig. 1-14 Planned Number of Electrified Households up to 2020 (FCT)

Based on the above analysis, Table 1-30 lists the PV systems of which the introduction in the FCT is planned by 2010 and 2020. Here, it is assumed that a private RESCO will act as the principal project implementing organization in accordance with the REA's policy of facilitating the entry of private companies as much as possible. The operation and maintenance of a mini-grid system by a village electrification association is not considered because the maintenance of a mini-grid system involves regular patrolling and checking by a PV engineer.

Table 1-30 PV Systems of Which the Introduced is Assumed in the FCT by 2010 and 2020

Year	～2010	～2020
System	Mini Grid	Mini Grid
Implementing organization	1.RESCO 2.Gov / ODA	RESCO
No. of PV systems	20	85

Source: The Study Team

1.5.4 Financial Analysis and Economic Evaluation

(1) Financial Analysis of Mini-Grid Systems

For the implementation of mini-grid based electrification projects in the FCT, implementation by a RESCO is assumed as in the case of Ondo State instead of the village-based participatory approach for BCS or SHS projects. The pace of project implementation will correspond to the planned schedule shown in Table 1-30. The year 2007 will be considered the preparatory year to establish a RESCO, followed by the installation of 20 systems serving 400 households (20 households/system x 20 systems) in the three year period from 2008 to 2010 (seven systems serving 140 households each in 2008 and 2009 and six systems serving 120 households in 2010). In the 10 year period from 2011 to 2020, a further 65 systems serving 1,300 households (20 households/system x 65 systems) will be installed at an annual rate of six systems (serving 120 households) in the first five years and seven systems (serving 140 households) in the second five years.

Table 1-31 Annually Required Equipment Investment for Mini-Grid Systems in the FCT

(Unit: NgN million)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Price of mini-grid system	0	3.55	3.39	3.22	3.05	2.89	2.72
Number of mini-grid systems to be installed	0	7	7	6	6	6	6
Investment cost	0	25	24	19	18	17	16
Necessary subsidy for 50% initial cost	0	12	12	10	9	9	8
Installation year	2014	2015	2016	2017	2018	2019	2020
Price of mini-grid system	2.55	2.38	2.22	2.05	1.88	1.72	1.55
Number of mini-grid systems to be installed	6	6	7	7	7	7	7
Investment cost	15	14	16	14	13	12	11
Necessary subsidy for 50% initial cost	8	7	8	5	3	2	0

Source: The Study Team

As the market size of the FCT is much smaller than that of other states, it may be that a RESCO which is engaged in mini-grid based electrification in a neighbouring state will establish a branch in the FCT to be solely responsible for mini-grid electrification projects in the FCT. Given the significance of examining the financial viability of the assumed mini-grid projects in the FCT for the Study, it is assumed here that a private RESCO will conduct the mini-grid projects in the FCT and the FIRR and

NPV of this company are calculated under the present financial analysis. The other preconditions are the same as those for the financial analysis of mini-grid electrification in 3.3. As the table below shows, the FIRR and the financial internal NPV are 17.5% and some NgN 320 million respectively.

FIRR (Financial Internal Rate of Return)	17.5%
Financial NPV (Net Present Value)	NgN 320,897,841

In regard to sensitivity analysis, two cases where the income (collected electricity charge) is 15% and 30% below the expected level are analysed. Two further cases where the investment cost is 15% and 30% above the expected level (meaning that the PV equipment cost and the installation cost do not fall below the expected levels) are also analysed.

Table 1-32 Sensitivity Analysis

Case	FIRR (%)	NPV (NgN)
Base Case	17.5	320,897,841
Case 2 (Income: 15% down from the expected level)	14.0	184,739,889
Case 3 (Income: 30% down from the expected level)	10.5	45,398,379
Case 4 (Investment cost: 15% up from the expected level)	15.3	260,281,076
Case 5 (Investment cost: 30% up from the expected level)	13.5	199,125,857

Source: The Study Team

(2) Economic Evaluation of PV Electrification Projects in the FCT

The economic evaluation of the mini-grid projects described above using the same method employed in 3.5 (where the economic evaluation of PV electrification projects nationwide is conducted) produces the following results.

Table 1-33 Economic Evaluation of PV Electrification Projects in the FCT

Item	Numerical Value
EIRR	47.7%
Economic NPV	NgN 469,859,988
B/C Ratio	2.76

Source: The Study Team

Chapter 2 National PV Electrification Programme

2.1 Direction for Off-Grid Rural Electrification in Rural Electrification Policy

2.1.1 Outline of Rural Electrification Policy

As the National Rural Electrification Programme formulated in 1981 assumes rural electrification based on extension of the grid, the FMPS is required to finalise the Rural Electrification Policy as a guideline with a view to proceeding with both on-grid and off-grid rural electrification to achieve the medium to long-term targets for rural electrification. Moreover, the FMPS is in the process of formulating the Renewable Electricity Policy Guidelines and the Renewable Electricity Action Programme to implement the said policy guidance. The present M/P is considered to be a medium to long-term master plan for off-grid rural electrification to materialise the above-mentioned Rural Electrification Policy and the Renewable Electricity Policy Guidelines.

In general, there are two types of approaches for the implementation of rural electrification programmes. One is the top-down type where projects are implemented based on an electrification programme formulated by either the central or local government. The other is the bottom-up approach where projects are implemented based on an electrification request by (and with the financial capacity of) residents. The top-down approach has been employed for the implementation of rural electrification in Nigeria based on the National Rural Electrification Programme formulated by the FMPS in 1981. The draft Rural Electrification Policy (REP), however, stipulates that the government decides the electrification priority of unelectrified areas based on the "village size", "intensity of commercial activities" and "willingness and ability to pay the electricity charge" and formulates highly transparent top-down type projects. Rural electrification projects which are sustainable for a long period should target those areas where the electrification demand of local residents who have realistic payment ability is strong. For this reason, the active invitation of the private sector and such stakeholders as local residents is essential for the formulation of bottom-up type electrification projects based on the market principles. The profit margin of electrification projects which serve small-scale household users in remote areas, however, is actually small despite the fairly large initial investment. The injection of a subsidy by the Rural Electrification Fund (REF) described later is, therefore, necessary to establish a fair and transparent market which allows the entry of many organizations, including local NGOs, as in the case of the SELF in Jigawa State, village electrification associations and private companies. The REP lists facilitation of the introduction of renewable energies among its targets in addition to more conventional power sources and plans the use of renewable energies to meet the power demand of new users in the coming years.

2.1.2 Rural Electrification Approaches

For the efficient and strategic planning of rural electrification projects, it is essential to consider such factors as the distance from an existing distribution line, topography, demand density, potential for commercial activities and charge collection possibility, etc. to achieve the optimal combination of on-grid and off-grid electrification. Here, the desirable approaches to on-grid and off-grid electrification are examined, taking the contents of the REP into consideration. Based on this examination, the proposals of the Study Team for PV rural electrification are described in 2.8 – PV

Rural Electrification Promotion Measures.

(1) On-Grid Electrification

In general, on-grid electrification offers highly reliable power supply and is more economical than off-grid electrification if the demand density is above a certain level. The level of user satisfaction is high because it allows the use of electrical appliances with a large capacity. As such, on-grid electrification should continue to be the electrification method to be considered first. One important issue to improve the payability of on-grid electrification is how to reduce the cost of the labour-intensive work of electricity charge collection. This cost includes monthly meter reading and billing in rural areas which are characterised by a small population size and low demand density. Another important issue is how to reduce non-technical losses, primarily the theft of electricity. One measure to deal with these issues is to increase the ownership of rural users of an electrification project to make it a participatory project. To achieve this, it is necessary to transfer the project management authority from the PHCN (or distribution companies after the breaking up of the PHCN) to rural cooperatives, local governments and local NGOs in order to reduce the project operation and maintenance cost, including the electricity charge collection cost.

(2) Off-Grid Electrification

To determine the subject areas for off-grid electrification, the selection of those areas for which there is no on-grid electrification plan for the next five years and which cannot be expected to recover the investment cost of on-grid electrification due to their remote location is necessary. It is also important not to regard off-grid electrification facilities as permanent facilities and a flexible approach to the connection of off-grid facilities to the grid will be necessary once economic development resulting from the limited electrification has increased the demand density in the future and passes the break-even point. According to the life-cycle cost analysis conducted as part of the Renewable Energy Master Plan prepared by the ECN with the technical assistance of the UNDP, PV rural electrification is economically more advantageous than diesel power generation when the demand per household is small at 300 W or less. Off-grid rural electrification is similarly more advantageous than on-grid electrification if the required distribution line extension distance is 1.8 km or longer. However, as recommended by the M/P, the economy of on-grid and off-grid PV rural electrification must be judged based on comprehensive comparison of the respective life-cycle costs, taking not only the required extension distance of the distribution line but also the village size and expected hours for electricity supply by on-grid electrification into consideration.

Off-grid electrification is considered next in terms of the mini-grid system and independent system.

1) Mini-Grid System (Centralised System)

Under this system, a centralised PV generation plant is installed in a village and low voltage power which is changed to AC by an inverter is supplied to each household. Compared to the independent system described in 2) below, the facilities can be centrally maintained and power supply to large capacity loads is possible unlike the independent system. Another advantage is the ease of relocation to another village when the grid is extended to the village in the future. In Nigeria, this system has been experimentally introduced in Sokoto State and Enugu State, etc.[1)]

The mini-grid system is economically advantageous when the day-time load due to such agricultural machinery as corn mills and other machinery and the use of electricity by stores reaches the same load level due to lighting at night, resulting in an insufficient battery capacity. Although this system is generally more expensive than the independent system, the size of the initial investment per household can be reduced provided that the village in question has a relatively high geographical concentration of users, thereby shortening the required total length of low voltage distribution lines. The REP proposes the following policies to spread the use of the mini-grid system.

・ Instead of awarding a supplier with a monopoly franchise, the barriers for entry to the market should be lowered to allow the operation of many suppliers while introducing the minimum but necessary safety regulations and technical standards.
・ An operating licence is not required for a mini-grid system of which the generating capacity is 1 MW or lower or of which the distribution capacity is 100 KW or lower.
・ No extension of the grid will be made during the period in which the initial investment in the construction of a mini-grid system is recovered.

In Nigeria, rural electrification in the past has often involved the introduction of a mini-grid system using a diesel engine generator. However, the maintenance of the generator, including its rotating and driving units, has proved to be too great a burden for a community-based maintenance organization and no plan is currently said to exist to introduce this type of mini-grid system. The recent hike of the diesel oil price has also contributed to the current absence of such a plan. For this reason, the possibility of introducing a mini-grid system using a diesel engine generator is not examined under the Study.

2) Independent System

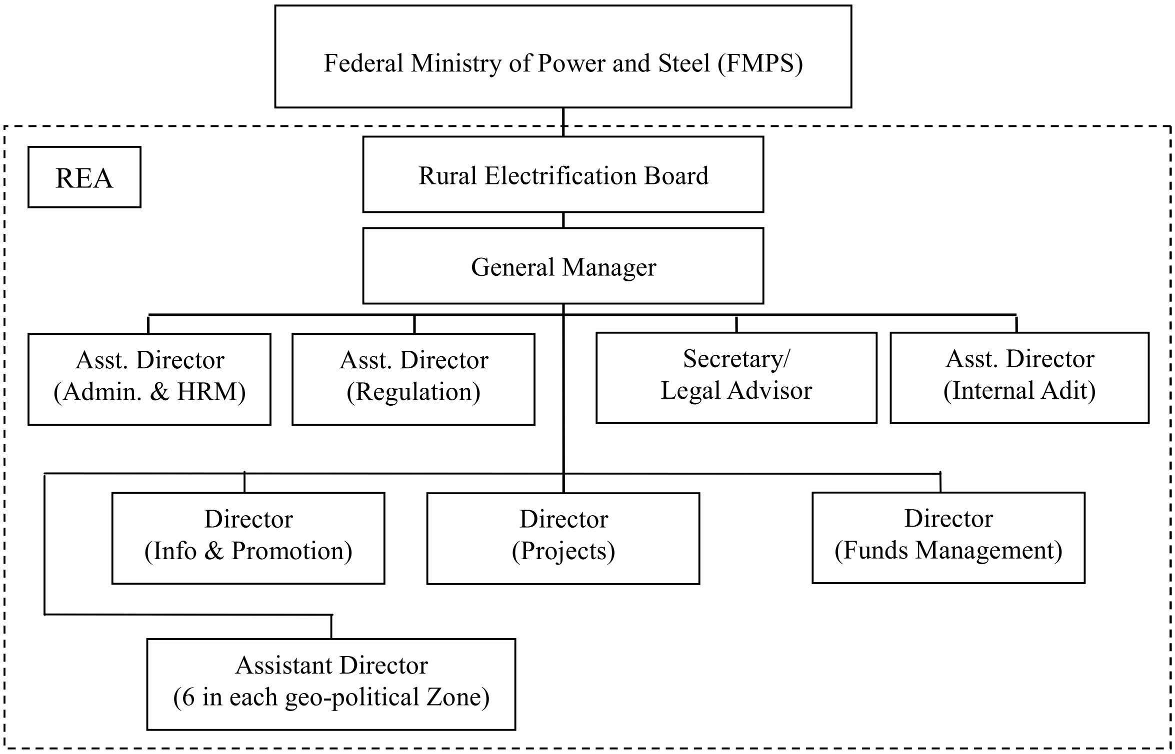
An independent system means electrification by a distributed power source at each user site and a SHS is a typical example. Because of the independent installation of equipment on the premises of each user, it has the advantage of increasing the ownership of users compared to the mini-grid system which is maintained as a village facility. The REP proposes the following policies to spread the use of the independent system.

・ Preparation of only the minimum quality and safety standards relating to the manufacture and installation of equipment to avoid an excessive regulatory regime
・ Reduction of the import tariff for equipment to use renewable energies
・ Promotion of the domestic production of equipment to use renewable energies

1) Refer to Part 1, 3.7 – Present Situation and Pending Issues for the Use of Solar Energy for further details.

2.2 Roles, Organization and Work of the REA

The REA was established in March, 2006 as an independent organization from the government and is required to select candidate rural electrification projects and to distribute funds based on fair and transparent rules in regard to its management of the REF. The REA is planning to prepare policy guidelines to ensure the fair management of the REF without segregating off-grid rural electrification from on-grid rural electrification. In addition, acting as the regulatory organ for rural electrification projects, the REA must prepare and enforce the minimum safety regulations, technical standards and required standard level of service, etc. The headquarters of the REA are located in Abuja. The REA will be responsible for the monitoring of rural electrification projects in collaboration with state and other local governments as well as distribution companies after the breaking up of the PHCN using its own network of branch offices to be established in due course.



Source: REA

Fig. 2-1 Organizational Structure of the REA

The reform of the power sector in Nigeria also saw the establishment of the Nigerian Electricity Regulatory Commission (NERC) on 31st October, 2005. The NERC acts as the regulatory and supervising body for companies involved in power generation, transmission and distribution, including private companies. The scope of the jurisdiction of the NERC includes rural electrification projects except for those of which the generating capacity is up to 1 MW or of which the distribution capacity is up to 100 KW and, therefore, off-grid rural electrification projects will not be subject to regulatory control and supervision by the NERC for some time. While the NERC intends to minimise its safety and quality regulations to facilitate the entry of new private companies into the market, its important roles include the appropriate protection of rural users who have little knowledge of electricity.

2.3 Business Models

There are two principal business models designed to spread PV rural electrification. One is the sales model and the other is the service model. The selection of a suitable model in correspondence with the number of users, demand density and users' ability to pay the electricity charge, etc. is the key to the successful implementation of a project. With the service model, the ownership of equipment remains with the service provider (called a Rural Energy Service Company (RESCO)) and the RESCO (be it community-based, a PV supplier or an electric company) is responsible for equipment maintenance, including the renewal of equipment due to age or damage, and collection of the electricity charge. In contrast, the ownership of equipment is eventually transferred to each user in the case of the sales model although the timing of such transfer depends on the type of purchase, i.e. outright purchase, loan or hire purchase. The individual user is responsible for the installation, operation and maintenance of the system which he does himself or entrusts such work to an outsider based on a contract. The characteristics of these business models are summarised in Table 2-1. The past experience of the JICA's pilot project and the projects of other donors indicate that it is essential to propose the optimal business model or method to prepare such a business model for each country or region to the implementing organization for electrification projects. For the immediate future, however, it is necessary to examine the possibility of facilitating government or ODA-assisted PV rural electrification projects as the sales model has some restrictive factors. These factors include the facts that only wealthy users comprising some 20 – 50% of the households in unelectrified villages are said to be able to afford a PV system[2)] and that the system ownership is transferred to each user from the dealer when payment of the initial investment cost has been made (in the case of SHSs).

Table 2-1 Comparison of Business Models

Item	Sales Model	Service Model
Target Users	The large monthly repayment amount even with a loan or hire purchase is a heavy burden for low income households.	As the RESCO makes bulk purchase using the funds raised, the lower unit price makes the system accessible by many users.
Operation and Maintenance	Because the system becomes the user's property, individual users become more conscious of their own responsibility for operation and maintenance. The lack of external control could lead to the remodelling or abuse of the system.	Because the system is not the user's own property, operation and maintenance tend to be left to the RESCO. Guidance by the RESCO is possible regarding remodelling or abuse of the system to suit the user's requirements.
Collection of the Charge	As charge collection is unnecessary after recovery of the initial investment cost, the operating cost can be reduced.	The charge collection cost is high when the users are geographically scattered as in the case of a remote area, squeezing the business management of the RESCO.
Flexibility Towards On-Grid Electrification	Future on-grid electrification will render the system useless. It is desirable for an electricity supplier to provide a service to purchase and relocate the system.	As the RESCO owns the system, it can be recovered from the user and relocated/re-used in another unelectrified area after on-grid electrification.

Source: The Study Team

2) The GEF Solar PV Portfolio: Emerging Experience and Lessons (2000), p. 18

One point which an RESCO must be aware of is that the cost of battery replacement must be borne by the users even with the service model. In this way, users are more careful of their handling of the battery to prolong its life and the regular replenishment of distilled water (in the case of a vent-type battery) will be properly conducted. If an RESCO does bear the battery replacement cost, there will be customer complaints regarding deterioration of the battery performance due to aging. As a result, the RESCO will be obliged to respond to such complaints and the resulting cost of battery replacement will increase the operating cost of the RESCO.

In the case of rural electrification using a PV system, if the charge level is set higher than the charge level for on-grid electrification, local residents will not opt for a PV system, making continuous spread of the use of PV systems difficult. Accordingly, one precondition is for the charge level for off-grid PV electrification to be similar to or lower than the charge level for on-grid electrification. Meanwhile, the reality of a SHS, which is the most common PV system, is that the charge level will be higher than the level of the on-grid electrification charge (fixed charge: NgN 304.5/month) which is deliberately kept low by a subsidy if the level is determined based on the total cost of the SHS, including the initial equipment investment cost, maintenance cost and battery and other equipment replacement cost. This means that the securing of a subsidy or another source of income resulting from the project is essential to ensure the sustainability of PV rural electrification. In this context, it is important for PV rural electrification to be included in the REF Scheme introduced in March, 2006 so that the question of a suitable charge level for a PV system can be solved within the entire framework of the power sector (refer to Part 2, Chapter 3 for details of the subsidy system).

2.4 Selection Method of Priority Areas for PV Electrification

2.4.1 Basic Conditions

Rural electrification with grid extension is in progress in Nigeria based on the Rural Electrification Programme formulated by the FMPS in 1981. However, this programme only targets LGHQ areas and important towns for electrification. In reality, electrification is conducted in response to requests made by state and other local governments. According to the REP, the target areas for off-grid electrification must, in principle, meet the following conditions.

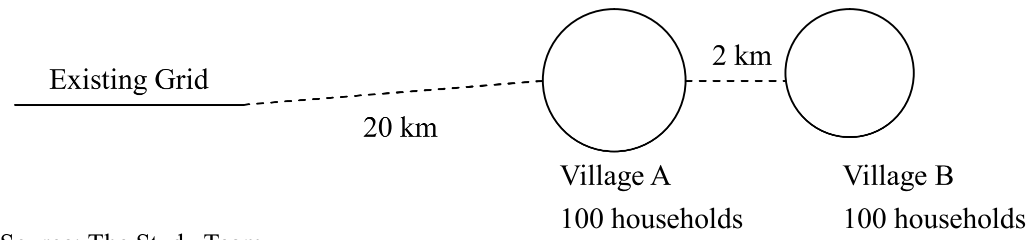
① Area for which no plan exists for extension of the grid in the next five years

② Area where on-grid electrification is not economical as recovery of the investment cost cannot be expected

To confirm the eligibility of an area regarding condition ① above, it is necessary to clarify the areas to which grid extension is planned in the next five years. Moreover, it is desirable for the REA to publicly announce its future electrification plan via the state and other local governments. The reason for this is that continued expectation on the part of the residents of unelectrified areas for grid extension in the near future is the largest stumbling block for the promotion of PV electrification.

In general, the markets for off-grid electrification are located in remote areas where the demand density is low and the distance from the existing grid is far. For these reasons, the selection of suitable areas for PV electrification based on the number of target households for electrification and distance from the grid to meet condition ② is possible.

If a village to be electrified by means of grid extension (for example, Village A) is locates sufficiently near another village (Village B), the possibility of the on-grid electrification of Village B is examined first. If the answer is yes, the total number of households in Village A and Village B is calculated so that the costs of grid extension can be proportionally borne by the two villages.



Source: The Study Team

Fig. 2-2 Concept of Determining the Target Villages for Electrification

Using Fig. 2-2 as an example, if Village A is the initial target for electrification, the nominal distance from the grid and the target number of households is 20 km and 100 respectively. When Village B is also included, the average distance to these villages and the target number of households for electrification is 11 km and 300 respectively, increasing the rationality for on-grid electrification rather than PV electrification. These pairs of villages or concentrations of villages are particularly noticeable in southern Nigeria and, in such a region, PV electrification is restricted to a small number of remote villages.

2.4.2 Selection of Off-Grid PV Electrification Systems

There are several types of off-grid PV electrification systems. These are the SHS (solar home system) system whereby a solar panel(s) is installed on a steel pole in the garden or on the roof of the house, the BCS (battery charging station) system whereby individual users transport their own battery for an automobile or for exclusive use with a PV generation system to a station for recharging, the mini-grid system which is a centralised system involving a PV power plant and low voltage distribution lines and a system which serves public facilities (including street lighting). Table 2-2 lists the general characteristics and important issues of each system.

Table 2-2 Selection of an Off-Grid PV Electrification System

Type	General Characteristics	Important Issues
BCS	➢ The ownership and the scope of responsibility between an RESCO and the users are clearly distinguished. ➢ Maintenance is easier than that for a SHS because of the concentration of the equipment. ➢ It is necessary for the users to transport their own batteries. ➢ Excess discharge by a battery may shorten the battery life, making the intensive education of users necessary.	➢ The charge level is established taking the investment recovery period, equipment operating rate, charge level in the surrounding area and cost of kerosene into consideration. ➢ The number of initial users must be carefully determined to avoid excessive investment. ➢ A regular support system by engineers must be established while training on-site maintenance staff. ➢ Collaboration with indoor cabling companies and their introduction to users are required. ➢ Distilled water to replenish the battery should be made available.
SHS	➢ As the battery can be recharged every day, deep discharge is less likely to occur if the battery in use is in adequate condition. ➢ The size of the initial investment per household is larger than that for a BCS. ➢ A better operation and maintenance system than that for a BCS must be established to prevent abuse or remodelling of the system by users. ➢ Users must understand the differences between a SHS and on-grid electrification and the technical limitations of a SHS.	➢ The battery replacement cost must be clearly identified. ➢ The charge collection system, method and collection rate must be carefully examined. ➢ The maintenance records of on-site maintenance staff and engineers must be checked. ➢ The situation of the use, repair and replacement of the PV panels and auxiliary equipment (charge controller and battery, etc.) must be checked. ➢ The situation of the wide use of deep cycle batteries and DC electrical appliances must be checked.
Mini-Grid	➢ This system is effective for unelectrified villages which are large and near the existing grid. ➢ The types and capacities of the usable electrical appliances are large. ➢ AC electrical appliances can also be used. ➢ An inverter to change DC to AC is required and can be a source of system failure.	➢ Users must be informed in advance of the service hours and limitations on capacity to avoid excessive discharge. ➢ A watt-hour meter or MCCB should be installed at each household to prevent an unlimited increase of the power consumption. ➢ Such professional work as cable connection work on poles and equipment installation is required for proper installation, operation and maintenance and it is necessary for the PHCN and the service provider to conclude a maintenance agreement.
System Serving Public Facilities	➢ The owner of each system is the competent ministry/agency and is different from the users. It is, therefore, essential to properly divide the maintenance responsibility. ➢ The system operating rate can be higher than that of a SHS provided that it is introduced in a place where people gather together with a well planned operating method. ➢ Measures to prevent the theft of the PV panels and batteries are important.	➢ The need for PV electrification must be identified along with the establishment of criteria for introduction. ➢ The need for the use of equipment using PV generation at each facility must be identified. ➢ Ways to use the system to achieve the social benefits of electrification must be examined. These include the use of vaccine refrigerators (clinics) and PCs (schools) in addition to battery chargers and lighting equipment. ➢ In addition to clarifying the demand for street lighting, it is also necessary to clarify who will bear the cost of battery replacement.

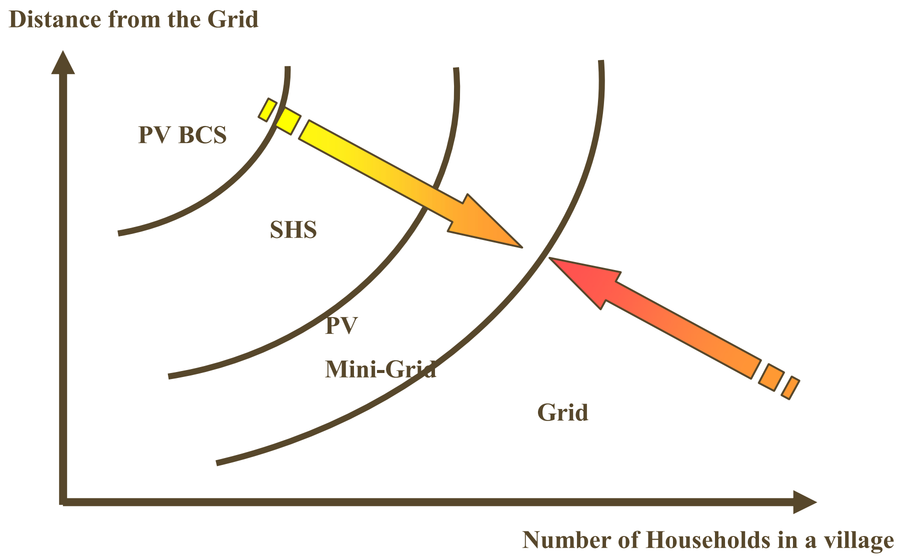
Source: The Study Team

On-grid BCSs already exist in the suburbs of large cities in Nigeria. Most of the batteries recharged at these BCSs are car batteries and vent-type or sealed-type solar batteries are only used for SHSs or at public facilities. At local workshops or local work group meetings in Jigawa State and Ondo State which are the targets of the pilot project, state and local maintenance organizations have repeatedly made requests for “the introduction of SHSs if possible because the regular transportation of a battery to a BCS during the dry season when men seek temporary employment away from their villages is quite difficult”. In both Jigawa State and Ondo State, the BCS system is unpopular because of the inconvenience of its use. While several JICA development studies in the past have examined the possibility of introducing the BCS system in such Asian countries as Laos and Cambodia, there are few successful examples in Africa. The reason for the poor performance of the BCS system in Africa is assumed to be the need for the system to satisfy various conditions, including “a relatively large number of households wanting a BCS system (at least 20 households)”, “geographically compact community” and “vigorous communal activities to enable a village electrification association to control the system”. When the erroneous selection of a target village is made, there is a good chance that a BCS system will not be used at all in the coming years.

In the case of the mini-grid system, the ECN has already introduced this type of system in Sokoto State and Enugu State and all aspects of operation, ranging from collection of the electricity charge to maintenance work, have been smoothly conducted. Meanwhile, the World Bank is planning to introduce this type of system at six sites nationwide as a single project under the UNDP’s Renewable Energy Master Plan. When planning the electrification of villages which are located relatively near to a city and of which the demand is fairly large, neither SHSs nor BCSs can meet the high power demand. The possibility of the successful introduction of a mini-grid system in those villages with a large potential power demand is quite high, therefore, as the system can be easily relocated to remote villages once those villages near a city are connected to the grid. Another advantage of the mini-grid system is that its low voltage distribution lines can be used as they are for on-grid electrification. A paper entitled “Objectives and Plans of the REA Within the Reform Framework” prepared by the REA in May, 2006 defines the mini-grid system as “one of the best tools for future rural electrification”.

Nevertheless, even in the case of the mini-grid system, it is still necessary to educate users on restrictions relating to the hours during which the users can use electricity and also on the maximum power they can receive. The installation of a watt-hour meter is also important to record the electric energy consumed.

In connection with the selection of off-grid PV systems, the Study Team proposes a PV electrification approach based on the distance from the grid and the demand density (i.e. number of households) of each target area (village) for electrification as shown in Fig. 2-3. According to this approach, the BCS, SHS and mini-grid systems will be introduced in this order starting with villages with a low demand density in order to smoothly transform the target areas for off-grid electrification ultimately into target areas for on-grid electrification. In reality, however, sustainable system maintenance by a private RESCO or community will not be smoothly achieved unless there are at least some 100 households in the target area (village) for electrification.



Source: The Study Team

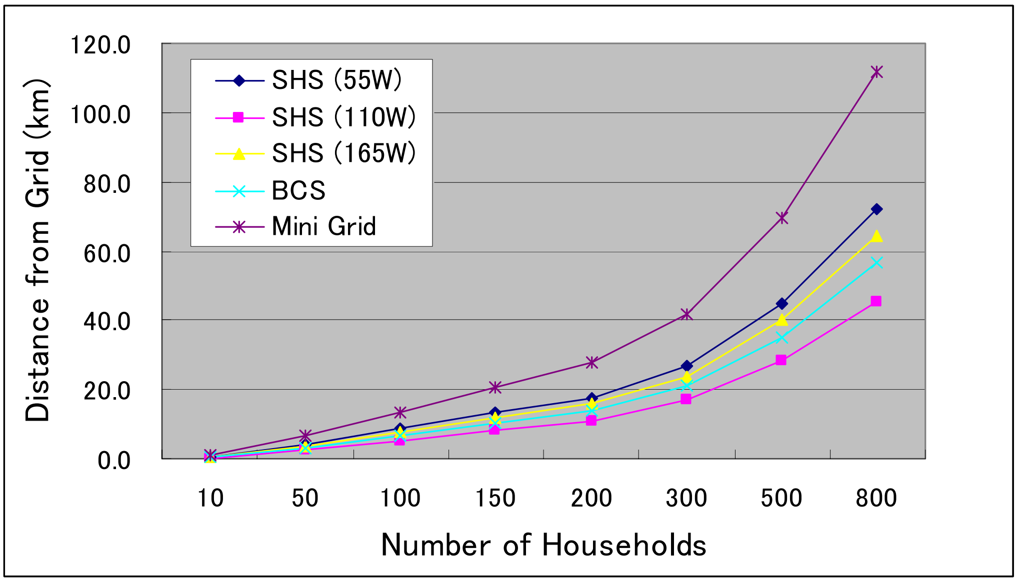
Fig. 2-3 Concept for Selection of Off-Grid PV Systems

2.4.3 Comparison of Economy Between On-Grid Electrification and Off-Grid Electrification

In this section, comparison of the economy is made between on-grid electrification and off-grid electrification based on the results of the financial analysis described in Chapter 3. Fig. 2-4 shows an equal cost curve where the electricity supply cost per KWh is equal for both on-grid electrification and off-grid electrification. For those villages positioned above the curve, off-grid electrification is more economical. Conversely, for those villages positioned below the curve, on-grid electrification is more economical. The curve in Fig. 2-4 is based on the case where electricity is supplied for 12 hours per day as a result of on-grid electrification and a PV system is purchased at the current market price in Nigeria. In terms of the life cycle cost per KWh, a SHS (110 W) is the cheapest option while the mini-grid system is the most expensive option. Therefore, for the introduction of a mini-grid system, it is essential to determine whether or not collection of the charge at a level corresponding to its high life cycle cost is possible while assuming the use of electricity by commercial and agricultural facilities.

There are many more affluent villages in southern Nigeria than northern Nigeria and such diverse electrical appliances as TVs, refrigerators and irons, etc. are used in addition to lighting equipment in areas which have been electrified through connection to the grid. In these areas, it can be inferred that the range of equipment (lighting equipment, radio and black and white TVs) using the DC supplied by a SHS cannot meet the local power demand. It is, therefore, safe to assume that the scope of SHS use is limited. Moreover, the distance of unelectrified villages in southern Nigeria to the grid is generally relatively short. The introduction of a mini-grid system in these villages is desirable as the system can be easily relocated to another village when grid extension to these villages is conducted.

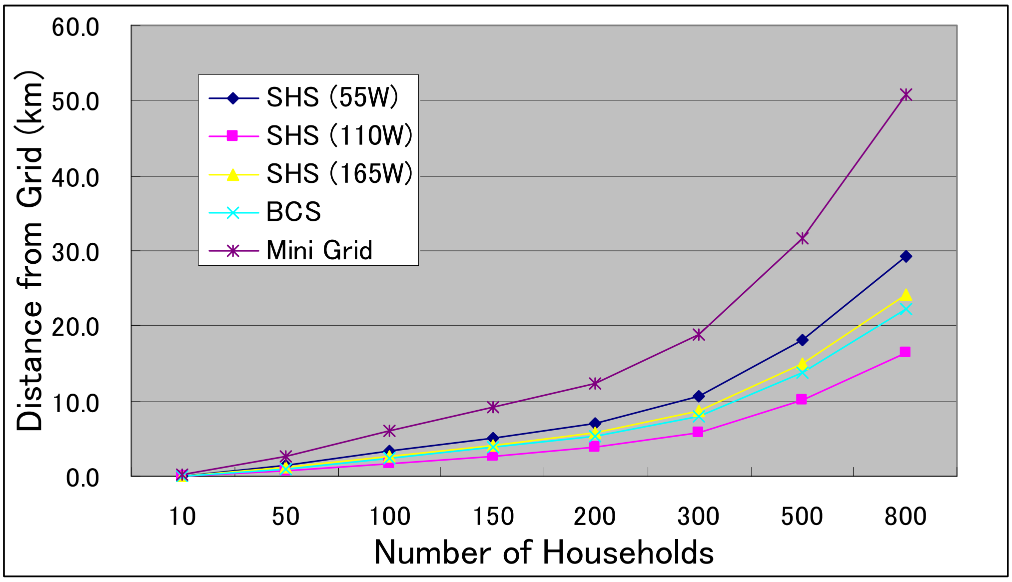
During the latest study period, it was found that nationwide statistical data on the population, number of households and distance from the grid, etc. is insufficient for rural villages in Nigeria. It is, therefore, necessary for the REA to collaborate with state governments to develop a database featuring unelectrified villages with a view to identifying the target villages for off-grid electrification in accordance with the selection method recommended by the M/P.



Source: The Study Team

Fig. 2-4 Equal Cost Curve for Off-Grid Electrification and On-Grid Electrification (Power Supply for 12 Hours/Day; Present Price)

A realistic business model for off-grid electrification should compare the predicted system cost with the on-grid electrification cost. This predicted system cost of off-grid electrification should take the future cost reduction originating from the mass production effect due to the large-scale extension of PV systems, withdrawal of the high import tariff and competition between PV dealers, etc. into consideration. Under these circumstances, the size of the initial investment will steadily decrease with the passing of time and the area for which off-grid electrification is economically more advantageous will expand for all types of PV systems as shown in Fig. 2-5. In short, it can be inferred that off-grid electrification will spread in an exponential manner once it reaches a certain level.

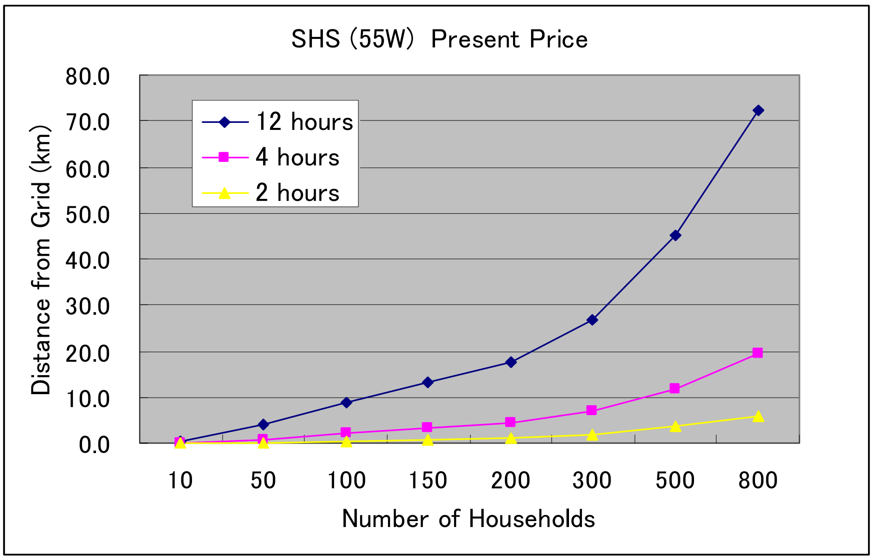


Source: The Study Team

Fig. 2-5 Equal Cost Curve for Off-Grid Electrification and On-Grid Electrification (Power Supply for 12 Hours/Day, Predicted Price for 2020)

2.4.4 Impact of Power Supply Hours of On-Grid Electrification

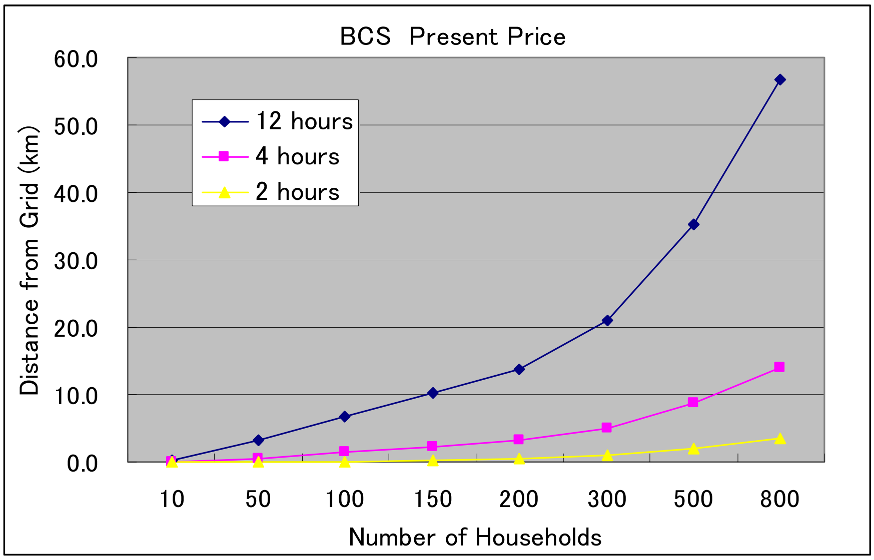
In view of the situation in Nigeria where the size of rural villages is relatively large, it is clear from the economic point of view that the target areas for off-grid electrification are restricted to those villages with a small size and which are located quite far from the grid. In the analysis in 2.4.3 above, however, the annual electric energy consumption is calculated based on power supply by the grid for 12 hours per day. For more detailed analysis, the actual frequency and duration of outages (power cuts) in each target area for electrification must be studied to infer the average hours of power supply per day prior to the selection of the target areas for off-grid electrification. Fig. 2-6 shows the equal cost curve for SHS (55 W) and on-grid electrification when the power supply duration is two hours per day or four hours per day. It must be noted that when the duration of power supply by the grid is as short as 2 – 4 hours per day (while accurate outage statistics do not exist, an extremely large number of users only receive power for a short period each day as outages are observed every day, even in Abuja), the life-cycle cost per KWh of on-grid electrification increases. Accordingly, the economically viable areas for off-grid electrification widen. In this section, the current market price of each PV system is used as the initial investment cost for the purpose of comparison with the on-grid electrification cost.



Source: The Study Team

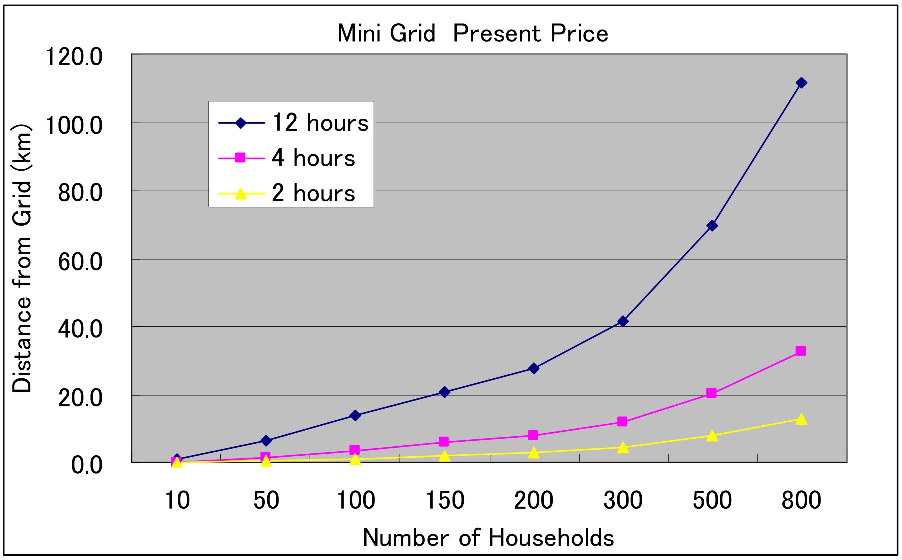
Fig. 2-6 Equal Cost Curve for SHS (55 W) and On-Grid Electrification (Changes Caused by Different Power Supply Hours)

Fig. 2-7 and Fig. 2-8 show the equal cost curves for the BCS and mini-grid systems and on-grid electrification respectively when the duration of power supply by the grid is reduced to two hours, four hours and twelve hours per day. In southern Nigeria, i.e. the target area for the introduction of the mini-grid system, the distance from the grid to a village rarely exceeds 20 km and the village population size is generally expressed in units of 1,000. Accordingly, the potential for the introduction of the mini-grid system is extremely high in those areas where the expected duration of power supply is as short as some two hours per day due to scheduled outages caused by the insufficient generating capacity.



Source: The Study Team

Fig. 2-7 Equal Cost Curve for BCS and On-Grid Electrification (Changes Caused by Different Power Supply Hours)



Source: The Study Team

Fig. 2-8 Equal Cost Curve for Mini-Grid System and On-Grid Electrification (Changes Caused by Different Power Supply Hours)

In short, for analysis of the life-cycle cost as a necessary step for the selection of the target areas for off-grid electrification, it is necessary to conduct a comprehensive comparison between PV systems and on-grid electrification after the gathering of the following data on the candidate villages for electrification.

①	Village size (population size and number of households)
②	Distance from the existing grid
③	Duration of expected power supply per day with on-grid electrification

2.4.5 Selection of Off-Grid PV Electrification Systems

In 2.4.3 and 2.4.4, how to compare the life-cycle cost of different electrification systems, including on-grid electrification, is explained using the demand for electrification, distance from the exiting grid and expected power supply hours through extension of the grid as the parameters. Although this technique is useful to simply compare the economy of each system, in reality it is essential for the REA, which is the main body for the implementation of off-grid PV rural electrification projects, to select the optimal PV electrification system based on the flow for the selection of an off-grid PV electrification system shown in Fig. 2-9, taking the geographical and socioeconomic conditions of the target villages into consideration.

The process leading to the selection of a system is outlined below.

(1) Checking of Grid Electrification Programmes

Whether or not the target areas are included in the NREP of the FMPS and/or an on-grid electrification project (plan) of a state/local government must firstly be checked.

(2) Checking of the Local Conditions

The number of estimated PV users, distance from the existing grid, population and number of public/commercial facilities must be checked for each target village for electrification. When there is a high likelihood that corn mill and other agricultural machinery and refrigerators, etc. are already being used with a diesel generator together with a high potential for the introduction of three phase electrical appliances, off-grid PV rural electrification will be unable to meet the power demand of this machinery and appliances. Therefore, the possibility of targeting such areas for on-grid electrification should be examined. When on-grid electrification appears to be a promising electrification method, the road conditions, including the number of river crossing sites to the target village(s) should be checked to examine a viable distribution route. Particular attention should be paid to southern Nigeria where villages may become inaccessible as they may be isolated due to the flooding of rivers during the rainy season.

(3) Analysis of the Life-Cycle Cost

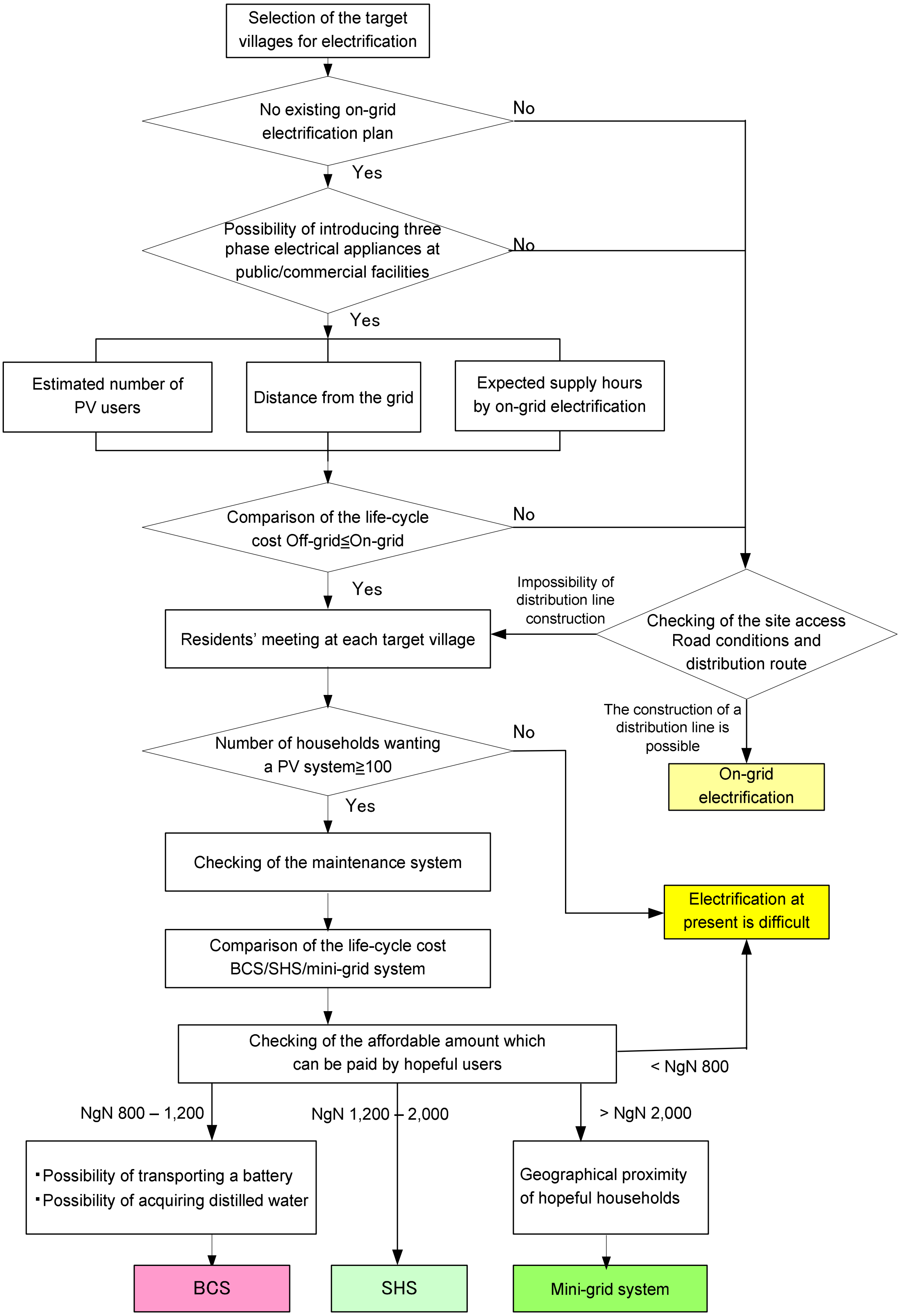
It must be confirmed that the life-cycle cost of off-grid electrification is lower than that of on-grid electrification based on the results of the life-cycle cost comparison described in 2.4.3 and 2.4.4. For this purpose, the expected power supply hours following on-grid electrification must be studied with a local distribution company using the target areas for on-grid electrification which are near to the candidate sites for off-grid electrification as samples.

(4) Checking of the Maintenance System and Affordable Electricity Charge at a Residents' Meeting

For the introduction of a PV system, it is essential to check the intentions of local residents by organizing a meeting in the target area. When the number of households hoping to have a PV system is less than 100 at the planning stage, the introduction of such a system should be abandoned because of the difficulty of establishing a village electrification association to be responsible for collection of the charge and also for the management of spare parts. Even if maintenance by an RESCO is assumed, the small size of the demand will make it difficult to sustain such a private business. After confirmation of the maintenance system and assigned work of a village electrification association,[3)] it is necessary to check the affordable electricity charge by willing users taking the life-cycle cost analysis results (BCS, SHS and mini-grid) discussed earlier into consideration. To determine the affordable amount which can be paid, the amount of expenditure for kerosene, diesel oil and dry cells for a radio out of the current expenditure for energy must be checked as the potential payment for a PV system. The affordable amount which can be paid is set at 90% of the above expenditure.

The selection of a PV system based on the above process assumed that all types of PV systems can be introduced. As the PV system recommended under the M/P differs for each state in correspondence with the electrification model in a specific project implementation period, the selection flow shown in Fig. 2-9 should be treated as a tool to check an area(s) where the introduction of a recommended system(s) is suitable.

3) Refer to Chapter 4 for further details



Source: The Study Team

Fig. 2-9 Flow for Selection of Off-Grid PV Electrification System

2.5 Estimation of the Power Demand

The 2005 results put the peak demand at 3,774 MW. However, because of the low reliability of power supply in Nigeria, the suppressed load is judged to be as high as 70 – 100% of the actual demand. The PHCN has conducted a linear regressive analysis of the nationwide power demand, including the suppressed load, based on the actual GDP growth rate as well as population growth rate shown in Table 2-3 and has estimated the likely power demand for three cases, i.e. high growth, medium growth (base case) and low growth as shown in Table 2-4.

Table 2-3 Historical Changes of the GDP and Population Growth Rates

(Unit: %)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GDP Growth Rate	-1.12	2.26	1.48	0.00	2.18	4.63	2.72	2.98	0.32	0.64
Population Growth Rate	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83

Source: PHCN

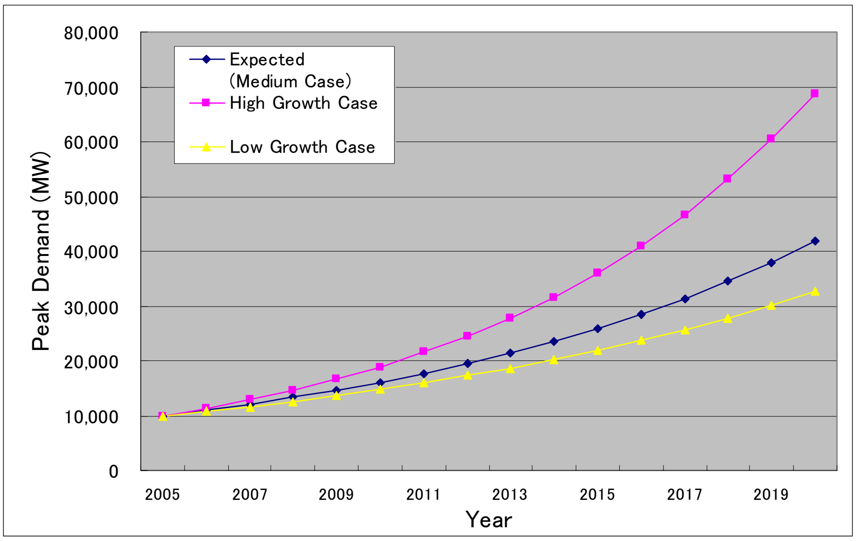
Table 2-4 Estimated Peak Demand up to 2020

(Unit: MW)

	2005	2006	2007	2008	2009	2010	2011	2012
Expected (Medium Case)	10,000	11,000	12,100	13,310	14,641	16,105	17,716	19,487
High Growth Case	10,000	11,270	12,837	14,621	16,624	18,901	21,548	24,564
Low Growth Case	10,000	10,760	11,632	12,574	13,605	14,720	15,957	17,297

	2013	2014	2015	2016	2017	2018	2019	2020
Expected (Medium Case)	21,436	23,579	25,937	28,531	31,384	34,523	37,975	41,772
High Growth Case	27,880	31,644	36,011	40,981	46,636	53,072	60,396	68,730
Low Growth Case	18,698	20,213	21,891	23,707	25,675	27,806	30,114	32,614

Source: PHCN



Source: PHCN

Fig. 2-10 Estimated Peak Demand up to 2020

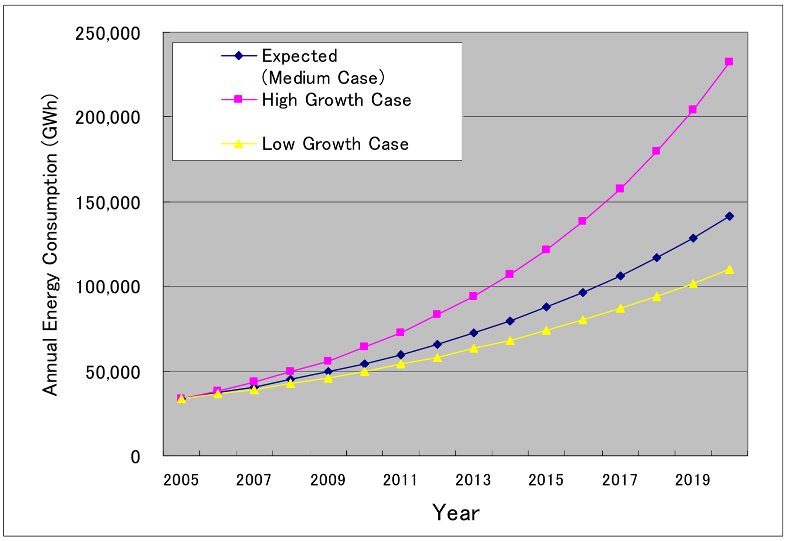
Table 2-5 Estimated Annual Energy Consumption up to 2020

(Unit: GWh)

	2005	2006	2007	2008	2009	2010	2011	2012
Expected (Medium Case)	33,800	37,180	40,898	44,988	49,487	54,435	59,879	65,867
High Growth Case	33,800	38,093	43,387	49,418	56,189	63,886	72,831	83,027
Low Growth Case	33,800	36,369	39,315	42,499	45,984	49,755	53,934	58,465

	2013	2014	2015	2016	2017	2018	2019	2020
Expected (Medium Case)	72,453	79,699	87,668	96,435	106,079	116,687	128,355	141,191
High Growth Case	94,236	106,957	121,717	138,514	157,629	179,382	204,137	232,308
Low Growth Case	63,200	68,320	73,990	80,131	86,782	93,985	101,786	110,234

Source: PHCN



Source: PHCN

Fig. 2-11 Estimated Annual Energy Consumption up to 2020

The above estimation results indicate that both the peak demand and the annual energy consumption are expected to increase at an average annual rate of 10% up to 2020 in the base case. The supply capacity of some 4,100 MW as of December, 2006 is, however, far below the estimated level (11,000 MW) in the base case. Even though the FMPS has formulated a supply programme up to 2010, the supply capacity under the PV electrification programme proposed by the M/P will have to be added to a medium to long-term plan (not yet formulated) to expand the generating, transmission and distribution facilities of the government and IPPs.

2.6 Formulation of a National PV Electrification Programme

For the formulation of a national PV electrification programme, it will be necessary to assume the parallel implementation of multiple models which can meet the PV electrification demand in different areas instead of the nationwide implementation of a single business model in view of the geographical spread and independent character of each state or geopolitical zone in Nigeria. To be more precise, one of the following PV electrification models introduced in four states (Jigawa, Ondo, Imo and the FCT) in Chapter 1 is applied to individual states in Nigeria and the quantity of the system to be introduced in individual states is estimated to formulate the required national PV electrification programme. Because of ① the Nigerian practice of giving the priority for grid electrification to areas where both the power demand density and the potential level of payment of the electricity charge are high and ② the difficulty of extracting uniform indicators for the comparison of different states, the existing electrification rate provided by the General Household Survey 1997/98 was used to classify the entire country into the following three models.[4)]

① **Electrification Model A (Jigawa State Model): States with an electrification rate of less than 30%**

In the short-term (up to 2010), priority will be given to the introduction of PV systems for public facilities and BCSs. Further BCSs and SHSs will be introduced at the stage where there is widespread use of PV equipment (2010 – 2020).

② **Electrification Model B (Imo State Model): States with an electrification rate of 30% or higher but less than 70%**

In the short-term (up to 2010), priority will be given to the introduction of SHSs, followed by the introduction of a mini-grid system at the stage where there is widespread use of PV equipment (2010 – 2020).

③ **Electrification Model C (Ondo State/FCT Model): States with an electrification rate of 70% or higher**

A mini-grid system will be introduced in both the short-term (up to 2010) and medium to long-term (2010 – 2020).

The reasons for the proposal of the above three models are given below based on the concept for the selection of off-grid PV systems (Fig. 2-3).

- In states with a low electrification rate, the possibility of extension of the existing grid to the target villages for electrification in the near future is low because of the long average distance from the grid to these villages. This makes the potential for the introduction of a PV system high. However, given the low level of the electricity charge payment capacity, the introduction of a PV system which is the least expensive is desirable.
- In states with a high electrification rate, the introduction of a mini-grid system is possible because of the short average distance from the existing grid to the target villages for electrification, the possibility of grid extension in the near future and the relatively high electricity charge payment capacity.

The different principal project implementation bodies for each PV system are proposed as described below in respect of the concept adopted for the draft REP by the FMPS while intending the

4) Another type of classification can be conducted based on the socioeconomic indicators and power demand density. Here, Nigeria's states are classified using the electrification rate as the indicator for the sake of easy review and renewal work to be conducted by the Nigerian side in the future.

promotion of the participation of private companies, such as RESCOs and community-based (village) electrification associations, in the medium to long-term.

① **BCSs**

In the short-term, the introduction of BCSs led by the government/ODA as well as the private sector (RESCOs and communities) is expected with a view to shifting the stress from government-led introduction to private sector-led introduction in the medium to long-term.

② **SHSs**

The introduction of SHSs led by the government/ODA and the private sector (RESCOs and communities) is expected in both the short-term and the medium to long-term but it is assumed that 10% of the entire supply will be through direct sales by PV dealers to users.[5)]

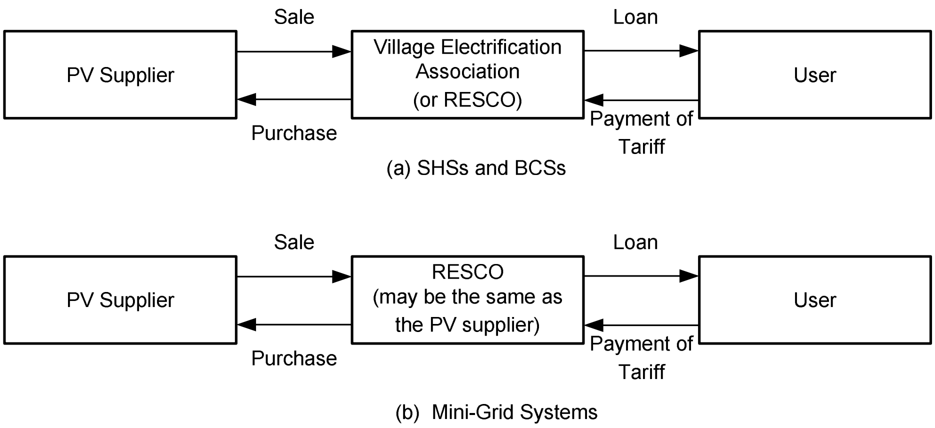
③ **Mini-Grid Systems**

In the short-term, the introduction of mini-grid systems led by the government/ODA and the private sector (RESCOs) is expected with a view to shifting the stress from government-led introduction to private sector-led introduction in the medium to long-term. As this type of system must be regularly maintained by a professional PV company, RESCOs are considered to be the principal implementing bodies while excluding community-based (village) electrification associations from the potential implementing bodies.

④ **Public Facilities**

The minimum but necessary quantity of PV systems will be introduced by the government in the short-term to schools and clinics, including PV systems for the operation of borehole pumps, from the viewpoint of meeting the BHN.

Fig. 2-12 and Table 2-6 show the relationship between the PV supplier, service provider and users for each of the PV systems described above.



Source: The Study Team

Fig. 2-12 PV Systems to be Introduced and Relationship Between Service Provider and Users

5) As the battery and indoor cabling for a SHS may become the personal property of the user depending on the business model, the introduction of SHSs by the government/ODA is not planned in the M/P.

Table 2-6 Business Models in the National PV Electrification Programme

	Electrification Rate (1997)	Proposed PV Systems (up to Year 2010)				Proposed PV Systems (from Year 2010 to 2020)			
		BCS	SHS	Mini grid	Pubic Facilities	BCS	SHS	Mini grid	Pubic Facilities
Group A	～30%	○			○	○	○		
Group B	30%～70%		○					○	
Group C	70%～			○				○	
Implementing Organization									
Private	ESCO	○	△*	○		○	△*	○	
	Community	○	△*			○	△*		
Public	Gov / ODA	○		○	○				

* In the case of SHSs, direct sales by PV dealers to users (sales model) is taken into consideration.

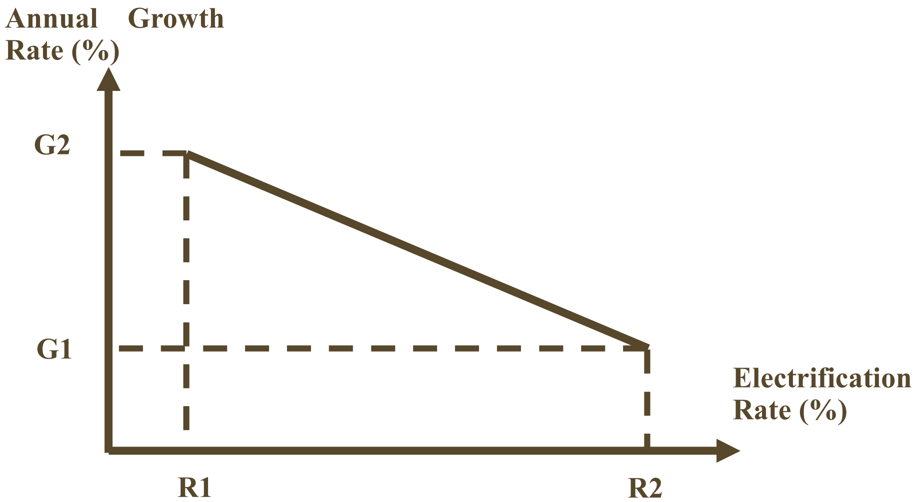
Source: The Study Team

In this M/P, Nigeria's states are classified into three business types based on the household electrification rate in 1997 and the rate of user (on-grid + off-grid) growth is calculated using the following expression.

$$Y = \frac{G_2 - G_1}{R_1 - R_2} X + \frac{G_1 R_1 - G_2 R_2}{R_1 - R_2}$$

Where,

Y : Rate of user growth
X : Electrification rate of a given state
R_1 : Electrification rate of the state with the highest electrification rate
R_2 : Electrification rate of the state with the lowest electrification rate
G_1 : Rate of user growth in the above R_1 state
G_2 : Rate of user growth in the above R_2 state



Source: The Study Team

Fig. 2-13 Relationship Between the Electrification Rate and User Growth Rate

The relationship shown in Fig. 2-13 shows that the rate of user growth is high in less developed states with a currently low electrification rate to achieve the national target for the electrification rate and that the rate of user growth in the future is low in Lagos and other urban areas as the growth of users through extension of the grid has reached saturation point.

Based on the PV electrification business models described earlier, Table 2-7 shows the medium to long-term electrification (on-grid + off-grid) programme to achieve 75% electrification nationwide in 2020 in accordance with the NEP. Table 2-8 shows the national PV electrification programme which has been formulated based on the assumption that 10% of new users are supplied with electricity generated by renewable energy in accordance with the REP and that some 18% of renewable energy comes from PV generation. The latter is based on the proposal by the draft Renewable Energy Action Programme of the FMPS to make PV generation account for 130 MW or some 18% of the 735 MW provided by renewable energy as the target figure for the introduction of renewable energy in 2016.

Table 2-7 National Electrification Programme (On-Grid + Off-Grid)

No.	State	No. of Households as of 1997 (*1)	% of Household with Electricity as of 1997 (*2)	No. of Households with Electricity as of 1997	Annual growth rate of consumers (%)	% of Household with Electricity			No. of Household with Electricity		
						2006	2010	2020	2006	2010	2020
1	Taraba	432,880	12	50,301	7.80	17	21	34	98,888	133,542	283,012
2	Jigawa	823,164	12	99,685	7.77	18	22	35	195,520	263,766	557,554
3	Zamfara	593,479	13	77,924	7.71	20	23	37	152,101	204,752	430,492
4	Sokoto	686,178	13	90,095	7.71	20	23	37	175,859	236,734	497,734
5	Kebbi	592,137	13	77,807	7.71	20	23	37	151,866	204,431	429,794
6	Katsina	1,074,392	14	145,902	7.69	20	24	38	284,184	382,194	801,663
7	Gombe	426,284	17	72,553	7.49	25	30	46	139,031	185,628	382,367
8	Bauchi	819,259	17	139,438	7.49	25	30	46	267,198	356,753	734,857
9	Benue	788,111	17	135,003	7.49	25	30	46	258,565	345,146	710,537
10	Yobe	400,682	19	75,729	7.39	27	32	50	143,826	191,270	390,098
11	Ebonyi	416,196	25	102,759	7.06	39	46	69	189,857	249,413	493,343
12	Enugu	608,334	25	150,198	7.06	39	46	69	277,505	364,554	721,096
13	Cross River	547,224	29	159,954	6.80	40	47	68	289,196	376,273	726,572
14	Nassarawa	345,773	31	108,607	6.68	43	49	71	194,326	251,669	480,372
15	Plateau	602,456	31	189,231	6.68	43	49	71	338,583	438,495	836,973
16	Kano	1,663,337	32	538,256	6.62	44	51	72	958,709	1,239,106	2,353,218
17	Borno	725,970	34	248,935	6.51	46	53	75	439,310	565,469	1,062,926
18	Adamawa	601,745	35	210,069	6.48	47	54	76	369,621	475,140	890,189
19	Akwa-Ibom	689,703	36	246,638	6.43	47	55	77	432,200	554,578	1,034,327
20	Niger	693,215	42	288,932	6.10	54	61	83	492,124	623,542	1,126,789
21	Kaduna	1,126,632	43	479,607	6.05	55	62	84	813,402	1,028,655	1,850,037
22	Kogi	614,828	50	309,996	5.60	62	70	90	506,218	629,499	1,085,526
23	Bayelsa	321,102	52	167,069	5.51	64	71	91	270,706	335,469	573,511
24	Rivers	912,575	52	474,813	5.51	64	71	91	769,348	953,408	1,629,926
25	Abia	547,888	52	287,587	5.48	53	58	75	464,946	575,611	981,623
26	Imo	711,551	61	433,833	5.00	72	78	96	673,132	818,258	1,333,107
27	Delta	741,568	62	462,294	4.92	73	79	96	712,530	863,590	1,396,589
28	Edo	621,770	63	388,855	4.91	73	79	96	598,757	725,382	1,171,814
29	Kwara	443,257	68	299,509	4.63	77	83	98	450,021	539,288	847,795
30	Osun	617,802	71	436,539	4.45	80	85	99	646,094	769,082	1,188,952
31	Abuja	106,397	71	75,436	4.44	80	85	99	111,517	132,676	204,841
32	Ogun	668,065	72	483,813	4.35	81	86	99	709,928	841,842	1,289,056
33	Ekiti	439,644	72	318,698	4.35	81	86	99	467,484	554,265	848,386
34	Ondo	643,968	72	466,812	4.35	81	86	99	684,748	811,860	1,242,673
35	Anambra	800,534	78	621,295	4.06	85	88	99	888,786	1,042,097	1,551,263
36	Oyo	988,395	78	771,541	4.03	85	89	100	1,101,286	1,289,986	1,915,566
37	Lagos	1,638,903	96	1,577,936	3.00	96	96	97	2,058,848	2,317,252	3,114,193
	Total Nigeria	25,475,400	44	11,263,648	6.04	53	58	75	17,776,220	21,870,672	37,168,770

(Remarks)
(*1) No. of Households as of 1997 was extraporated based on the result of 1991 Census.
(*2) % of Household with Electricity as of 1997 was quoted from the result of General Household Survey 1997/98.

Average number of persons per household	4.13	
Annual growth rate of consumers (Highest)	7.80	%
Annual growth rate of consumers (Lowest)	3.00	%

Source: The Study Team

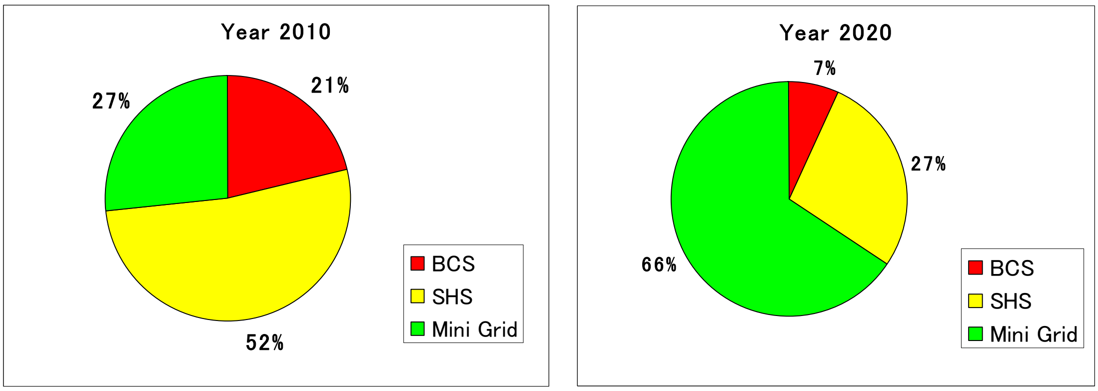
Table 2-8 National PV Electrification Programme

No.	State	Target No. of Households for Year 2010 (Accumulated sum)						Target No. of Households for Year 2020 (Accumulated sum)					
		BCS	SHS		Mini Grid	Total for Household electrification	Public Facilities (*2)	BCS	SHS		Mini Grid	Total for Household electrification	Public Facilities (*2)
			RESCO Community	Direct Sales(*1)					RESCO Community	Direct Sales(*1)			
1	Taraba	600				600	1	1,000	2,100	200		3,300	1
2	Jigawa	1,200				1,200	1	1,900	4,000	400		6,400	1
3	Zamfara	900				900	1	1,500	3,100	300		4,900	1
4	Sokoto	1,100				1,100	1	1,700	3,600	400		5,700	1
5	Kebbi	900				900	1	1,500	3,100	300		4,900	1
6	Katsina	1,700				1,700	2	2,800	5,800	600		9,200	2
7	Gombe	800				800	1	1,300	2,700	300		4,300	1
8	Bauchi	1,600				1,600	2	2,500	5,200	600		8,300	2
9	Benue	1,500				1,500	2	2,400	5,000	600		8,000	2
10	Yobe	800				800	1	1,300	2,800	300		4,400	1
11	Ebonyi	1,100				1,100	1	1,600	3,400	400		5,400	1
12	Enugu	1,500				1,500	2	2,400	5,000	600		7,900	2
13	Cross River	1,500				1,500	2	2,300	4,900	500		7,700	2
14	Nassarawa		900	100		1,000			900	100	4,100	5,100	
15	Plateau		1,620	180		1,800			1,620	180	7,000	8,800	
16	Kano		4,500	500		5,000			4,500	500	19,700	24,700	
17	Borno		1,980	220		2,200			1,980	220	8,800	11,000	
18	Adamawa		1,710	190		1,900			1,710	190	7,300	9,200	
19	Akwa-Ibom		1,980	220		2,200			1,980	220	8,500	10,700	
20	Niger		2,070	230		2,300			2,070	230	8,900	11,200	
21	Kaduna		3,420	380		3,800			3,420	380	14,500	18,300	
22	Kogi		1,980	220		2,200			1,980	220	8,100	10,300	
23	Bayelsa		990	110		1,100			990	110	4,300	5,400	
24	Rivers		2,970	330		3,300			2,970	330	11,900	15,200	
25	Abia		1,800	200		2,000			1,800	200	7,100	9,100	
26	Imo		2,340	260		2,600			2,340	260	9,100	11,700	
27	Delta		2,430	270		2,700			2,430	270	9,400	12,100	
28	Edo		1,980	220		2,200			1,980	220	7,900	10,100	
29	Kwara		1,440	160		1,600			1,440	160	5,400	7,000	
30	Osun				2,200	2,200					9,600	9,600	
31	Abuja				400	400					1,700	1,700	
32	Ogun				2,300	2,300					10,300	10,300	
33	Ekiti				1,500	1,500					6,700	6,700	
34	Ondo				2,200	2,200					9,900	9,900	
35	Anambra				2,700	2,700					11,700	11,700	
36	Oyo				3,300	3,300					14,400	14,400	
37	Lagos				4,600	4,600					18,700	18,700	
	Total Nigeria	15,200	34,110	3,790	19,200	72,300	15	24,200	84,810	9,290	225,000	343,300	15

(Remarks)
(*1) 10% of total number of SHS will be supplied directly by PV dealers.
(*2) Average number of public facilities (mosque, church, school, clinic) is assumed 1 per 1,000 households.

Source: The Study Team

Fig. 2-14 shows the projected breakdown of PV systems for 2010 and 2020. While BCSs and SHSs will be the principal PV systems at the beginning, they will be gradually overtaken by the mini-grid systems to be introduced in Business Models B and C with the spread of the use of PV systems. In 2020, mini-grid systems will account for 66% of all PV systems in use in terms of the quantity.



Source: The Study Team

Fig. 2-14 Off-Grid PV Systems in Use in 2010 and 2020

The overall plan is the introduction of PV systems serving some 1.94 million households nationwide in 2020. Assuming a power demand of 100 W per household, the nationwide power demand for off-grid PV systems will be approximately 34 MW. As the total power demand in Nigeria in 2020 is estimated to be 41,772 MW according to the findings in 2.5 – Estimation of the Power Demand, off-grid PV systems will cater for some 0.1% of the total power demand (peak demand base) in Nigeria at this point.

2.7 Project Implementation Plan

2.7.1 Basic Policies

There are two important matters for which the REA as the implementing organization of the M/P will be responsible. One is the clear announcement of the selection results of the areas subject to on-grid electrification and those subject to PV rural electrification by 2020, notifying the public of the project implementation plan of the federal government. The other is the active appeal of the entry of private companies into the electrification market by showing the stance of the federal government of fostering private companies engaged in the PV rural electrification business and the development of a suitable business environment for these companies in collaboration with the FMPS and the ECN.

As already described in 2.6, the introduction of PV systems for a total of some 340,000 households between 2007 and 2020 is planned. To achieve this, the strong determination of the federal government and the establishment of a long-term strategy are essential. Given the present situation in Nigeria where the capital as well as technological accumulation of the private sector are insufficient and where there is a lack of a subsidy system for the extension of PV-based rural electrification, the possibility of the early involvement of private companies in this business is rather weak. Accordingly, it is necessary for the federal government to jointly promote PV rural electrification projects with the private sector to start with so that the resulting technological accumulation on the part of private companies and expansion of the market will gradually increase the number of capable private companies to enable the move to the next phase.

Table 2-9 shows the planned number of households for which PV systems will be introduced by the public and private sectors in three phases up to 2020 based on Table 2-8. The projects expected to be implemented in each phase are briefly described in the following sections.

Table 2-9 Number of Subject Households for Introduction of PV Systems by the Public and Private Sectors

	Public Sector	Private Sector	Total
Phase 1 (2007 – 2010)	17,200	55,100	72,300
Phase 2 (2011 – 2014)	0	108,400	108,400
Phase 3 (2015 – 2020)	0	162,600	162,600
Total	17,200	326,100	343,300

Source: The Study Team

2.7.2 Phase 1 (2007 – 2010)

In Phase 1, the REA Headquarters will determine the subject areas for the introduction of PV systems each year for each state while the REA branch offices will clarify the subject areas for on-grid electrification in cooperation with local distribution companies with a view to the selection of the target villages for PV electrification. In Jigawa State, Ondo State and Imo State where the pilot project has already been implemented, the section responsible for electrification of the state/local government will continually monitor the system maintenance situation under the pilot project and will horizontally spread maintenance know-how when similar projects are implemented within the state. In other states, a model project of which the scale is the same as that of the pilot project will firstly be implemented for the purpose of capacity development at the state/local government level. For this purpose, personnel of the FMPS, FMST and ECN who are involved in the surveying of the target villages, explanation of the project to villagers, planning of the work plan, procurement of equipment and materials, schedule control and guidance for residents' organizations (village electrification associations and others) in the pilot project under the Study will transfer the necessary skills to their counterparts of the state/local governments and the REA. In observance of the principal ideas of the REP, it is assumed that the introduction of PV systems by the public sector will be restricted to Phase 1 and that the private sector will play the main role in the introduction of PV systems.

In Phase 1, the business scale of the private sector will be small and the priority for the introduction of PV systems will be given to, for example, the introduction of mini-grid systems in southern Nigeria with a relatively high income level to make the introduction of PV systems as a private business economically feasible. Meanwhile, it will be important for the federal government to clarify the target for medium to long-term rural electrification using PV systems and also to indicate its stance for the promotion of the introduction of PV systems as a private business practice through its own public awareness raising activities.

2.7.3 Phase 2 (2011 – 2014)

In Phase 2 from 2011 to 2014, private PV dealers fostered in Phase 1 will commence full-scale marketing. At the same time, the business infrastructure, such as a supply network for PV-related equipment and agents for repair work, will be developed to stimulate the initiative of the private sector to actively seek more business. As the implementation of model projects in Phase 1 and the transfer of know-how to the REA as well as state/local governments will have been mostly completed by the start of Phase 2, it will be necessary for state/local governments to assist private dealers by means of studies on unelectrified villages in their respective areas and explanation of PV projects to local residents. Meanwhile, the REA should publicly announce the amount of subsidy by state/area in an impartial manner and publicise the subsidy system to private dealers to encourage their use of this system.

2.7.4 Phase 3 (2015 – 2020)

In Phase 3 from 2015 to 2020, a fall of the unit PV system prices and the expansion of related businesses are expected to increase the number of private dealers, thereby causing a further fall of prices and the diversification of services due to competition between private dealers. When PV rural electrification reaches the stage where its payability as a private business is a reality, the subsidy will be either reduced or withdrawn to minimise the involvement of the public sector as described in Chapter 3. However, it will be necessary for the REA to strictly examine the contents of the business of private dealers and to conduct control and guidance in view of the provision of good quality services nationwide.

2.8 PV Rural Electrification Promotion Measures

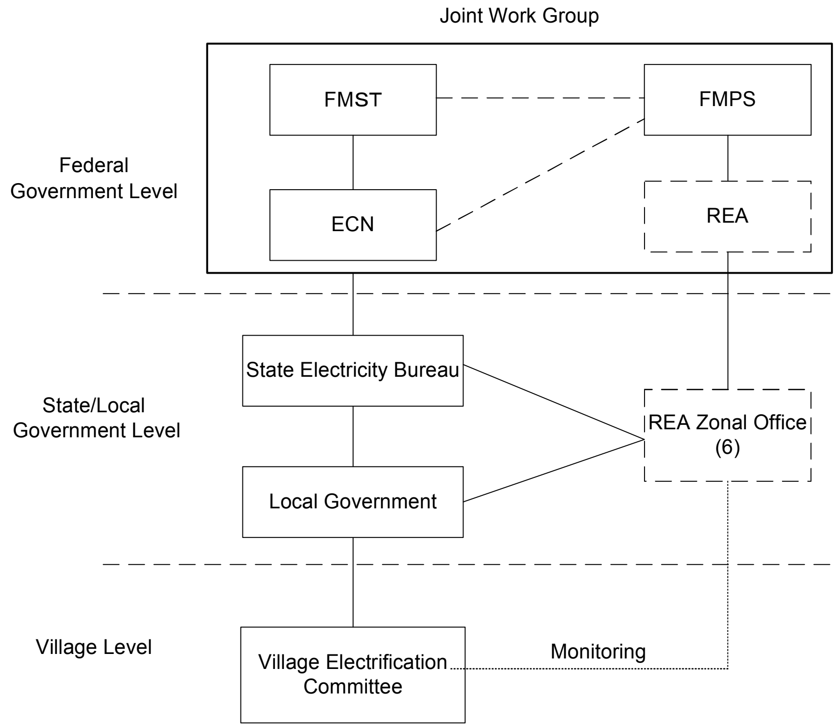
2.8.1 Establishment of Organizational Structure, Human Resources Development System and Maintenance System

For the sustainable implementation of the National PV Electrification Programme, strengthening of the service and maintenance systems through the direct participation of local governments and village electrification associations will be important in addition to the capacity building of the federal government offices (FMPS, FMST and ECN) and state governments, both of which will play the principal role in the promotion of the M/P. Because electrification associations in small villages do not have the necessary know-how for a technical response to equipment breakdowns, spare parts procurement and charge collection, etc., the establishment of an appropriate support system for village organizations will be essential to ensure the continuance of projects. For this reason, the M/P addresses the establishment on an on-site support system by state/local governments in addition to the development of local level organizations and also examination of the possible use of local NGOs.

In March, 2006, the REA was established to commence the operation of the REF (Rural Electrification Fund). In addition to its headquarters in the capital, Abuja, the REA is expected to set up a branch in each of six geo-political zones to enable the monitoring of electrification projects in the target villages in collaboration with not only state/local governments but also local distribution companies. As the implementing organization of the M/P, the REA will organize regular meetings of the Joint Working Group (JWG)[6)] to coordinate with other related government offices.

In regard to capacity development (CD), an appropriate training programme should be prepared at each of the village, state/local government and federal government levels. In addition, a system for the effective collaboration of all of the organizations shown in Fig. 2-15 for the planning and management of projects must be established.

6) During the fifth field survey period, it was agreed that this meeting would take place at least once a month.



Source: The Study Team

Fig. 2-15 Organizational Structure for PV-Based Rural Electrification

(1) Development of Village-Level Organizations

Guidance will be provided to enable state/local government organizations to establish village-level organizations as described below to ensure a proper response to system breakdowns and collection of the charge as in the cases of the village electrification associations in the pilot project (refer to Chapter 4 for further details). Members of the village electrification associations in the target villages of the pilot project and staff members of state/local governments should visit the villages as often as possible with a view to spreading the required know-how for the establishment of a village organization for the implementation of the M/P. The formats for the recording of the inspection results, charge collection and response to breakdowns (trouble-shooting) of PV systems should be shared by all stakeholders.

① Selection of a representative (village head class) of the village organization to thoroughly enforce the rules for collection of the charge and the use of the PV system to ensure proper organizational control

② Selection of such technicians as car mechanics, bicycle technicians and generator mechanics for training by a state/local government engineer as local maintenance personnel capable of conducting simple repairs, including the poor connection of indoor wiring

③ Education/training of the technical personnel referred to in ② above to be responsible for collection of the charge and book-keeping, if necessary, provided that the capacity to take on additional duties is satisfactorily established. In the case of a SHS, a deep cycle battery used for PV generation will be used and its renewal cost must be paid by the reserve fund to which a certain proportion of the charge collected by the association is regularly contributed.

Given the current maintenance situation of borehole pumps and other facilities in Nigeria, it will be difficult to expect users to save money to pay for the battery replacement cost.

The types of work described in the box below comprise the planned maintenance work (tentative) to be conducted by local maintenance personnel.

- Monthly checking of all PV systems and recording of the inspection results in a ledger
- Monthly (or regular) collection of the electricity charge and storing of the payment records
- Determination of the causes of rudimentary problems and their rectification, if possible. If village-level repair is found to be impossible, requesting of the assistance of the state/local government
- Prevention of use of the system by users whose payments are in arrears or illegal users
- Procurement and maintenance of spare parts to be stored in the village (to be assisted by the state/local government and the JAEF)
- Provision of services for villagers and handling of any complaints made by them

For the education/training of local maintenance personnel, the manual prepared by the Study Team will be used to ensure a proper understanding of the basic principles of PV systems for the implementation of appropriate maintenance. State/local government engineers will conduct a periodic sampling survey to check whether or not daily and periodic inspections are properly conducted by the maintenance personnel.

For examination of an appropriate level of the electricity charge and the charge collection system, a detailed socioeconomic study on the target villages for electrification will be required in addition to studies on the electricity tariff (including battery recharging fee) and the charge collection system in the surrounding area. The use of a RESCO or PV dealer to design the optimal charge level and the collection system at a low cost is possible. In poor areas in particular, collection of the charge by a maintenance organization may not actually take place due to such problems as bribery by users and disguised collection records involving the entire organization, etc. It is, therefore, essential to establish an efficient charge collection and PV system maintenance system while proposing measures designed to properly educate and maintain the moral standard of the organization in question.

Table 2-10 Examples of Collection Rate Improvement and Operating Cost Reduction Measures

Collection Rate Improvement Measures	Operating Cost Reduction Measures
➢ Confiscation of systems from non-payers and re-allocation to waiting users ➢ Introduction of a system to fine non-payers or those in arrears (arrear charge) ➢ Introduction of a system to reward (discount) users with a good payment record ➢ Setting up of the tariff focusing on users with ability to pay ➢ Timing of collection (flexible collection time) with the crop harvesting period	➢ Review of the charge collection interval (example: from monthly to every three months) ➢ Review of the battery specifications (example: from car battery to deep cycle sealed type batter) ➢ Regular replenishment of the battery water (in the case of car battery) ➢ Improvement of the collection method (examples: reduction of surplus staff and efficient collection using a car or bicycle) ➢ Abolishment/integration of local offices involved in system operation and maintenance (medium to long-term measure)

(2) Development of a Local Support System by State/Local Governments

1) State/Local Governments

State/local governments will train engineers to regularly train and supervise village-level maintenance personnel and will develop a system under which engineers regularly visit villages to solve any problems. They should also clarify (i) the required response to problems which cannot be solved at the village level, (ii) procedures to convey information to engineers of PV equipment manufacturers, etc. and to purchase materials and equipment and (iii) who pays the necessary costs. For the training of engineers, a system should be established whereby the counterparts of the REA, FMPS or FMST are able to conduct continuous CD without external help by referring to the PV manual prepared by the Study Team (this PV manual is attached to Volume 3 of the Report).

As state/local governments possess know-how regarding the order placement and maintenance of electrical cables and electric poles, they are expected to assist the procurement and maintenance of the spare parts to be stored in villages.

2) REA Branch (Zone) Offices

The headquarters of the REA is located in Abuja, the capital, and will establish branch (zone) offices to be responsible for the selection of the target areas for on-grid or PV off-grid rural electrification projects which will receive funding by the REF in collaboration with state/local governments and distribution companies after the breaking up of the PHCN. At the present time, the required technical standard of the technical staff of the REA is unclear and clarification by the REA of the respective roles of its branch offices, state/local governments and distribution companies is essential.

(3) Development of an Implementation System for PV Rural Electrification Projects by the Federal Government

While the FMPS, FMST, ECN and REA are involved in PV rural electrification at the federal government level, each organization is conducting its own PV rural electrification projects without any coordination. To improve this situation, regular meetings of the Joint Work Group

(JWG) will be held so that the federal government can plan policies and implement projects in collaboration with all organizations concerned. The JWG is already in operation during the study period. However, meetings are only held when the Study Team is in Nigeria. The status of the JWG vis-à-vis various federal government bodies as an organization which can be independently managed by the Nigerian side must be enhanced. There is a clear agreement between the Nigerian side and the study Team on the prospective roles to be played by related ministries and other bodies.

1) FMPS (Federal Ministry of Power and Steel)

The FMPS is responsible for policy planning and the supervision of on-grid as well as off-grid rural electrification projects and conducts the monitoring and evaluation of PV rural electrification projects from the viewpoint of government policies. The actual rural electrification projects (on-grid and off-grid) are implemented by the REA and state/local governments and the FMPS monitor the state of project implementation nationwide with a view to establishing or revising targets, if necessary. Although the Department of Power of the FMPS has a section in charge of renewable energy, the staff are also responsible for the construction of thermoelectric and hydroelectric power plants. In view of this situation, it is desirable for FMPS staff to conduct the following work while collaborating with ECN staff who have actual experience of PV rural electrification.

- Improvement of the quality and performance of PV systems through the introduction of quality standards for local products and standards for installation work
- Introduction of a type approval system for PV-related equipment
- Determination of standard unit prices for equipment and materials so that they can be procured by the government at a fair price

2) FMST (Federal Ministry of Science and Technology)

The FMST controls the energy research institutes at Sokoto and Nuskka, promotes the development of new PV-related equipment and is responsible for confirmation of the quality of the acceptance test of new equipment. In addition, the FMST will obtain domestic data on solar energy using instruments handed over under the guidance on technological development provided during the study period and will attempt to spread such data to other ministries and organizations concerned.

3) ECN (Energy Commission of Nigeria)

The ECN has experience of installing PV systems, mainly SHSs and mini-grid systems, and has accumulated technical know-how regarding planning, system design, placement of work orders and work supervision. As such, it should try to horizontally spread its accumulated skill using the JWG and should provide guidance on the basic knowledge and maintenance skills regarding the use of PV systems for not only the electricity bureaus of state/local governments but also village-level system maintenance organizations.

4) REA (Rural Electrification Agency)

As the implementing organization of the M/P, the REA will manage the REF independently from the federal government. To ensure the selection of candidate rural electrification projects and the distribution of funds based on fair and transparent rules, the formulation of guidelines for the management of the REF is planned. The REA will also act as the regulatory body for rural electrification projects and will formulate and manage the minimum safety standards, technical standards and standards on the service level.

(4) Use of Local NGOs

In Jigawa State, one of the targeted areas of the pilot project, the SELF Project of the USAID is already in progress and the Jigawa Alternative Energy Fund (JAEF), a local NGO, is responsible for the maintenance work. Given the in-depth knowledge of the JAEF of the local geographical and socioeconomic conditions and its possession of the manpower and basic technical knowledge required to support village electrification associations, a cooperation system with the JAEF will be established for the operation and maintenance of the pilot project with a view to introducing similar projects within the state as well as in neighbouring states.

In similar pilot projects of the JICA in the past, a fee for service model where a contract is concluded between a residents' organization and an out-sourced local company with experience of operation and maintenance, etc. after ascertaining the capacity of the said local residents" organization has been employed.[7)]

However, this method is prone to causing conflict between dissatisfied residents and an outside organization and could hinder spontaneous and active maintenance by residents. Accordingly, the M/P adopts a basic policy of educating and training village electrification associations as much as possible.

2.8.2 Federal Government Measures to Promote the Extension of PV Systems

For the full-scale introduction of off-grid PV rural electrification in the coming years, it is necessary to clearly identify the measures to be implemented by the public sector (federal government) and the private sector (PV industry and financial sector) to develop suitable conditions for sustainable extension and maintenance systems.

The same issues listed in the box below are important policy issues which the federal government (REA) should be responsible for to extend PV rural electrification at the national level.

7) "Program on PV Rural Electrification in Senegal" and "Study on Program on Rural Electrification Utilizing Renewable Energy" in Bolivia, etc.

- Clear establishment of the status of PV rural electrification as a consistent policy objective in the framework for rural electrification by its incorporation in the Rural Electrification Programme of the FMPS
- Development of the business conditions for investment in and loan finance for PV systems in order to create a new PV industry
- Strengthening of the collaboration with other donors and international organizations regarding the extension of PV systems
- Reduction of the initial investment cost through the fair operation of the REF and realisation of a spiralling cost reduction of PV systems through the expansion of their market

It is also recommended that the issues described below are tackled as technical support measures for the extension of PV systems.

(1) Reduction of Import Tariff on PV-Related Equipment

In Nigeria, PV-related equipment is subject to the import tariff table which is applied to ordinary electrical products. The ECN submitted the Bill on Importation of Renewable Energy Equipment designed to apply a lower tariff to such equipment to the Upper House in 2002. This Bill proposes a reduction of the import tariff as shown in Table 2-11 and the Study Team has recommended the early approval of the Bill to the JWG.

Table 2-11 Proposed Reduction of Import Tariff

Product	Tariff (Present)	Tariff (Proposed)
PV Modules	10%	0%
PV Batteries	20%	0%
Inverters	0%	0%
Charge Controllers	10%	0%

Source: ECN

The introduction of other financial support measures designed to reduce the required initial investment amount for the introduction of PV systems is also desirable. These measures include a reduction of the corporate tax (currently 30%) for PV-related private companies and a reduction of the VAT on the purchase of PV-related equipment.

(2) Introduction and Application of Technical Standards for PV-Related Equipment and Installation Work

As most of the main components of PV systems, including PV modules, are imported to Nigeria, the international cooperation of foreign donors and private companies will be essential for the full-scale extension of PV systems in the coming years. For this reason, the avoidance of uniquely domestic standards when formulating technical standards is necessary to achieve compatibility between the domestic technical standards and the relevant international standards. Study of (i) the fields which are not covered by the existing international standards and (ii) newly required testing methods and standards because of the local characteristics is also necessary. As an international organizational activity, the PV-GAP (Photovoltaic Global Approval Programme) and the IEC (International Electro-Technical Commission) are conducting work aimed at establishing international standards for PV systems and unifying the certification and approval systems.

Meanwhile, it is necessary to request agents for PV-related products to submit a certificate stating that their PV modules are compatible with the existing international standards (of the IEC and PV-GAP). After the introduction of the domestic certification system described in (3) below, the establishment of fair rules for the development of the market as well as a quality control system will be necessary by introducing a certification label to be attached to products which have passed the inspection. Given the fact that the absence of international standards for peripheral equipment/products other than PV modules often causes problems in terms of reliability, the establishment of technical standards for peripheral equipment/products marketed in Nigeria is the next step.

(3) Introduction of a PV-Related Equipment Certification System

A quality testing system and measuring instruments to assess the compliance with the technical standards mentioned in (2) above should be introduced, followed by the introduction of a certification system for equipment/products which pass the test. As it is assumed that the wide use of PV-related equipment will be achieved through shop sales as in the case of ordinary electrical appliances in the coming years, a certification label should be attached to PV-related equipment/products for easy judgement by purchasers. In this manner, the risk of ordinary users purchasing a defective product will be reduced, enabling the supply of high quality PV-related equipment/products.

In past PV projects implemented by other donors, the insufficient quality control of PV-related equipment/products had led to a vicious cycle of immediate malfunctioning after installation which had dented the confidence of users, resulting in reluctance on the part of users to pay the charge. To avoid the repetition of such a situation, it must be noted that thorough quality control together with the measures described in (2) above is very important to increase the level of satisfaction of PV system users at the initial stage of system introduction.

2.8.3 Measures to Promote the Extension of PV Systems by the Private Sector

According to the Survey on Business Activities in Solar-PV in Nigeria, a report published by the ECN, 44 private companies (including research institutes) were active in this sector as of 1999, 30 of which had a registered office in Lagos. Even though the extent of the introduction of PV systems in Nigeria is still limited, those companies anticipating the eventual expansion of PV rural electrification commenced activities in 1993 and have sold and installed PV-related equipment/products albeit on a small scale. It is highly desirable for the federal government to clearly state its stance of promoting the increased sale of PV systems by private companies, to exempt PV-related equipment/products from tax, to reduce the corporate tax for PV dealers, etc. and to commence activities to raise awareness of PV systems among the public as soon as possible to stimulate the demand for such systems (refer to Chapter 5 for such awareness raising activities).

Another important measure is the training of RESCOs which should play a central role in the introduction of PV systems by the private sector in the coming years during the implementation process of PV rural electrification projects by the federal government as well as donors. While there are many private companies in Nigeria which are capable of conducting the procurement and installation of PV systems, the maintenance work, including regular system inspection and charge collection, to be conducted by RESCOs has been monopolised by the PHCN as far as on-grid electrification up to the present is concerned. Careful consideration should, therefore, be given to changing this situation so that private companies are entrusted with such maintenance work in the future. In this context, it will be necessary to examine the viability of the affording of a concession (i.e. franchise system) to a single company by the state or local government which covers the geographical area of jurisdiction from the viewpoint of fostering a healthy company while preventing small companies from mushrooming.

What is required is the examination of viable measures to gradually reduce the scope of work of the public sector in the medium to long-term and the stimulation of the maximum promotion of the use of the private sector. Kenya in east Africa is an example which is worthy of note. In Kenya, the annual growth rate of PV systems has been as high as 10 – 18% since 1990 due to the active involvement of the private sector without relying on a government subsidy or the assistance of a donor or aid organization. The public sector in Kenya has reduced the import tax (5% for PV modules), which had been a stumbling block for the introduction of PV systems, together with the abolition of VAT, successfully reducing the sales price of PV systems by 15 – 20%.[8] (The large demand to watch television in Kenya, which could only be met by the supply of electricity, in addition to that for lighting is said to have been a factor for the successful extension of PV systems.)

In regard to financial support, promising measures include micro-finance for PV rural electrification projects and soft loans designed to foster SMEs and these measures have frequently been used in Asia and Latin America. As the solar energy-related market size in Nigeria is as small as 100 KW or less, measures to support private PV companies should feature the production and supply of peripheral equipment (such as DC fluorescent lamps and charge controllers) for SHSs in the short-term and the introduction of PV panel assembly lines in the medium to long-term. At the same time, capacity building efforts should be made through the implementation of the Action Plan for the Development of Solar Energy Technology formulated under the Study.

8) Case study on the private provision of photovoltaic systems in Kenya (2000)

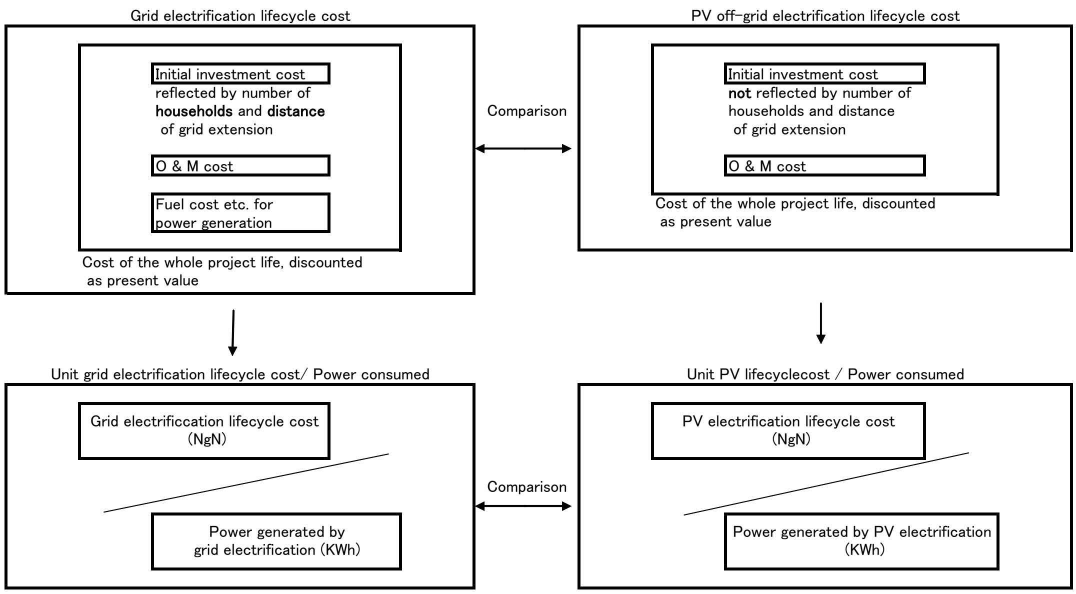
Chapter 3 Financial and Economic Analysis

3.1 Condition setting for financial analysis

3.1.1 Life cycle cost of grid electrification

The life cycle cost of grid electrification is calculated and the financial characteristics of off-grid electrification are verified in this section. Life cycle costs of rural electrification per kWh are examined in terms of the total cost of facilities over their economic life to be determined based on the distance between the grid and the village to be electrified and the number of households in the villages to be compared with benefits of electrification. The economic comparable advantage of the grid electrification is examined by these two factors. In reality, other factors also affect the economic efficiency of electrification such as population/household survey, distribution of villages, topography, economic activities and location of major facilities in surrounding areas.

From the point of view of electricity ensures utility and ease of use of electricity are very significant. As compared to the electrification based on renewable energy sources such as solar photovoltaic, mini-hydro and wind power for which the time and duration of electricity use and electrical appliances that can be used are constrained by weather conditions, the grid electrification is more convenient for the electricity users and market. Moreover, a 50% subsidy applies to the initial investment for the grid electrification in Nigeria, and therefore the comparative advantage of the grid electrification is further enhanced in the power market. Fig. 3-1 shows financial comparison between gird electrification and PV electrification.



Source: JICA Study Team

Fig. 3-1 Financial comparison between gird electrification and PV electrification

The costs are compared on investment costs, power generation cost, O&M costs and others for the project life, 20 years, judged from the durability of PV equipments. The initial investment per household is expensive but there is no need to pay for fuel as for PV. The costs for grid extension depend on the distance between the existing grid and the village in case of grid electrification, and more village are electrified, the costs to be burdened are less. Financial comparative superiority depends on the various surrounding conditions.

Given the present conditions, the off-grid electrification is considered to be an interim measure until the grid electrification is realized. This view is showed by the officials of the rural electrification authorities in the three states interviewed for the Study (Jigawa, Ondo and Imo). Nigeria is by far the largest country in Africa with the total population of 139 million as of 2005 (World Bank). The population density is 147 per km^2, much higher than other countries in Africa. Its topography with large flat land make the off-grid electrification less advantageous. Thus, the grid electrification is comparatively more meaningful. Advantages of grid and off-grid electrification and roles of alternative means of electrification are examined by one socioeconomic analysis conducted as part of the socioeconomic survey of the Study. In view of the present level at electrification and the large population, however, there still exist many areas where the grid extension is not likely in the next 10-15 years, while the off-grid electrification approach is applied to niche markets, the utility of electrification by solar photovoltaics is very high in such remote areas. Even in areas grid-electrified, back-up supply by solar photovoltaics may be useful for city residents as well, given the high frequencies of power back-out.

In order to examine the power generation costs of grid electrification in Nigeria, the life cycle cost and the unit cost per kWh are calculated in this section. The following are assumed.

- Period of calculation: 20 year project life
- Discount rate for present value calculation: 10%
- Maximum power demand per consumer household: 300W
- Load factor (average power demand divided by maximum demand): 0.5
- Duration of power use per day: 5.2 hours
- Annual electricity consumption: 219 kWh
- Unit power distribution cost by 33 kV line: NGN. 3,900,000 /km
- Installation cost of 33 kV power distribution line (including construction cost):
  the unit power distribution cost times the length of line extension
- Length of low voltage distribution line extension: 20m /household
- Unit cost of low voltage distribution line extension: NGN. 1,650,000 /km
- Installation cost of low voltage power distribution line (including construction cost):
  Multiplication of the above two time the length of line extension
- Cost of transformer for distribution: NGN. 1,700,000
- Total initial investment cost: sum of the three costs above (cost of 33kV distribution line installation + cost of low voltage distribution line installation + cost of transformer for distribution)

- Annual O&M cost: 5% of the total initial investment cost
- Unit generation cost: NGN 1.2495/Wh
- Transmission and distribution cost loss ratio: 0.40
- Annual power generation: Annual power consumption:
  Annual power consumption/(1- Transmission & distribution loss ratio)
- Total Generation cost: Annual power generation x unit generation cost

Estimate of power generation cost is calculated by dividing the present value of costs to be generated over the project life of investments for facilities and others by the expected power consumption over the same period. The results are summarized in the table below.

Table 3-1 Life Cycle Cost Per Household by Grid Extension (unit NGN)

Distance from grid	The number of households for electrification								
	10	50	100	300	500	800	1000	1500	2000
0 km	294,743	100,851	76,615	60,457	57,225	55,408	54,802	53,994	53,590
1 km	850,758	212,054	132,216	78,991	68,346	62,358	60,362	57,701	56,370
2km	1,406,772	323,257	187,817	97,524	79,466	69,308	65,922	61,407	59,150
3km	1,962,787	434,460	243,419	116,058	90,586	76,258	71,482	65,114	61,930
4km	2,518,801	545,663	299,020	134,592	101,706	83,208	77,042	68,821	64,710
5km	3,074,816	656,866	354,622	153,126	112,827	90,158	82,602	72,528	67,490
6km	3,630,830	768,068	410,223	171,660	123,947	97,109	88,163	76,234	70,270
7km	4,186,845	879,271	465,825	190,194	135,067	104,059	93,723	79,941	73,050
8km	4,742,859	990,474	521,426	208,727	146,188	111,009	99,283	83,648	75,830
9km	5,298,874	1,101,677	577,028	227,261	157,308	117,959	104,843	87,355	78,610
10km	5,854,888	1,212,880	632,629	245,795	168,428	124,909	110,403	91,061	81,391
11km	6,410,903	1,324,083	688,230	264,329	179,549	131,860	115,963	94,768	84,171
12km	6,966,917	1,435,286	743,832	282,863	190,669	138,810	121,523	98,475	86,951
13km	7,522,932	1,546,489	799,433	301,396	201,789	145,760	127,084	102,182	89,731
14km	8,078,946	1,657,692	855,035	319,930	212,909	152,710	132,644	105,888	92,511
15km	8,634,961	1,768,895	910,636	338,464	224,030	159,660	138,204	109,595	95,291
16km	9,190,975	1,880,097	966,238	356,998	235,150	166,610	143,764	113,302	98,071
17km	9,746,990	1,991,300	1,021,839	375,532	246,270	173,561	149,324	117,009	100,851
18km	10,303,004	2,102,503	1,077,441	394,066	257,391	180,511	154,884	120,716	103,631
19km	10,859,019	2,213,706	1,133,042	412,599	268,511	187,461	160,444	124,422	106,411
20km	11,415,033	2,992,126	1,188,644	431,133	279,631	194,411	166,005	128,129	109,191

Source : JICA Study Team

In the case of the grid extension by 5km, where there are only 300 households or less in the extension area, the life cycle cost became larger than NGN.150,000, exceeding the life cycle cost of the 55W SHS system. For the grid extension of 10km, the life cycle cost exceeds NGN.150,000, if there exist fewer than 500 households in the extension area., The life cycle cost exceeds NGN.150,000 for the 15kn extension, if there exist fewer than 800 households in the extension area. For the 20km extension the threshold number of households are 1,500, beyond which the life cycle cost exceeds NGN.150,000.

With the 20km extension, the life cycle cost does not exceed NGN.150,000 if there are more than 1,5000 households in the extension area. With 1,000 households in the extension area, the life cycle cost exceeds NGN.150,000 if the extension becomes 18km. With 300 households in the extension area, the life cycle cost exceed NGN.150,000 if the extension is large than 5km.

The analysis above does not reflect the difference in the amount of energy that can be supplied by the grid and by the solar electrification, which is meaningful in remote areas with very limited power consumption, even if the life cycle cost exceeds the threshold. In some unelectrified areas, however, a portable gasoline generator is used for electrical appliances. In such a case, the life cycle cost will have to be examined for one expected power consumption.

The life cycle cost of the grid electrification corresponding to the expected power consumption over the 20 year project life is presented in Table 3-2 in the calculation, it is assumed that the power consumption will increase at 2% per annum.

Table 3-2 Life Cycle Cost Per Consumed Power by Grid Extension (unit: NGN/KWh)

Distance from grid	The number of households for electrification								
	10	50	100	300	500	800	1000	1500	2000
0km	46.16	15.79	12.00	9.47	8.96	8.68	8.58	8.46	8.39
1km	133.24	33.21	20.71	12.37	10.70	9.77	9.45	9.04	8.83
2km	220.31	50.62	29.41	15.27	12.45	10.85	10.32	9.62	9.26
3km	307.39	68.04	38.12	18.18	14.19	11.94	11.19	10.20	9.70
4km	394.47	85.46	46.83	21.08	15.93	13.03	12.07	10.78	10.13
5km	481.54	102.87	55.54	23.98	17.67	14.12	12.94	11.36	10.57
6km	568.62	120.29	64.24	26.88	19.41	15.21	13.81	11.94	11.00
7km	655.70	137.70	72.95	29.79	21.15	16.30	14.68	12.52	11.44
8km	742.77	155.12	81.66	32.69	22.89	17.38	15.55	13.10	11.88
9km	829.85	172.53	90.37	35.59	24.64	18.47	16.42	13.68	12.31
10km	916.93	189.95	99.08	38.49	26.38	19.56	17.29	14.26	12.75
11km	1,004.00	207.36	107.78	41.40	28.12	20.65	18.16	14.84	13.18
12km	1,091.08	224.78	116.49	44.30	29.86	21.74	19.03	15.42	13.62
13km	1,178.16	242.19	125.20	47.20	31.60	22.83	19.90	16.00	14.05
14km	1,265.23	259.61	133.91	50.10	33.34	23.92	20.77	16.58	14.49
15km	1,352.31	277.02	142.61	53.01	35.08	25.00	21.64	17.16	14.92
16km	1,439.38	294.44	151.32	55.91	36.83	26.09	22.51	17.74	15.36
17km	1,526.46	311.85	160.03	58.81	38.57	27.18	23.39	18.32	15.79
18km	1,613.54	329.27	168.74	61.71	40.31	28.27	24.26	18.91	16.23
19km	1,700.61	346.69	177.44	64.62	42.05	29.36	25.13	19.49	16.66
20km	1,787.69	468.59	186.15	67.52	43.79	30.45	26.00	20.07	17.10

Source : JICA Study Team

Reflecting the difference in the amount of energy that can be consumed, the 55WSHS has a comparative advantage to the grid electrification, if the number of households in the service area is less than 100. it is more advantageous in the area with fewer than 100 households where the extension of 8km or larger is necessary for the grid extension.

The 110W SHS may be competitive with one grid extension over 15km, it there are 300 households in the service area. The 165W SHS has an advantage as it is converted to alternate current to allow the use of various home appliances available broadly in the market. Its life cycle cost, however, becomes comparable to that of the 55W SHS, it the loss in conversion to alternate current and additional costs involved in inverter for the conversion and other one taken into account. A mini grid system also allows the use of general electrical appliances and the alternate current, but the economy of scale cannot be expected for such a small mini grid with only 20 household or so, and it is slightly more expensive than the SHS type electrification.

The BCS System is less costly than the SHS system or the mini grid, and competitive with the grid electrification for remote areas with 500 households where the grid extension of 15k or larger is necessary. According to the socioeconomic survey on power demand as part of the Pre-F/S, however, the demand for BCS is low for the residents who consider it troublesome to bring the equipment to the battery charging station one in 4-5 days for recharging. This recharging involves also opportunity costs, and this preference by residents appears reasonable. In Nigeria, the half of the initial investment cost for the rid electrification is subsidies. Taking this subsidy into account, the life cycle cost and its unit cost per kWh consumed are calculated as shown in Table 3-3 and Table 3-4 respectively.

Table 3-3 Life cycle cost of Grid Electrification including 50% Subsidy for Initial Investment

(Unit: NGN)

Distance from grid	The number of households for electrification								
	10	50	100	300	500	800	1000	1500	2000
0km	193,243	53,091	40,973	32,894	31,278	30,369	30,066	29,662	29,460
1km	428,044	108,692	68,773	42,161	36,838	33,844	32,846	31,516	30,850
2km	706,051	164,294	96,574	51,428	42,398	37,319	35,626	33,369	32,240
3km	984,059	219,895	124,375	60,694	47,958	40,794	38,406	35,222	33,630
4km	1,262,066	275,497	152,175	69,961	53,519	44,269	41,186	37,076	35,020
5km	1,540,073	331,098	179,976	79,228	59,079	47,745	43,967	38,929	36,410
6km	1,818,080	386,700	207,777	88,495	64,639	51,220	46,747	40,783	37,800
7km	2,096,088	442,301	235,578	97,762	70,199	54,695	49,527	42,636	39,190
8km	2,374,095	497,902	263,378	107,029	75,759	58,170	52,307	44,489	40,581
9km	2,652,102	553,504	291,179	116,296	81,319	61,645	55,087	46,343	41,971
10km	2,930,109	609,105	318,980	125,563	86,879	65,120	57,867	48,196	43,361
11km	3,208,117	664,707	346,781	134,830	92,440	68,595	60,647	50,049	44,751
12km	3,486,124	720,308	374,581	144,097	98,000	72,070	63,427	51,903	46,141
13km	3,764,131	775,910	402,382	153,364	103,560	75,545	66,207	53,756	47,531
14km	4,042,138	831,511	430,183	162,630	109,120	79,020	68,987	55,610	48,921
15km	4,320,146	887,113	457,983	171,897	114,680	82,495	71,767	57,463	50,311
16km	4,598,153	942,714	485,784	181,164	120,240	85,971	74,547	59,316	51,701
17km	4,876,160	998,315	513,585	190,431	125,800	89,446	77,327	61,170	53,091
18km	5,154,167	1,053,917	541,386	199,698	131,361	92,921	80,107	63,023	54,481
19km	5,432,175	1,109,518	569,186	208,965	136,921	96,396	82,888	64,876	55,871
20km	5,710,182	1,498,729	596,987	218,232	142,481	99,871	85,668	66,730	57,261

Source: JICA Study Team

Table 3-4 Life cycle cost per consumed power including 50% Subsidy for Initial Investment

(Unit:NGN/KWh)

Distance from grid	The number of households fro electrification								
	10	50	100	300	500	800	1000	1500	2000
0km	30.26	8.31	6.42	5.15	4.90	4.76	4.71	4.65	4.61
1km	67.04	17.02	10.77	6.60	5.77	5.30	5.14	4.94	4.83
2km	110.57	25.73	15.12	8.05	6.64	5.84	5.58	5.23	5.05
3km	154.11	34.44	19.48	9.51	7.51	6.39	6.01	5.52	5.27
4km	197.65	43.15	23.83	10.96	8.38	6.93	6.45	5.81	5.48
5km	241.19	51.85	28.19	12.41	9.25	7.48	6.89	6.10	5.70
6km	284.73	60.56	32.54	13.86	10.12	8.02	7.32	6.39	5.92
7km	328.27	69.27	36.89	15.31	10.99	8.57	7.76	6.68	6.14
8km	371.80	77.98	41.25	16.76	11.86	9.11	8.19	6.97	6.36
9km	415.34	86.68	45.60	18.21	12.74	9.65	8.63	7.26	6.57
10km	458.88	95.39	49.95	19.66	13.61	10.20	9.06	7.55	6.79
11km	502.42	104.10	54.31	21.12	14.48	10.74	9.50	7.84	7.01
12km	545.96	112.81	58.66	22.57	15.35	11.29	9.93	8.13	7.23
13km	589.49	121.51	63.02	24.02	16.22	11.83	10.37	8.42	7.44
14km	633.03	130.22	67.37	25.47	17.09	12.38	10.80	8.71	7.66
15km	676.57	138.93	71.72	26.92	17.96	12.92	11.24	9.00	7.88
16km	720.11	147.64	76.08	28.37	18.83	13.46	11.67	9.29	8.10
17km	763.65	156.34	80.43	29.82	19.70	14.01	12.11	9.58	8.31
18km	807.19	165.05	84.79	31.27	20.57	14.55	12.55	9.87	8.53
19km	850.72	173.76	89.14	32.73	21.44	15.10	12.98	10.16	8.75
20km	894.26	234.71	93.49	34.18	22.31	15.64	13.42	10.45	8.97

Source: JICA Study Team

Only the residents in cities that have been grid electrification can benefit from the 50% subsidy by the Government, and those in remote areas can not make access to electricity nor the subsidy. It makes sense form the equity point of view that a s subsidy is provide at a higher rate to non-grid electrification for residents in such areas, that are in unlikely to be served by the grid electrification.

The life cycle cost is reduced to slightly over 50% level of what it is without the subsidy, if a 50% subsidy is applied. The unit life cycle cost per kWh becomes lower than NGN.5 in areas with large number of households close to the grid (or urban area), closer to the present electricity tariff of NGN.4 per kWh for domestic consumers.

3.1.2 Variation of PV Rural Electrification

(1) Mini grid system

Economically more developed states and areas in the south have higher requirements for electrification to support the better quality of life. Many residents want to use colour TV, refrigerator, electric fan and other appliances. The 55W SHS or BCS cannot meet these requirements. In addition, electrification rate is relatively high and the probability to be connected to the exiting grid is high in those areas, and if connected the mini-grid facilities can be utilized as they are and the investments are not wasted. Accordingly, mini-grid system is proposed in the sates where the electricity rate is higher than a certain level. For the mini-grid system, the following conditions are set for financial analysis.

(1) Basic conditions

1) Project life

The project life is set at 20 years as PV arrays constituting the major part of system costs have 20 years durability.

2) Discount rate for present value calculation

The discount rate at 10-12% is commonly used by international funding organizations such as the World Bank, ADB and JBIC for project evaluation. Market interest rates in Nigeria are currently in the rage at 9-13% for bank transactions (as of February 20, 2006). The prime lending rate of commercial banks fluctuates very much, by month and by year. Individual lending rate for each project will be changed largely. We shall use herein the capital asset pricing model to fix the discount rate for present value calculation. The real cost of fund procurement shall be calculated under the consideration of capital composition.

3) Implementing agency (for which the financial analysis is made)

The privatization of the electrification would have to compete with the grid electrification. These conditions indicate that the implementing entity for the PV mini grid system , unlike the grid electrification would better be the subject village or the private sector-led organization. Since the system is larger than the SHS or the BCS system, requiring technical expertise for installation and maintenance of equipment, the participation of private enterprises capable of handling these needs are desirable. There are two alternatives as the implementing body: one is a private energy service company (RESCO), stated in the next section, or a community based village organization. It is assumed that a RESCO will be the one for mini-grid system.

The advantage of the private RESCO of the equipment for solar electrification is that the same equipment can be transferred to other remote villages and effectively used, rather than the ownership by the subject village, after its installation once the grid extension reaches the subject village. The original wiring within houses can be used as is after the grid extension. The management by the village initiative is necessary, whether the electrification is implemented by a public entity or private power company, as the equipment is located in the remote villages.

4) Subject villages for mini grid application

The mini grid system is applicable to relatively rich villages, where houses are comparatively more densely located to form communities. Also it is more applicable to areas closer to the power supply gird (within 10km). Larger villages are more suitable for the system with the population of several hundreds to 1,000 or more households. Nigeria has many villages corresponding to this range. A module of the mini grid system with 1200W generating capacity, covering 20 households, is considered here, and the application of the system by increasing the number of the module is considered.

(2) Revenues

1) Revenue from electricity charge collected form residents according to their use

2) Maintenance and management fee collected from residents at fixed rate

The sum of the charge is adopted for financial calculation.

(3) Costs

1) Initial investment for the mini-grid system: It is assumed to be 3,720,000 NGN based on the estimation from a dealer and the bidding price of the pilot projects. It is supposed that mini-grid will be promoted by private RESCOs, and therefore, the price will be lower than the procurement by the government. In addition, it is supposed that the price will become lower as more PV system will penetrate in the Nigerian market (details are explained later). The system used for calculation is as follows:

- PV solar module (1200 W solar array, 60W panel – 4 series x 15 rows)
- Battery (12V, 2000Ah, sealed type, deep crystal use- 24 units)
- Inverter (48V, 30,000W- one unit
- Low voltage distribution lines
- Concrete power pole
- Mini grid system installation, etc.

2) Operation and maintenance staff: NGN. 60,000/person/year

3) Equipment renewal cost (Batteries, controller, etc.)

In case of the public entity, the following apply.

- Battery change in every five years: NGN.540,000 (three times)
- Controller renewal after 10 years: NGN.35,000 (one time)
- Inverter renewal after 10 years: NGN 150,000 (one time)

In case of private RESCO, the following apply.

- Battery change in every five years: NGN.432,000 (three times)
- Controller renewal after 10 years: NGN.28,000 (one time)
- Inverter renewal after 10 years: NGN 120,000 (one time)

4) Repair cost

It is assumed that that the annual cost equivalent to 2% of the initial investment will be recurred for repair.

5) Miscellaneous cost

It is assumed to be 1% of the initial investment for one system.

(4) Funding

1) Public subsidy for initial investments

In view of the existing 50% subsidy of initial investment for the grid electrification and considering that the PV mini grid applies to such areas that are not likely to be covered by grid electrification, 50% subsidy for the initial investment is assumed (-2016). However, it will be decreased during 2017-2020 to be zero in 2020 (2017:37.5%、2018:27.5%、2019:12.5%、2020:0%）.

2) Funding for the remaining 50%

When a private firm implements the PV mini grid electrification, as a private business, the remaining initial investment should be borne by the firm, which should recover the investment through the business operation. 20% is covered by funds by self-procurement by the village and village people, and 30% by loan. It is assumed that soft loan system for rural electrification by the government will be available for the loan. The grid electrification is operating in the red, and the red part is the substantial subsidy to the users of the grid electrification areas.)

(2) SHS system

Only one type of the SHS system cannot cope with the rage of electrification use and variety of electrical appliances, that vary depending on the income level and the life style of people in different villages. Therefore, a few alternatives need to be provided for the SHS system. Three types of system for 55W, 110W and 165 W are essential as follows:

- 55W system: minimum system to allow the use of two fluorescent lamps
- 110W system: applicable to four fluorescent lamps and black-and-white TV
- 165W system: SHS system wit alternate current capable of coping with general electrical appliances available in the market; applicable to households in unelectirified villages already using colour TV and refrigerator by an independent generator and also to potential users of these appliances of relatively rich households.

(1) Basic conditions

1) Project life

PV module itself has physical durability of 20 years. Considering the changes in needs of consumers for more diversified and advanced uses, however, it may be difficult for the SHS system at 55W or 110W to cope with these changing demands of consumers over the 20 period. The 165W system can deal with the needs for several electrical appliances, such as colour TV and refrigerator. Given the poverty situation in remote areas at present, however, it is assumed here that all the three types of the SHS system can retain economic utility for 20 years. That is, the project life is assumed to be 20 years for the 55W, 110W and 165W SHS system.

2) Discount rate for the present value calculation

It is assumed as done for the mini grid system.

3) Implementing entity (for which the financial analysis is made)

PV electrification by SHS is applied to remote villages. The implementing entity should be a community based village organization or a private RESCO, and it is indispensable to promote private companies' participation is for the spread of SHS system. In case of bottom-up approach by community, state/local governments or NGOs should instruct or support the organizations. It is desirable that REA, state/local governments and NGOs will make effort to capacity development.

SHS system, originally can be supplied to the households respectively, there should be a scheme by which respective households purchase the system from PV dealers directly.

4) Subject villages for SHS application

The applicability of the SHS system is the highest for remote villages far from urban areas and the existing power supply grid at the distance of 10-20 km or larger. Such villages may be relatively small, and it may be advantageous. The probability is high that that those may be used in the villages in the north, where population density may be low and the poverty levels are high. However, in the villages near large cities, there are some houses that use gasoline potable generators, and SHS 55W, which can provide only several lights, may be not enough for their needs. Accordingly, it is considered that SHS 55W is suitable for remote villages, SHS 165W is for suburbs of the cities and SHS 110W is for the middle areas between those.

(2) Revenues

1) User charges

SHS system is independently installed in each household. Therefore, electricity charge does not need to be collected according to its used quantity. A fixed charge should be collected form each household. The charge will be determined through the financial analysis later. The charge ratio of each system is as follows and those are used for the calculation (it depends on the ratio of the initial investment).

- 55W system: 1
- 110W system: 1.35
- 165W system: 2.25

(3) Costs

1) Initial investment:

Based on the results of tendering for the pilot project, especially the successful bid by the International Energy Services Ltd in the Imo state, the price quoted is considered ① is well within the range that can be realized. Further reduction in prices is expected due to technological advancement. The following are assumed for the system.

<u>55W SHS system</u>

① NGN.120,000 in case of installation in small lot by village organization

② NGN.100,000 in case of large scale installation organization-wise by a private RESCO (the price is similar to the international one)

- PV solar module (Silicon crystal – one panel)
- Battery (50Ah, sealed type, deep crystal use – on unit)
- Charge controller (12V, 4.5A-one unit)
- Steel pole and support device for the module
- Connecter (DC/DC type) etc.

<u>110W SHS system</u>

① NGN.190,000 in case of installation in small lot by village organization

② NGN.150,000 in case of large scale installation by a private RESCO

- PV solar module (60W Silicon crystal – two panels)
- Battery (120Ah, sealed type, deep crystal use – one unit)
- Charge controller (12V, 6A-one unit)
- Steel pole and support device for the module
- Connecter (DC/DC type) etc.

165W SHS system

① NGN.260,000 in case of installation in small lot by village organization

② NGN.210,000 in case of large scale installaton by a private RESCO

(Those are the prices in the conditions where PV market is limited. Further reduction in prices is expected due to enlargement of PV market. Details are stated later).

2) Salaries for operation and maintenance staff: NGN. 60,000/person/year

3) Equipment renewal cost (batteries, controller, etc.)

55W SHS system

- Battery charge in ever five years: NGN. 14,000 (three times)
- Controller renewal after 10 years: NGN. 14,000 (once)

110W SHS system

- Battery charge in ever five years: NGN. 19,000 (three times)
- Controller renewal after 10 years: NGN. 19,000 (once)

165W SHS system

- Battery charge in ever five years: NGN. 34,000 (three times)
- Controller renewal after 10 years: NGN. 23,000 (once)
- Inverter renewal after 10 years: NGN. 100,000 (once)

4) Repair cost

Approx. 2% of the initial investment of the whole system annually

5) Miscellaneous cost

Approx. 1% of the initial investment of the whole system annually

(4) Subsidy

1) Public subsidy for the initial investment: 50%

For 50% of the initial investment, subsidy provision is assumed (-2016) as the same as mini grid. However, it will be decreased during 2017-2020 to be zero in 2020 (2017:37.5%、2018:27.5%、2019:12.5%、2020:0%）.

2) Funding for the remaining 50%

The remaining 20% should be borne by the private RESCO or a village organization, which is the implementing entity, and the 30% should be covered by loan, which will be recovered through the business operation. It is assumed that soft loan is to be provided by the government.

(3) BCS system model

The initial investment is small, though users have to take them to battery charging station every several day, and therefore, BCS is suitable for the remote and poor villages in the states where electricity rate is low.

(1) Basic conditions

1) Project life

It is set to be 20 years, the same as in the case of the mini grid or the SHS system.

2) Discount rate for present value calculation

It is assumed to be the same as in the case of the mini grid.

3) Implementing entity

The same type of arrangements as describes for the SHS system are adopted.

(2) Revenues

1) Revenue from the user charge for battery recharge (approx. every 5 days or 72 times per year)
2) Maintenance and management fee colleted from residents

(3) Costs

1) Initial investment for the BCS system introduction: ① NGN.1,000,000 in case of installation in small lot by village organization; ② NGN.800,000 in case of supply in large lot by a private RESCO are assumed. Based on the results of tendering for the pilot project, especially the successful bid by the International Energy Services Ltd in the Imo state, the price quoted is considered ① is well within the range that can be realized. ② is also attainable if private companies, procurement entities, order the equipment in bulk. (Those are the prices in the conditions where PV market is limited. Further reduction in prices is expected due to enlargement of PV market. Details are stated later).The following are assumed for the system.
   - PV solar module (60W panel, 2 series x 9 rows)
   - Battery (100Ah, sealed type, deep crystal use – 24 hrs)
   - Controller (12V, 6A-one unit)
   - Battery charger (12V, 20A, 6units)
   - Concrete foundation with a security fence
   - Structure to support the module, etc.
2) Salaries of operation, maintenance and management staff
3) Equipment renewal costs (batteries, controller, etc.)
   - Battery charger every five years: NGN.17,000 (three times)
   - Controller renewal (after 10 years): NGN 56,000 (once)
4) Repair cost

It is assumed that that the annual cost equivalent to 2% of the initial investment will be recurred for repair.

5) Miscellaneous cost

It is assumed to be 1% of the initial investment for one system.

(4) Funding

1) Public subsidy for initial investments

For the initial investment 50% subsidy for the initial investment is assumed (-2016) as the same as mini grid. However, it will be decreased during 2017-2020 to be zero in 2020 (2017:37.5%、2018:27.5%、2019:12.5%、2020:0%).

2) Funding for the remaining 50%

The remaining 20% should be borne by the firm or a village organization, which is the implementing entity, and the 30% should be covered by loan, which will be recovered through the business operation. It is assumed that soft loan is to be provided by the government. In case of a private company, the composition 50% should be prepared so that cash operation will be done properly based on cash flow analysis.

3.1.3 Economy of PV Rural Electrification on the present cost structure

The life cycle cost of electrification by solar PV system and its unit cost per kWh are shown below. Details are stated in 3.2. The PV equipments are introduced just as experiment ant not in a large scale at present in Nigeria. Accordingly, the present cost is just the cost at that time and not the market price formed through market mechanism. The bidding prices for the pilot projects were also fluctuated widely.

For the purpose comparison, the life cycle cost of the grid electrification in remote villages with small number of households away from the grid is also included in the Table.

Table 3-5 Life Cycle Cost of Solar System

(Unit:NGN)

Type	Implementing agency	No subsidy	Subsidy 50%	Subsidy 70%	Subsidy 100%
55w SHS	Public	171,846	108,721	83,471	45,596
55w SHS	Private ESCO	139,284	89,647	69,447	39,147
110w SHS	Public	251,580	159,354	121,704	65,229
110w SHS	Private ESCO	204,314	130,913	100,793	55,613
165w SHS	Public	411,296	253,984	191,059	96,671
165w SHS	Private ESCO	332,300	206,450	156,110	80,600
Mini-grid	Public	206,576	149,289	119,626	75,133
Mini-grid	Private ESCO	172,034	119,431	95,701	60,106
BCS	Public	82,603	55,544	44,244	27,294
BCS	Private ESCO	70,798	47,764	38,524	24,664
Grid electrification (50households/10km)	Public	1,212,880	609,105	–	–
Grid electrification (50households/15km)	Public	1,768,895	887,113	–	–
Grid electrification (50households/20km)	Public	2,992,126	1,498,729	–	–
Grid electrification (100households/10km)	Public	632,629	318,980	–	–
Grid electrification (100households/15km)	Public	910,636	457,983	–	–
Grid electrification (100households/20km)	Public	1,188,644	596,987	–	–
Grid electrification (300households/10km)	Public	245,795	125,563	–	–
Grid electrification (300households/15km)	Public	338,464	171,897	–	–
Grid electrification (300households/20km)	Public	431,133	218,232	–	–
Grid electrification (500households/10km)	Public	168,428	86,879	–	–
Grid electrification (500households/15km)	Public	224,030	114,680	–	–
Grid electrification (500households/20km)	Public	279,631	142,481	–	–

Source: JICA Study Team

The comparison for the 55W SHS as an example show that the life cycle cost of 55W SHS is in the range of NGN. 80,000-90,000 under the 70% Government subsidy for the initial investment, higher than the subsidy of 50% for the grid electrification, as competitive as in the case where these two methods are compared without any subsidies. That is, the solar electrification becomes less favourable with subsidies if the same subsidy rate is applied to both of the method.

With the 100% of subsidy for the initial investment, the life cycle cost of solar electrification is a lower than NGN.100,000 and price competitive. Especially, for small or remote villages, the life cycle cost at solar system is considerably lower than that of the grid electrification.

Table 3-6 Life Cycle per Consumed Power Cost by Type

(Unit:NGN/KWh)

Type	Implementing agency	No subsidy	Subsidy 50%	Subsidy 70%	Subsidy 100%
55w SHS System	Public	91.46	57.86	44.42	24.27
55w SHS System	Private ESCO	74.13	47.71	36.96	20.83
110w SHS System	Public	66.94	42.40	32.89	17.36
110w SHS System	Private ESCO	54.37	34.84	26.82	14.80
165w SHS System	Public	91.20	56.32	42.37	21.44
165w SHS System	Private ESCO	73.69	45.78	34.62	17.87
Mini-Grid(1200w/20households)	Public	107.35	72.83	58.36	36.65
Mini-Grid(1200w/20households)	Private ESCO	89.19	58.26	46.69	29.32
BCS(20households)	Public	43.96	29.56	23.55	14.53
BCS(20households)	Private ESCO	37.68	22.88	18.45	11.81
Grid electrification (50households/10km)	Public	189.95	95.39	–	–
Grid electrification (50households/15km)	Public	277.02	138.93	–	–
Grid electrification (50households/20km)	Public	468.59	23.47	–	–
Grid electrification (100households/10km)	Public	99.08	49.95	–	–
Grid electrification (100households/15km)	Public	142.61	71.72	–	–
Grid electrification (100households/20km)	Public	186.15	93.49	–	–
Grid electrification (300households/10km)	Public	38.49	19.66	–	–
Grid electrification (300households/15km)	Public	53.01	26.92	–	–
Grid electrification (300households/20km)	Public	67.52	34.18	–	–
Grid electrification (500households/10km)	Public	26.38	13.61	–	–
Grid electrification (500households/15km)	Public	35.08	17.96	–	–
Grid electrification (500households/20km)	Public	43.79	22.31	–	–

Source: JICA Study Team

3.2 Market size and Price

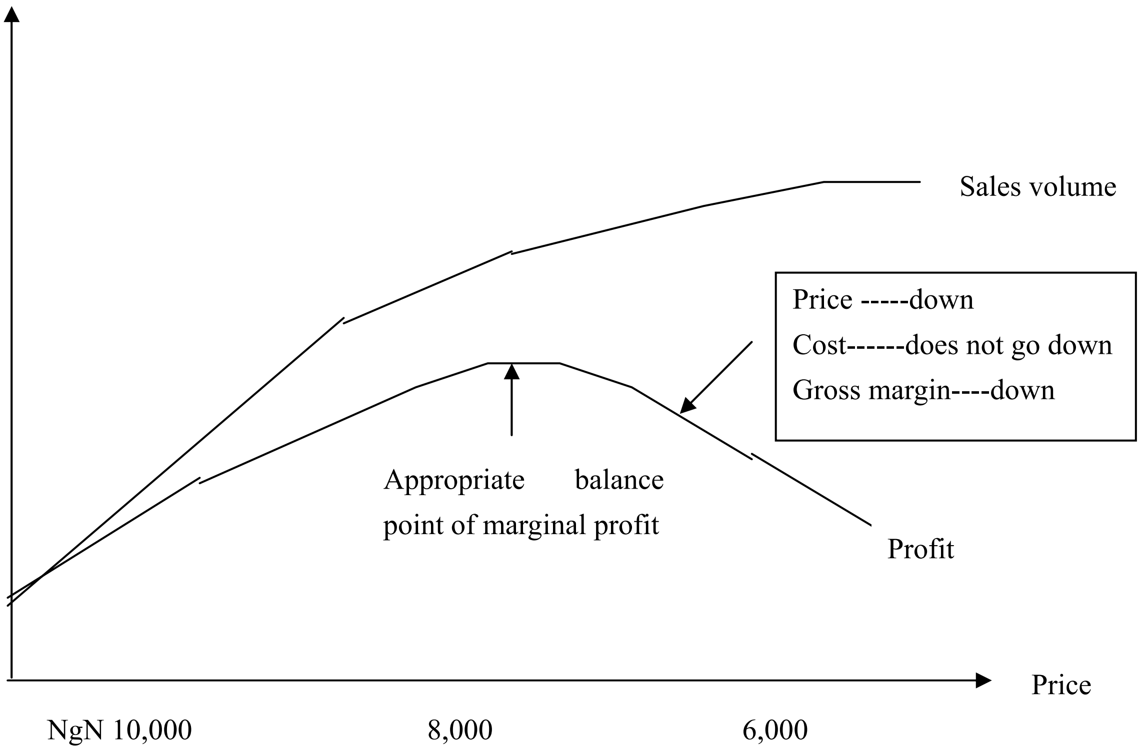
As expressed so far, in Nigeria, the electrification with PV systems is still at experimental stage, and a very limited numbers of the PV systems have been used in the country, whose population accounts for around 130 million people and even more in future. Provided that the market has not been formulated sufficiently, the supply cost is inevitably higher than international standard because of not taking advantage of scale merit. Regarding to this condition, it is not appropriate to carry out the financial analysis, if we take the current high price level as not-changing in future, that is to say, constant assumption towards the PV electrification work plan which will spread to the whole country. The market would work its usual magic: the price level of PV equipments would go down as the market extension would advance.

Presently, one unit of SHS with 50W output in the international market costs in the range of US$350-700 (this includes the charge controller, the battery and indoor wiring etc.). In the country where only the small quantity of the PV systems has spread, the same unit costs around US$600-700 (US$12-14 per watt), and around US$350-450 (US$7-9 per watt) in the country where the PV systems are quite prevailing. Meanwhile, in Nigeria, the price of the same unit is several times higher than its standard due to the limited extension of PV systems In addition, because of the rare procurement on PV systems, the procurement prices vary to a large extent in Nigeria. Considering the results of procurement in this pilot project, one price of successful bid was 128,418 NgN (approximately US$900 per unit or US$16 per watt) for the SHS with 50W in Imo state, and other price of successful bid enterprise was 171,300 NgN (approximately US$1,200 or US$ 22 per watt) in Ondo and Jigawa states. This way, being a variation, the price of PV systems is kept relatively high in Nigeria.

In addition, taking a look at the previous JICA development studies on PV systems, the price of one unit of SHS with 50W was US$713 in Laos in the period of year 2001, but the study estimated that the price would reach to US$300 level when the PV electrification would be due in the implementation. Even in Ghana, the neighboring country of Nigeria, it is estimated that local electrification will be carried out with the following prices approximately; US$ 600 for a 50W SHS, US$1,200 for a 100W SHS, and US$6,000 for a BCS.

The above said fact evidently indicates that the price of the PV equipment in Nigeria is kept very high in comparison with international price. This is the consequence of particular situations in Nigeria where the market penetration of PV system has not taken place, and the real market is not established yet. Of course, you may consider the applied tariff problem as a cause, however, it is much more related to the rare supply of PV equipments to Nigeria because of the almost non-existed market (while there is a limited supply, mainly for experimental introduction and import). Actually, the tariff rates of PV module and the charge controller are 10%. No tariff is charged for the inverter. For the battery, the special one for PV is charged with 20%, but no tariff is charged to the ordinal one for automobile use.

The graph as shown below explains the conceptual framework based on the marketing theory. It indicates the correlation of sale quantity, price and the profit etc. As commonly recognized by majority of people, if price goes down, you can anticipate the sale of products in a large scale. If the price is set high, the products are sold in a smaller volume. With a view of the company which sells a certain product A, when it keeps lifting the price range with just a little price pulling up, there is no excessive difference in the sale quantity. When the price reaches to a certain price range, however, the sale quantity decreases at once. Generally the companies analyze such factors via various market surveys, and set to the price where balance comes off exactly. Concerning the sale quantity and price in details, when it keeps reducing the price of a certain product, the sale quantity increases, and the profit keeps increasing. However, when it comes to a certain point in time, the sale quantity keeps increasing while the profit itself goes down. Because the cost does not go down beyond a certain level, the rough profit goes down. Therefore it reaches the point where the profit stops being obtained after all. The company, which tries reducing price, observes carefully the balance related to trade-off that the profit goes down due to the reduced price with the merit of the sale quantitative increase. Considering this trade-off, the company usually designs the sales planning.

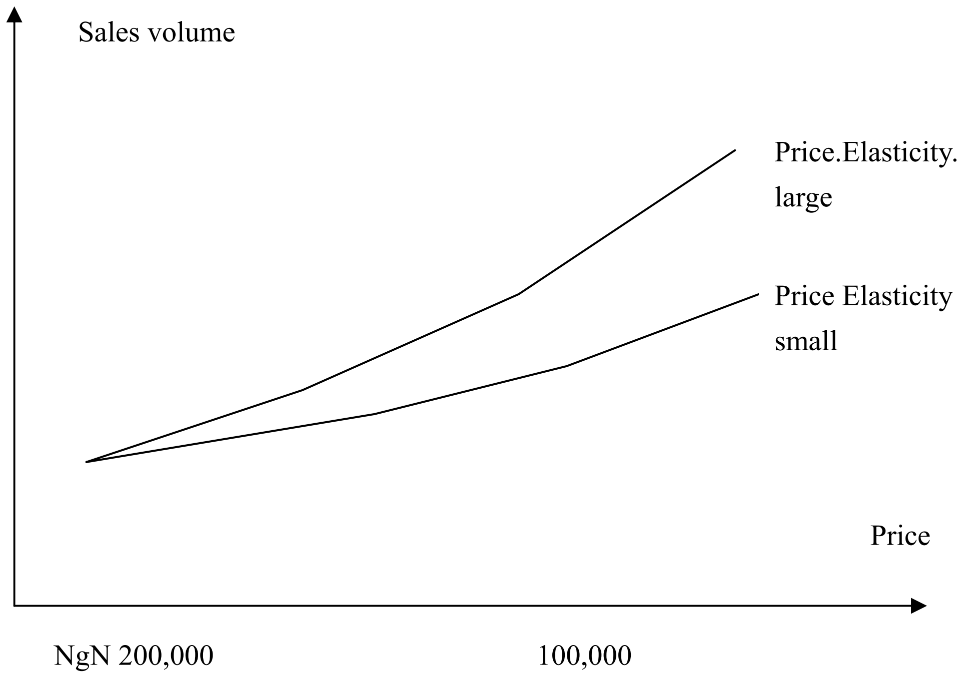


Source: JICA Study team

Fig. 3-2 Relationship between sales volume and price

Furthermore, generally speaking, a company cannot sell the product markedly if the price is set high. If the price becomes cheaper, the sales of the product will be expanded. This is related to the price elasticity as it is called in marketing theory. When a certain product was not sold well at price of 50,000 NgN, however, if it becomes 100,000 NgN in the market, 10 thousand units would be sold and even 50 thousands units to be sold if it becomes available at 50,000 NgN.

Related to the price elasticity, two lines are drawn in the following graph; when the price elasticity is large and when it is small. Generally, as for the daily products, the sale quantity changes largely in a little price difference. This is the case when price elasticity is large. Demand does not change relatively in comparison with that, the price fluctuation is small as for the brand products and others. This means that price elasticity is small. When selling the products in the market, there are various influential factors as primary ones. If the ratio of the price factor is high among them, price elasticity becomes large. This depends on the nature of targeted customers (market segment) and the characteristic of the products.



Source: JICA Study team

Fig. 3-3 Price elasticity

In case of the PV system, you need to analyze following factors in detail; 1) the price range of the level where customers can afford to purchase the PV system, 2) the nature of targeted customers (market segment), 3) the characteristic of the PV equipments, and 4) the fee setting of the level which the customers can pay smoothly. Furthermore, relationship between price and sale quantity is mutual one, and difficult to detect which one will precedes another. Certainly, it is something which is decided by the action of market mechanism. The equipments for PV systems are different than conventional and popular products in the market. Hence, for the extension of PV systems in Nigeria, it is necessary to implement various schemes such as public awareness raising of PV systems among the Nigerian people, related advertisement and campaign, and provision of equipments without charge which becomes priming with the interested groups of people for PV electrification.

As described in the chapter 2, the nationwide PV electrification plan is designed in the form which parallels to the planned policy of local electrification of Nigeria. According to this plan, approximately 72,000 households will be electrified with PV by 2010, and approximately 343,000 households by 2020. Namely, the PV market will be created with the amount of 18,000 units per year from present extending through 2010. From the year of 2011 onwards (till 2020), this market will be grown to the size of 27,000 units. Considering this opportunities, some of the PV systems such as described previously (e.g. SHS of 55W, 110W and 165W) will be standardized and be offered in the market with cheaper price than now. So, if it will not occur in the future, it is expected that the extension of PV systems in Nigeria will be quite difficult.

Therefore, in this paragraph, we analyze the price fluctuation (between 2007 and 2020), based on the calculation of Financial Internal Rate of Return (FIRR) and Net Present Value (NPV) as shown at table 3-7 below.

Table 3-7 Estimate of falling prices as market grows

Unit：NgN

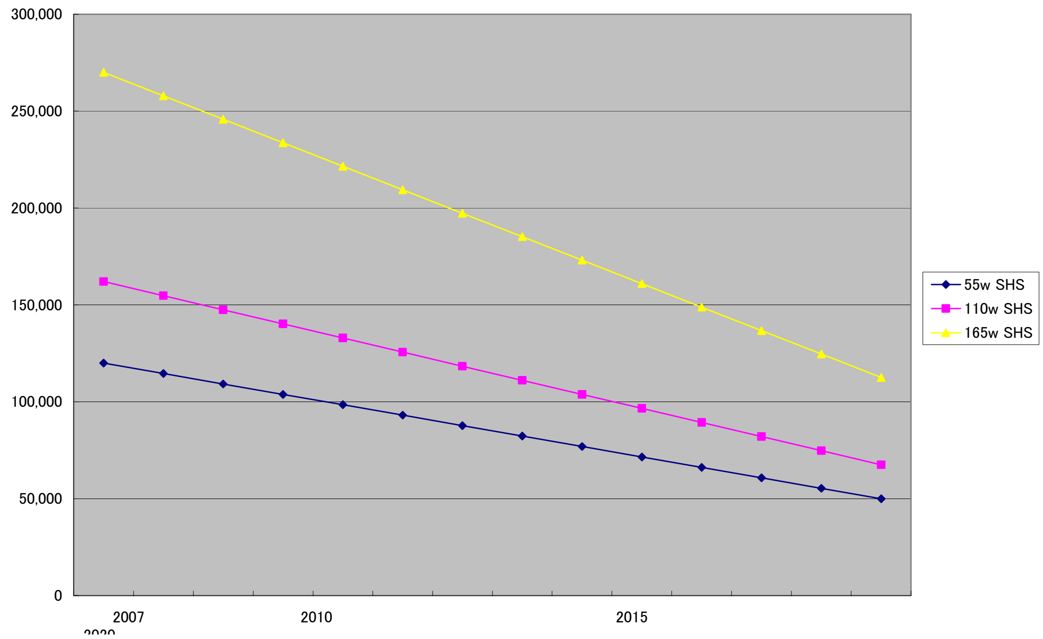
Installation year	2007	2008	2009	2010	2011	2012	2013
55w SHS	120,000	114,615	109,231	103,846	98,462	93,077	87,692
110w SHS	162,000	154,731	147,462	140,192	132,923	125,654	118,385
165w SHS	270,000	257,885	245,769	233,654	221,538	209,423	197,308
BCS	1,920,000	1,833,846	1,747,692	1,661,538	1,575,385	1,489,231	1,403,077
Min-Grid	3,720,000	3,553,077	3,386,154	3,219,231	3,052,308	2,885,385	2,718,462

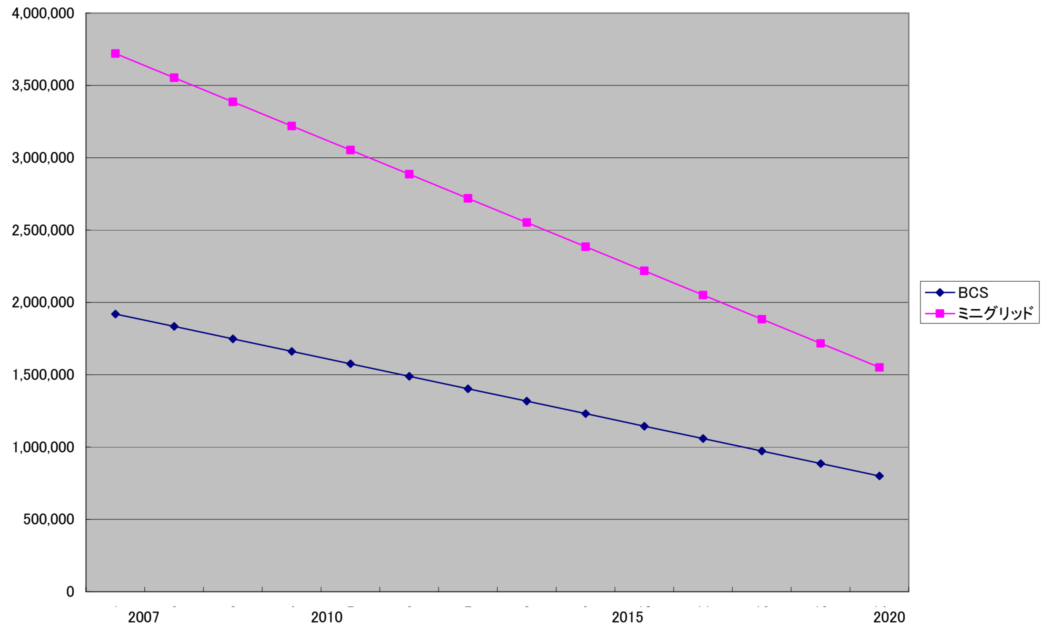
Installation year	2,014	2,015	2,016	2,017	2,018	2,019	2,020
55w SHS	82,308	76,923	71,538	66,154	60,769	55,385	50,000
110w SHS	111,115	103,846	96,577	89,308	82,038	74,769	67,500
165w SHS	185,192	173,077	160,962	148,846	136,731	124,615	112,500
BCS	1,316,923	1,230,769	1,144,615	1,058,462	972,308	886,154	800,000
Mini-Grid	2,551,538	2,384,615	2,217,692	2,050,769	1,883,846	1,716,923	1,550,000

2007: the price at present in Nigeria, where no PV system is implemented
2010: the highest price level in the international market at present
2015: the medium price between case 2 and case 4
2018: the cheapest price level in the international market at present
2020; the future price expecting the advanced technology and expanded market

Source: JICA Study team

The above mentioned table indicates the expected trend of decreased market prices in different PV systems. In Nigeria, the market price in the present condition is much higher, compared with international level. The slumping curve is sharp, but it is based on the assumption that the market prices in Nigeria will finally correspond to the international level of at the year around 2020. The trend assumption of the price for each PV system is shown in the following figure.





Source: JICA Study team

Fig. 3-4 Trend estimates of prices on SHS, Mini-gird,and CBS

3.3 Financial analysis

Following the previous settings, this chapter explains about the financial analysis of national PV rural electrification in Nigeria, with main focus on 1) village electrification committee, and 2) private energy service company (RESCO)

3.3.1 Financial analysis for the PV Rural Electrification by Village Electricity Committee

Village electrification committee is a community initiated and is not a usual company type of organization, but rather a sort of non profit-making organization, thus is not the object of taxation. This is the organization that villagers will receive the benefit of electrification, while paying rational amount of fee and trying to establish a sustainable structure of the organization. Therefore, we recommend not analyzing or examining the profitability of organization by using Financial Internal Rate of Return (FIRR), Net Present Value (NPV) and other examining measures. It is thus important to calculate the cash flow for the organizing period (20 years) in order to determine the feasible amount of fees to be collected from each household who use the PV system. For this calculation, the committee should also consider that there is no year when it becomes the deficit with respect to cash flow. In addition, the committee should consider whether just 50% subsidy in early investment stage is sufficient or not, other subsidy, and favorable treatment of financing.

Furthermore, based on the proposal at chapter 2, there are three different types of PV rural electrification which will be managed by the village electrification committee.

1) <u>Model No.1 for the financial analysis of village electrification committee; Rural electrification by SHS (only SHS with 55W)</u>
   - It is assumed that all households use SHS with 55W.
   - Being located at a remote village, it is assumed that the size of village is small. Regarding the socio-economic character of Nigeria which has predominant population in Africa, there are very few villages of less than 100 households. Hence it is examined and analyzed at the case of 150 households.
   - It is assumed that 20 % of the total amount in the system price will be offered to the public facilities such as streetlight installation and electrification of meeting halls, clinics, etc (such needs were highly observed during the village social economy survey and some public facilities were electrified during the pilot project implementation)

Followings are the summary of proceeded calculation;

- Each household of SHS in the village needs to prepare an amount of 28,800 NgN (at a price in 2007) as deposit, if it is agreed to pay 20 % of the initial investment individually. For the household with annual income of 100,000 NgN, it becomes the burden of 30 percent of its annual income. For the household with annual income of 50,000 NgN, it is equivalent to about 60 percent of its annual income. Even at a remote area, there are some households which possess motorbikes and others which use private generators, so we presume that some households can afford to pay the amount of initial investment without any difficulty. However, generally speaking, this initial investment is a considerable burden for the majority of households in the remote and poverty-prone areas.

- Even after paying the amount of initial investment, the households are supposed to arrange the remaining 30 percent of debt by loan. In case the government introduces the soft loan of preferential treatment loan conditions (it will be refunded in 3% of interest rates for a period of five years), they need to pay 1,210 NgN monthly for the first 5 years (in the 6th and afterwards, it will fall to the amount of 620 NgN per month), based on the price calculation in 2007. Otherwise, the village electrification committee can hardly manage the installed PV systems for 20 years in sustainable way.
- If the price of one SHS with 50W will be lower from the present international price level to US700$ per unit (assumed price in 2011 by the study team, and the market price in Ghana at present), which is the highest price level at international market, 20 percent of charge for each household will be reduced both for the initial investment and monthly loan payment for the first 5 years. In case of cheapest price in the present international market, one SHS with 50W is available at price level of US$350. Then, the burden for each household will be around 10,000 NgNs as the initial investment and about 500 to 600 NgNs as the monthly loan payment for the first 5 years. This charge level is almost same as at SELF Project in Jigawa state. The price of available private generator of gasoline fuel is around 10,000NgN which is the equivalent amount of the initial investment for one SHS with 50W (this is based on the assumption that 50% of subsidy will be introduced to SHS. Considering the total amount of fuel to be consumed by the generator, SHS has an advantageous in price competition).
- The forthcoming big objective of PV rural electrification is how to expand and grow the PV market in Nigeria until the domestic price of PV units will go down to the international level.
- For this purpose, it is essential at first to provide trainings for PV dealer, to formulate a nationwide distribution channel, to raise public awareness, and to implement some public projects as a pump-priming policy.
- Moreover, it should be designed and planned to introduce government subsidy to PV users with 70-80% of preferential treatment at the beginning. The percentage of subsidy can be reduced gradually as the expansion of PV systems, and then can be arranged to the same level as a grid system. This is a similar policy which was introduced and carried out in Japan.

Table 3-8 SHS (55W) with electrification of 150 households (fee level for sustainable management)

(Unit：NgN)

Installation year	2007	2008	2009	2010	2011	2012	2013
Initial payment	28,800	27,508	26,215	24,923	23,631	22,338	21,046
Monthly tariff (1-5 year)	1,210	1,160	1,110	1,050	1,000	950	900
Monthly tariff (6-20year)	620	590	570	550	530	500	470
Installation year	2014	2015	2016	2017	2018	2019	2020
Initial payment	19,754	18,462	17,169	15,877	14,585	13,292	12,000
Monthly tariff (1-5 year)	850	800	750	700	650	600	550
Monthly tariff (6-20year)	450	420	400	370	350	320	290

Source: JICA Study team

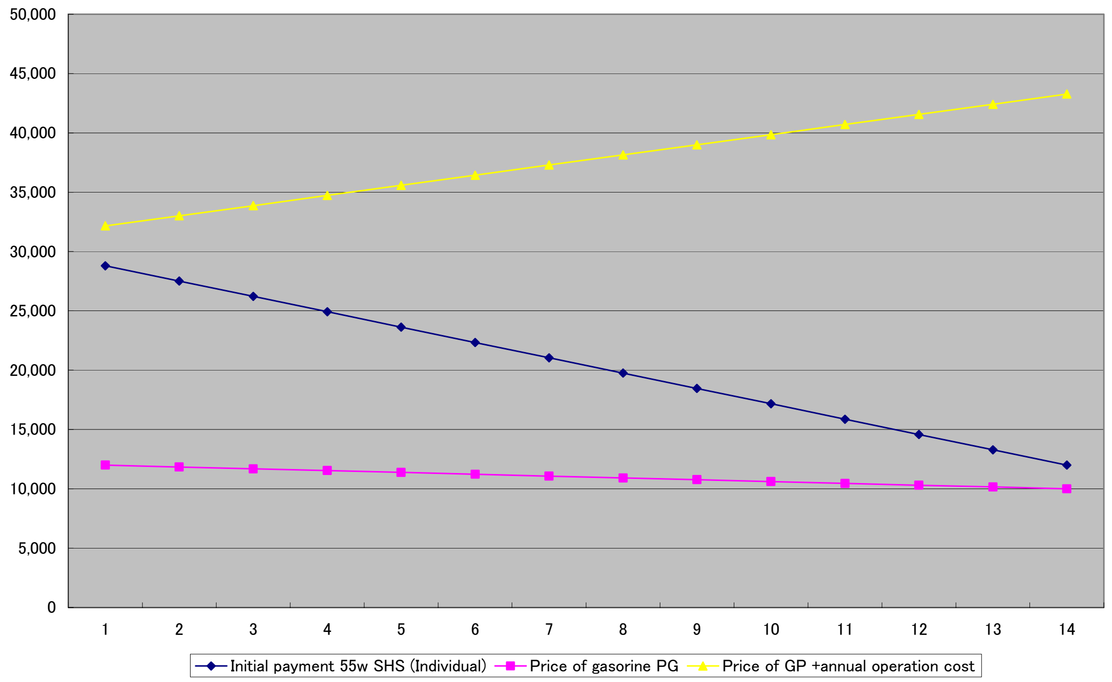
Note 1: 20% of early investment with cash individual payment

Note 2: 30% of early investment as soft loan (with interest rate of 3% in 5 years redemption)

Note 3: 50% of early investment with subsidy maintained as same as grid electrification

In addition, FIRR is calculated for reference. The fee collection from each household is expected to be done under the supervision of village electrification committee in the range out of which a deficit does not come on total cash flow, FIRR in this case is nearly 0 percent to the investment cost of 50% of individual coverage except the subsidy (the amount of loan is included in this calculation since the loan will be paid individually after all).

(Unit：NgN)



Source: JICA Study team

Fig. 3-5 Successive diminution curve of payment-in-advance payment required frame (20% of initial investment) of SHS (55W), and price of gasoline portable dynamo (only initial investment initial investment + annual operation cost)

In the above mentioned figure, PG means the Portable Generator (type; YAMAHA ET1000 fuel-tank 4 liter capacity / 650W) of the gasoline which has been spread through the villages in Nigeria. This has a capacity to produce electricity for 5 to 6 hours a day, consuming the 4 liter of gasoline at 80% rate of standard output. The present market price of this PG is 12,000 NgN, meanwhile economical and popular model from China is also available at the price of 10,000 NgN which is actually less powerful. Herewith the annual operation cost is calculated with following conditions; monthly consumption is 24 liter for 1 hour daily use, the price of gasoline is 70 NgN per liter and shall go up 5% every year.

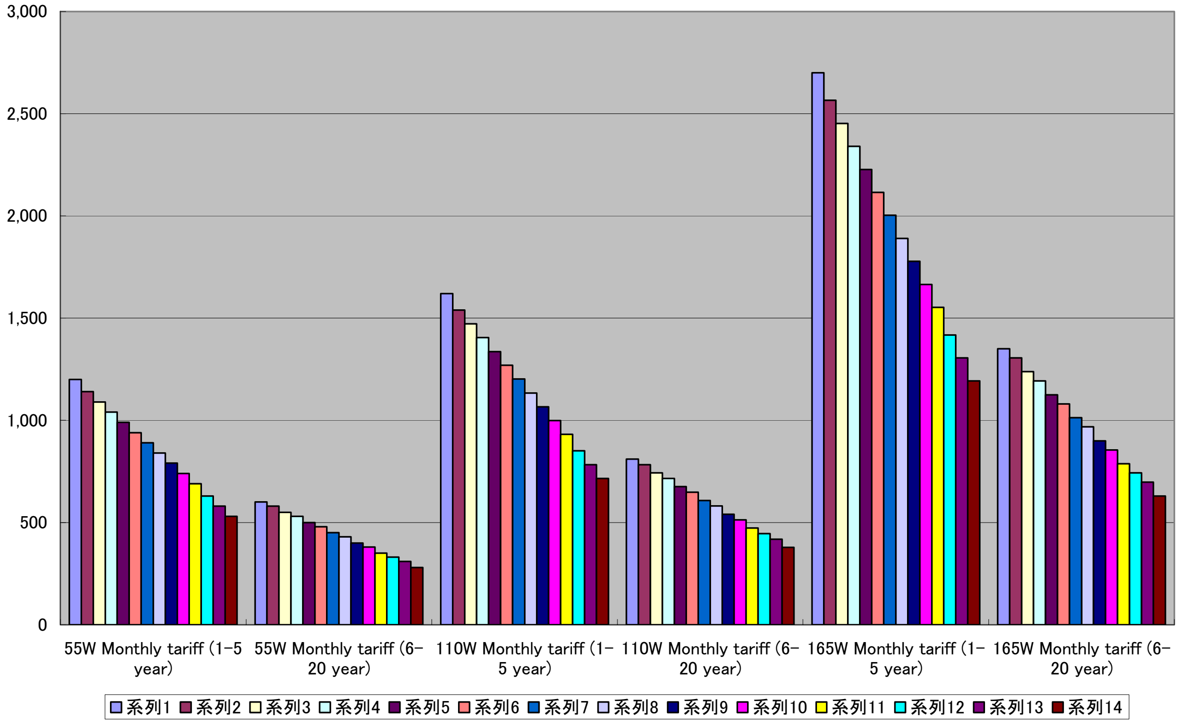
2) Model No.2 for the financial analysis of village electrification committee; Rural electrification by SHS (SHS with three different capacities)

- It is assumed that SHS with three different capacities will be supplied in the village; SHS with 55W for 60% of households, SHS with 110W for 30% of households, and SHS with 165W for 10% of households.
- In comparison with previously mentioned Model 1, it is assumed that the size of village is relatively big despite of the remote location. Hence it is examined and analyzed at the case of 300 households.
- Financial portfolio of each household is at same condition as Model 1. It consists of early investment with 20 % by cash, 30% by soft loan, and 50% by subsidy.

Followings are the summary of proceeded calculation;

- As shown in the following tables and figures, the monthly tariff for the users of SHS with 50W remains almost same as described in the previous chapter of Model 1.
- For the users of SHS with110W, it is possible to install maximum of 4 fluorescent lights (as for 55W only 2 lights) and to watch a black & white television (with 30W) for 2 hours daily. In addition, a radio can be used. Comparatively, the capacity is doubled, but the increase of early investment cost for the user of SHS with 110W is around 35% as well as 35% increase for the monthly tariff. The users need to pay 1,620 NgN monthly for the first 5 years and 810 NgN per month in the 6th and afterwards, based on the price calculation in 2007. This unit is quite attractive for some affordable families in the village because of its high cost performance.
- Based on the price calculation in the period of 2016 with the redemption of first 5 years, the users need to pay around 1,000 NgN monthly, and a little bit above of 500 NgN per month in the 6th and afterwards. In case of the year 2020, the monthly tariff will be 710 NgN and 380 NgN respectably.
- Considering the bigger capacity of SHS with165W, the users can apply to several different electronic products, such as a color television, a refrigerator, and a ceiling fan as well as fluorescent lamps. As for degree of satisfaction of the users, it is expected to be sufficiently high, the monthly tariff will be also higher; 2,700 NgN during the beginning of 5 years, and 1,350NgN after the 6th year with computation on 2007 price rate.

– As same as other models (1 & 2), each user of SHS with 165W is supposed to pay 20 % of the initial investment individually by cash. Therefore the potential users of this unit will be limited because of the high level of cash payment even though the percentage of initial investment is only 20%. Based on the price calculation in 2007, the amount of initial investment will be 64,800 NgN. In other words, some rich households with the annual income of several 100000 NgN can afford to pay this amount by cash. In the village where the study team has visited, there exist these kind of wealthy households in fact.



Series 1: Monthly tariffs for the sustainable maintenance of the PV system based on the price calculation in 2007

Series 2: Monthly tariffs for the sustainable maintenance of the PV system based on the price calculation in 2008

Series 3: Monthly tariffs for the sustainable maintenance of the PV system based on the price calculation in 2009

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Series 14: Monthly tariffs for the sustainable maintenance of the PV system based on the price calculation in 2020

Source: JICA Study team

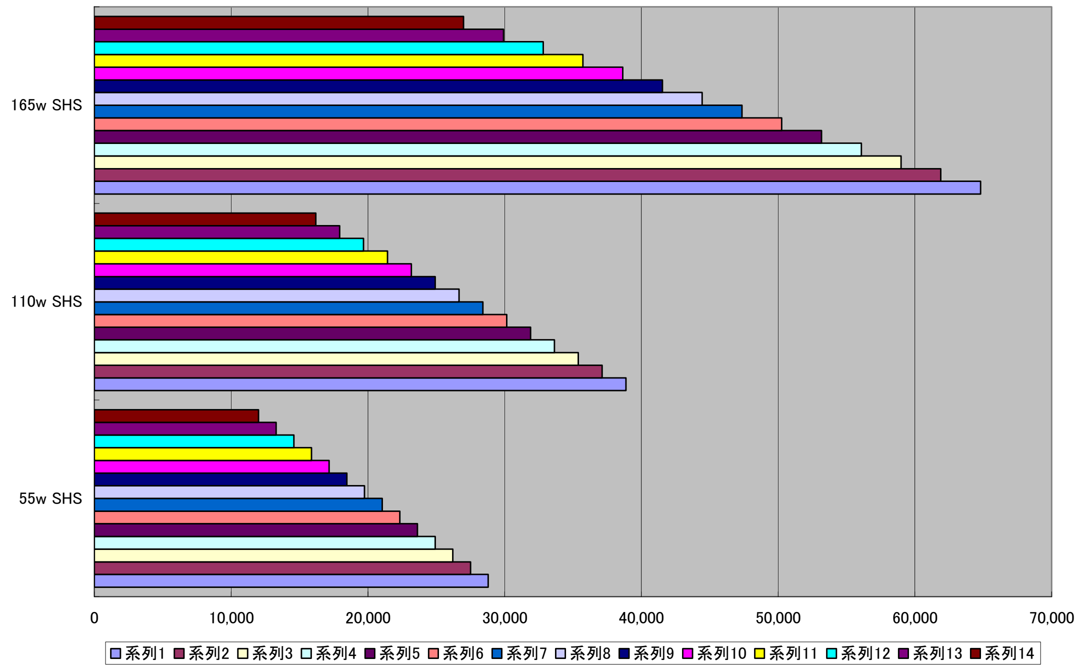
Fig. 3-6 Monthly tariffs for the sustainable maintenance of the PV system in each SHS type

Table 3-9 Monthly tariffs for the sustainable maintenance of the PV system in each SHS type

（Unit：NgN）

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
55W Monthly tariff (1-5 year)	1,200	1,140	1,090	1,040	990	940	890
55W Monthly tariff (6-20 year)	600	580	550	530	500	480	450
110W Monthly tariff (1-5 year)	1,620	1,539	1,472	1,404	1,337	1,269	1,202
110W Monthly tariff (6-20 year)	810	783	743	716	675	648	608
165W Monthly tariff (1-5 year)	2,700	2,565	2,453	2,340	2,228	2,115	2,003
165W Monthly tariff (6-20 year)	1,350	1,305	1,238	1,193	1,125	1,080	1,013
Installation year	2,014	2,015	2,016	2,017	2,018	2,019	2,020
55W Monthly tariff (1-5 year)	840	790	740	690	630	580	530
55W Monthly tariff (6-20 year)	430	400	380	350	330	310	280
110W Monthly tariff (1-5 year)	1,134	1,067	999	932	851	783	716
110W Monthly tariff (6-20 year)	581	540	513	473	446	419	378
165W Monthly tariff (1-5 year)	1,890	1,778	1,665	1,553	1,418	1,305	1,193
165W Monthly tariff (6-20 year)	968	900	855	788	743	698	630

Source: JICA Study team



Series 1: The amount of initial investment for each household by based on the price calculation in 2007

Series 2: The amount of initial investment for each household by based on the price calculation in 2008

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Series 14: The amount of initial investment for each household by based on the price calculation in 2020

Note; The amount of first 5 years is higher due to the extra payment for the soft loan (30% of early investment with interest rate of 3% in 5 years redemption)

Fig. 3-7 Necessary advance payment in each SHS classified type (20% of initial investment)

Table 3-10 Necessary advance payment in each SHS classified type (20% of initial investment)

（Unit：NgN）

Installation year	2007	2008	2009	2010	2011	2012	2013
55w SHS	28,800	27,508	26,215	24,923	23,631	22,338	21,046
110w SHS	38,880	37,135	35,391	33,646	31,902	30,157	28,412
165w SHS	64,800	61,892	58,985	56,077	53,169	50,262	47,354
Installation year	2014	2015	2016	2017	2018	2019	2020
55w SHS	19,754	18,462	17,169	15,877	14,585	13,292	12,000
110w SHS	26,668	24,923	23,178	21,434	19,689	17,945	16,200
165w SHS	44,446	41,538	38,631	35,723	32,815	29,908	27,000

Source: JICA Study team

- In case of cheapest price in the present international market, one SHS with 165W will be available in a range of 64,000 NgN (installation year of 2007) and 27,000 (year 2020) NgN with advance payment by cash (including 20% of equity capital). However, if it is lowered to the cheapest level of international level of present condition, cash which is prepared the case of purchase (it is 20% individual payment), 64,000-27,000 the amount of NgN is sufficient even with SHS of 165W.
- For the case of SHS with 110W, each household needs to prepare an amount of 39,000 NgN by cash based on the price calculation in 2007, but approximately 16,000 NgN in 2020.
- The presented argument so far is premised on the available financial supports such as 50% of subsidy and 30% of soft loan. For the case of 50% subsidy, it is done to the grid electrification as well, hence it is highly possible that same scheme be applied to the poverty-prone off-grid electrification areas. There are a limited number of households in the non-electrified villages, however, which can afford to prepare the remaining amount of 50% as equity capital. Because of this, it is necessary to raise the amount of financial support (e.g. more than 30% for soft loan and above 50% for subsidy) during the initial stage. As PV systems will be spread in advance, the price of PV equipments will go down, then modified financial plan should be introduced to the PV users in order to gradually decrease the amount of financial support such as subsidy.

3) Model No.3 for the financial analysis of village electrification committee; Rural electrification by BCS (only BCS)

- BCS system (100% of household will use BCS).
- In comparison with previously mentioned Model 1 (SHS only), it is assumed that the targeted village is located in a quite isolated area, and is one of the poorest villages. Hence it is examined and analyzed at the case of 100 households.

Based on the estimated cash flow for a period of 20 years project life cycle, the monthly tariffs are calculated for the sustainable maintenance of the BCS. Followings are the summary of proceeded calculation;

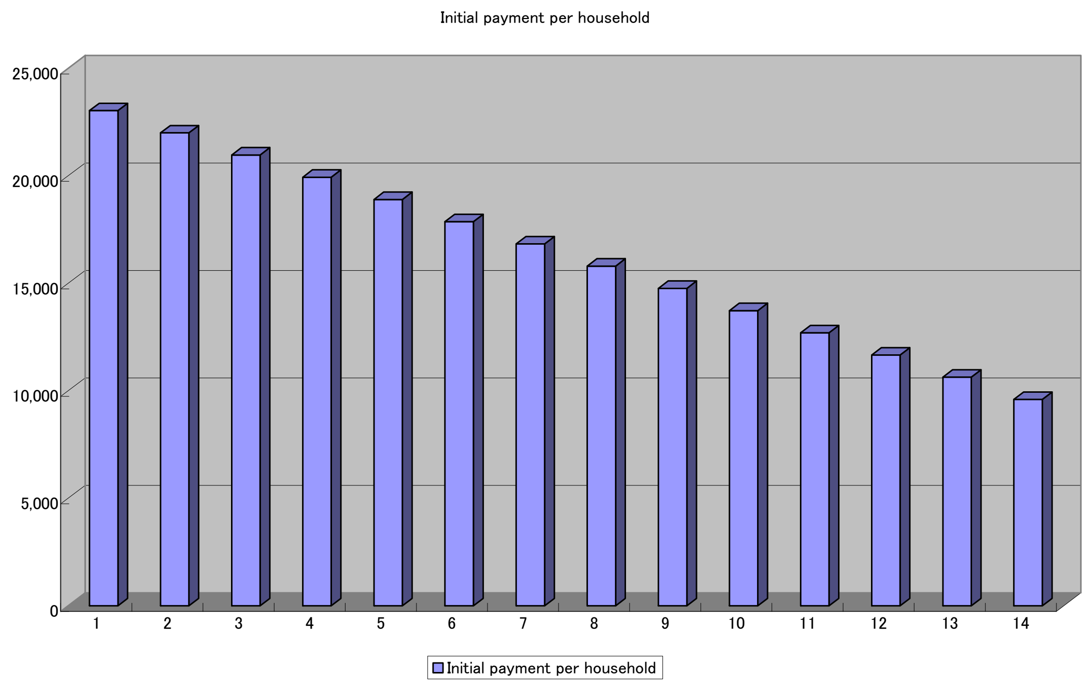
- In comparison with above mentioned models for PV rural electrification (Model 1 and 2), BCS will be installed for the poverty-prone villages as a suitable scheme of PV rural electrification. One of the biggest challenges in this scheme is the initial payment with an amount of 20% by cash. Though the financial support (50% of subsidy and 30% of soft loan) is available, each household is requested to prepare the remaining amount (20%) by cash.
- The amount of initial investment for each household by based on the price calculation in 2007 will be approximately 23,000 NgN per household. In case the cheapest price is available in the present international market, each household should prepare about 10,000 NgN.
- Next challenge will be the monthly payment for soft loan (30% of the initial investment). The estimated amount is around 630 NgN per month, which is similar amount to the case of SELF project (supported by USAID with SHS). Each household is obliged to pay this amount for a period of first 5 years.
- The estimated fee for battery charge per time is 66 NgN. This is the cheap amount as an absolute amount. When the households face with harsh circumstance at home, it is possible for them to correspond by decreasing charge frequency.

Table 3-11 the case of BCS installation the amount which is paid with cash as an advance payment

（Unit：NgN）

Installation year	2007	2008	2009	2010	2011	2012	2013
Initial payment per household	23,040	22,006	20,972	19,938	18,905	17,871	16,837
Installation year	2014	2015	2016	2017	2018	2019	2020
Initial payment per household	15,803	14,769	13,735	12,702	11,668	10,634	9,600

Source: JICA Study team



Note: From the left, the estimated initial payment per household is displayed from the year 2007 to the year 2020.

Source: JICA Study team

Fig. 3-8 The estimated initial payment per household by cash for the BCS installation

Table 3-12 The possible amount of monthly tariff for the sustainable maintenance of BCS in a village of 100 households

(Unit:NgN)

Installation year	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Monthly tariff (1-5 year)	621	593	565	537	510	482	454
Battery charger tariff (1-20 year)	66	64	61	59	57	54	52
Installation year	2014	2015	2016	2017	2018	2019	2020
Monthly tariff (1-5 year)	426	398	370	342	314	287	259
Battery charger tariff (1-20 year)	50	47	45	43	40	38	36

Source: JICA Study team

3.3.2 The PV mini-grid system and BCS electrification with private RESCO initiated by the market principle,

Rural Electrification Agency (REA), which was established on March 16th 2006, has some business promotion policy to utilize the vitalities of commercial sectors, and to encourage the electrification activities by market initiatives, in a parallel way with the big movement of commercialization in the whole electrification business. Therefore, the public sectors are not supposed to implement the electrifications directly as before, but it is desirable that the private energy service company (RESCO) would establish and participate in the business of electrification in Nigeria. Therefore it is presumed that RESCO will carry out the implementation of PV rural electrification, as an option for the rural electrification besides the way lead by the village electrification committee.

There are several commercial companies as a feasible RESCO, and some companies which have worked for the maintenance and procurement of PV equipments are considered as the best private RESCO at present because of their accumulated knowledge and technique about PV. Presently, in Nigeria, the extension of PV systems is in the early stage, and the market of PV equipment is not brought up. Considering the future extension of PV systems, it is necessary to empower the domestic market, and to introduce the strong propulsion step to reduce the prices. Consequently several stakeholders such as REA, state government and local government should collaborate and coordinate several approaches. For example, they can organize public awareness programmes on PV systems, and to implement some pioneering project for the pump priming (e.g. capacity building of the private RESCO and other companies, joint project of public and private sectors for market development). Then the private RESCO should develop some applicable schemes for PV business as well as select the practical target areas for further implementations.

From the company's point of view, the SHS system is not suitable for the private RESCO to implement PV rural electrification, because individual generating facility will be build to each household under the SHS system, and the responsibilities for its maintenance and repair are unclear, then it is quite inefficient to maintain the system in a centralized way. As for SHS with 55W, it is quite difficult to satisfy all the clients in many places because of its limited capacity. Therefore the private RESCO should prepare different PV packages including high specs models such as SHS with 110W and SHS with 165W. For the SHS business in future, it is easier for private companies to sell those SHS equipments directly to the clients (agency model) than to apply the RESCO model (including procurement, installation and collection of fees from clients). In other word, this is a sort of marketing activity toward the whole market, and a method to sell SHS kits. Not targeting the whole village, this is a business model to sell SHS equipments only to the wishful clients. This sort of dealer business should be included to the business domain of the company, the conduct of company will be stabilized.
As for BCS, the private RESCO can contribute to the rural electrification in different way, though it is not attractive for most of the private RESCO to implement BCS business because of the most remote and poverty-prone areas. Preferably the private RESCO is in the better position to implement mini-gird systems in the buffer zones between remote areas (the area which is electrified with BCS or SHS) and urban districts (the grid electrification area). Under this circumstance, the financial estimates and analysis of private ECSO should be carried on.

Namely, the target areas of electrification work by private will be probably the buffer zones between the grid electrification areas and the area where community based organizations are in charge of electrification, and the distance will be in the range of 7-8 km and a dozen of km from the existing grids. In addition, for the mini-grid electrification, it is important to identify the target villages with following criteria; houses are assembled closely, and the distance among houses is close to each other.

Above mentioned type of villages are often found around the sub-urban areas, and the size of village is quite large (between a couple of hundreds and one thousand households). Some of the inhabitants in this kind of village are commuters to the urban area nearby their houses, and their economic situation is beyond self-sufficiency. Some of them are also the owners of portable generator using gasoline, and they enjoy using several electric products such as TV and fan.

In the southern states where better development has been achieved, the grid networks are also quite advance at state level, though the density of networks is often rough. The mini-grid electrification has also an advantage to correspond to the future electrification work when the stretching of the existing grid will happen. Furthermore, when the village which enjoys the rural electrification with PV will be connected to the grid network 10-15 years later, the used PV equipments will be transferred from the above mentioned village to some new but much remote village. This is efficient and less wasteful because the private RESCO owns the PV equipments and basic equipments for mini-grid such as low power distribution lines.

Regarding this business structure, it is important to promote and utilize private business. Then REA and/or the local electrification department at state government should select suitable companies from the interested private RESCO, and should support them by using subsidy, and to build up their capacity.

In this section, we propose the following business model for further financial analysis.

Private RESCO Model for financial analysis: Mini-grid system

- One unit covers 20 households, and the number of households is fixed systematically based on the unit calculation for the maintenance.
- It is assumed that the bigger scale to be maintained, the cheaper the costs of procurement for PV equipment will be. This is based on the calculation available from the price reduction curve shown on Fig. 3-2.

Table 3-13 Estimated decreasing prices through the extension of PV system

Unit : NgN

Installation year	2007	2008	2009	2010	2011	2012	2013
55w SHS	120,000	114,615	109,231	103,846	98,462	93,077	87,692
110w SHS	162,000	154,731	147,462	140,192	132,923	125,654	118,385
165w SHS	270,000	257,885	245,769	233,654	221,538	209,423	197,308
BCS	1,920,000	1,833,846	1,747,692	1,661,538	1,575,385	1,489,231	1,403,077
Min-Grid	3,720,000	3,553,077	3,386,154	3,219,231	3,052,308	2,885,385	2,718,462

Installation year	2,014	2,015	2,016	2,017	2,018	2,019	2,020
55w SHS	82,308	76,923	71,538	66,154	60,769	55,385	50,000
110w SHS	111,115	103,846	96,577	89,308	82,038	74,769	67,500
165w SHS	185,192	173,077	160,962	148,846	136,731	124,615	112,500
BCS	1,316,923	1,230,769	1,144,615	1,058,462	972,308	886,154	800,000
Mini-Grid	2,551,538	2,384,615	2,217,692	2,050,769	1,883,846	1,716,923	1,550,000

2007: the price at present in Nigeria, where no PV system is implemented

2010: the highest price level in the international market at present

2015: the medium price between case 2 and case 4

2018: the cheapest price level in the international market at present

2020; the future price expecting the advanced technology and expanded market

Source: JICA Study team

The business scale

According to the PV rural electrification plan, 225,000 households will be electrified by the mini-grid system until 2020. Since the market growth should be stimulated by healthy competition among many private companies, it is presumed that 15-20 private RESCO will participate to this market (225,000 households) for mini-grid electrification.

For example, it will be 225,000 household / 15-20 companies □13,000 household (between 11,250 and15,000 households) .In average, one private RESCO will electrify approximately 13,000 households by the mini grid until 2020.

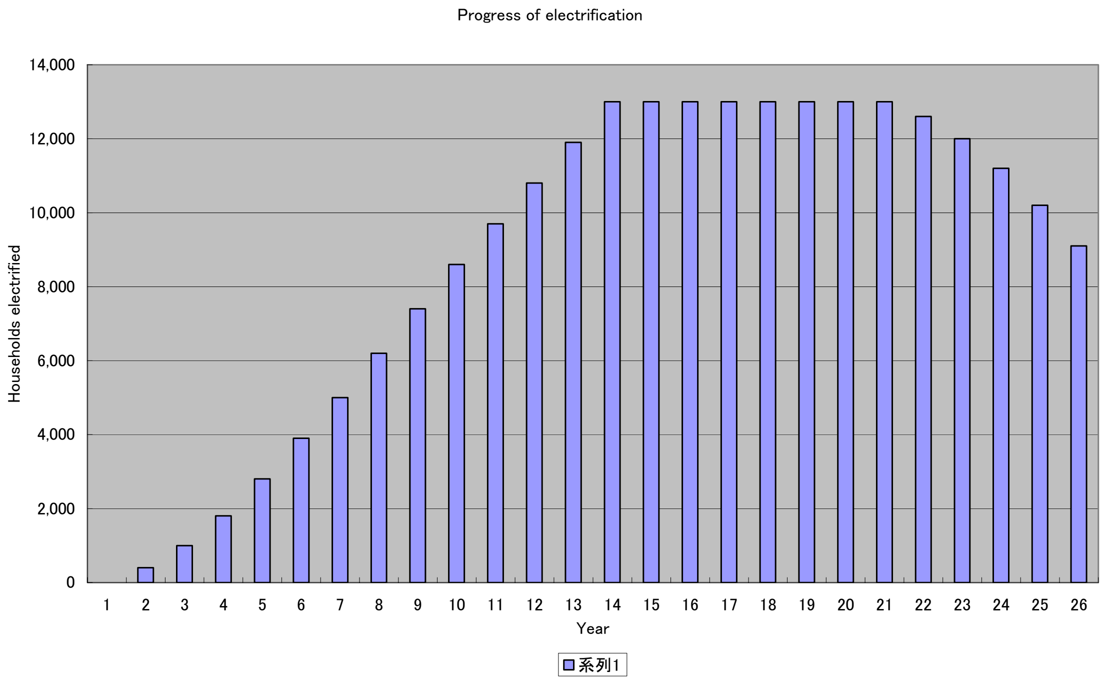
Project Life

Since the company will advance the business in multistory way every year, the project life cannot be economically divided into the period functioned by a single system. After 20-30 years from now on, it is expected that the extension of grid electrification will also progresses considerably. Herewith we assume that the project life is 25 years for this business company.

The time schedule of electrification promotion

Table 3-14 Estimated schedule of mini-grid electrification by private RESCO

Year	2007	2008	2009	2010	2011	2012	2013
Annual progress	0	400	600	800	1000	1100	1100
Accumulatet total	0	400	1000	1800	2800	3900	5000
Year	2014	2015	2016	2017	2018	2019	2020
Annual progress	1200	1200	1200	1100	1100	1100	1100
Accumulatet total	6200	7400	8600	9700	10800	11900	13000
Year	2021	2022	2023	2024	2025	2026	2027
Annual progress	0	0	0	0	0	0	0
Accumulatet total	13000	13000	13000	13000	13000	13000	13000
Year	2028	2029	2030	2031	2032		
Annual progress	-400	-600	-800	-1000	-1100		
Accumulatet total	12600	12000	11200	10200	9100		



Source: JICA Study team

Fig. 3-9 Mini-grid electrification scheduled by private RESCO

Subsidy: it is 50% of initial investment, same as the grid electrification. The rate of subsidy is made to decrease successively in a period between 2017 and 2020 so that it will be zeo-subsidy by 2020. (37.5% in 2017, 27.5% in 2018, 12.5% in 2019 and 0% in 2020)

The capital composition

It consists of 130 million NgN as equity capital and 270 million NgN as debt (gross capital 400 million NgN). The electrification project is one of the key infrastructure industries, and this mini-grid electrification presents also very similar aspect according to the financial analysis forecast. In order to overcome the burden of infrastructure investment during the first 10 years, be equal to the present plant-and-equipment investment burden for ten years, the above-mentioned scale of fund of is needed.

The following is the financial-analysis forecast in a period of 25 years (between 2008 and 2032) for the mini-grid electrification by the private RESCO.

Table 3-15 Financial analysis forecast of the private RESCO

Projected Income Statement

Year	2008	2009	2010	2011	2012	2013	2014	2015
Sales	9,600,000	24,480,000	44,945,280	71,313,178	101,315,650	132,489,696	167,572,968	204,006,575
Cost of sales	−11,695,308	−19,423,731	−28,913,578	−40,480,406	−51,907,001	−65,982,708	−81,193,249	−97,205,205
Gross profit	−2,095,308	5,056,269	16,031,702	30,832,772	49,408,649	66,506,989	86,379,719	106,801,370
Cost of operation	−3,653,000	−3,161,080	−3,189,322	−3,217,728	−3,891,303	−3,634,049	−3,642,970	−3,652,069
Operating profit	−5,748,308	1,895,189	12,842,380	27,615,044	45,517,347	62,872,940	82,736,749	103,149,301
Net income before interest and taxes	−5,748,308	1,895,189	12,842,380	27,615,044	45,517,347	62,872,940	82,736,749	103,149,301
Interest	−28,000,000	−26,243,129	−24,310,571	−22,184,757	−19,846,361	−17,274,127	−14,444,668	−11,332,264
Net income before tax	−33,748,308	−24,347,940	−11,468,190	5,430,287	25,670,985	45,598,813	68,292,081	91,817,037
Provision for income tax	0	0	0	1,900,600	8,984,845	15,959,585	23,902,228	32,135,963
Net profit after tax	−33,748,308	−24,347,940	−11,468,190	3,529,686	16,686,141	29,639,229	44,389,853	59,681,074
Retained earnings	−33,748,308	−58,096,248	−69,564,438	−66,034,752	−49,348,611	−19,709,383	24,680,470	84,361,544

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Sales	241,830,496	278,217,550	315,963,354	355,107,702	395,691,440	403,605,269	411,677,374	419,910,922	428,309,140	436,875,323
Cost of sales	−113,026,582	−127,810,440	−145,541,170	−161,619,731	−175,516,513	−182,640,590	−181,212,429	−188,687,254	−190,602,103	−194,629,887
Gross profit	128,803,914	150,407,110	170,422,184	193,487,972	220,174,927	220,964,679	230,464,945	231,223,668	237,707,037	242,245,436
Cost of operation	−4,161,350	−3,805,817	−4,019,474	−4,029,323	−4,039,370	−4,539,370	−4,039,370	−4,039,370	−4,039,370	−4,039,370
Operating profit	124,642,564	146,601,292	166,402,710	189,458,648	216,135,557	216,425,309	226,425,575	227,184,298	233,667,667	238,206,066
Net income before interest and taxes	124,642,564	146,601,292	166,402,710	189,458,648	216,135,557	216,425,309	226,425,575	227,184,298	233,667,667	238,206,066
Interest	−7,908,619	−4,142,610	0	0	0	0	0	0	0	0
Net income before tax	116,733,944	142,458,682	166,402,710	189,458,648	216,135,557	216,425,309	226,425,575	227,184,298	233,667,667	238,206,066
Provision for income tax	40,856,881	49,860,539	58,240,949	66,310,527	75,647,445	75,748,858	79,248,951	79,514,504	81,783,684	83,372,123
Net profit after tax	75,877,064	92,598,143	108,161,762	123,148,121	140,488,112	140,676,451	147,176,624	147,669,794	151,883,984	154,833,943
Retained earnings	160,238,608	252,836,751	360,998,513	484,146,634	624,634,746	765,311,197	912,487,821	1,060,157,615	1,212,041,599	1,366,875,542

2026	2027	2028	2029	2030	2031	2032
445,612,829	454,525,086	449,350,493	436,511,907	415,559,336	386,024,940	351,282,695
-195,326,789	-195,895,712	-191,250,089	-190,984,046	-177,584,332	-168,244,534	-157,357,626
250,286,040	258,629,374	258,100,403	245,527,861	237,975,004	217,780,406	193,925,070
-4,539,370	-4,039,370	-4,013,751	-3,989,414	-3,966,293	-3,944,328	-5,278,985
245,746,670	254,590,004	254,086,652	241,538,448	234,008,711	213,836,078	188,646,085
245,746,670	254,590,004	254,086,652	241,538,448	234,008,711	213,836,078	188,646,085
0	0	0	0	0	0	0
245,746,670	254,590,004	254,086,652	241,538,448	234,008,711	213,836,078	188,646,085
86,011,335	89,106,502	88,930,328	84,538,457	81,903,049	74,842,627	66,026,130
159,735,336	165,483,503	165,156,324	156,999,991	152,105,662	138,993,450	122,619,955
1,526,610,877	1,692,094,380	1,857,250,704	2,014,250,695	2,166,356,357	2,305,349,807	2,427,969,762

Projected cash flow statement

	0	1	2	3	4	5	6
Year	2007	2008	2009	2010	2011	2012	2013
Cash receipts							
Operating cash flows							
Net profit after tax		-33,748,308	-24,347,940	-11,468,190	3,529,686	16,686,141	29,639,229
Add back:							
Depreciation		3,553,077	8,632,308	15,070,770	22,701,540	30,636,349	40,834,287
Other non-cash expenses		1,076,800	1,076,800	1,076,800	1,076,800	1,076,800	0
Sub-total from operations		-29,118,431	-14,638,832	4,679,380	27,308,026	48,399,289	70,473,516
Subsidy from Government		35,530,770	50,792,310	64,384,620	76,307,700	79,348,088	74,757,705
(50% 0f mini-grid electrificafication							
capital expenditure investment)							
Cash receipts from other sources							
Loan		0	280,000,000		0	0	0
Equity	130,000,000	0	0	0	0	0	0
Sub-total from other sources	130,000,000	0	280,000,000	0	0	0	0
Total net cash receipts	130,000,000	6,412,339	316,153,478	69,064,000	103,615,726	127,747,377	145,231,221
Cash dsibursements							
Capital expenditure							
Mini-grid eilectrification expenditure		-71,061,540	-101,584,620	-128,769,240	-152,615,400	-158,696,175	-149,515,410
Change of inverter, controller,etc		0	0	0	0	0	-13,610,839
Sub-Toal : cash expenditure		-71,061,540	-101,584,620	-128,769,240	-152,615,400	-158,696,175	-163,126,249
Pre-operation expense	-5,384,000						
Amortization of loan	0	0	0	-17,568,711	-19,325,582	-21,258,140	-23,383,954
Total : cash disubursement	-5,384,000	-71,061,540	-101,584,620	-146,337,951	-171,940,982	-179,954,315	-186,510,202
Net cash inflow	124,616,000	-64,649,201	214,568,858	-77,273,951	-68,325,255	-52,206,938	-41,278,982
Cash balance, beginning	0	124,616,000	59,966,799	274,535,657	197,261,706	128,936,451	76,729,513
Cash balance, end	124,616,000	59,966,799	274,535,657	197,261,706	128,936,451	76,729,513	35,450,531

7	8	9	10	11	12	13	14	15	16
2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
44,389,853	59,681,074	75,877,064	92,598,143	108,161,762	123,148,121	140,488,112	140,676,451	147,176,624	147,669,794
52,450,701	64,549,285	77,062,792	88,796,340	103,546,239	116,635,819	128,243,487	135,254,256	133,707,123	141,430,659
0	0	0	0	0	0	0	0	0	0
96,840,554	124,230,359	152,939,856	181,394,484	211,708,001	239,783,940	268,731,599	275,930,707	280,883,747	289,100,452
76,546,140	71,538,450	66,530,760	56,396,148	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
173,386,694	195,768,809	219,470,616	237,790,631	211,708,001	239,783,940	268,731,599	275,930,707	280,883,747	289,100,452
−153,092,280	−143,076,900	−133,061,520	−112,792,295	−103,611,530	−94,430,765	−85,250,000	0	0	0
−19,809,001	−24,723,694	−29,302,157	−30,469,666	−47,178,811	−56,151,107	−61,002,275	−65,288,862	−62,980,605	−72,438,065
−172,901,281	−167,800,594	−162,363,677	−143,261,961	−150,790,341	−150,581,872	−146,252,275	−65,288,862	−62,980,605	−72,438,065
−25,722,349	−28,294,584	−31,124,042	−34,236,447	−37,660,091	−41,426,101	0	0	0	0
−198,623,630	−196,095,178	−193,487,719	−177,498,407	−188,450,432	−192,007,972	−146,252,275	−65,288,862	−62,980,605	−72,438,065
−25,236,936	−326,369	25,982,897	60,292,224	23,257,568	47,775,968	122,479,324	210,641,845	217,903,142	216,662,387
35,450,531	10,213,595	9,887,226	35,870,123	96,162,346	119,419,914	167,195,882	289,675,206	500,317,052	718,220,193
10,213,595	9,887,226	35,870,123	96,162,346	119,419,914	167,195,882	289,675,206	500,317,052	718,220,193	934,882,581

17	18	19	20	21	22	23	24	25
2024	2025	2026	2027	2028	2029	2030	2031	2032
151,883,984	154,833,943	159,735,336	165,483,503	165,156,324	156,999,991	152,105,662	138,993,450	122,619,955
143,381,783	147,634,029	148,544,170	149,315,669	146,608,647	148,054,066	136,319,971	128,689,201	118,792,907
0	0	0	0	0	0	0	0	0
295,265,767	302,467,972	308,279,506	314,799,172	311,764,971	305,054,057	288,425,633	267,682,651	241,412,862
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
295,265,767	302,467,972	308,279,506	314,799,172	311,764,971	305,054,057	288,425,633	267,682,651	241,412,862
0	0	0	0	0	0	0	0	0
−77,804,937	−78,348,919	−63,951,377	−59,840,779	−74,159,253	−80,740,878	−83,201,375	−65,288,862	−62,980,605
−77,804,937	−78,348,919	−63,951,377	−59,840,779	−74,159,253	−80,740,878	−83,201,375	−65,288,862	−62,980,605
0	0	0	0	0	0	0	0	0
−77,804,937	−78,348,919	−63,951,377	−59,840,779	−74,159,253	−80,740,878	−83,201,375	−65,288,862	−62,980,605
217,460,830	224,119,053	244,328,129	254,958,393	237,605,718	224,313,179	205,224,258	202,393,789	178,432,258
934,882,581	1,152,343,410	1,376,462,463	1,620,790,593	1,875,748,986	2,113,354,703	2,337,667,883	2,542,892,140	2,745,285,929
1,152,343,410	1,376,462,463	1,620,790,593	1,875,748,986	2,113,354,703	2,337,667,883	2,542,892,140	2,745,285,929	2,923,718,187

Source: JICA Study team

FIRR and NPV

Quoting these financial analysis forecasts, the Financial Internal Rate of Return (FIRR) and the Net Present Value (NPV) are calculated as below.

FIRR (Financial Internal Rate of Return)	19.7%
NPV(Net Present Value)	499,543,738 NgN

The applied discount rate for NPV calculation is 9.4%. This is done by the capital asset pricing model, with a rate calculating the weighted average of the opportunity cost between equity capital and a borrowed capital as stated at chapter 3.1.2 .

Sensitivity analysis

Firstly, the sensitivity analysis is applied to the income side (income from collected fees) about two cases in 15% down and 30% down from the forecast. Moreover, then the investment cost (the price of PV equipments and installation cost) is analyzed about the case of 15% up and 30% up from the forecast.

Table 3-16 Sensitivity analysis

	FIRR(%)	NPV（NgN）
Base Case	19.7%	499,543,738 NgN
Case 2 (income is 15% down from the forecast)	16.0%	271,800,188 NgN
Case 3 (income is 30% down from the forecast)	12.3%	105,432,875 NgN
Case 4 (investment cost is 15% up from the forecast)	17.3%	363,477,870 NgN
Case 5 (investment cost is 30% up from the forecast)	15.3%	290,574,687 NgN

Source: JICA Study team

The impact of decreased income is bigger for the private mini-grid RESCO than of the rise of investment cost. Overall, above mentioned case2, 3,4 and 5 show that the FIRR of cash flow for 25 years are exceeded 10%. If the above situations happen, some countermeasures are needed such as reinforcement of equity capital and increased loan in the critical period (between 5th and 10th year).

Examination on the conditions of zero-subsidy

If the government would not introduce the 50% of subsidy as a part of initial investment, what would be happened? If the FIRR should be kept as same level as Base case, it is necessary to raise the amount of monthly tariff (2,000NgN -> 3,210NgN) without changing other conditions. During the project cycle, the FIRR is kept at same level, but it will be difficult to raise fund for the first 10 years (because it is impossible to erase the minus of the bottom line with respect to cash flow), the private RESCO should assure the capital reinforcement. Because of this, the financing between 5th and 10th year is very crucial. In order to overcome this situation, financial support of more than 2 hundreds million NgN is essential. Actually, no private company will invest to the mini-gird electrification without subsidy, because of investment risk and the opportunity cost of capital.

In other words, it is not attractive market for the private RESCO to start business of mini-grid electrification under the present price level without any subsidy for early investment which corresponds to grid electrification.

In case the price level of the PV equipments is equal to the international price from the beginning

In this case, it is possible for the private RESCO to implement the project without receiving government subsidy and keeping the same amount of monthly tariff (2,000 NgN with 2% rise yearly). The FIRR is estimated at 21.4% and NPV becomes 470 million NgN. Followings are the examined financial cases without subsidy in different conditions

Table 3-17 Examined financial cases without the government subsidy for initial investment

Zero Subsidy	Major conditions	FIRR / NPV	Suggestions
Case 6	Same as Base Case	FIRR:11.1% NPV: NgN 75,740,866	FIRR is kept higher than10%, but lack of funds within 5-10 years
Case 7	Higher monthly tariff and same FIRR	FIRR:19.7% NPV: NgN 825,716,134	Monthly tariff is up to 3,210 NgN. Needed capital reinforcement
Case 8	Increased amount of equity capital against infrastructure investment	FIRR:12.4% NPV: NgN 154,971,497	No subsidy and insufficient cash only by equity capital (inconceivable option for private company)
Case 9	The price of PV equipments are equal to the international price from the beginning	FIRR:21.5% NPV: NgN 471,271,332	Avoiding cash shortage, and reasonable cash flow

Source: JICA Study team

3.4 Amount of investment, the subsidy which becomes necessary, and related financing scheme to execute "national PV electrification plan"

First, the necessary amount of investment is calculated to execute "national PV electrification plan" which is presented in chapter 2.2.6 (see table 3-18).

Table 3-18 The necessary amount of investment to execute "national PV electrification plan"

Investment cost Unit: NgN million

Year	2007	2008	2009	2010	2011	2012	2013
Mini-grid	536	682	975	1,082	1,758	1,939	2,088
BCS	365	348	332	316	71	67	63
SHS	1,510	1,443	1,375	1,307	737	697	656
Total	2,411	2,473	2,682	2,704	2,566	2,703	2,807
Year	2014	2015	2016	2017	2018	2019	2020
Mini-grid	2,205	2,454	2,282	2,166	2,170	2,143	2,083
BCS	59	55	52	48	44	40	36
SHS	616	576	535	495	455	414	374
Total	2,880	3,085	2,869	2,708	2,669	2,597	2,493

Source: JICA Study team

As the grid electrification is financed by subsidy which covers 50% of initiative investment, the above-mentioned investments also receive 50% of subsidy. However, as an opinion of government and in addition, as a policy of the international finance organizations like World Bank and IMF clearly indicate that ., the subsidy for the electrical sector will twist the electrical market in Nigeria, and it is not desirable with respect to social fairness. Hence, for the time being, 50% of subsidy will be provided, but if the PV market will be matured and the prices of PV equipment will be decreased to the level of international market, then the subsidy should be discontinued. In this case, the rate of subsidy is made to decrease successively in a period between 2017 and 2020 so that it will be zeo-subsidy by 2020. Actually, as previously mentioned financial analysis indicates, the rate of subsidy will be decreased during the late stage, and in 2020 there will be no subsidy available. Financial calculations such as FIRR are done according to this schedule. Regarding to this condition, REA should prepare following amount of subsidy.

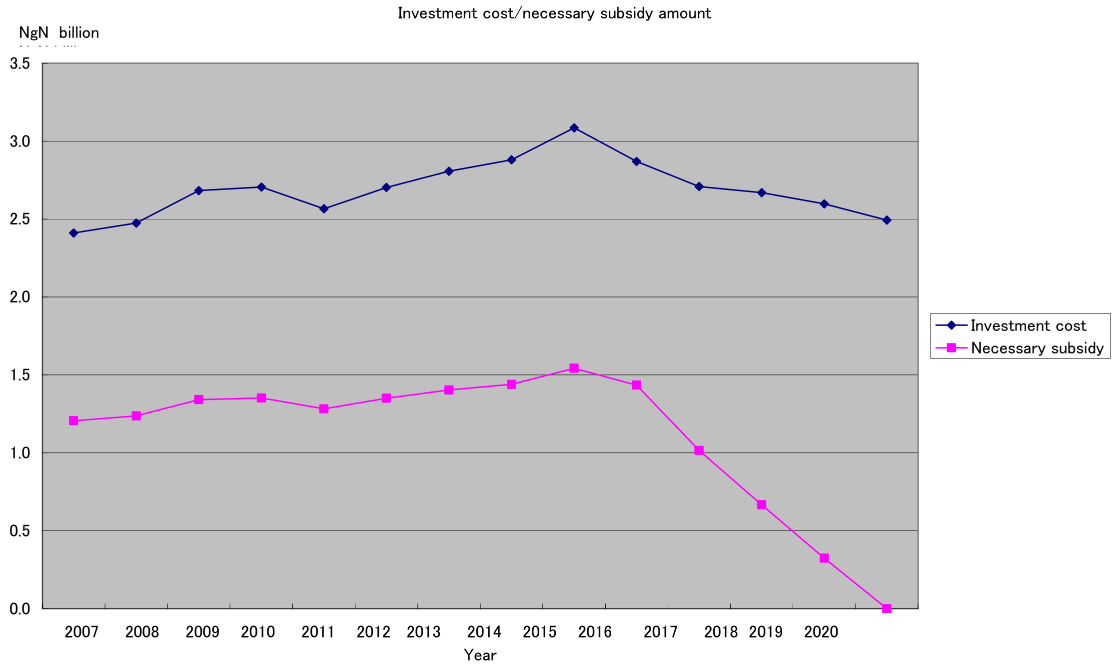
Table 3-19 The necessary amount of subsidy to execute "national PV electrification plan"

Necessary subsidy cost Unit: NgN million

Year	2007	2008	2009	2010	2011	2012	2013
Mini-grid	268	341	488	541	879	969	1,044
BCS	182	174	166	158	35	34	32
SHS	755	721	687	654	368	348	328
Total	1,205	1,237	1,341	1,352	1,283	1,351	1,404
Year	2014	2015	2016	2017	2018	2019	2020
Mini-grid	1,102	1,227	1,141	812	543	268	0
BCS	30	28	26	18	11	5	0
SHS	308	288	268	186	114	52	0
Total	1,440	1,542	1,434	1,016	667	325	0

Source: JICA Study team

The following figure shows the transition of the amount of investment and the subsidy which are needed in the period from the present to 2020.



Source: JICA Study team

Fig. 3-10 The estimated transition of the amount of investment and the subsidy from the government to execute "national PV electrification plan"

The annual investment begins from approximately 2.4 billion NgN, and will rise gradually, then fluctuate in the range of 2.5 and 3.0 billion NgN. By the year 2020 the total amount of investment will be approximately 37.6 billion NgN. In case of the subsidy, it begins from approximately 1.2 billion NgN, and will fluctuate in the range of 1.2 and 1.5 billion NgN. From the year 2017, the amount will be decreased and the amount of subsidy will be zero by 2020. By the year 2020 the total amount of subsidy will be approximately 15.6 billion NgN.

On the one hand, it is essential to check the feasibility of the Nigerian government whether its fiscal expenditure can be corresponded or not toward the above mentioned financial demands. At the year 2005, the annual budget for rural electrification in FMPS is about 7.8 billion NgN, both for the grid electrification and off-grid electrification (actually most of them are spent for the grid electrification). The above subsidy of 1.2 billion NgN is equivalent to 15% of the budget in year 2005. Simply, the financial condition in Nigeria is getting quite better in last 1-2 years due to the soared price of crude oil (a large portion of annual revenue of the country depends on the petroleum earnings). In the summer of this year, it is widely reported that the external debt of Nigeria become zero by the international cooperation agreement among creditor’s countries and donor countries. Hence the government has some extra financial margin, and it is scheduled to distribute a big portion of budget to the improvement and expansion of infrastructures, as a policy of national government. For the time being, the government will keep enough reserves for the fiscal expenditure. Some evidences are found as follows; 1) presently, REA is planning a budget program for 3 years (2007-2009) and the assumed amount is sufficient to correspond to the above investment, 2) there exists a financial account called "Excess Crude Oil Account" where the exceeded amount of revenue above the common financial account fixed at US$ 40 per barrel is saved. It is possible to allocate the above mentioned fund from this account, 3) as being suggested by the study team in the latter part of this paragraph, 2% added taxation on the electric fees (intended tax for the promotion of PV electrification) should be introduced. If possible, it can cover the all required amount of subsidy for the PV electrification which is planned in this Master plan.

REA, which is recently established (in this year), will be the major stakeholder that is financially responsible for the expenditures of rural electrification programmes, In the future, REA should apply the Rural Electrification Fund (REF) to the rural electrification business in national level with using fair and transparent methods. By doing so, it is expected that government organizations (e.g. federal governments, state governments and local governments) as well as private companies will promote the off-grid rural electrification. According to the rural electrification policy, the REF is established with following objectives.

(1) realize the fairness in terms of electric power supply over the country,
(2) maximize the economic and social & environmental benefits of rural electrification works by using subsidy.
(3) promote the rural electrification by grid extensions and off-grid electrification.
(4) promote the innovative rural electrification apart from the previous customs.

As above mentioned, REF can select more optimal electrification business models, by fairly comparing the cons and pros of the grid and off-grid local electrifications both under the same initial conditions. So far, federal governments, state governments and local governments used to be the main stakeholders for the rural electrification by the grid. In the future, REF should stimulate new stakeholders (e.g. private companies, community based electrification committees, and NGOs) to participate for both grid and off-grid electrification plans, then REF should be institutionalized and designed with following considerations;

1) REF should be based on the minimum cost option at long term electrification cost by calculating the life cycle cost per electric power consumption quantity (per kWh), then should be decided whether this is feasible or not.
(2) REF should be consulted with future users (community) in advance at village meeting whether they are eager to pay for the electrification tariff in order to verify their intention to introduce the electrification. Whole process should be changed gradually from top-down system to bottom-up system.
(3) The preliminary review standard and the procedures should be clarified in order to verify

the future financial planning which is prepared by the future users

In addition, REF should be allocated only to the initial investment of business. The costs for maintenance and equipment replacement in the business should be covered in the range of collected fees from beneficiaries. Furthermore, the main financial sources of REF (this is a fund aiming to promote rural electrification) are obtained from the fixed percentages[1] of yearly electrical incomes in the entire country. Towards the whole local electrification, it is considered to introduce a mechanism to guarantee a certain fixed amount of fund every year. In reality, it is possible that most of them will be applied to the grid rural electrification works which have been planned in the past. of being used is strong to only the local electrification work where the large portion of that depends on the grid and is from the past planned. Therefore, in order to promote the rural electrification with PV systems as proposed in this report, it is important to identify the budget source which limits the use only to the subsidy for PV electrification.

<u>Institutionalization of subsidy for PV electrification</u>

Furthermore, in order to promote the reduction of price by the mass spread of PV systems, we propose to introduce and implement the subsidy system which is similar to "the PV introduction and promotion business for the residence" initiated by New energy foundation in Japan. Same rate of subsidy should be granted not only to the organizations like private RESCO and village electrification committee, but also to the ordinal households which will purchase the PV equipment in the common market. This will promotes the further extension of PV systems, and with point of view of fair policy this is desirable. This can be combined with additional efforts, such as public awareness raising, public relations. If market mechanism favors the spread of PV systems, this will eventually happen in a natural way. In Japan, this project cycle has been experienced: PV systems for general family households have been installed quickly, then the coverage and ratio of the subsidy have been gradually reduced, finally this subsidy system has become end because sufficient volumes of PV systems have been installed in Japan. As for this subsidy system, In Nigeria, the spread of PV equipments to the market will strongly make advance while the prices will become lower. In this situation, it is preferable to apply the subsidy system temporally, which means the coverage and ratio of the subsidy will be gradually reduced. At the part of financial and economic examination in this study, we propose to introduce 50% subsidy in initial investment for first10 years (from 2007 to 2016), then we propose that the rate of subsidy will be reduced in 4 years from 2017 till 2020 and it will become zero in 2020. Regarding this condition, the simulation for financial analysis is done in this study, and it is possible to achieve the previously mentioned FIRR and NPV.

[1] This percentage is fixed for 5 years and revised every 5 years.

Adoption and execution of intended tax to obtain the revenue for subsidy

Under the current privatization of electricity sector, National Electricity Regulatory Commission was established quite recently with aims to set electric charges and to check independently. This is the organization which becomes independent from each ministry and agency in 2005. NERC is the government agency which decides the electric charges. NERC can also fix the percentage of fund allocation for REF. As described previously, REF will be used mainly for the grid electrifications, so it is unclear how much can be allocated from REF to PV electrification. Therefore we propose to introduce intended tax for the promotion of PV electrification. The intended tax will be collected by adding 2% tax on the electric charges from the areas which are already electrified by the grid. The collected tax will be converted to the fund and will be used only to actualize the PV electrification projects in the areas which are not electrified by the grid. For the financial management and investment of this sort of fund, we propose to establish a "solar energy utilization and extension fund" (the tentative name). you propose here. This kind of financial strategy to adopt the intended should be developed in Nigeria. In the year 2005, the collected amount of revenue in the electricity sector is around 687 million dollars. The 2% of this revenue is equivalent to 1.38 million dollars per year. This is almost same amount to the previously mentioned subsidy (1.2 -1.5 billion NgN). If the government is capable of executing the capital return as above mentioned way, it probably becomes effective step to correct the gaps between urban and rural areas, between rich and poor households as well as to contribute to the income redistribution.

Financial support plan

Though 50% of the initial investment will be provided by subsidy for PV electrification, the rest of funds should be supplied either from cash which the villagers possess, or from the loan.

In Nigeria, the banking facilities in the farming villages are quite pre-matured. Many farmers eventually depend on the informal banking systems. According to the World Bank investigation in 1994, 90% of them depend on the informal banking institutions. For example, there are some saving and loan institutes called "Adashis" and "Esusus" in Nigeria. In addition, some loan is available from the wealthy individuals and family members and relatives often accommodate necessary fund each other. Simply, informal financial institutions often charge very high interest in comparison with formal ones. In order to keep promoting PV electrification strongly, it is desirable to devise the financial supports for the PV electrification. As formal financial institutions, there are several ones such as commercial banks, governmental banks, and rural sector support programs with government support.

Generally the commercial banks put their priorities on loan business in the urban areas, and their activities and presence are very low in the farming villages.

As a governmental bank, NACB (Nigerian Agricultural and Cooperative Bank) is very active in the farming villages. The NACB is the financial institution which Federal Government established in order to improve agricultural production, to promote the social economic development in the farming villages, and to improve income and living standards of farming village population. The targeted persons for the loan are individuals, farming village unions, farmers' groups, companies, enterprises, state governments, and the federal government. Mainly, these are the loan for the industrial activities such as agricultural production, distribution of agricultural commodities, and sales of agricultural commodities etc. The PV electrification can contribute to productive activity indirectly, however, the priority of bank for the village electrification is probably very low.

PBN (People's Bank of Nigeria) was established in1989 by the federal government to support the marginalized people from the existing financial institutions, and to improve the financial access to the small business enterprises. Not only the farming villages but urban areas are also their target areas. Micro credit scheme is one of the most loan fields for PBN. Considering the purpose of its establishment, PBN supports a wide range of financial opportunities such as, woman supports, widow relief programs, poverty eradication, and relief of handicaps. In the nation wide, there exists an entire network of 279 branches (60 branches in the urban areas and 219 branches in the farming villages), and their service ranges in the farming villages are relatively wide. Because the targeted people for loan are often weak and poor, bilks of loan are quite common. PBN depends heavily on the financial support from the federal government, and is not self sustained financial institute. As a formal financial institution, PBN probably possesses the best know-how of micro credit scheme in the farming villages. On the one hand, REA has hardly financial know-how, but can play a key role to execute effective financial supports for the farming villages to be electrified in the future. Whether or not, REA should consider a future collaboration with PBN to create a financial support program in order to supply a part of necessary fund for the PV electrification.

Furthermore, there are community banks (CBs). Under the umbrella of NBCB (National Board for Community Banks) which was established in 1990, 1368 branches are set up to affiliation. Main objective is to contribute to the community development in the farming villages, and to the financial access improvement of low income groups at root level of the grass. CBs are commercial banks, so the stocks are possessed by individuals, some associations and organizations of particular areas. CBs are managed by the ownership of community in the particular area. The range of active areas where each community bank can serve is determined, and the other community bank is not allowed to do business in that particular area. Being the commercial bank, CBs are not supposed to play catalytic roles for the political financial support, but can work as a complementary financial institute to support some operational capital at management stage of PV electrification.

3.5 Economic Analysis

The basis of economic appraisal of policy measures is the calculation of cost and benefit which occurs in the whole society due to the policy as well as the evaluation how the benefit can exceed the cost. The economic appraisal in this study of PV rural electrification in Nigeria is done from the viewpoint of consumer surplus to count the benefit, by adding the merit of the fuel consumption saving which is previous alternative method to save the cost. With computation of cost, it calculates by excluding the subsidy and the tax (In the economic evaluation model, the consumer surplus approach is often applied. The World Bank and the Asian Development Bank and others also recently use this approach to presume the benefit in the economic appraisal of rural electrification projects.)

As for the supposition "of With project" or "Without project", we assume that the “with case” is the situation where the policy is executed and PV electrification is implemented (by mini-grid, SHS, or BCS), meanwhile the “without case” is the situation where the areas are not electrified continuously, and local people keeps spending fuel expenses like the kerosene for lamps as an alternative way, and they can enjoy only a limited amount of light (base line circumstance will be continued).

Economic benefits consist of the following items.

- The consumer surplus generated by the electrification
- The saved amount of fuel cost which was consumed before

Applying these items to the calculation, Economic Internal Rate of Return (EIRR) , Economic Net Present Value (ENPV), and B/C rate (10% discount rate, based on the commonly used rate by JBIC, World Bank and ADB) are counted on the type of Mini-grid, SHS and BCS. The result is shown below.

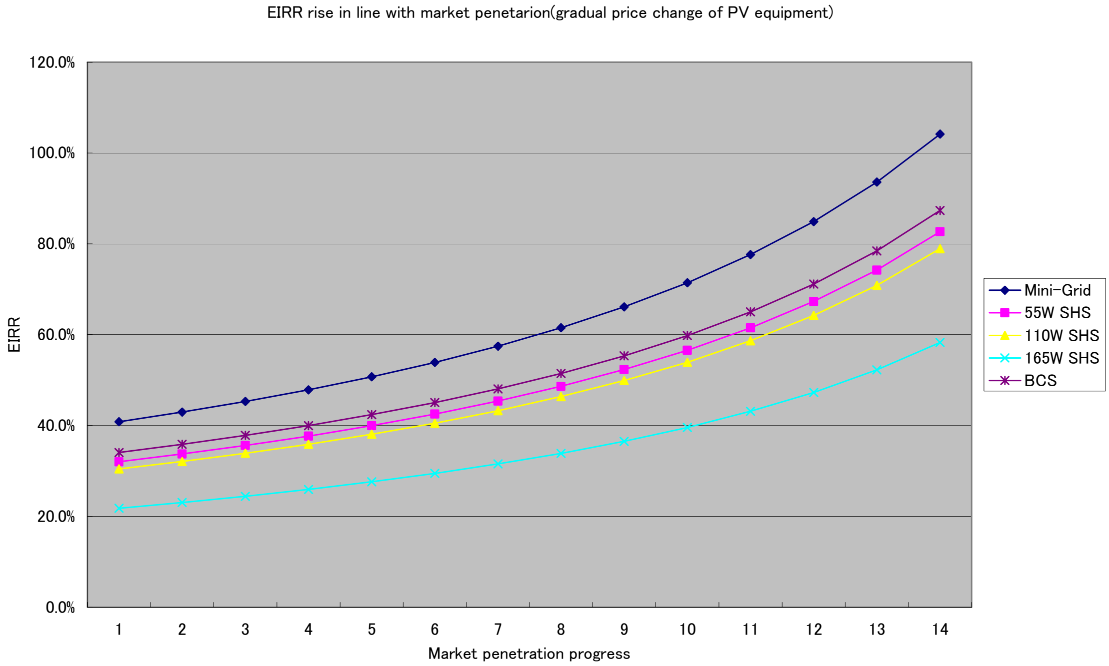
Table 3-20 EIRR, ENPV and B/C rate of each type

	Mini-grid	55WSHS	110W SHS	165WSHS	BCS
EIRR(%)	40.9%	32.0%	30.5%	21.8%	34.1%
ENPV(NgN)	442,243	202,901	253,646	238,087	181,074
B/C Ratio	2.71	2.24	2.15	1.67	2.36

Note: ENPV is per household

Source: JICA Study team

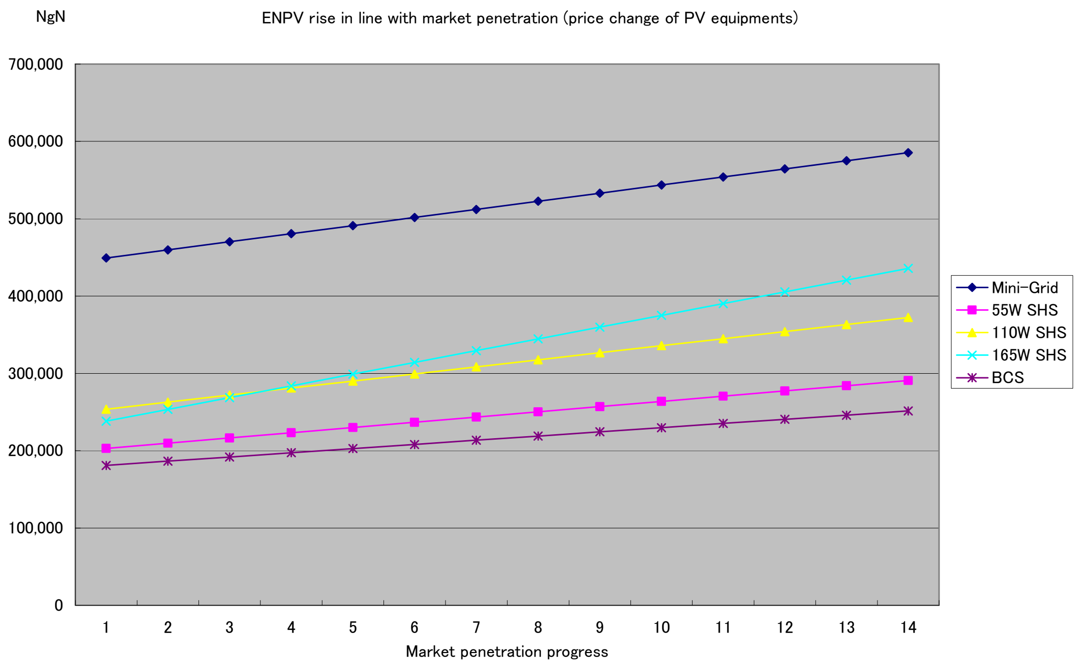
As seen with financial analysis, the PV equipments are not penetrated in the Nigerian market, so the price will be gradually lower as the market penetration will progress. When the price goes as shown in the table 3-7, the numbers of EIRR and ENPV rise. The below-mentioned figure shows the progress.



Note: The change of the horizontal shift shows the change of price decrease of PV equipment as shown at table 3-7.

Source: JICA Study team

Fig. 3-11 Estimate of the EIRR rise in line with market penetration (gradual price change of PV equipment)



Note: The change of the horizontal shift shows the change of price decrease of PV equipment as shown at table 3-7.

Source: JICA Study team

Fig. 3-12 Estimate of the ENPV rise in line with market penetration (gradual price change of PV equipment)

Next, the estimates of EIRR, ENPV and B/C rate are calculated with following conditions; the national PV electrification plan which is shown in chapter 2 is executed, and 343,300 households will be electrified by 2020 in the entire country, applying the mini-grid, BCS and SHS (see table 3-21).

Table 3-21 Proposing indicators for economic appraisal in the national PV electrification plan

Economic Internal Rate of Return	41.1%
Economic Net Present Value	NgN 76,720,585,342
Benefit/Cost Ratio	3.26

Source: JICA Study team

The estimated EIRR is 41.1% and this is the acceptable level in comparison with the recent electrification-related ODA projects by the World Bank, the Asian development bank, JBIC and others. This exceeds the marginal decision criterion of those international financial institutions (10-12%). Following the custom of the international financial institutions, the estimated ENPV with10% discount is 76.7 billion NgN and, the estimated B/C ratio is 3.26 probably, These numbers are quite superior.

Besides the basic analysis, following three different cases are examined with the sensitivity analysis: 1) 20% down in the benefits via reduced fuel consumption, 2) 20% down in the consumer surplus, and 3) 20% up in the initial investment and maintenance cost (see table 3-22).

Table 3-22 Sensitivity analysis for the economic appraisal of national PV electrification plan

	EIRR	ENPV(NgN)	B/C Ratio
Case1 (basic case)	41.1%	76,721 million	3.26
Case2 (20% down in the benefits via reduced fuel consumption)	38.0%	68,452 million	3.02
Case3 (20% down in the consumer surplus	36.7%	63,491 million	2.87
Case4 (20% up in the cost)	34.5%	69,930 million	2.72

Source: JICA study team

Chapter 4 Operation and Maintenance System for the Master Plan Implementation

4.1 The existing condition and challenge of operation and maintenance system

4.1.1 Introduction

The rural villages of Nigeria have been considerably left behind from the access to basic human needs such as improved infrastructures (e.g. roads, health and sanitation facilities) as well as better education systems. There exist several challenges to be tackled in the rural villages. In this environment, the villagers realize that the surrounding environment has been deteriorated in comparison with the past, though they have occasionally found the causes of this situation and implemented effective actions due to their lack of consciousness caused by the late education and technology transfer. At present, the country can not positively cope with this kind of problem because of the shortage of funds. Therefore, at the time of development, villagers should receive not only financial supports but also understand the plan of PV rural electrification concretely via the supports for education and technology transfer. Then they should precede the plan spontaneously by participatory approaches. Furthermore it is important for them to implement the plan in an organizational way in order to achieve the sustainable result. Otherwise the implemented plans in the rural villages will last for a short period and be disappeared. To prevent such situations, all stakeholders such as the federal ministries, the state and local governments should work together in cooperation with donor agencies in the areas of awareness raising and education for the villagers as well as institutional building of the responsible village organization.

In Jigawa, Ondo, Imo states and FCT of Nigeria, the study team has carried out baseline surveys, information collection about the PV rural electrification and implementation of the pilot projects. In the pilot project areas, the study team supported to organize the Village Electrification Committees, and has developed their capacities. For the master plan implementation, this chapter will examine the lessons learned from the above mentioned study and will analyze the problems of operation and maintenance system and their solutions as well as the possible participatory methods for the better organizational management.

4.1.2 The existing condition of social organizations

The urbanization ratio of Nigeria has increased year by year; 10.7 % in the national census of year 1952/53, and 35.7 % in 1991. This trend seems to be continued in near future. However, in many states of Nigeria, 60-70 % of population still stays in the rural areas. As indicate in chapter 2, Nigeria is the biggest country in West Africa, and there are two principal religions (approx. 50 % of Islam and 40 % of Christian), and also land-specific traditional belief is deep-rooted. In entire country, there are more than 250 different tribes, and over 500 local languages are spoken. This reflects the complex and diversified social organizations in Nigeria in regards to their histories, occupations, languages, and races.

In the rural areas of Nigeria, a group of elder villagers often possess the all powers including village management, land property and other issues. Therefore it is often difficult to decide by consensus among villagers in a democratic way. Depending on religion and tribe, the family in rural areas often consists of extended family members headed by the patriarch, hence the young and female members have less voice in the family matter.

4.1.3 The traditional village societies and the development organizations

The most common and basic community organization in Nigeria is the traditional village. The power of the village is mostly shared by only a group of elder villagers. Without having the support from them, it is quite impossible to introduce a sort of new technology to the village. It is generally seen that the elders are conservative, and the traditional customs and experiences are only their foundation. Hence they are often reluctant to integrate the suggestions from outsiders smoothly. The introduction of new technology to the village often disturbed by the low educational level and delayed technology extension.

In the rural society of Nigeria, a variety of local organizations have been set up. Unfortunately there exist a limited number of organizations which have been operated and managed by villagers themselves without troubles. It is commonly observed that the established organizations guided by the donor agencies collapsed in the post-project period.

Youths in the villages take a positive attitude to the new technology such as PV system in comparison with the village elders. In case a village system should be prepared in order to receive a development program, it is desirable to establish a new village organization initiated by the youths in collaboration with the elders. To implement the PV rural electrification plan, the planners should discuss with village elders, examine their decision making process, stimulate the proper judgment by villagers over the development program, and avoid the internal conflict in the village.

4.2 Establishment and stabilization of operation and maintenance organizations through participatory methods

4.2.1 Participatory methods in general

The principle ideas and tools about participatory approach are commonly known among the development professionals and others. In the participatory project, it is single-handed if only the participatory tools are used without understanding the concept of participatory approaches. This chapter will introduce some participatory methods based on the concepts and practical examples with intention to establish and to sustain the operation and maintenance organizations.

Recently, the participatory methods are not regarded as new and unusual ones, but are commonly accepted, and even essential for the development assistant projects. This is due to the change of trend from the conventional hard components approaches in the development programs to the project sustainability. To operate and maintain the installed facilities (hard components) properly, the beneficiary organization should be well managed and their capacity should be strengthened (capacity development). The concept of participatory methods is extended in several forms from the impartial and proper decision making process to the labor provisions by villagers.

4.2.2 The principles of people's participation

As shown in chapter 2, the study team proposes the national PV electrification plan with three different types of electrification model (see below) based on the available electrification rates in Nigeria.

① **Model A (Jigawa state model):** States where the electrification rate is below 30 %
- For short term (until 2010), the PV systems for public facilities and BCS will be introduced in advance, then BCS and SHS will be introduced eventually during the next step (from 2010 till 2020) when the PC systems will become more popular.

② **Model B (Imo state model):** States where the electrification rate is between 30 % and 70 %
- For short term (until 2010), SHS will be introduced in advance, then mini-grid systems will be introduced eventually during the next step (from 2010 till 2020) when the PC systems will become more popular.

③ **Model C (Ondo state and FCT model):** States where the electrification rate is above 70 %
- Mini-grid systems will be introduced for short term (until 2010) as well as for mid-long term (from 2010 till 2020).

The PV rural electrification plan with villager's participation can be implemented mainly at Model A, for instance, a village community based electrification with SHS and BCS in Jigawa state through community participation. For Model B and C where the mini-grid system will be introduced and operated, the participatory methods will not be applied with intention to establish a operation and maintenance organization and to sustain it.

Followings are the basic principles to design, plan, implement and evaluate the PV rural electrification program with participatory methods.

- To balance the villager's needs and the object of PV electrification,
- To respect the villagers' life, to design an affordable integrated plan with PV electrification, and to implement it in a flexible way,
- To promote it with attention to the villagers' initiatives,
- To examine in advance the financial capacity of villagers in the un-electrified village.

(1) Villager's needs

It is quite uncommon from the beginning that the villager's needs and the object of PV electrification are in accord with each other. If the needs assessment is carried out, it is quite common to hear from the villagers that they wish to satisfy their passive and dreaming needs such as "to repair roads", "to build a community hall", etc. At this stage, it is important to listen carefully and to understand their background well, not neglecting their voices as unrealistic or not being listed on the study agenda. Based on this process, it is necessary to harmonize the surrounding situations and the villagers' livelihoods with a scope of PV electrification plan. It is an important process that villagers recognize and understand how they can improve their livelihoods with PV electrification. Without the good understanding, villagers will lose their motivations to participate to the future activities, and be unable to plan by themselves.

(2) Making up the resource maps

For the planning stage of PV electrification, the villagers will make a seasonal calendar with daily farming activities, and then add the date of festivals, ceremonies and other events. Using this seasonal calendar, they will design their own working schedules with the activity components of PV electrification. During the implementing stage, this schedule will be often modified in a flexible way due to the natural factors (e.g. disasters, bad climates) and social conditions (e.g. change of political parties, strikes).

(3) Facilitators in the field

The staff members of institute/organization in charge (e.g. state or local government) will play their roles as facilitators in the field. They should avoid giving their ideas to the villagers, and, instead, to create an informal setting and to stimulate them to discuss openly with proper advices. There often exists a sort of closed and exclusive society in the village, so the staff members of institute/organization are also regarded as outsiders at the beginning. It is important that the staff members will consider the mentality of villagers carefully and respect their initiatives.

(4) Remarks

- To grasp the villager's needs sufficiently,
- To change the implementation schedule in flexible and prompt way along with the villagers' livelihoods if necessary,
- To comprehend the characters of villagers that they are often suspicious to outsiders because of a sort of closed and exclusive society in the village.

4.2.3 The roles of villagers, state and local governments, federal ministries and others

To promote the national PV rural electrification plan, it is essential to clarify the roles and responsibilities of all stakeholders, such as the federal ministries (e.g. FMPS, FMST, REA, ECN) and state/local governments who are main actors for the plan, as well as villagers. The roles and responsibilities are described in details at chapter 2 (Volume 2). In this section, followings are the roles and responsibilities to design, plan, implement and evaluate the PV rural electrification program with participatory methods.

(1) The roles of stakeholders such as villagers, state and local governments, federal ministries and others

The expected roles and responsibilities of each stakeholder are as follows;

- The villagers are leading actors,
- The villagers will operate and manage the Village Electrification Committee which is the main organization for the PV electrification,
- The local government will coordinate the PV electrification with villager's participation,
- The state government will facilitate the implementation process in the field and provide advices to the villagers so that they can plan and design their activities by themselves.
- The federal ministries (e.g. FMPS, REA) will supervise the PV electrification with villager's participation, and provide financial supports as well as technical supports if necessary.

(2) The leading stakeholders are villagers

The villagers are the leading stakeholders to grasp the village situation as an initial stage, to analyze the problems, and then to discuss possible solutions. During this process, they should raise the issues and problems to be tackled and provide possible solutions by themselves. In case that the problems remain unsolved, they should consider what kind of external supports will be essential, and what kind of materials/services they can offer by themselves. For the implementation state, the villagers will carry out the activities spontaneously with their own initiatives. It is vital that the villagers will participate to the whole process actively with some encouraging supports by the other stakeholders to them.

① The Village Electrification Committee

The Village Electrification Committee will be established when the implementation plan is made for further activities. Ideally the Village Electrification Committee by itself will design the implementation plan, it is quite impossible if the villagers are not familiar with participatory methods. Therefore the committee should be established at the end of planning process or at the beginning of implementation process (see Fig. 4-1). After its establishment, the committee will be responsible for the decision making, coordinating and leading the activities.

② The state and local governments

The state and local governments in the areas of PV electrification should avoid suggesting their own opinions and pushing the villagers to give their opinions on the occasion of village meetings. The state and local governments should remember that "Villagers know best about their village", and try to raise the motivation of participants as well as to facilitate the impartial discussions and information exchanges among the villagers.

③ The federal ministries

The federal ministries should supervise the PV electrification activities with villager's participation via supervising the state/local governments. They should hold consultations with the state/local governments, and provide direct supports to the villagers if necessary.

④ **Remarks**

- To respect the villager's customs and proceed the activities on their way,
- The state and local governments as well as the federal ministries should pay attention to the villagers' needs, but should not be dominated by the needs. They should find the optimal solution, aiming to implement the PV electrification, and suggest them how to solve their problems by their own ways.
- The state and local governments as well as the federal ministries should coop with redundant demands from villagers and with misunderstandings sincerely.

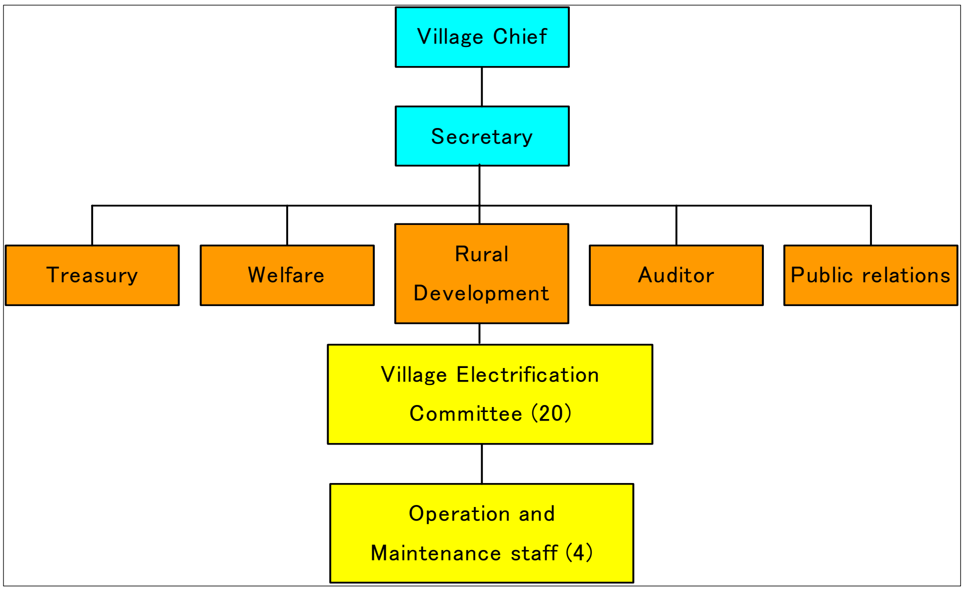
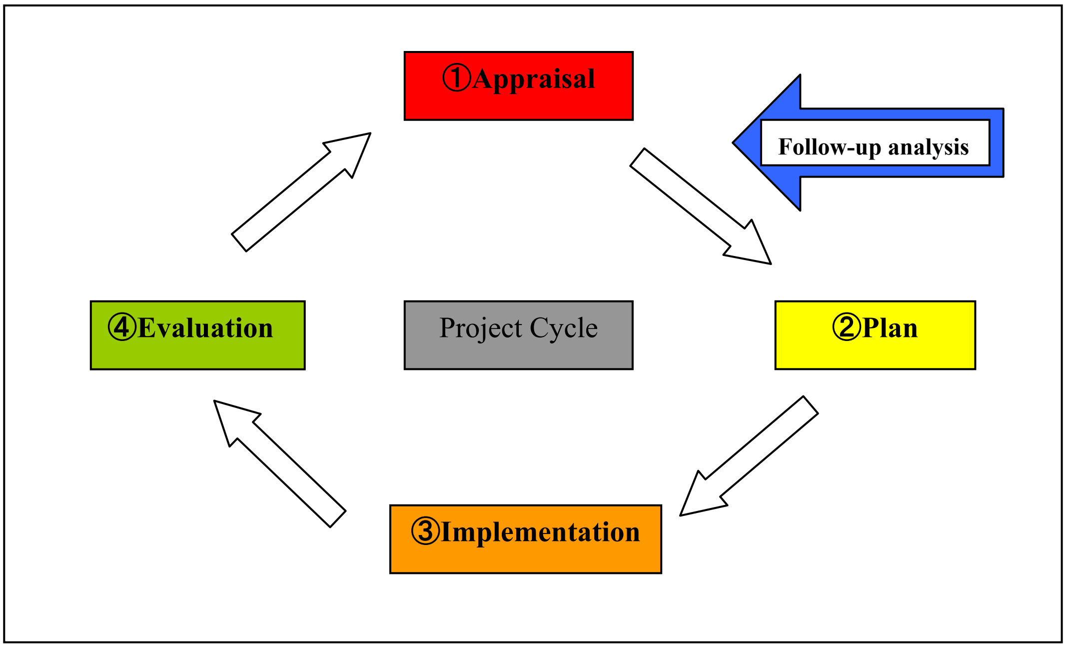


Fig. 4-1 Structure of Village Electrification Committee at Garkon Alli village, Jigawa state

4.3 Design of a future plan for the operation and maintenance system

The project cycle of participatory implementation can be divided into four stages as follows:

① 1st stage: Appraisal of the village situation
② 2nd stage: Planning
③ 3rd stage: Implementation
④ 4th stage: Evaluation



4.3.1 1st stage: appraisal of the village situation for PV electrification through people's participation

(1) Explanations by the federal ministries to governmental stakeholders

The staff members of responsible federal ministries should visit and explain about the national PV electrification to the state/local governments;

① State government → Local government → Village council. This is a top-down way regarding to the visit and explanation,

② The staff members of responsible federal ministries will visit governors and related persons in charge, and explain the objectives of plan, field visits, and then request their cooperation.

③ When they visit the village council for the first time, they should request the governor or relevant personnel to accompany with them.

<u>Remarks</u>

- The staff members of related federal ministries should also accompany to the visit and explanation,
- At the local government, it is often called the regular meeting with village authorities/heads. This type of meeting is a good occasion to utilize for the explanation of

PV electrification.

- It is important to organize some sessions to receive further questions and comments from all stakeholders with regards to the project survey plans, introductions of other related organizations/institutions, and the contents of project.

(2) Preparation to organize and manage a PRA[1] workshop

- The staff members of responsible federal ministries should explain to the related federal ministries about the PRA,
- The selection of PRA facilitators will be carried out,
- The staff members of responsible federal ministries will give guidance to some staff members of state/local governments.

Remarks

- If the staff members of federal ministries have project working experiences with some donor agencies and are familiar with PRA, it is relatively easy to carry out the workshop preparation. Otherwise it requires detailed careful preparation. If necessary, PRA expert(s) should be invited for the workshop preparation.
- Different types of stakeholders, such as staff of concerned organizations, representatives of formal and informal groups, will participate to the workshop. Hence the organizer (s) should carefully select the participants.
- If the whole participants of the PRA workshop can not discuss with common language, the numbers of languages should be limited and translators should be hired for smooth discussion.
- The facilitator(s) of workshop should distinguish the different languages by colors or other device on the cards and posters where the participants write their opinions.

(3) PRA workshop into action

PRA is considered also as a Participatory Action Method (PAM), so the facilitators try not to prepare the answers, but stimulate participants, especially poors and illiterates, to learn and to act by themselves (=empowerment). To do so, the facilitators should try to use not only words, but symbols (meaning can be different according to culture), locally available materials (e.g., seeds, wooden branches) during the workshop. With this kind of consideration, participants feel much easier to be a part of discussion process, and the hierarchy among them will be diminished.

[1] Participatory Rural Appraisal: Though the rural appraisal was used to be done by external experts, this method tries to stimulate and empower the villagers to carry out own appraisal, and aims to raise the participants' awareness and build their capacity. Recently, this has been applied not only to the development oriented projects but also to the urban planning, education, and extended areas.

Characteristics of PRA

- People participate and lead
- The workshop is taken at local place
- The stick is handed over to the people
- Diversity is appreciated
- Local indicators/measures are used
- Participants use locally available materials
- Process is simple and joyful
- Social change is expected
- Three elements are cross-checked (see the figure below)
- Action is derived from PRA
- Outsiders and local people can share the happiness.

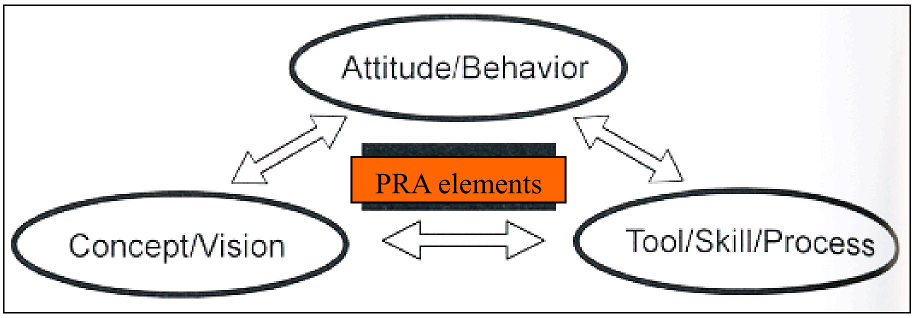


Fig. 4-2 Three elements in PRA

(4) Appraisal of the situation

Before initiating the PV electrification activity, it is essential to analyze the situation of target village properly. At first, appraisal of the situation (=Diagnosis of the village) should be carried out. For the appraisal, several different tools will be used to cross-check the analysis results (one issue can be analyzed by different tools for the comprehensive judgment). Some PRA tools are listed at annex 2.

Remarks

- The appraisal of the situation should be carried out by the villagers themselves,
- If the underprivileged villagers can hardly express their opinions, it is better to increase their members and to try to keep a good balance among the participants.

4.3.2 2nd stage: Planning period for PV electrification through people's participation In respect

After the 1st stage (appraisal), the villagers should prepare the action plans for PV electrification which contain basic socio-economic data such as demographic statistics, numbers of livestock and land ownership as well as other source of information as follows;
The followings are the summary of proposed lease agreement (see Annex 4 for details).

1) Each action plan per village unit will be prepared,
2) The prepared action plan should be feasible by villagers,
3) Appropriate techniques and operational methods will be applied,
4) The priority of each action will be given in three different levels (high, modest and low) according to the villager's needs,
5) The action plan should include following elements; inputs (human resources, equipments and budget), total amount of man-months, responsible units, implementing periods, target villages, technique applications, and required conditions.

<u>Remarks</u>

- No objection to the conflict of opinions. Try to respect the diversity of opinions,
- The action plan should focus on the situation of underprivileged villagers,
- The villagers are not accustomed to implement a particular activities such as PV electrification, therefore a sort of relaxed time schedule should be prepared,
- The plan tends to be a bit exaggerated due to the unrealistic vision of villagers who can rarely imagine the plan in the daily life,
- If there are too many activities involved in the plan, the schedule will be busy with daily and farming activities. This will eventually lower the villager's motivation and lead to unfinished activities and to corner-cuttings. To prevent this kind of trouble, it is necessary to put the action plans in order with a priority list, and minimize the contents of action plans.

4.3.3 3rd stage: Implementing the PV electrification through villager's participation

(1) Preparation for PV electrification

As similar in the appraisal stage, the staff members of responsible federal ministries should visit and explain about the plan of national PV electrification to the state/local governments. They should also organize a joint working group to discuss how to start and implement the PV electrification as well as the implementing schedules, and operational system. Based on these discussions, the detailed plan will be made including following remarks;

- The staff members of responsible federal ministries will propose the implementing plan, then will discuss with villagers for consensus,
- The annual action plan for each component of the implementing plan should be prepared either at the end of or at the beginning of calendar year.
- The operational system should be established in collaboration with Village Electrification Committee and the state/local governments.
- If the blank between the planning stage and the implementing stage is long, the planning

sessions should be organized again.

Remarks

- The schedule of villager's livelihoods is the highest priority to decide the actual dates of implementation,
- The state/local governments should always coordinate in the field for the weekly plans in cooperation with villagers,
- A good communication system in the village is also important matter in order to inform the villagers about, for instance, the date and venue of opening ceremony, or monthly meeting.
- The back-up system to the federal ministries or the state/local governments should be also established (ref. chapter 2, 2.8).

(2) Selection of participating households

In order to advance the implementing plan of PV electrification, the participating households will be selected with following criteria;

- If the target village consists of several communities, all corresponding communities should select participating households for PV electrification,
- Fair selection should be proceeded in consideration with the socio-economic classes in the village, such as rich, poor, and middle classes,
- For the selection, gender consideration is also important criterion so that the participation of women should be promoted,
- Spontaneous participation from all the stakeholders in the village, such as village chief, community leader and school teachers, should be stimulated during the selection process.
- Minimum numbers of participating households per village should be fixed in advance (e.g., 30 households).

(3) Organization of Village Electrification Committee

The Village Electrification Committee (herewith the committee) will be organized according to the following criteria;

- In principle, the committee will be established one per village,
- The committee consists of chairman, secretary, treasury, vocal and others,
- Under the supervision, several project staff members for operation and maintenance will be hired (see box below),
- The organizational components of the committee should be simple,
- The appointed treasury is responsible for the operation and maintenance fees, and to keep at the bank account[2].

If some institutional or time constraints occur to organize the committee, it is also possible to allocate the project staff members in the existing village committee(s).

[2] In the capital of each state in Nigeria, there exist several banks where villagers can open their bank accounts. The required amounts to open the account depend on the banks. For example, in Akure, the capital of Imo state, Ita-Ogbolu bank requests to deposit at least an amount of 10,000 NgN.

Box: The roles and responsibilities of project staff members

The project staff members (e.g. technicians, watchman, fee collector) are stationed in the village to carry out following tasks;

- To record the technical data of installed PV systems at regular base,
- To repair and change the PV equipments in case of trouble and life expectancy,
- To inspect whether the installed PV systems are used properly,
- To collect electricity tariffs from the PV system users,
- To keep the collected money in the bank account, and to maintain the proper bookkeeping.

Remarks

- It is optional for each community to select the representative for the committee, though it is desirable to nominate representatives from all communities in the village, since the committee is the superior decision making institute in the village,
- The committee plays important catalytic roles to connect villagers and external organizations (e.g. the state and local governments, the federal ministries, NGOs, and private companies),
- The committee should coordinate with government institutes,
- Traditional customs, rules and regulation should be respected when the committee is established and organized.

(4) Agreements with villagers

In case of the implementation of the PV electrification with villager's participation, an agreement should be arranged with participating households as following concerns;

- The state/local government will prepare the draft version of agreement with guidance and supervision of the federal ministries (see annex 3),
- Upon the mutual understanding with the participating household, the agreement becomes an official document.

(5) Procurement of equipments and transportations

- The state/local governments will mediate between the contractors and the committee to procure the necessary equipments and transportations (including fuels),
- In case of difficulty to procure some equipments and transportations, the state/local governments should request the support from the federal ministries and other related agencies,
- The state/local governments should make an estimate of necessary equipments and transportations as well as those quantities in discussion with the committee.

Remarks

- The equipments for PV electrification should be maintained collectively,
- For the quantities of equipments, the committee should discuss with villagers for details in order to avoid some troubles later.

(6) Technical workshops in the field

For the participating households in the PV electrification, technical workshops will be held in aiming to train and practice the necessary techniques as follows;

- The technical workshops are divided into two different ones; technical explanations and practices in the field. These will be organized for each component of activities.
- In the technical explanations, the facilitators should organize visual materials such as flip chart with illustrations and capital keywords,
- The field practices are based on the acquired knowledge from the technical explanations. The participants should carry out in practice what s/he has learned. This will be practiced after the technical explanations.

In the pilot project of the JICA study team, some counterparts of the state governments and some project maintenance and operation staff of Village Electrification Committees have experienced and learned how to deal with PV equipments from the contractors during the implementation period of the pilot project. Furthermore some researchers at ECN and other research institutes are also capable to organize technical workshops in the field.

Remarks

- Materials such as posters and distributing documents for the technical workshop should be user-friendly with easy vocabularies. The participants should keep those materials well after the workshop whenever they will need to examine. Those materials can be also used for non-attendants,
- In the technical explanations, any question should be received from the participants and given right answers back to them. After the good level of technical knowledge, the participants will proceed to the field practices,
- During the field practices, any question and doubt should be treated in prompt,
- Locally available equipments and materials for the field practices should be arranged as much as possible. The facilitators should inform the list of equipments to the villagers in advance,
- For some smaller Village Electrification Committees, collaboration with local NGOs can be also considered.

4.3.4 4th stage: Monitoring and evaluation of the PV electrification through villager's participation

(1) Evaluation methods

- The evaluation aims to grasp the achievement of PV electrification as well as to improve the installed PV system in sustainable way by the hands of villagers, Mid-term evaluation will be carried in 1st year, and final evaluation in 2nd year,
- Above mentioned 2 sets of evaluation are different from the evaluations done by the federal ministries, the state and local governments. Being coordinated by Village Electrification Committee, the participatory evaluation workshop will be held as described below section of (2),
- Field visits and villager's interviews are good complement to the evaluation if necessary.

Remarks

- This evaluation also aims to empower the capacity of villagers. Some PRA experts/consultants can be invited if necessary.
- Considering verification of activities, commands of implementation process, and baseline survey, evaluation items are listed as following 5 points; 1) relevance, 2) effectiveness, 3)efficiency, 4) impact, and 5) sustainability.
- Besides the above mentioned 5 items, it is also important to check the influence of external factors to the project.

(2) Evaluation workshop through villager's participation

- During the project implementation, it is desirable that participatory evaluation workshops will be held twice (mid-term and final evaluation) hosted by Village Electrification Committee,
- The state/local governments will coordinate the preparation and implementation of the workshop,
- Evaluation items should be classified into activity-oriented and site-oriented.
- During the mid-term evaluation workshop, participants will focus on the degree of villager's participation, and will exchange opinions about the problems caused by the implementation and possible improvements.
- During the final evaluation workshop, participants will evaluate outputs, degree of satisfaction, delayed activities and their causes, positive and negative influences, reasons why some villagers did not participate to the project, and others.

Remarks

- Participants to the evaluation workshop are not necessary those who have been involved in the project. Any villager should be welcomed,
- Visual methods such as action maps should be frequently used to identify the implemented activities in the evaluation workshop,
- The state/local government will supervise the workshop, and sometimes should try to

appoint some villagers to be facilitator in the workshop. This will give an opportunity for villagers to build their capacity,

- The items for activity-oriented evaluation are; degree of villager's participation, outputs, delayed activities and their causes, and others.
- The items for site oriented evaluation include the problems caused by the implementation and possible improvements, degree of satisfaction, delayed activities and their causes, positive and negative influences, reasons why some villagers did not participate to the project. These items should be discussed with villagers in advance, and should be corresponded flexibly.

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Web sites related to PRA/PLA

- Participation Resource Centre, Institute of Development Studies (IDS), University of Sussex, UK (http://www.ids.ac.uk/ids/particip/research/pra)
- Resource Centre, Internacional Institute for Environment and Development (IIED), UK (http://www.iied.org/resource/)
- Statical Services Center (SSC), University of Reading, UK (http://www.reading.ac.uk/ssc/workshops/partdata.html
- USAID in Africa, Success store in Ghana (http://www.usaid.gov/regions/afr/success_stories/ghana.html)
- Stakeholder Participation in Monitoring and Evaluation, UNFPA (http://www.unfpa.org/monitoring/toolkit/stakeholder.pdf)

Annex 1 : Some experienced consultants for PRA in Nigeria (in November 2006)

1. Theatre for Development Centre (TFDC), Ahmadu Bello University	The Octopus, Faculty of Arts, Ahmadu Bello University, Zaria, Nigeria Phone: + 234 69 550205, 551287 Fax: + 234 69 550205, 551143 Mr. Steve Oga Abah Email: npta@inet-global.com ogaabah@yahoo.com	TFDC is located in the city of Zaira, mid-Nigeria. Mr. Steve Oga Abah has practiced participatory approach for more than 20 years. He is introduced by IDS, Sussex University, UK.
2. Triple "E" Systems Associates Limited	Goodwill House 278 Ikorodu Road, Anthony P.O.Box 8306, Ikeja, Lagos Tel: ＋ 234 1 4974751 ＋ 234 80 2342 5416 Fax: ＋ 234 1 4974751 www.triplesys.com Mr. Aliu Abass Email: env@triplesys.com, triple－e@triplesys.com	Office is located in Lagos. They provide engineering services, EIA and other technical services, mainly in oil and natural gas sectors. 3 consultants (Lawrence Ibhafidon、Adeolu Ojo, and Abass Aliu) have received PRA/PLA trainings during the WB assignments.
3. Friends of the Environment (FOTE)	106/110 Lewis Street, Lagos Tel: ＋ 234 1 2633981/2647435 ＋ 234 80 23188059 Fax: ＋ 234 1 2647436 Engr. (Mrs.) Joanna Maduka jmaduk2@yahoo.co.uk Engr. Chike Chikwendu c_chikwendu@hotmail.com	FOTE is a grass-root NGO in the sectors of environmental conservation and renewable energy with focus on awareness raising and capacity development.

Annex 2：Some PRA tools

(1) Seasonal calendars

This describes the seasonal events, types of diseases, economic situation in the village on the calendar, and then it is easy to understand the annual cycle of villager's livelihood.

(2) Participatory mapping and modeling

This is a people's mapping, drawing and coloring by a group of villagers on the ground with sticks, seeds, powders, etc, or on paper to make social, health or demographic maps (of residential village). Mapping exercises as used in a PRA activity not only provide the evaluator with information about the physical characteristics of the community, but can also reveal much about the socio-economic conditions and hot the participants perceive their community. These popular methods can be combined with or lead into wealth or well-being ranking, action planning, and others.

(3) Institutional or "chapati" / Venn diagramming

This is to identify individuals and institutions important in and for a community or group, or within an organization, and their relationship. This describes the seasonal events, types of diseases, economic situation in the village on the calendar, then it is easy to understand the annual cycle of villager's livelihood.

(4) Daily time use analysis

This indicates relative amounts of time such as working hours, time for hobby, study, and sleeping. If men and women prepare separated time maps and compare them, it will be quite clear the commonalities and differences of time allocation from the gender points of view. To avoid the bias from the male dominance during the process, it is recommended to make separated maps (men and women).

(5) Matrix scoring and ranking

This is especially used to compare through scoring, for example in the field of education. Participants can use locally available materials such as beans and stones to express preferences. This can be applied to the evaluation. Optimal numbers of participants are between 6 and 12.

(6) Wealth ranking (or well-being grouping)

This is a tool to group or rank households in the village according to well-being, including those considered poorest or worst off. This is a sensitive issue, and facilitators need to build up good rapport with villagers at first. A small group is optimal. A good lead by facilitator will give some discussions of the livelihoods of the poor and how they cope with. Words such as rich and poor are often avoided to be used, instead "the best conditioned person" in the village.

Annex 3: An example of lease agreement

Lease Agreement

On

The Solar PV System

For

Individual Lessee

(Draft)

1. We, the Name of Leaser: ____
   Address: ____, __________ State, would like to make solar PV system available for the use of individuals to lease as follows:

   ☐ a. Solar Home System (PV module for 55W, Charge controller: 12V, 4.5-6A, Battery: Sealed Type, 50-300Ah, Circuit Breaker: 2pieces, 10A each, Stand/cable and Fluorescent Lamp: DC12V, 9-11W, 2 sets)

   ☐ b. Battery Charging System (Charge controller: 12V, 6A, Battery: Vent Type, 80Ah, Circuit breaker: 2piees, 10A each, Stand/cable and Fluorescent Lamp: DC12V, 9-11W, 2 sets)

2. I, Name of the Lessee: ____
   Address: __________________________________Village, ______________________
   Local Government Area, _______________________ State,
   ID No.: ____

   would like to apply for the above (tick marked) solar PV system for individual use and would agree conditions as per this Lease Agreement.

3. Duration of Lease
   The term of lease of solar PV system under the lease agreement shall be indefinite period.

4. Ownership of Solar PV System
   a. Ownership of Solar PV System

The ownership of the above (tick marked) solar PV system shall remain indefinite period with JICA Nigeria Office. The lessee shall not be allowed to sell any part or whole of the above (tick marked) solar PV system to other individuals or private or public organizations at all.

b. Relocation of the Solar PV System Within the Same Village

In the event that the lessee shall move to other place within the village, the above (tick marked) solar PV system shall be relocated to the lessee's new place of resident and the cost of relocation shall be born by the lessee.

c. Relocation of the Solar PV System to Other Village

In the event that the lessee shall move to other place than the village in which the lessee reside, the lease agreement of the above (tick marked) solar PV system shall be terminated as expressed in "d. Termination of Lease".

d. Termination of Lease

In case the lessee should wish to terminate the lease, the lessee shall notify Village Electrification Committee (the name subject to agreement) one month in advance and the lessee shall dismantle at the cost of lessee whole of the above (tick marked) solar PV system and return it to Village Electrification Committee (the name subject to agreement) of the village in which the lessee resides.

e. Transfer of Lease

The lessee will be able to transfer the lease of the whole of the above (tick marked) solar PV system to the resident residing within same village in which the lessee resides. The lessee shall notify the Village Electrification Committee (the name subject to agreement) his/her intention of the transfer of the above (tick marked) solar PV system one month in advance. Any cost incurred for the transfer of the above (tick marked) solar PV system shall be born by the lessee while technical assistance on the installation of the above (tick marked) solar PV system shall be provided by the Village Electrification Committee (the name subject to agreement).

5. Payment for the Solar PV System

a. Monthly Payment

The following amount shall be paid to the Village Electrification Committee (the name subject to agreement) of the village in which the lessee reside as monthly charge for the lease of above (tick marked) solar PV system:

1) Solar Home System: ____________________ Naira
2) Battery Charging System: ______________________Naira

The above monthly charge will be made in cash and paid to the person designated by the Village Electrification Committee (the name subject to agreement) of ______________________Village, _______________________ Local Government Area, ____________________ State on the designated date of payment.

b. Failure of Payment

Should the lessee fail to make the above monthly payment for three consecutive months, this Lease Agreement shall be terminated upon decision made by the Village Electrification Committee (the name subject to agreement) in which the lessee resides.

c. Removal of Solar PV System upon Failure of Payment

Upon decision made by the Village Electrification Committee (the name subject to agreement) for the termination of this Lease Agreement due to the failure of monthly payment for three consecutive months by the lessee, the Village Electrification Committee (the name subject to agreement) shall take action as necessary but not limited to as follows:

i. Notify and request for assistance on the failure of such payment of such individual lessee to the local government and the state government responsible to the Pilot Project;
ii. Consider the above (tick marked) solar PV system shall be removed at the expenses of the Village Electrification Committee (the name subject to agreement) upon decision made for removal and transfer of the said solar PV system in question to other potential lessee within the village;
iii. The entire system is so transferred and installed to other individual as the Village Electrification Committee (the name subject to agreement) should make such decision for new lease agreement and that it would be subject to the agreement of such nominated individual; and
iv. Village Electrification Committee (the name subject to agreement) shall maintain inventory of such removal and transfer of solar PV system in the log book maintained at the office of Village Electrification Committee (the name subject to agreement).

d. Non-refundable Policy of the Payment for Lease

All of the payment made under this contract shall not be refunded.

6. Warranty of the Solar PV System

Natural wear and tear of the battery, fluorescent lamp, indoor wiring, switches, and wall outlet of the above (tick marked) solar PV system shall be covered by the warranty of the supplier of the above (tick marked) solar PV system for one year from the date of completion of installation.

7. Liability of the Lessee and Leaser
   a. Liability of Lessee

   The lessee shall repair and/or replace at the his/her expenses, the battery, fluorescent lamp, indoor and outdoor wiring, switches and wall outlet of the above (tick marked) solar PV system after one year warranty period is expired.

   In the event that the above (tick marked) solar PV system malfunctioned, the lessee shall notify the Village Electrification Committee (the name subject to agreement) for checking, technical assistance for repairing and execution of such repairing works and any replaced portion of the above (tick marked) solar PV system shall be so recorded in the log book maintained at the Village Electrification Committee (the name subject to agreement).

   In the event that the battery, charge controller and solar panel malfunction due to their own life spun, such portion of the above (tick marked) solar PV system shall be replaced at the cost of Village Electrification Committee (the name subject to agreement).

   b. Liability of Leaser

   The Leaser shall be responsible at the expenses of the Leaser the installation of the whole of the above (tick marked) solar PV system and its maintenance works during the lease period.

   The Leaser shall also be responsible for providing technical assistance on repairing and replacing of any parts of the above (tick marked) solar PV system upon request made by the lessee.

   Replacement of the battery, charge controller and solar panels as they become malfunction or upon reaching their own life period, which varies from __ years to __ years subject to frequency and running hours of its use, shall be made at the cost of the Leaser. Such replacement should be clearly recorded and notified to JICA Nigeria Office through the state government responsible to oversee the above (tick marked) solar PV system and that it shall notify to the Federal Government of Nigeria

I HAVE READ AND UNDERSTAND THE ABOVE LEASE AGREEMENT AS STATED AND I CERTIFY THAT THE INFORMATION PROVIDED BY THE VILLAGE ELECTRIFICATION COMMITTEE (THE NAME SUBJECT TO AGREEMENT) IS COMPLETE AND ACCURATE. I WOULD THEREFORE AGREE TO BE BOUND BY THE TERMS AND CONDITIONS CONTAINED HEREWITH.

Date:__________________________________

Primary Lease

Lessee: ______________________________ Leaser:____________________________

Secondary Lease (In the case of transfer is made):

Date:__________________________________

Lessee: ______________________________ Leaser:____________________________