3.2.2 National Energy Policy

The Energy Commission of Nigeria (ECN) prepared the Draft National Energy Policy in 1993 as a comprehensive energy policy for Nigeria covering multiple energy sources, including oil, natural gas, electricity and renewable energies and produced the final version in August, 2005. According to this policy, the following targets are identified for the power sector.

- Securing of a stable power supply which is not restricted to grid electrification for 75% of the people by 2020
- Completion of the electrification of all state capitals, local government headquarters (774 nationwide) and major cities by 2010 (note: the electrification of 661 LGHQs has so far been completed)
- Promotion of the participation of the private sector based on the precondition of participation by the Nigerian people
- Promotion of industrial development in rural areas to restrain immigration from rural areas to urban areas

In regard to solar energy, the current use has been confined to the use of solar heat for the drying of agricultural crops, etc. However, as a solar radiation intensity of 12.6 MJ/m^2/day in coastal areas and 25.2 MJ/m^2) day in the northern area is observed, the National Energy Policy calls for the active use of hitherto untapped solar energy. For this reason, the policy adopts the ultimate goal of advancing solar energy utilisation technologies through the consolidation of the domestic R & D system and the training of human resources to catch up with the technological standard of industrialised countries but does not clearly state more concrete policies or targets.

3.2.3 National Rural Electrification Programme

The National Rural Electrification Programme (NRER) is the master plan for rural electrification which was formulated in 1981 by the FMPS and others. At present, the programme is being implemented with the technological assistance of the PHCN and electrification work is being conducted by establishing links with the national transmission grid. The second Obasanjo administration which started in 2003 considers improvement of the living conditions in rural areas to be an important target for national policies and is directly promoting the NRER. However, the NRER only plans electrification down to LGHQs and major cities and does not specify such necessary contents of the policy guidelines as a concrete time schedule and the selection of an economical electrification method. As such, the FMPS is currently preparing a new Rural Electrification Policy (REP).[2)] The priority of the subject sites for electrification under the NRER has been given to unelectrified areas of LGHQs and important towns/villages from the viewpoint of rural development. As shown in Table 3-8, 661+ LGHQ areas, 85% of the total number of such areas of 774, have been electrified as of October, 2005 and an electrification plan is in progress for 56 of the remaining 113 LGHQ areas. However, there is currently no prospect of the early electrification of the last 57 remaining LGHQ areas because of the lack of funding. According to the FMPS, the electrification of these 57 LGHQ areas will be feasible based on self-help efforts in the

2) This is called the Rural Electrification Strategy in the Preliminary Study Report.

coming years. In contrast, the progress of the electrification of important towns has been extremely slow, making an increase of the efforts to electrification these towns in addition to the LGHQ areas essential.

Table 3-8 Progress Situation of the NRER (2005)

LOCAL GOVERNMENT HEADQUARTER (LGHQ)						IMPORTANT TOWNS			
Total No. of Towns	On Grid	% On Grid	% On Grid by Geopolitical Zone	On-Going	Yet to be Committed	Total No. of Projects (A)	Completed	On-Going	Proposed in 2005 (B)
16	16	100	99	0	0	28	0	28	17
20	20	100		0	0	61	19	42	39
20	20	100		0	0	167	49	118	39
18	17	94		0	1	97	16	81	6
30	30	100		0	0	92	33	59	64
33	32	97		1	0	136	49	87	37
17	16	94	89	1	0	48	13	35	83
21	19	91		1	1	66	21	45	56
13	10	69		3	0	28	8	20	16
17	16	94		1	0	65	18	47	27
27	24	89		2	1	95	37	58	16
27	25	93	88	2	0	80	26	54	26
23	22	96		1	0	15	4	11	31
44	41	93		3	0	87	29	58	61
34	31	91		2	1	63	15	48	24
21	16	76		4	1	16	4	12	12
23	16	70		6	1	27	5	22	18
14	13	93		0	1	8	3	5	8
21	20	95	71	1	0	42	25	17	35
20	20	100		0	0	49	28	21	64
27	18	63		1	8	98	62	36	42
11	11	100		0	0	146	72	74	77
16	4	25		6	6	19	3	16	22
17	7	41		5	5	23	0	23	37
6	6	100	83	0	0	3	0	3	1
23	16	70		3	4	83	10	73	27
21	16	76		3	2	73	23	50	26
16	15	94		0	1	114	43	71	30
13	13	100		0	0	13	6	7	5
25	22	88		2	1	52	7	45	32
17	13	77		3	1	48	5	43	17
31	27	87	78	0	4	135	28	107	54
8	0	0		3	5	21	1	20	15
18	14	78		0	4	46	3	43	21
25	22	88		0	3	48	28	20	10
18	17	94		0	1	83	32	51	17
23	16	65		2	5	68	9	59	10
774	661	85%	85%	56	57	2,343	734	1,609	1,122

Source: FMPS

3.2.4 Rural Electrification Policy

The Rural Electrification Policy is a strategic paper[3)] for the comprehensive planning of both off-grid and on-grid rural electrification which sets out the medium to long-term targets for rural electrification and the means of achieving such targets.

The basic principle adopted for the policy is the departure from the conventional style of the

3) The Draft Policy Paper was completed in December, 2004 and the final version has not yet been produced.

centralised implementation of rural electrification projects under the guidance of a federal government to a demand-driven and market-oriented approach in the medium to long-term. The draft policy states that while extension of the grid to rural areas (on-grid electrification)[4] will continue to be the principal mode of rural electrification through the fair application of the Rural Electrification Fund, off-grid rural electrification using independent power systems will also be encouraged. Accordingly, the policy aims at supplying a minimum 10% of the electricity supplied to newly connected users from renewable energies in rural electrification projects to be implemented in the coming years.

3.2.5 Renewable Electricity Policy Guidelines

Draft guidelines designed to expand the power supply using renewable energies are being prepared by the FMPS as of November, 2006. These guidelines will feature the diversification of generating sources and the facilitation of power supply using renewable energies to improve the electrification rate in rural areas from the viewpoint of energy security. The Renewable Electricity Action Programme is also being prepared in tandem with the guidelines to spell out the concrete implementation methods to achieve the targets of the guidelines. This action programme sets out the targets for the use of renewable energies in the 10 year period from 2007 to 2016 as shown in Table 3-9. In the case of solar energy, PV generation is required to meet some 18% of the electricity supply target using renewable energies in 2016.

Table 3-9 Targets for Use of Renewable Energies in Nigeria

(Unit: MW)

Type of Energy	Target		
	2007	2015	2025
Mini Hydropower	50	100	400
PV	10	20	130
Wind Power	0	20	100
Biomass	0	15	105
Total	60	155	735

Source: FMPS, Renewable Electricity Action Programme

Among the various national development plans described above, the present M/P occupies the position of a medium to long-term master plan for off-grid rural electrification to materialise the Rural Electrification Policy and the Renewable Electricity Policy Guidelines.

4) For the promotion of on-grid electrification in rural areas where the power demand density is low, the electricity charge paid by each user is small, making reduction of the management costs of meter reading and collection of the electricity charge, etc. essential.

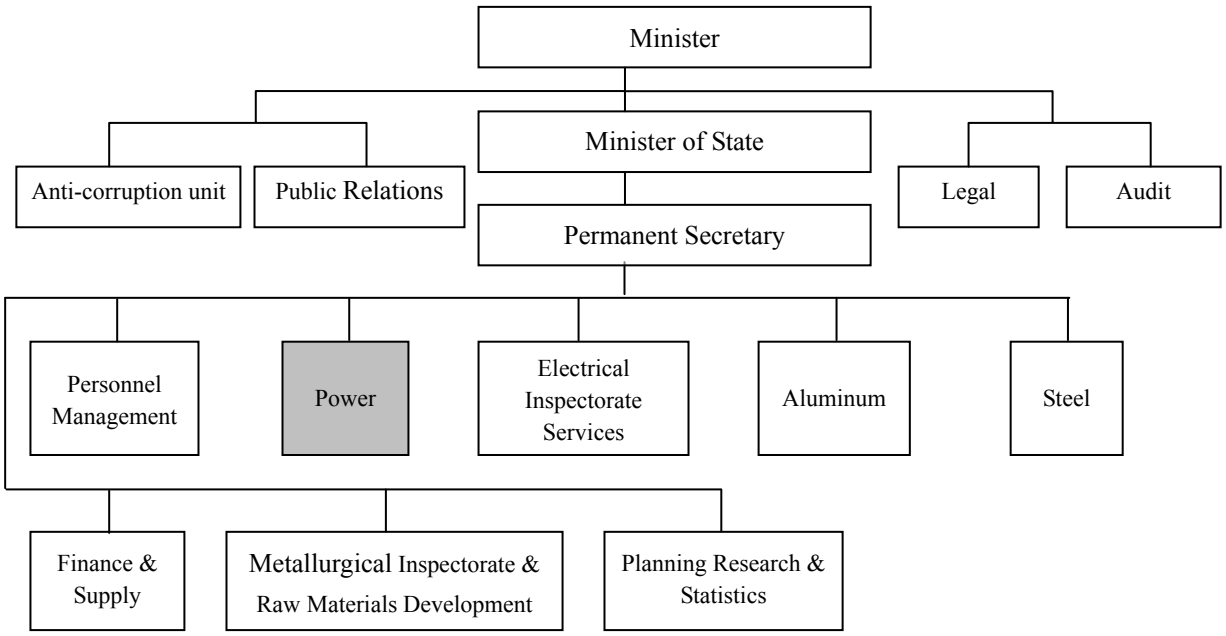
3.3 Organization and Human Resources

3.3.1 FMPS

The electricity sector in Nigeria is supervised by the FMPS and the NEPA used to be responsible for the operation and maintenance of the generating, transmission and distribution facilities nationwide under the supervision of the FMPS. There are areas where power facilities are planned and operated by the REB of the state government and services are provided by such IPPs as NESCO and AES. The Electricity Sector Reform Programme is being promoted in Nigeria in accordance with the NEEDS. Approval of the Electricity Sector Reform Bill by President Obasanjo in March, 2005 officially led to the effectuation of the Electric Power Sector Act. As a result, the NEPA was divided into six generating companies, one transmission company and 11 distribution companies and a holding company (PHCN) was established in May, 2005.

As shown in Fig. 3-7, the FMPS is made up of eight bureaus (Power, Electrical Inspectorate Services, Aluminium, Steel, Planning, Research & Statistics, Metallurgical Inspectorate & Raw Materials Development, Finance & Supply and Personnel Management). Of these, the Electrical Inspectorate Services Bureau is responsible for the NREP. In addition to the selection of the target areas of the NREP, this bureau plans and makes policy decisions, such as the annual budget. Based on these decisions, the PHCN conducts such technical issues as design and construction/installation work which is entrusted to contractors, mostly domestic companies. Up to facility completion, the FMPS is responsible for supervision while the Rural Electrification Bureau is responsible for facility operation and maintenance. The FMPS has 15 local branches nationwide and employs 907 staff members as of October, 2005.

Even following the reform of the electricity sector, the FMPS is still the highest supervisory body regarding the planning and implementation of policies related to rural electrification projects and monitors as well as evaluates the NREP from the viewpoint of the national policy. As the NREP is implemented by not only the REA described later but also by state and other local governments, the FMPS establishes the state of implementation of the NREP at the national level with a view to setting up and modifying the targets when necessary. Rural electrification projects are required to closely collaborate with other sectors, such as education, medical care and water supply. The functioning of the FMPS as the coordinator with other federal ministries and agencies is expected to facilitate comprehensive rural development.



Notes

① The shaded section is that in charge of the present project.

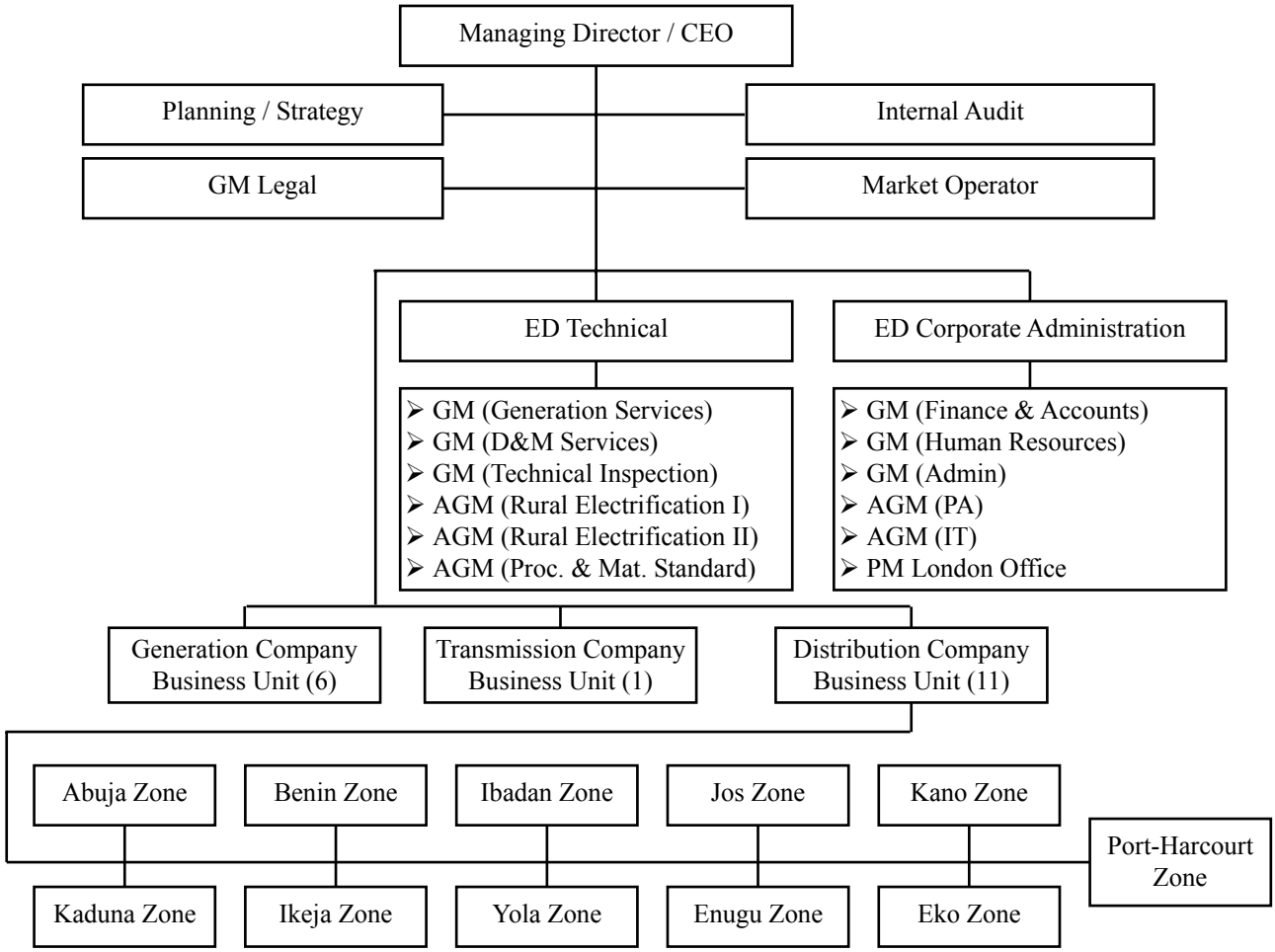
② Total staff strength: 907 (as of October, 2005)

Source: Federal Ministry of Power and Steel

Fig. 3-7 Organizational Structure of the FMPS

Within the FMPS, while the Power Bureau and the Electrical Inspectorate Services Bureau are related to the Study, the Power Bureau has been designated as the direct counterpart by the Study Team. The Power Bureau is responsible for the supervision of the PHCN and the introduction of renewable energies while the Electrical Inspectorate Services Bureau is responsible for on-grid rural electrification in addition to having the authority to regulate and permit the installation of independent power plants.

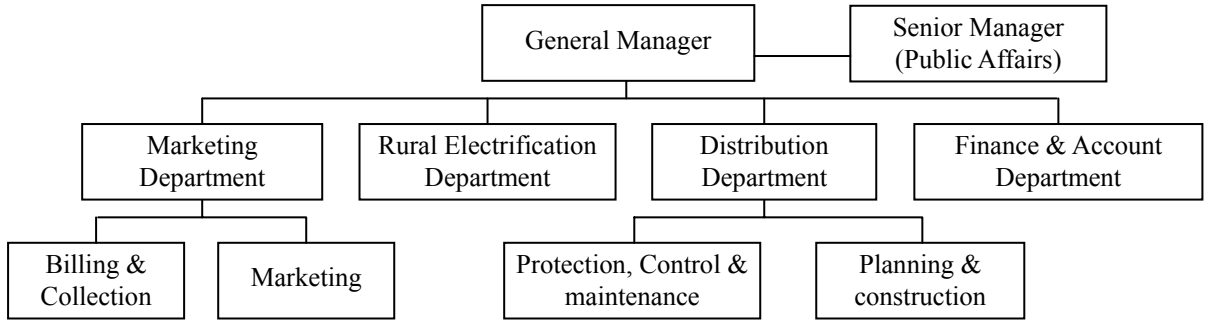
In regard to the organizational structure of the PHCN, the Managing Director directly controls the Planning/Strategy Office, Internal Audit Office, Legal Office and Market Operator Office as shown in Fig. 3-8. In addition, the PHCN has the Technical Department and the Corporate Administration Department among others. The voltage classes currently employed in Nigeria are 330 kV, 132 kV, 33 kV, 11 kV and 415 – 240 V. Of these, the 330 kV and 132 kV systems are managed by the business units of the generation and transmission companies while the 33 kV and lower voltage classes are managed by the distribution companies. There are 11 zoned distribution companies and each company controls the business units, undertakings and local offices in its zone.



Note : Staff Strength: 31,609 (2005)
Source : PHCN

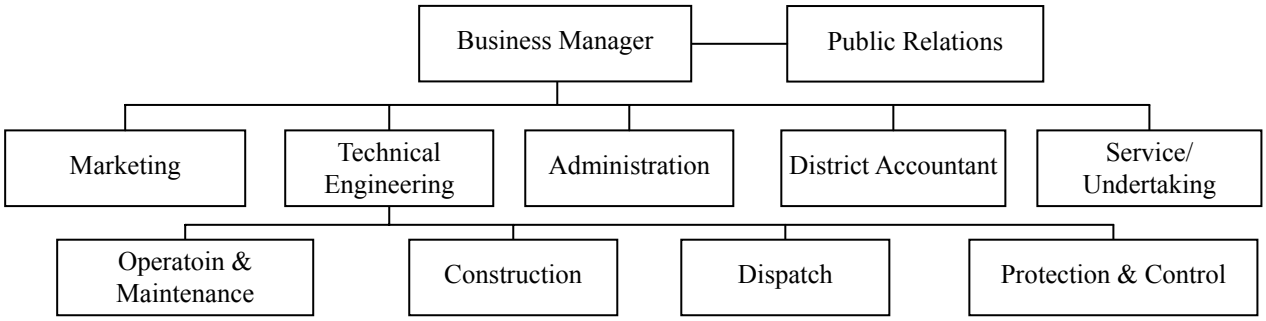
Fig. 3-8 Overall Organizational Structure of the PHCN

Fig. 3-9 and Fig. 3-10 show the typical organizational structure of the PHCN's zone offices and business units which are responsible for the day to day operation and maintenance of the distribution facilities. Undertakings, which are subordinate organizations of the business units, are responsible for the collection of the electricity charge and simple equipment maintenance in remote areas.



Source: PHCN

Fig. 3-9 Typical Organizational Structure of the PHCN's Zone Offices



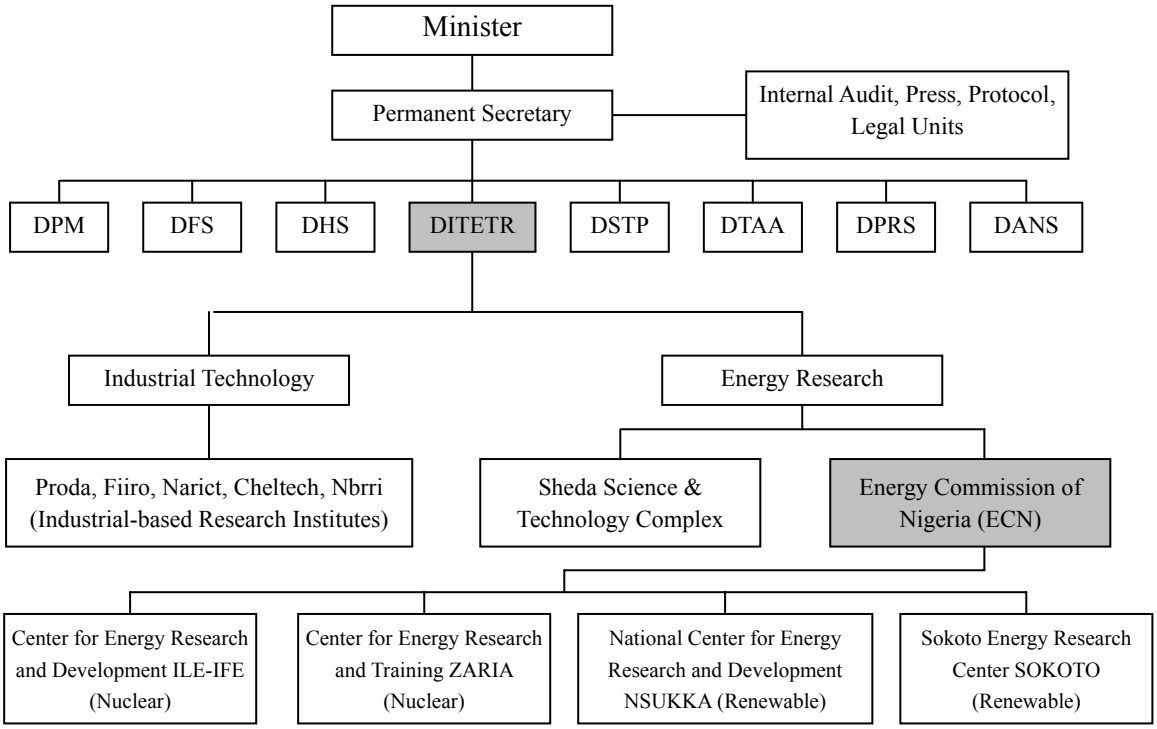
Source: PHCN

Fig. 3-10 Typical Organizational Structure of the PHCN's Business Units

Following the division and privatisation of the PHCN, private companies and NGOs, etc. are allowed to set up their own distribution businesses along with the zoned distribution companies. However, it must be noted that under the current distribution business set-up of the PHCN, funding for the operation and maintenance cost in rural areas with a low demand density is provided by an internal subsidy from urban areas with a high level of profitability to rural areas. In other words, it is essential for new entrants into the rural distribution business to introduce a metered charge system and to improve the electricity charge collection efficiency in areas where the users are widely scattered. For this reason, the possibility of transferring the ownership of distribution facilities (i.e. franchising) to organizations close to local communities (such as residents' organizations, village unions and NGOs, etc.) should be examined.

3.3.2 FMST

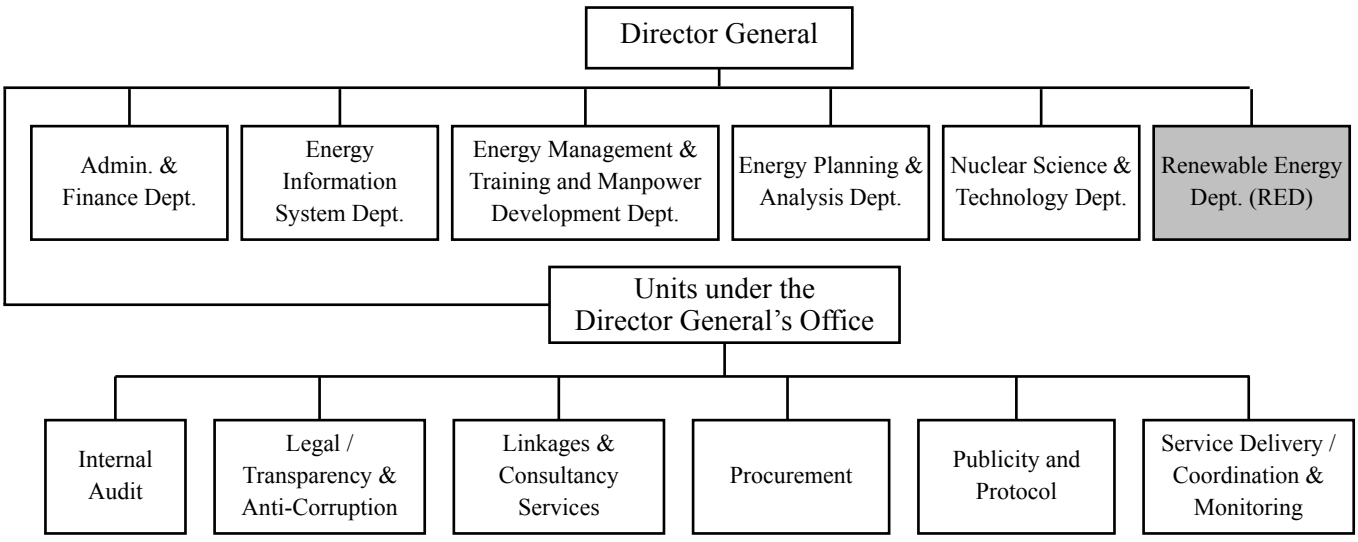
The Federal Ministry of Science and Technology (FMST) uses the Energy Commission of Nigeria (ECN), a subordinate organization, to promote the introduction of solar energy and other renewable energies. The ECN has renewable energy-related research institutes in Nsukka and Sokoto where pilot projects for solar heat utilisation technologies and PV generating technologies are being implemented to promote the use of solar energy. In regard to PV generation, the ECN is proceeding with its own demonstration study regarding a solar pump and rural electrification using a mini-grid as a separate activity from the rural electrification work conducted by the FMPS and state governments. As silicon is domestically produced in Nigeria, the ECN is planning new R & D activities with a view to domestically manufacturing PV modules.



Note : DPM : Department of Personnel Management
DFS : Department of Finance & Supplies
DHS : Department of Health Sciences
DITER : Department of Industrial Technology & Energy Research
DSTP : Department of Science & Technology Promotion
DTAA : Department of Technology Acquisition & Assessment
DPRS : Department of Planning Research & Statistics
DANS : Department of Agricultural and Natural Sciences
SHESTCO : Sheda Science and Technology Complex

Source : FMST

Fig. 3-11 Organizational Structure of the FMST



Source: ECN

Fig. 3-12 Organizational Structure of the ECN

3.4 Public Finance and Budget

3.4.1 State of Financial Management in the Electricity Sector

Table 3-10 shows the 2005 budget of the Electrical Inspectorate Services Bureau of the FMPS which supervises rural electrification projects. While 174 rural electrification projects have been completed along with the construction or upgrading of 228 related substations, some NgN 1.2 billion (approximately ¥970 million), equivalent to 15% of the total budget, is used for the payment of debts, limiting the available funding for investment in new rural electrification projects.

Table 3-10 Rural Electrification Budget of the FMPS (2005)

No.	Budget Item	Amount (million NgN)
1	Distribution Line Work for Completion (174)	565
2	Substation Work for Completion (228)	1,539
3	Cabling Work for Completion (526)	592
4	Payment of Debts (Construction Cost)	1,023
5	Payment of Debts (Consultant Fee)	167
6	Placement of Orders for New Projects	3,600
7	Technical Surveying, Project Commencement and Monitoring	100
8	Others	284
	Total	7,870

Source: FMPS

Table 3-11 shows the income and expenditure balance of the PHCN from 2000 to 2004. In these last five years, the net system energy demand steadily increased but the balance of the PHCN was constantly in the red. The causes of such a continual deficit are believed to be the large transmission and distribution loss (40% level), the low electricity charge collection rate (approximately 70%) and the low tariff for households as shown in Table 3-12. In terms of the operating cost, the personnel cost accounts for as much as 30 – 45%.

Table 3-11 Historical Changes of the Income and Expenditure Balance of the PHCN

(Unit: US$ million)

Item	2000 (Result)	2001 (Result)	2002 (Result)	2003 (Result)	2004 (Estimate)
Net System Energy Demand (GWh)	8,810	10,228	11,242	12,247	14,264
Average Electricity Charge (US¢/KWh)	3.84	3.42	4.96	4.67	4.36
Transmission and Distribution Loss (%)	40	40	46	45	39
1. Operating Income	**346.0**	**362.2**	**648.8**	**660.3**	**687.1**
2. Operating Costs	**378.4**	**522.8**	**700.6**	**693.4**	**724.6**
2.1 Purchase Cost of Electricity	0.6	21.2	54.4	70.8	63.9
2.2 Fuel Cost	10.7	40.1	46.3	36.2	21.7
2.3 Personnel Cost	166.9	234.5	200.1	209.2	224.9
2.4 Maintenance Cost	107.7	109.2	157.0	168.1	194.7
2.5 Depreciation Cost	40.9	33.1	37.7	36.6	47.5
2.6 Outstanding Charge	51.5	84.6	205.1	172.5	171.9
3. Operating Balance	**-32.4**	**-160.8**	**-51.8**	**-33.1**	**-37.5**
4. Interest Payment, etc.	**128.8**	**20.0**	**60.0**	**42.8**	**32.9**
5. Net Profit	**-161.3**	**-180.6**	**-111.8**	**-75.8**	**-70.3**

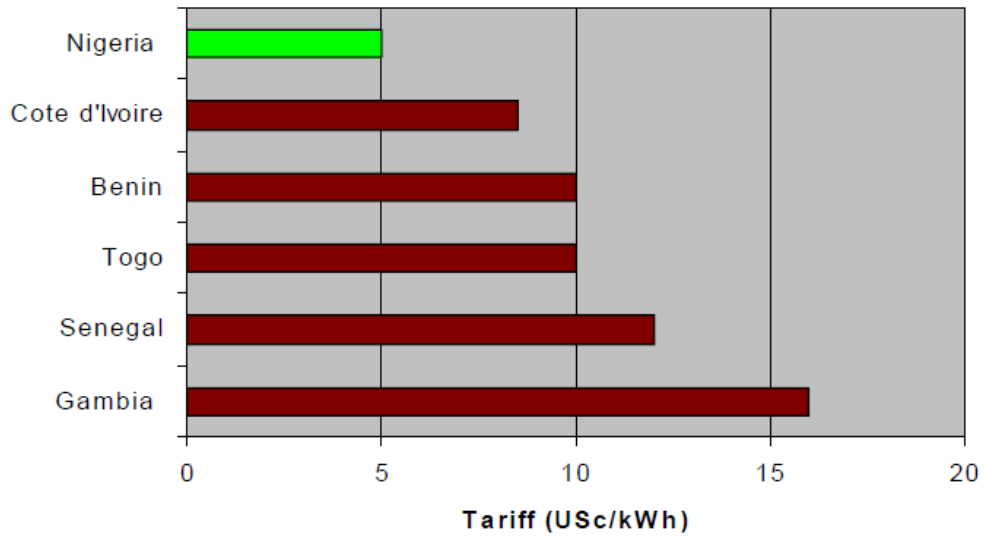
Source: World Bank, 2005, "Project Appraisal Document (National Energy Development Project)"

In its National Energy Development Project[5] which is designed to assist the electricity sector in Nigeria, the World Bank aims at achieving the development of transmission lines, improvement of the transmission and distribution loss through the improvement of distribution lines (target: 25% reduction of the current loss), establishment of customer centres and improvement of the electricity charge collection rate through improvement of the charging and meter reading methods. Improvement of the business management of the PHCN and distribution companies is hoped for based on such assistance by the World Bank and the reform of Nigeria's electricity sector.

3.4.2 Electricity Tariff

In regard to the electricity tariff imposed by the PHCN (see Table 3-12), although the fixed charge for users without a watt-hour meter was revised in 2004, the basic and metered charges have remained unchanged since 2002. As the domestic rate of inflation during this period has been has high as some 50%, the value of the naira, the local currency, to the US dollar and the euro dropped by 15% and 44% respectively, placing additional pressure on the financial balance of the PHCN. As the average electricity charge (weighted by the net system energy demand) shown in Table 3-11 is below the long-term marginal cost[6] (approximately US¢ 6.5/KWh), a loss of some US¢ 2 per KWh sold is incurred.

As shown in Fig. 3-13, the electricity tariff in Nigeria is much lower than that of its neighbours and an increase of the tariff is necessary to achieve the sound management of the electricity business. However, it is assumed that it will be difficult to obtain a positive understanding of an increase of the tariff unless the current unstable power supply and service level are improved. Therefore, the priority issues are the establishment of the power supply reliability and reduction of the cost through improvement of the management efficiency.



Source: PHCN, "The Power Sector: The Catalyst for Economic Growth & Development", March, 2004

Fig. 3-13 Comparison of the Tariff Between Nigeria and Its Neighbours

5) Project ID: P090104, approved on 1st July, 2005, IDA loan of US$ 172 million
6) Minimum total cost incorporating the operating cost and the capital cost

Table 3-12 Electricity Tariff of the PHCN (as of October, 2006)

	Category	Scope of Load	Contracted Capacity Charge (NgN/KVA)	Minimum Charge (NgN/month)	Basic Charge (NgN/month)	Metered Charge (NgN/KWh)
1.0	**Household**					
1.1	R1	<5kVA	-	-	20.00	1.20
1.2	R2	>5kVA <15kVA	-	-	30.00	4.00
1.3	R3	>15kVA <45kVA	-	120.00	120.00	6.00
1.4	R4	>55kVA <500kVA	-	5,000.00	120.00	8.50
1.5	R5	>500kVA <20MVA	-	31,250.00	-	8.50
2.0	**Commercial**					
2.1	C1	<5kVA <15kVA	-	90.00	90.00	6.50
2.2	C2	>15kVA <45kVA	-	120.00	120.00	8.50
2.3	C3	>55kVA <500kVA	230.00	5,000.00	240.00	8.50
2.4	C4	>500kVA <20MVA	250.00	31,250.00	-	8.50
3.0	**Industrial**					
3.1	D1	<5kVA <15kVA	-	90.00	90.00	6.50
3.2	D2	>15kVA <45kVA	-	120.00	120.00	8.50
3.3	D3	>55kVA <500kVA	230.00	5,000.00	240.00	8.50
3.4	D4	>500kVA <2MVA	250.00	31,250.00	-	8.50
3.5	D5	>2MVA	270.00	1,500,000.00	-	8.50
4.0	**Street Lighting**					
4.1	S1	1-Ph, 3-Ph	-	240.00	-	6.50
5.0	**Special Tariff***					
5.1	A1	<15kVA <45kVA	-	120.00	120.00	5.80
5.2	A2	>55kVA <500kVA	-	5,000.00	240.00	5.80
5.3	A3	>500kVA <2MVA	-	31,250.00	-	5.80
5.4	A4	>2MVA	-	31,250.00	-	5.80
5.5	A5	>2MVA	230.00	5,000.00	240.00	12.00
5.6	A6	>2MVA	250.00	31,250.00	-	12.00
6.0	**Welding**					
6.1	D1	>5kVA <15kVA	-	90.00	90.00	6.50
6.2	D2	>15kVA <45kVA	200.00	120.00	500.00	8.50
7.0	**Staff Member**					
7.1	R2	>5kVA <15kVA	-	-	30.00	4.00
8.0	**Pensioner**					
	R2	>5kVA <15kVA	-	-	30.00	4.00
9.0	**Power Company Facility**					
Commercial	C1	>5kVA <15kVA	-	90.00	90.00	6.50
	C2	>15kVA <45kVA	-	120.00	120.00	8.50
	C3	>55kVA <500kVA	230.00	5,000.00	240.00	8.50
	C4	>500kVA <20MVA	250.00	31,250.00	-	8.50
Industrial	D1	>5kVA <15kVA	-	90.00	90.00	6.50
	D2	>15kVA <45kVA	-	120.00	120.00	8.50
	D3	>55kVA <500kVA	230.00	5,000.00	240.00	8.50
	D4	>500kVA <2MVA	250.00	31,250.00	-	8.50
	D5	>2MVA	270.00	1,500,000.00	-	8.50

Source : PHCN

Note : * NPOs (mosques and churches, etc.), NGOs and international organizations

1 NgN = ¥0.938 (November, 2006)

3.5 Present Situation and Pending Issues for Rural Electrification Projects

Electrification in Nigeria is said to have a national average of 35% which drops to approximately 10% in rural areas. The Government of Nigeria has adopted a target of increasing the national electrification rate to 50% by 2010 and 75% by 2020 based on both on-grid and off-grid electrification.[7)] The Electrical Inspectorate Services Bureau of the FMPS is responsible for the formulation of rural electrification policies and decisions on the target villages for electrification. There are two types of rural electrification project implementation. One is top-down implementation in accordance with the NREP (LGHQs and major cities) while the other is bottom-up implementation based on requests made by state and other local governments. In the case of the former, individual projects are implemented according to the NREP without the approval of the minister. In contrast, projects in the latter category require the approval of the Minister of Power and Steel in consideration of the feasible funding size. In either case, the PHCN conducts a field survey, design of the distribution lines and estimation of the construction cost and a contract with a construction company is made by the FMPS after a project submitted to the National Assembly by the FMPS has been approved by the said assembly.

In addition to the rural electrification activities of the federal government, the State Electricity Boards (SEB), Rural Electrification Board and Integrated Rural Development Agency of each state government implement their own rural electrification plans (based on a separate budget from the federal government budget). The facilities constructed under these plans are transferred to the PHCN for their operation and management if such transfer is approved by the PHCN. In other words, when planning the electrification of an area, the state or other local government must decide either to make a request to the federal government (FMPS) or implement the project in question using its own funds.

Under the circumstances described above, the rural electrification projects of the federal government and those of state and other local governments are implemented side by side. The resulting lack of the systematic and efficient progress of rural electrification means that the size of the non-electrified population has steadily increased compared to 1981 when the NREP was first formulated. To make matters worse, the technical specifications of the distribution facilities tend to vary from one state to another and rural electrification projects are not necessarily implemented in accordance with the medium to long-term policy of the FMPS. Therefore, the establishment of a uniform command system from the FMPS to the PHCN and further to those bodies of state governments which are responsible for rural electrification is essential.

Although the PHCN sets out the technical standards for distribution facilities, state governments plan and implement rural electrification projects based on their own standards. There have been many cases of the PHCN refusing the transfer of newly constructed facilities because of the extremely poor quality of the facilities. Meanwhile, state governments do not have any technical or financial leeway to immediately rectify/improve work of poor quality pointed out by the PHCN and

7) The electrification rate referred to in this report is entirely based on the electrification rate of households.

poor facilities are left as they are in many projects. In order to solve this problem, it is necessary for an organization which is capable of addressing both the federal government and state governments to establish uniform technical standards for the distribution facilities which are constructed under rural electrification projects.

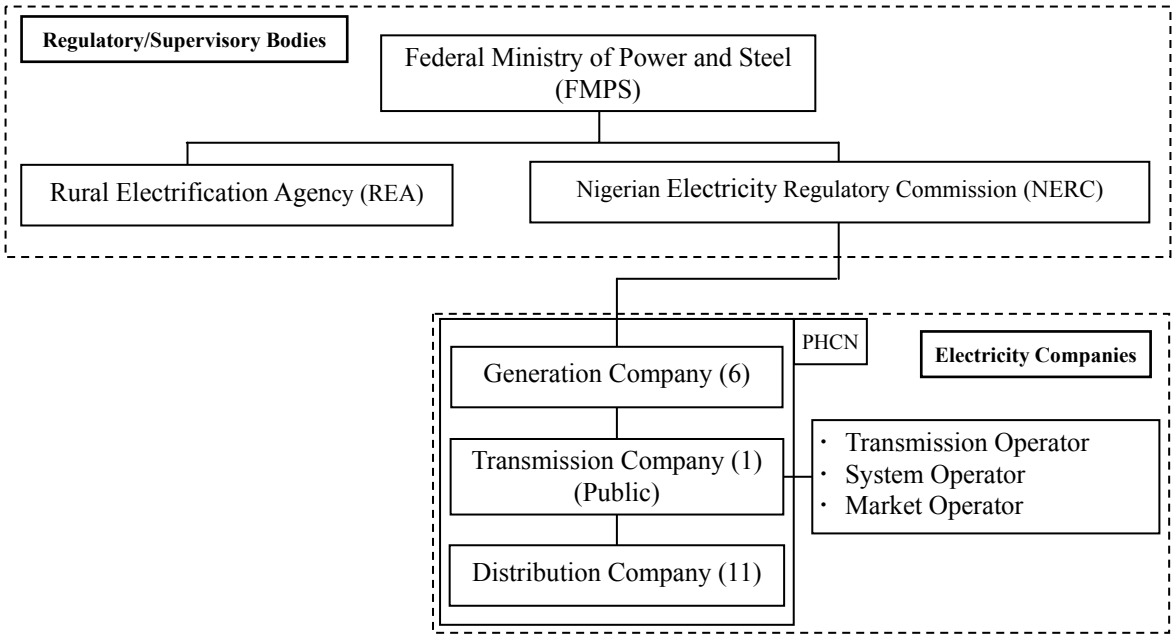
3.6 Reform of the Electricity Sector and Rural Electrification

The approval of the Electric Power Sector Reform Bill by President Obasanjo in March, 2005 led to the official effectuation of the Electric Power Sector Act. The NEPA was divided into six generating companies, one transmission company and 11 distribution companies. Meanwhile, a holding company (the Power Holding Company of Nigeria) was established in May, 2005.

With the disbanding of the PHCN itself in July, 2006, the generating, transmission and distribution companies as well as IPPs will operate their businesses under the regulatory regime of and with a licence issued by the Nigerian Electricity Regulatory Commission (NERC). Liberalisation of the wholesale market for electricity is planned in the coming years (to be followed by the next step of retail liberalisation). Following the disbanding of the PHCN, private companies will be allowed to participate in the generating and distribution businesses while the transmission company will continue to be owned by the federal government.

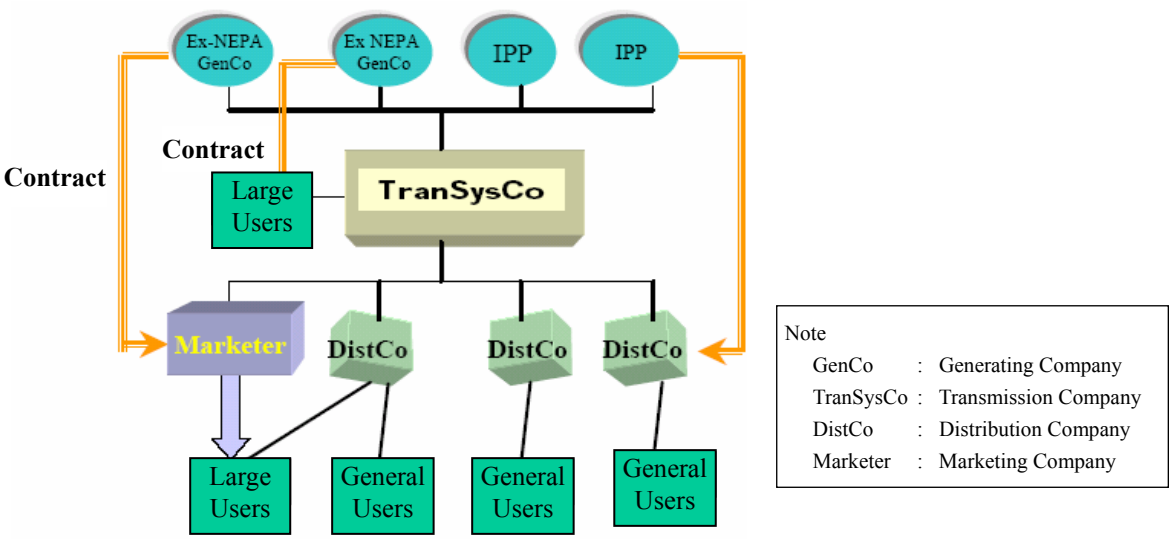
To promote the participation of private companies in rural electrification, it will be necessary to increase the currently low tariff which is 100% subsidised by the federal government at present (a fixed charge system[8]) of NgN 304.5/month). After an increase of the tariff, users will still find payment difficult without a subsidy. In March, 2006, the Rural Electrification Agency (REA) and the Rural Electrification Fund were established as subordinate organizations of the FMPS to provide a subsidy for local electricity providers (inclusive of all possible suppliers, ranging from private companies to NGOs, state governments and communities). The current arrangement is characterised by the fact that any organization which wants to enter into the rural electrification business may do so without obtaining permission from a distribution company in the area if it can secure a business permit from the REA. Fig. 3-14 shows the assumed organization and operating system of the electricity sector after reform while Fig. 3-15 and Fig. 3-16 show the range of electricity companies after reform.

8) For users without a watt-hour meter. The previous charge of NgN 150/month was increased to the present level in 2004.



Source: FMPS

Fig. 3-14 Organization and Operating System of the Electricity Sector (After Reform)



Source: NEPA, "The Power Sector: The Catalyst for Economic Growth for Development", March, 2004

Fig. 3-15 Composition of Electricity Companies After Reform of the Electricity Sector

3.7 Present Situation and Pending Issues for the Use of Solar Energy

3.7.1 Present Situation and Future Targets for the Use of Renewable Energies

The use of renewable energies in Nigeria began with the development of hydropower in the 1960's. At present, hydropower generation accounts for some 25% of the total electric energy generated and is the second-most important source of power generation after thermal power generation. As firewood comprises more than half of the energy consumption in Nigeria, the imbalance between the power supply and demand has led to such environmental problems as deforestation and the erosion of mountain forest land. In some areas, economic activities are hampered by this imbalance.

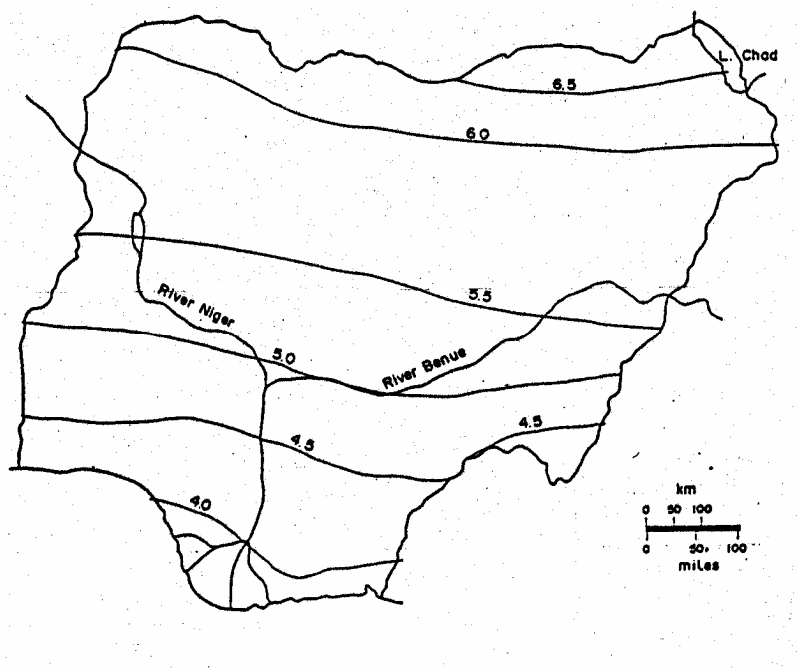
In rural areas, solar energy is widely used to dry vegetables and fruit.

Mini-hydropower and solar energy offer the most development potential in the future while wind power is unlikely to offer sufficient potential for power generation. According to the results of a study on the potential of mini-hydropower in 12 states in the 1980's, a total generating potential of 734 MW at 277 sites nationwide was confirmed. However, the lack of any follow-up study means an urgent need to update the database. The potential wind power generation is high in the north where the mean wind velocity is 4.0 – 5.12 m/s. In the south, the mean wind velocity at an elevation of 10 m is 1.4 – 3.0 m/s. The maximum wind velocity is observed between April and August. Based on such data, the potential of wind power generation is inferred to be low except at those sites along the coast or in the ocean.

A more detailed account of the present use of solar energy is given in the following sections.

3.7.2 Meteorological Conditions

The mean quantity of solar radiation in Nigeria is the highest in the semi-arid zone in the north at 7.0 KWh/m^2/day and the lowest in the coastal zone in the south at 3.5 KWh/m^2/day. The national average is 5.5 KWh/m^2/day with a duration of solar radiation of 6 hours/day, offering advantageous natural conditions for the application of PV generation. The quantity of solar radiation peaks in the dry season from November to April when there is no harmataan and hits its lowest level in the rainy season from May to October.



Source: ECN

Fig. 3-16 Nationwide Solar Radiation Map of Nigeria

Table 3-13 Nationwide Solar Radiation Data for Nigeria

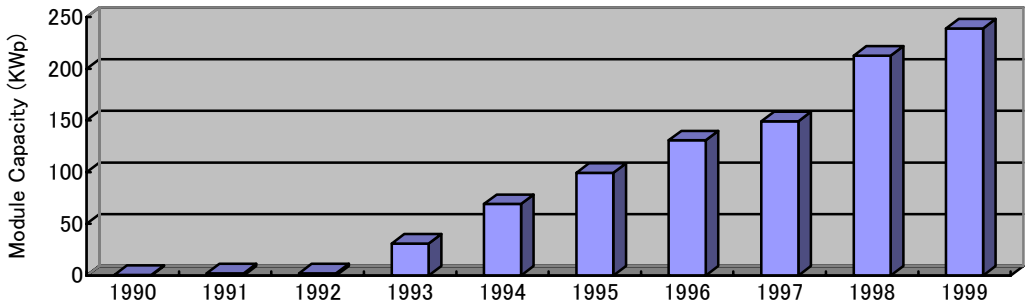
(Unit: KWh/m^2/day)

Stations	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Mean
Aheokuta	4.107	4.764	4.742	4.951	4.703	3.878	3.510	3.438	3.952	4.423	4.449	4.114	4.253
Abuja	5.404	5.695	5.986	5.811	5.521	5.114	4.533	4.184	4.880	5.520	5.753	5.637	5.337
Akure	4.184	4.881	5.153	5.191	4.590	4.206	3.983	3.639	4.021	4.574	4.694	4.608	4.485
Azare	5.202	5.756	6.176	5.491	5.638	5.771	5.370	5.592	5.880	5.828	5.301	4.842	5.571
Bauchi	5.614	6.082	6.405	5.913	5.907	5.398	5.194	4.577	5.371	6.037	6.063	6.011	5.714
B.City	3.963	4.355	4.517	4.784	4.491	4.100	3.619	3.613	3.939	4.279	4.557	4.206	4.202
Calabar	3.889	4.546	4.292	4.544	4.206	3.636	3.233	3.415	3.747	3.925	3.983	3.684	3.925
Enugu	4.472	4.903	5.013	5.156	4.981	4.332	3.954	3.993	4.234	4.050	4.805	4.571	4.539
Ibadan	4.740	5.150	5.299	5.106	4.984	4.285	3.764	3.480	4.437	4.616	4.956	4.577	4.616
Ilorin	4.717	4.456	5.706	5.470	5.182	4.787	4.176	4.016	5.310	4.964	5.017	4.940	4.979
Jos	6.108	6.656	6.416	5.598	5.350	5.365	4.730	4.347	5.216	5.865	6.118	4.060	5.653
Kaduna	5.700	6.050	6.340	5.930	6.050	5.410	4.707	4.184	5.172	5.930	6.020	6.566	5.673
Kano	5.577	5.849	6.114	6.421	6.572	6.121	5.881	5.245	6.115	6.361	6.062	5.899	6.003
Katsina	3.554	3.691	4.910	5.834	5.870	5.839	5.342	4.014	4.150	4.750	5.482	3.757	4.766
Lagos	4.372	4.146	5.012	5.014	4.536	3.837	3.762	3.779	3.953	4.401	4.471	3.780	4.256
LokoJa	4.815	4.797	5.099	5.890	5.388	4.622	4.891	4.931	4.737	5.309	5.154	4.845	5.035
Maidug	5.805	6.145	6.664	6.892	6.705	6.173	5.746	5.106	6.043	6.505	6.315	6.008	6.176
Makurdi	5.107	5.634	5.628	5.705	5.349	4.786	4.459	4.323	4.547	5.181	5.230	4.906	5.077
Minna	5.386	5.843	5.827	5.881	5.877	5.294	4.525	4.295	4.934	5.659	5.932	5.665	5.427
N.Bussa	4.647	5.103	5.557	5.509	5.292	4.786	4.268	4.032	4.975	5.083	5.135	5.040	4.952
Nguru	6.297	5.036	6.850	5.960	8.848	7.288	7.761	7.793	7.825	6.719	6.538	6.356	6.966
Obudu	3.574	4.438	5.505	4.797	4.520	3.879	3.176	3.750	4.160	4.425	4.275	3.850	4.224
Owerri	4.018	4.307	4.191	4.775	4.523	4.040	3.639	3.729	4.008	4.113	4.280	4.122	4.146
PH	4.000	4.517	4.211	4.634	4.210	3.878	3.477	3.610	3.893	3.968	3.890	3.992	4.023
Serti	3.936	4.522	4.678	4.758	4.281	4.476	4.760	4.009	4.611	4.696	4.416	4.782	4.488
Sokoto	5.417	6.038	6.284	6.266	6.321	6.169	5.743	5.026	5.799	6.205	6.004	5.772	5.920
Warri	3.060	3.486	3.822	4.429	3.139	3.420	3.585	3.386	3.764	4.045	3.865	3.462	3.746
Yola	5.459	6.282	6.460	5.942	5.978	5.630	5.141	4.806	5.262	5.941	6.106	6.277	5.774

Source: Renewable Energy for Rural Industrialization and Development in Nigeria, UNIDO and ECN, Dec. 2003

3.7.3 Actual Use of PV Generation Systems

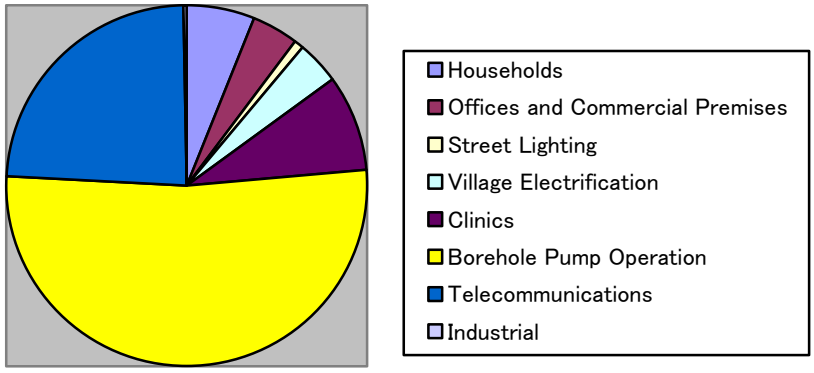
PV generation began in Nigeria in the 1980's but it was only in 1993 that such systems began to spread more widely. At present, all of the basic components of PV generating systems, ranging from modules, batteries, inverters and charge controllers, etc., can be procured domestically. Modules are imported from the US, Japan and China, etc. while inverters and charge controllers, etc. are imported from the US and European countries.



Source: ECN, "Technical Report No. ECN/EPA/02/03"

Fig. 3-17 Historical Changes of PV Module Capacity in Nigeria

The breakdown of the installed PV capacity by purpose of use shows that borehole pumps are the most popular purpose of use (52%), followed by telecommunications equipment (24%), home and office lighting (15%) and clinics (9%). Areas where PV generation is much used are the northern states (Yobo, Kano, Jigawa, Kaduna and Katsina) where power is mainly used to operate pumps or clinics. In Lagos and other southern states, the power from PV generation tends to be used for domestic lighting and telecommunication equipment. The reason for this different preference of use is assumed to lie with the facts that the annual rainfall level is relatively high in the south and that the demand for pumping is relatively low in river areas compared to the semi-arid areas in the north.



Source: ECN, "Technical Report No. ECN/EPA/0213"

Fig. 3-18 Use of PV Generation by Purpose of Use (1999)

The main bodies promoting the introduction of PV generation so far have been the FMST and the ECN, a subordinate organization of the FMST, both of which are implementing PV generating systems for the development (verification) of technologies. Since 2005, the FMPS has been implementing a pilot project in Katsina State and Bauchi State (at the equipment procurement stage as of October, 2006). Some state governments are conducting their own projects. The formulation of a master plan will be necessary in the coming years for the systematic introduction of PV generation systems through collaboration between the federal government and state/other local governments as in the case of on-grid rural electrification.

As examples of donor assistance, the Solar Electric Light Fund (SELF: a NGO based in Washington) and the Jigawa Alternative Energy Fund (JAEF: a local NGO set up by the state government of Jigawa in 2001) are jointly implementing a PV rural electrification project with the financial assistance of the USAID and the state government of Jigawa. The funding size of this project is US$ 280,000 by the USAID and US$ 242,000 by the state government of Jigawa. The experimental application of a PV generation system to palm oil extractors, commercial facilities were electric sewing machines can be used and mobile irrigation pumps, etc. is being conducted under the Project in addition to the installation of SHSs, PVs, PV street lamps and PV refrigerators, etc.

The post evaluation report of the USAID published in September, 2005 on the SELF Project lists the following lessons of the project.

1) With regard to SHSs, the introduction of a system which is capable of supplying power to multiple households under a single project is recommended. Most households which are hoping for the installation of a SHS have no problem regarding payment ability. The introduction of some 20 sets in each village cannot meet the electricity demand of the villagers and may well cause friction between villagers because of the need to select users.

2) The introduction of such experimental technologies as the use of PV power for palm oil extractors and mobile irrigation pumps under a large-scale project covering more than one village is undesirable. It is desirable for such experimental use to be tried in a small study or project.

3) While large-scale technical training was provided for JAEF staff, training on project management will be required for similar projects in the future with a view to developing personnel who can play a leading role in the body responsible for system maintenance.

Meanwhile, the UNDP has been implementing a pilot project since September, 2006 to demonstrate the viability of the Renewable Energy Master Plan. Under this plan, technical collaboration has been established with the Energy and Resources Institute (ERI) which has rich experience in India and Bangladesh, etc. to verify the viable operation of a mini-grid system using PV generating systems in six villages nationwide (one village in each geo-political zone). This South-South cooperation for the procurement of equipment and technical cooperation is a major characteristic of this pilot project. According to the UNDP, verification of the sustainability of a mini-grid system rather than independent SHSs is a priority to facilitate the application of PV generation for boreholes providing drinking water and for agricultural and commercial activities which lead to improvement of the income of the rural poor.

The PV mini-grid system (Hope Eden Village, Kuje LGA, FCT) installed and operated with the community's own funding without the external assistance of the government or a donor has important implications for the future introduction of PV generation systems. This village was formed in 1999 and has overnight accommodation facilities for visitors. Some 20 – 30 people living in the village at any time. Solar panels with a total generating capacity of 670 W are distributed and inverters, controllers and batteries are operated for two separate systems. The villagers can use refrigerators, sewing machines and radio-cassettes, etc. in their own homes from 18:00 to 06:00 on the following day and water is supplied by a PV pump.

In addition to those mentioned so far, the ECN has been playing a leading role in the active introduction of mini-grid systems in Nigeria as shown in Table 3-14. The system constructed in Ikeakpa Village in Enugu State in 1999 is currently partially used (550 W) as a power source for a meeting house as the village was connected to the main grid in 2003. Table 3-15 shows the specifications of the original system which was operated as a mini-grid. This system has a circuit breaker to restrict the use of power to one or two lamps by each household and street lamps at night in order to prevent the unrestricted use of electrical appliances by households. The FMPS is planning the introduction of a mini-grid system (17.5 kW) in Ogun State and Cross River State and

preparations for the tender are in progress as of October, 2006.

Table 3-14 Introduction of PV Systems by the Government and Donors

Implementing Body	Period	Project Outline
FMST (ECN)	Continual implementation since 1990	AC mini-grid rural electrification in six villages (for lighting, TVs, irons and refrigerators, etc.); generating capacity of 10 KW or higher each
		Lecturers' rooms and dormitories at universities, etc. (2 – 5 KW) (at 36 campuses)
		Borehole pump for irrigation (1.5 – 2 KW): 18 sites
		PV refrigerator for vaccine storage (0.45 KW): 36 sites
		Radio communication equipment: 4 sites
FMPS	Equipment procurement stage	SHS capable of serving 250 households (module: 50 Wp, 11 W x 3 fluorescent lamps and 5 W radios) each in Bauchi State and Katshina State
		Mini-grid (17.5 KW) in both Ogun State and Cross River State
		Borehole pump: 28 sites
		Community system (module: 200 Wp, 11 W x 10 fluorescent lamps) : 9 sites
		Street lamps (module: 42 Wp or higher): 36 sites
Sokoto State	2003	Borehole pump: 8 sites
Lagos State		Borehole pump: 1 site on a remote island
USAID	2004	Introduction of SHSs, PV powered street lamps, borehole pumps, public facilities and commercial facilities in five target villages in Jigawa State
UNDP	2006 – 2007	Planned introduction of a mini-grid system in six villages nationwide under a pilot project for a renewable energy master plan; possible power supply to a maximum of 1,000 households as well as borehole pumps and public facilities
UNIDO	Planning stage	Possible introduction of BCSs based on micro-finance for personal business operators and the productive use of electricity for an income increase
UNICEF		PV power-operated refrigerators in Sokoto State in 2001 and borehole pumps in Plateau State

Source: The Study Team

Table 3-15 Specifications of Mini-Grid System in Enugu State

1. PV Panel	Total capacity: 1.8 KW (PV module: 55 W made by Siemens)
2. Distribution Voltage	AC 220 V
3. Number of Users	54 households (14 with 2 lamps and 40 with 1 lamp)
4. Street Lighting	16 lamps
5. Total	84 lamps (1 lamp: 15 W)
6. Power Supply Hours	18:00 – 23:00

Source: Field interviews by the Study Team

As examples of the use of solar heat, the Sokoto Energy Research Centre displays water heaters (seven sets each made up of a plain plate, straight pipe and spiral pipe), dryers (five sets), large dryers (two sets), cookers (box type: three sets) and one water distiller. Table 3-16 outlines the equipment developed by the ECN to develop solar heat so far. Although this trial equipment was originally made 10 or more years ago, no improvement has since been made. Moreover, no current

measuring data is available. The lack of efforts to improve these prototypes to marketable products questions the need for the research and development of such products.

Table 3-16 List of Equipment Developed by the ECN to Use Solar Heat

Equipment Type	Description
Drier	For the dry storage of fruit, vegetables, meat and fish for rural farmers without a refrigerator; the temperature inside the box increases with solar radiation; dried fruit is marketable.
Incubator	Maintains a high temperature for the hatching of eggs at chicken farms; the unit installed at the Nusuka Research Centre can hatch 250 eggs simultaneously.
Chick Incubator	A F/S is in progress in both Enugu State and Benue State in addition to two research centres. Equipment using on-grid power supply is also used.
Water Heater	A demonstration test has been taking place for 10 years at a maternity clinic in Sokoto. A viable market demand exists as few households in rural areas have shower facilities.
Water Distiller	There will be a viable demand if this unit is installed to obtain water to replenish battery water as part of the rural electrification efforts to use PV power. Sunlight is guided into a concrete or steel box through a transparent glass lid to evaporate water and the condensed water drops are recovered from the glass surface.
Cooker	Box-type cooker using a mirror to maximise the condensation of light.

Source: ECN

Chapter 4 Environmental Consideration

4.1 Rules and Regulations on Environment

Environmental Impact Assessment (EIA) in Nigeria is conducted based on the Environmental Impact Assessment Act No. 86(Decree No. 86), and its guideline issued in 1995. Federal Ministry of Environment (MOE) is in charge of EIA. All the development projects in Nigeria are categorized into the following three (3) categories.

- Category-1:A project that needs a full-scale EIA
- Category-2:A project that needs a partial EIA of which main parts are environmental impact mitigation measures and environmental plan (if located in or close to environmentally sensitive areas, a full-scale EIA is required.)
- Category-3: A project that is expected to have essentially beneficial impacts on the environment

The EIA procedure is as below.

1) The project proponent submits a project proposal to the MOE to apply for the process of an EIA. The following items are required to be mentioned: project name, location of the project, outline, sector of the project, predicted project life, procurement source of materials, person(s) who will conduct the EIA
2) The MOE examines the project proposal and decide the category to which the project belongs.
3) The proponent prepares the TOR of the EIA based on the decision.
4) The proponent conducts the EIA after receiving the approval of the TOR by the MOE.

The followings are the environmental rules and regulations that are related to the selection of equipments and preparation of implementation plan in the Study.

- S.I.8 National Environmental Protection (Effluent Limitation) Regulation, 1991
- S.I.9 National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, 1991
- Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991

4.2 EIA for the Pilot Projects

A development project of renewable energy including solar power is classified as Category-2, for which a partial EIA is required. Accordingly a partial EIA is required for the pilot project, and therefore, FMPS applied for an EIA as regulated (Nov. 2005). The FMPS attached a project document to the application form, so as to explain the possible environmental impact including that the photovoltaic electrification does not cause serious environmental impact only if proper attention is paid to dealing with the used batteries. The MOE informed to FMPS of the exemption of an EIA for the pilot projects (Feb.2006). The MOE instructed to FMPS to submit an environmental management plan, and FMPS followed the instruction. The following items are

included in the project document and the environmental management plan which FMPS submitted respectively.

Items included in the project document

Outline of the project (proponent, components, location, finance source, etc.), background, schedule, present social environment, facilities to be installed, experts to be assigned, predicted environmental impact, mitigation measures

Items included in the environmental management plan

Organization for O&M, predicted environmental impact, environmental management (implementation body, method), capacity development plan for environmental management

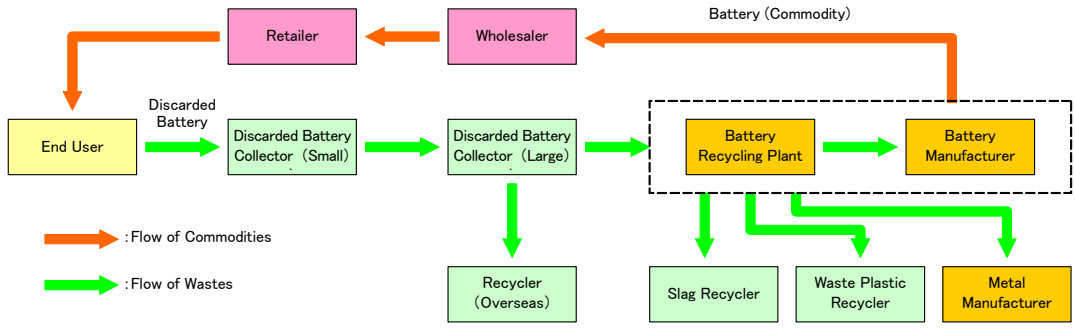
4.3 Important issues in M/P implementation

(1) Battery recycle

Special attention should be paid to the used battery disposal in PV electrification projects. It is stated in the above mentioned environmental management plan that the most important issue in environmental management is the used battery disposal and the recommendable way is to ask to a battery collector.

A recycling system for batteries has been established in Nigeria, and used batteries are handled as valuables. In addition to a Nigerian domestic recycling system there is an international recycling system, where Nigerian traders sell tons of collected batteries to overseas traders (Fig. 4-1). JICA study team confirmed that there are battery collectors in Kano, Akure and Owerri, which are near the pilot project villages respectively, and therefore, it is probable that there exist similar kinds of battery collectors in big cities such as state capitals.

Accordingly, it will be a common way to ask those collectors to deal with the used batteries discharged from the future PV electrification projects.



Source: JICA Study Team

Fig. 4-1 Battery Recycling System in Nigeria

It will be necessary to inform the members of the importance of battery recycling and confirmation of the existence of a battery collector nearby, when the O&M organization is established in a village. It is suggested that REA zonal offices are responsible to instruct them.

(2) EIA application

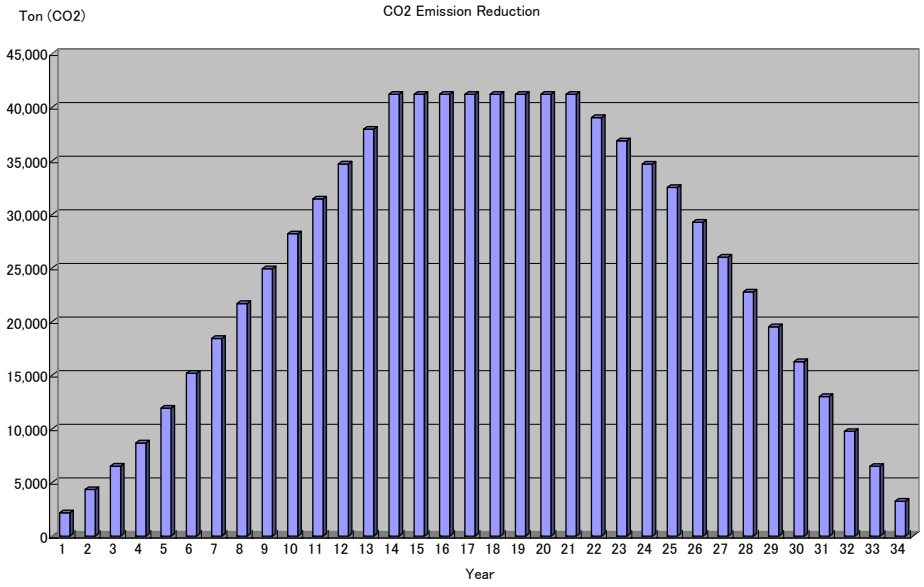
An EIA application should be done by the project proponent. States governments or local governments may be the one to do it, but it may be difficult if they are not used to that kind of procedure. In such cases, it is suggested that the REA zonal offices help them.Fundamentally, however, it is not considered appropriate that all the renewable energy projects are categorized as Category-2, which needs a partial EIA. It is reasonable, for example, to oblige them to submit only an environmental management plan instead of conducting a partial EIA for renewable project. It is suggested that a discussion be held with the MOE to change the guideline regarding this point. REA or ECN may be the best organization to play the leading role.

(3) Social environmental aspect

Attention should be paid to the consensus formation, selection of households to be electrified and others when PV electrification is to be started in a village from a social environmental aspect. Those issues should be discussed in the framework of establishment of the village organization.

(4) Reduction of CO_2 emission

PV electrification can reduce CO_2 emission produced by fossil fuel consumption. It is reported that a SHS system reduce CO_2 of 120kg/household/year in a report on the Rural Electrification and Renewable Energy Development Project, Nigeria (World Bank), and CO_2 reduction effect by the M/P was calculated based on this data. It is predicted that the emission reduction corresponds to 865,101 tons of CO_2 based on the conditions that the facilities are provided during 2007-2020 and the life of the facilities is 20 years. The effects change is shown in Fig.4-2. The reduction effect at the maximum is 41,000 tons/year.



Source: JICA Study Team

Fig. 4-2 Predicted CO2 emission reduction by the PV electrification M/P

Attachment: Battery recycling in Nigeria

(1) Battery recycling facility

JICA Study Team visited the Union Recycling Plant, located at Umuzu Otolo, Nnewi, Anambra to study the present battery recycle. The plant is owned by Union Autoparts, which is a car parts maker, established in 1987 as one of the group companies of Ibeto, petrochemical industry. Union Autoparts manufactures various kinds of car spare parts including batteries in the main factory in the premise of Ibeto Petrochemical Industry, Nnewi. The batteries they produce are all vented type, not sealed type.

The recycling plan is located in a mountainous area, 20 minutes car ride from the main factory. The batteries are taken apart and treated after removing the electrolytic solution from them. Lead, lead alloy, plastic are taken from the batteries, and slug remains. The recycling flow is shown below.

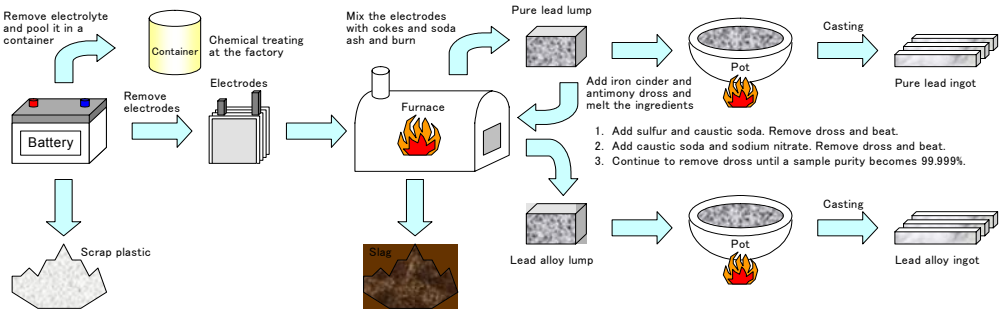


Fig. 4-3 Recycling Flow at Union Recycling Plant

Union Autparts buy used batteries from collectors, at the price of 400-480₦/piece for a small one with 50Ah. They utilize the recycled lead to manufacture new batteries. The plastic and slug obtained through the recycling process are sold to the traders to be used as recycled plastic or paving/filling materials.

(2) Disposed Battery Collectors

JICA Study Team conducted a survey on disposed battery collectors. The collectors in Kano, Akure and Owerri respectively say they can collect disposed batteries in the future in the villages where PV electrification pilot projects take place.

1) Suburb of Abuja

Sani Investment, located at Durami, a suburb of Abuja, buy the disposed batteries in and around Abuja, handling about 7,000 – 8,000 pieces of batteries per month. They sell parts of the batteries to other traders as they are, and they treat the rest parts of the batteries to take out lead alloy. The lead ally is sold to other recycling trader. The buying price of a battery is 11-12 ₦ /kg (250₦/piece for a small battery with 50 Ah), and the selling price to a trader is

400₦/piece. They handle not only ordinary batteries but also sealed type lead storage batteries. Sani Investment is running a recycling business in Sokoto State.

Sani Investment throws away the electrolytic solution without neutralization, though proper treatment is required for electrolytic solution, which is classified as a strong acid, in Japan. Therefore, it is necessary to neutralize electrolytic solution by battery collectors when they remove the solution so as to avoid negative effects on human and environment. A recommendable simple method is to add alkaline matters such as sodium bicarbonate ($NaHCO_3$), sodium hydroxide (NaOH), magnesium hydroxide (NaOH) to the electrolytic solution in a plastic container.

2) Kano (Kano State)

There seem to be no battery collectors in Jigawa, and JICA Study Team visit a battery collector in Kano city (Kano Sate), 90 minutes car ride from Dutse, capital city of Jigawa State. They collect used batteries and sell them after reproducing them. They buy batteries at the price of 200₦ /piece and sell reproduced batteries at 1,500 ₦/piece. They have ten (10) customers a day on average. The batteries that can not be reproduced are sold to a battery factory in Sabon Gari, Kano State at 300₦ /piece to be recycled(Interviewee: Mr. Solomon Battery Center, Masallagi St., Tarauni, Kano, c/o 080-2840-0797).

3) Akure (Ondo State)

JICA Study Team visited a battery collector in Akure. The number of battery collectors is limited in Akure and they may be a sole collector. They are automobile electricians and also engaged in battery sales and battery charge by grid. They collect used batteries from customers who buy new batteries, and sell them to a trader from Oyo State once in three (3) months. The selling prices are 200～300 ₦ (60Ah)、400 ₦ (100Ah)、500 ₦ (200Ah). They say they can collect disposed batteries in Oke Agunla, where a PV electrification pilot project takes place, in the future, but they want to sell new batteries at the same time (Interviewee: Mr. Akomolafe Oyewole, 29 Afere St. Owocle Qut. Akure, 080-3369-0570）.

4) Owerri (Imo State)

JICA Study Team visited a battery collector in Owerri. The number of battery collectors is also very limited in Owerri. They collect waste articles such as used metals, emptied bottles other than used batteries. They have a warehouse apart from a crowded residential area. They collect disposed batteries from automobile electricians paying 30～50 ₦ /piece or free of charge. They carry the collected batteries to Lagos or Nnewi, where battery recycling plants are located, to sell them to traders. They did not open their selling price because it is a business secret (Interviewee: Mr. Uchem Gerald, 37 Amaiybo Street, Owerri, 080-3782-1981）.

Chapter 5 Pre-Feasibility Study

5.1 Study Outline

The survey-2, part of the socio-economic rural survey, was conducted for twenty (20) villages, which were selected out of the 100 target villages of the Survey-1, through the procedure stated in 2.3.3. The field survey is placed as a preliminary study for A Pre-Feasibility Study (Pre-F/S). A Pre-F/S is conducted based on the analysis of the above survey and the knowledge obtained through the implementation of the pilot projects, and a proposal is made on a sustainable solar power utilization model and its promotion strategy in this Chapter.

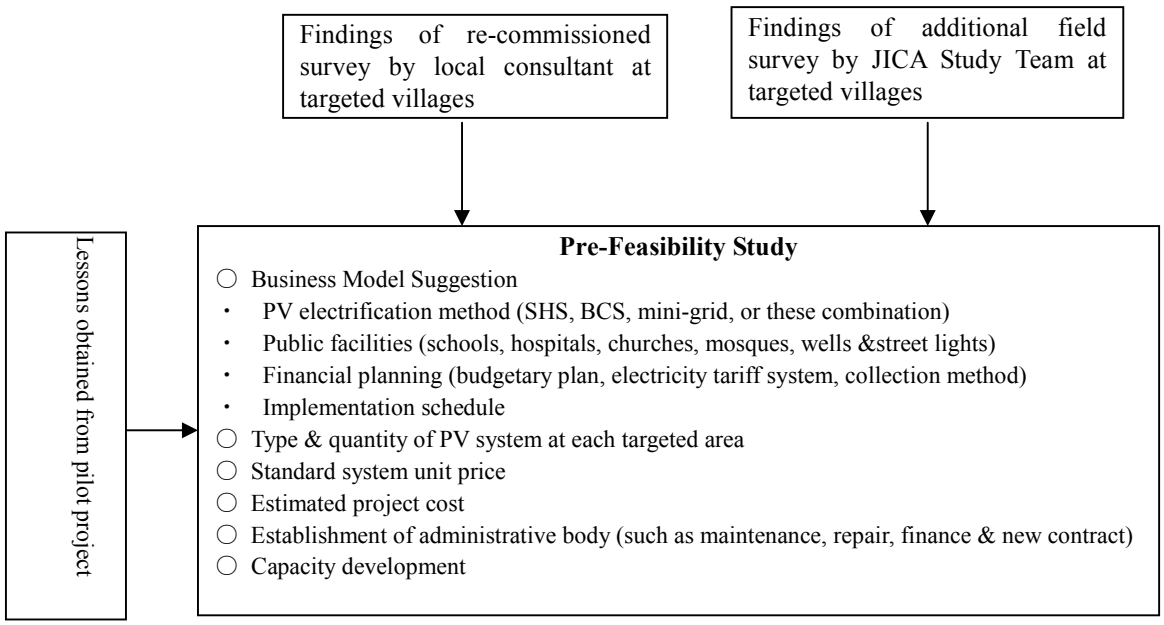


Fig. 5-1 Pre-Feasibility Study Overview

5.2 Current Situation of Target Sites

(1) Present Conditions of Pre-F/S Villages

The present conditions of the selected twenty (20) villages are shown in Table 5-1. The results of the field survey in those villages can be summarized below. There are no striking differences among villages. Those opinions may help, when a village organization for PV system is to be established. The model, which is considered as the most feasible one at present, is described in 5.5～5.7.

Table 5-1 Present Conditions of Pre-F/S Villages

Village	Population	Number of Household	Average Income* 〔N/month〕	Average expenditure for energy* 〔N /month〕			
				Kerosene	Diesel	Dry cell for radio	Total
Jigawa State							
Giginya	6,700	650	13,983	288	0	150	438
Maitsamiya	4,000	500	14,433	448	320	160	928
Jarmari	5,500	600	29,150	928	288	180	1,396
Auramo Tudu	4,600	600	5,425	172	0	160	332
Kale Hayintara	3,650	120	22,133	672	0	160	832
Dankoshe	1,970	60	9,567	704	0	120	824
Ondo State							
Tekule	1,200	117	30,833	1,426	260	180	1,866
Shegbemi	2,300	126	12,017	1,680	0	150	1,830
Oloruntedo	1,200	200	16,333	1,400	0	140	1,540
Fayomi Camp	500	62	22,333	1,400	0	NA	－
Kajola Camp	500	60	13,133	1,680	320	NA	－
Onisere	1,500	300	NA	NA	NA	420	－
Imo State							
Agunumee(Nri-Ukwu)	4,000	800	20,800	2,440	0	120	2,560
Obokuwu (Mbutu)	8,000	500	57,300	2,624	0	180	2,804
Umuokpo (Emeabiam)	3,300	1,000	21,600	1,736	0	120	1,856
Omudim(Onicha-Uboma)	6,500	1,700	21,400	1,190	0	150	1,340
Obibi(Okwuamasihe)	4,000	800	8,000	2,588	0	200	2,788
Mgbee	11,000	2,000	19,100	2,680	0	120	2,800
FCT							
Gudun Karya	1,000	100	26,333	800	6,440	200	7,440
Yelwan Gawu	1,100	100	95,717	1,200	288	360	1,848

* Average Income is the result of Survey-1, and average expense for energy is the result of Survfey-2.Therefore, both respondents and methods of those are different.
Source: JICA Study Team

(2) Business Model

As for business model (sales model and service model), almost all the residents preferred the service model. The reason is payment is relatively easy because they can avoid the large amount of the initial payment and the monthly payment is balanced. It is easily understood that a household whose average income is 170,000-340,000 N/year cannot afford to buy a SHS55W set, which costs 120,000N. And, it is also pointed out that there are no financial institutions that provide loan, even if they who want to buy PV system.

Judging from those opinions and the costs of PV facilities, it is considered as a realistic arrangement that a village organization (or an ESCO in case of mini-grid) buy all the PV facilities required in the village, and lease them to the users and provide necessary services. In the M/P study, a support structure by the local governments and the state governments, and a monitoring structure for

electrification schemes in villages by the REA Zonal offices. It is possible to confirm that the system is working so that the users can have satisfactory services under those support and monitoring structures.

(3) Tariff collection

The following opinions/ideas were raised by the residents to collect tariff properly.

Way of collection

- Collect tariff in every district under the control of the district chief

Frequency of collection

- Collect all the tariff at the time of the harvest
- Collect tariff at the end of month
- Collect tariff on every market day
- Set the best collection way and frequency for every person (eg. weekly for traders, monthly or yearly for farmers)

Management of the collected money

- Record it on the ledger and issue a receipt
- Deposit the money in the bank account, and make three (3) members signers for the bank account
- Audit the account several times a year

Idea to prevent default

- Promote lump sum payment or advance payment
- Inform that the PV system can be shifted to the person who can/will pay the tariff
- Ask participation of an authorized person in collection
- Announce the name of the defaulters
- Seize the harvest of the defaulters
- Ban the defaulters to enjoy other benefit in the village
- Impose fine

(4) Management of village organization

The following opinions/ideas were raised regarding the management of the village organization

- Include the village representative as a member
- Appoint an independent account audit
- Maintain contact with research institutes for training
- Maintain contact with PV dealers to procure necessary parts
- Include both men and women in the organization

(5) Capacity development

The following items are raised as those for which capacity development is required in the villages. The issues include not only practical ones, but also the ones with the view of future village development.

- Technical skill (installation of PV system, O&M)
- Wise use of the system to prevent much burden on the PV system
- Keeping record and accounting
-Participatory decision making
- Conflict prevention and solution of conflict
- Village organization development including providing bylaws

- Efficient evaluation of PV facilities
- Best way to select an appropriate PV dealer

5.3 Power Demand of the Target villages

(1) Electrification of houses

A survey was conducted on which type of PV system the residents want to have, and it was found that many of them desire the PV system that they cannot afford to. Then an appropriate PV system should be estimated based on their financial conditions and estimated capacity to pay. The realistic quantities of the PV system that can be introduced to each village were estimated based on the following conditions. The total amounts shown in Tables 5.4-5.7 are calculated based on the quantities estimated here.

1) It is assumed that the target households in the Survey-1 represent the whole village in view of income and expense structure. The households are supposed to pay 90% of the present expenditure for kerosene, diesel and batteries for radio. The excluded 10% is the expenditure for the energy that is still used even after PV electrification.
2) The calculated amount is an estimated capacity to pay. The amounts are categorized to six (6) brackets based on the 'Table 2-21, Chapter 2 Socio-economic Conditions and the Electricity Demand'. The distribution of the capacity to pay of each village is shown in Table 5-2.
3) The total number of households in each village was divided proportionally based on the percentage of Table 5-2. If mini-grid households and SHS165W exist together in one village, all those users are supposed to use mini-grid because it is more flexible and cheaper. It is not realistic that all the households that are capable to pay will participate in PV electrification, and therefore, it is assumed that 80% of those people will participate in it. The result is shown in Table 5-3.

Table 5-2 Distribution of the capacity to pay of each village

(Unit : %)

	Village	Not enough -800 N/month	BCS 800-1200 N/month	SHS55W 1200-1600 N/month	SHS110W 1600-2000 N/month	Mini-grid 2000-2700 N/month	SHS165W 2700－ N/month
Jigawa	Giginya	100	0	0	0	0	0
	Maitsamiya	80	0	0	20	0	0
	Jamari	40	0	40	0	20	0
	Auramo Tudu	100	0	0	0	0	0
	Kale Hayintara	80	20	0	0	0	0
	Dankoshe	60	0	40	0	0	0
Ondo	Onisere	0	80	20	0	0	0
	Oloruntedo	0	0	100	0	0	0
	Kajola Camp	0	0	60	20	0	20
	Fayomi Camp	0	0	100	0	0	0
	Shegbemi	0	0	60	40	0	0
	Tekule	0	40	20	0	0	40
Imo	Umuokpo	0	20	60	0	0	20
	Agunumee	0	0	40	0	20	40
	Umudim	25	0	75	0	0	0
	Obibi	0	0	0	0	100	0
	Ozara	0	0	0	0	40	60
	Obokuwu	0	20	0	0	40	40
FCT	Gudun Karya	0	80	0	0	0	20
	Yelwan Gawu	20	20	20	0	20	20

Source: JICA Study Team

Table 5-3 Quantities of each PV system that can be Introduced

(unit: %)

State	Village	Total Households	BCS 800-1200 N/month	SHS55W 1200-1600 N/month	SHS110W 1600-2000 N/month	Mini-grid 2000-2700 N/month	SHS165W 2700－ N/month
Jigawa	Giginya	650	0	0	0	0	0
	Maitsamiya	500	0	0	80	0	0
	Jamari	600	0	190	0	80	0
	Auramo Tudu	600	0	0	0	0	0
	Kale Hayintara	120	20	60	0	0	0
	Dankoshe	60	0	20	0	0	0
Ondo	Onisere	300	180	45	0	0	0
	Oloruntedo	200	0	160	0	0	0
	Kajola Camp	60	0	25	10	0	10
	Fayomi Camp	62	0	50	0	0	0
	Shegbemi	126	0	60	40	0	0
	Tekule	117	40	15	0	0	35
Imo	Umuokpo	1000	160	480	0	0	160
	Agunumee	800	0	255	0	380	0
	Umudim	1700	0	1020	0	0	0
	Obibi	800	0	0	0	640	0
	Ozara	500	0	0	0	400	0
	Obokuwu	500	80	0	0	320	160
FCT	Gudun Karya	100	60	0	0	0	15
	Yelwan Gawu	100	0	15	0	20	10

Source: JICA Study Team

(2) Electrification of public facilities

The residents raised a clinic, a mosque/church, street lights and others as the public facilities that they want to be electrified. The kinds and quantities are shown in Tables 5-4～5-7. Their intention that they will bear the expense for those facilities is shown in all the villages.

(3) Electrification of business equipments

A survey on electrification of business equipments is not included in the survey, but the survey was done, in Tekule, Ondo, and the followings are raised as the equipments which they want to be electrified. It is considered that there is the similar demand in other villages, and therefore, it may be desirable to keep them in mind as the next issue to be challenged.

- Milling Machine
- Wood processing machine
- Baking machine
- Oil palm processor
- Incubators for eggs
- Drier for cocoa
- Kerosene selling pump
- Pepper grinder
- Palm kernel cracker
- Welding equipment
- Hair dressing equipment

5.4 Project Implementation Period

In order to implement an off-grid PV rural electrification project in Nigeria, taking technical standards of implementing agencies of the governments and the private PV industry into account, it is necessary to provide soft-technical support in establishing an operation and maintenance organization at the community and state government level. Therefore it is important to apply REF (Rural Electrification Fund) or aid-scheme by other donors for Rural Electrification in combination

with such soft-technical support. In other words, after procurement and installation of PV system, Capacity Development (CD) for village electrification committee and State / Local Government is required from time to time for payment collection and minor repair works on PV equipment. Thus it is better to provide a scheme enabling feasible project implementation by creating a proper operation and maintenance system through careful technical guidance by experts on PV rural electrification.

In the event of implementing this Pre-F/S, with the experience of detail design, tender opening and supervising the Pilot Project, the following project implementation shall be scheduled. In such case, since a minimum twenty (20) months is required from the start of the Basic Design Study to the completion of installation work, and taking into consideration the support over an extended period of time, the implementation schedule shall be carefully examined.

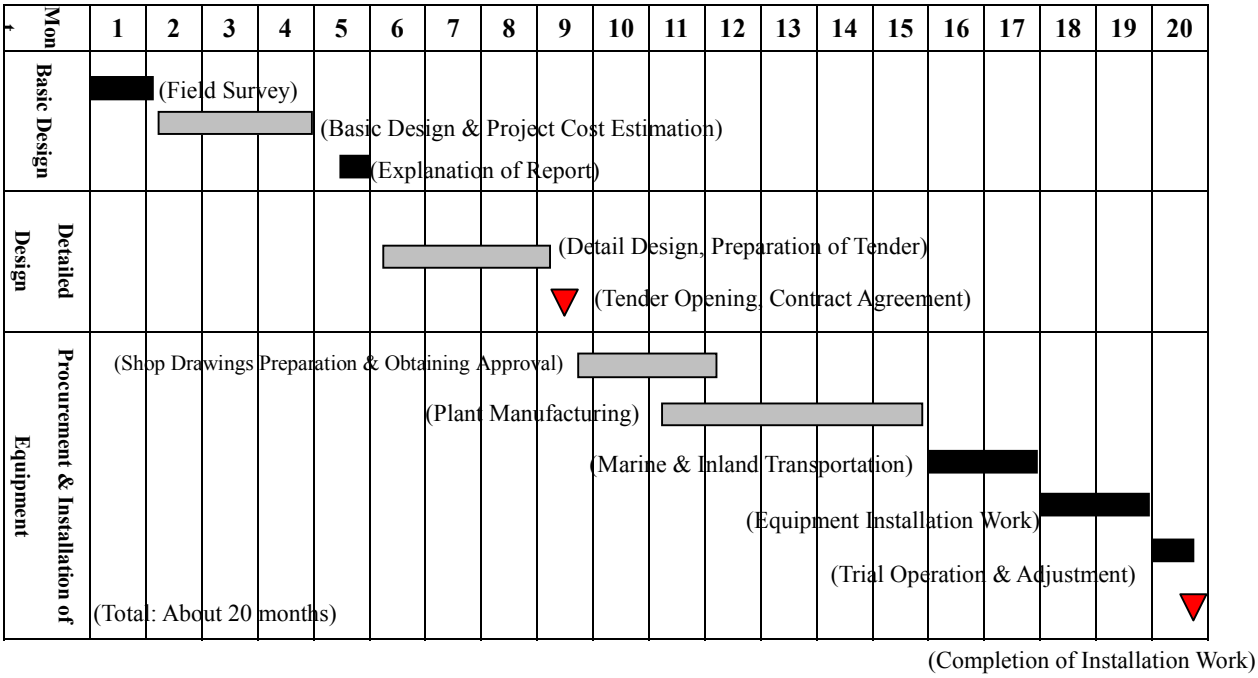


Fig. 5-2 Project Implementation Schedule

5.5 Business Model

As for the business model in the Pre-Feasibility Study, Service Model will be preferred instead of Sales Model since it is assumed that Nigerian Government (Federal or State Government) own and maintain PV equipment. Also it should be noted that intensive Operation and Maintenance system will be required as Mini-grid system in addition to BCS and SHS is expected to be introduced.

In case of Pilot Project, operation and maintenance will be directly entrusted to local residents by establishing village electrification committee, instead of newly introducing private PV dealers. In such a way, necessary cost for Operation and Maintenance will be reduced as well as ownership of system users will be raised. In Jigawa State there is the Jigawa Alternative Energy Fund (JAEF), a local NGO acting as the existing maintenance body, so organizational operation is possible with the collaboration of the said body. In other states, following measures will be introduced to support Operation and Maintenance by local residents. It is agreed that necessary cost allocation and liaison

system will be coordinated and established through monitoring on the Pilot Project.

1) Researchers from Sokoto Energy Research Centre will handle technical problems in Jigawa State, and researchers from Nuska Energy Research and Development Centre will handle technical issues in Ondo and Imo State as well.
2) The Electricity Bureau in each state will transfer technical knowledge and experience obtained through the Pilot Project, and support local organization in parallel with support structure proposed in the above 1).
3) Engineers and technicians from ECN will periodically supervise and train the local technicians at site to transfer basic technical knowledge for PV system and support local organization.

However, since the Pilot Project has not yet been implemented in the FCT (Federal Capital Territory), by inviting personnel from the Electricity Bureau to the Electricity Bureau in Jigawa and Ondo States and targeted sites of the Pilot Project, necessary information on completing forms for maintenance and manuals should be developed in a horizontal manner.

5.6 Expected introduction of PV Systems

(1) Solar Home System (SHS)

In the Pilot Project, a 55W solar home system (SHS) was introduced in order to reduce the burden of electricity tariff payments on poor residents and to use as many households as possible. In due consideration of the findings of the socio-economic rural survey and community discussions, three (3) capacities: 55W, 110W and 165W will be selected for the Pre-Feasibility Study according to the user's ability to pay.

1) 55W System

Taking the small initial investment and monthly payments of electricity tariff into account, a 55Wsystem is the most popular system mainly for lighting demand. Despite the installation of outlets, the system is limited to small equipment such as radios, so black and white televisions cannot be used.

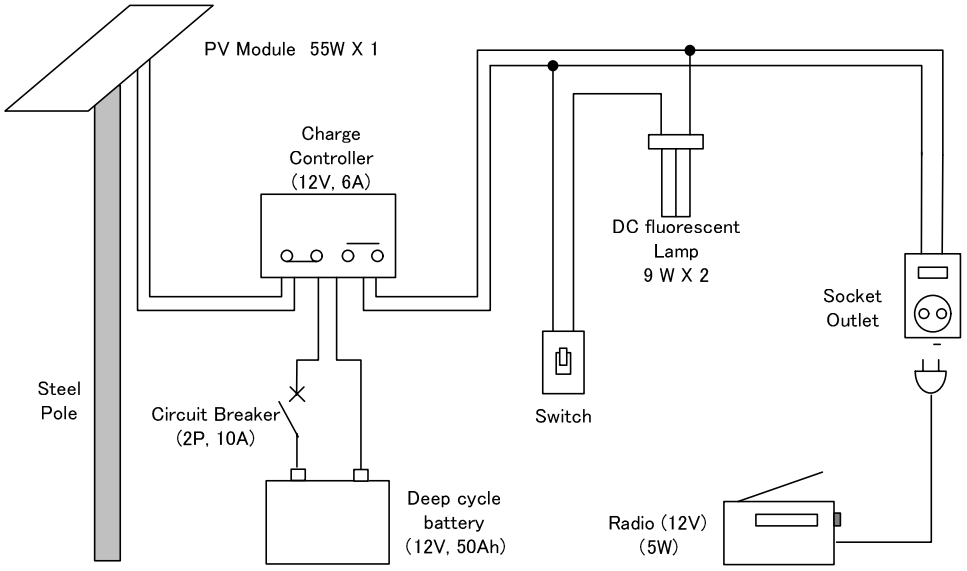


Fig. 5-3 Standard SHS (55W) Configuration

2) 110W System

A 55W system is limited to 2 fluorescent lamps maximum (usage time is 4 hours per day) and 2 hours for a radio (5W). Moreover, the system cannot utilize televisions, which are very popular in Nigeria. Therefore, the 110W system is recommended for consumers who can handle an increase in service charges. The 110W system can handle up to the maximum 4 fluorescent lamps (usage time is 4 hours per day) in addition to 2 hours per day for a black and white TV (30W) or radio. However, consumers should be made fully aware when choosing a system where battery capacity of the 55W system will be increased from 50Ah to 120Ah to cope with the increase in PV module capacity, and necessary increase in cost for battery replacement.

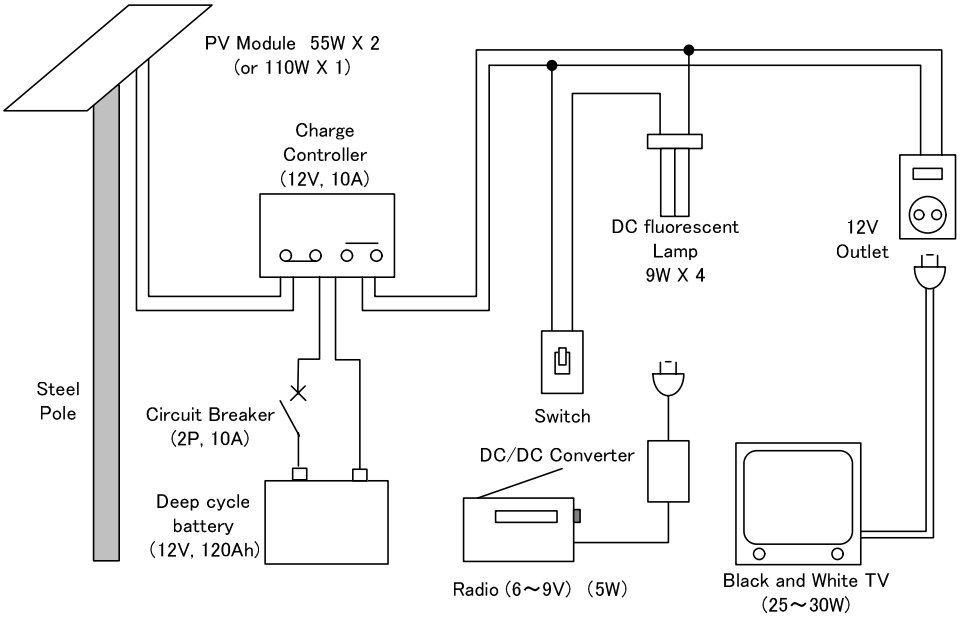


Fig. 5-4 Standard SHS (110W) Configuration

3) AC System

If a SHS is diffused on a commercial basis in Nigeria in the future, the first persons to introduce the system in the villages will be the wealthy such as village chiefs and the majority of anticipated consumers who already own a color television or refrigerator using a private generator. An AC SHS adopting an inverter will therefore be examined as a system for well-off users. The said system can be utilized up to 4 hours for fluorescent lamps (40W × 6 units) and 8 hours for a color television (300W), 8 hours for a refrigerator and 8 hours for a ceiling fan daily. However, 150W is necessary for a PV module output, so the number of consumers who can afford a higher initial investment and maintenance cost should be confirmed should trouble arise. Simultaneously, an after-service system by a PV company should be established in the targeted areas.

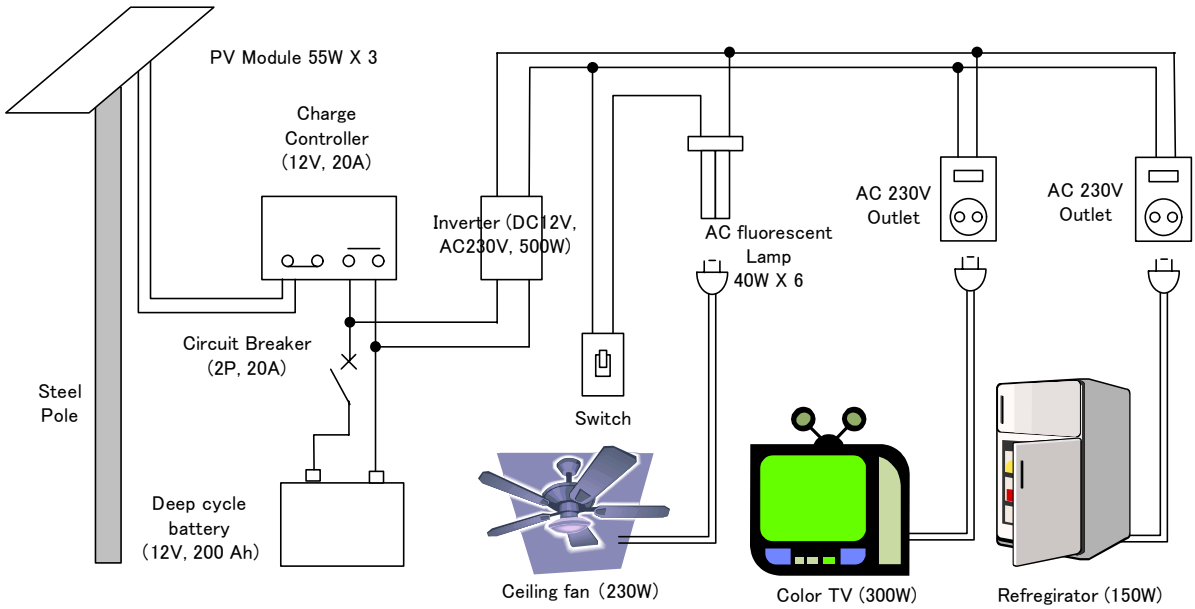


Fig. 5-5 Standard SHS (AC System) Configuration

(2) Battery Charging Station (BCS)

The following socio-economic conditions for diffusing a BCS can be assumed:

- Residents are concentrated in a village.
- The head (village chief) has strong control and a climate in which users will observe certain rules such charging regulations exists.
- The average income of residents is so low that the paying of electricity tariffs will be difficult if a SHS is introduced.

The initial cost of a BCS is cheaper that a SHS (55W) per household and there might be room to examine its introduction only in a case where the conditions are satisfied and residents of the proposed sites agree to bear the cost of equipment to be installed (such as batteries, in-house wiring and lighting) and the cost of installation work.

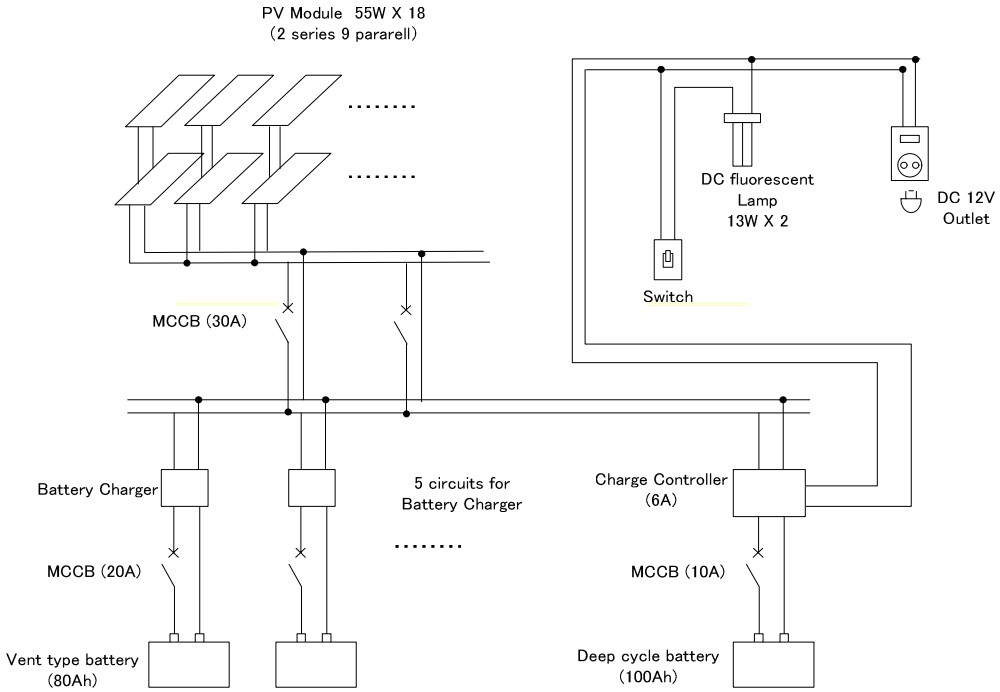


Fig. 5-6 Standard BCS System Configuration

(3) Mini-grid System

To meet the demands of residents who intend to utilize an AC load such as color TVs, fans and refrigerators, the ECN has taken initiatives to introduce its introduction since the 1990s. The mini-grid system is easier maintained than an independent type SHS as the system can be maintained intensively. Also it has an advantage to apply AC system, however, users should be fully aware that electricity cannot be freely utilized so the available time and capacity of equipment will be restricted to prevent over discharging of batteries.

The results of a mini-grid system designed for twenty (20) general consumers are shown in Fig. 5-7. For instance, in the case of a village of one hundred (100) households, five (5) systems as described can be connected in a parallel manner.

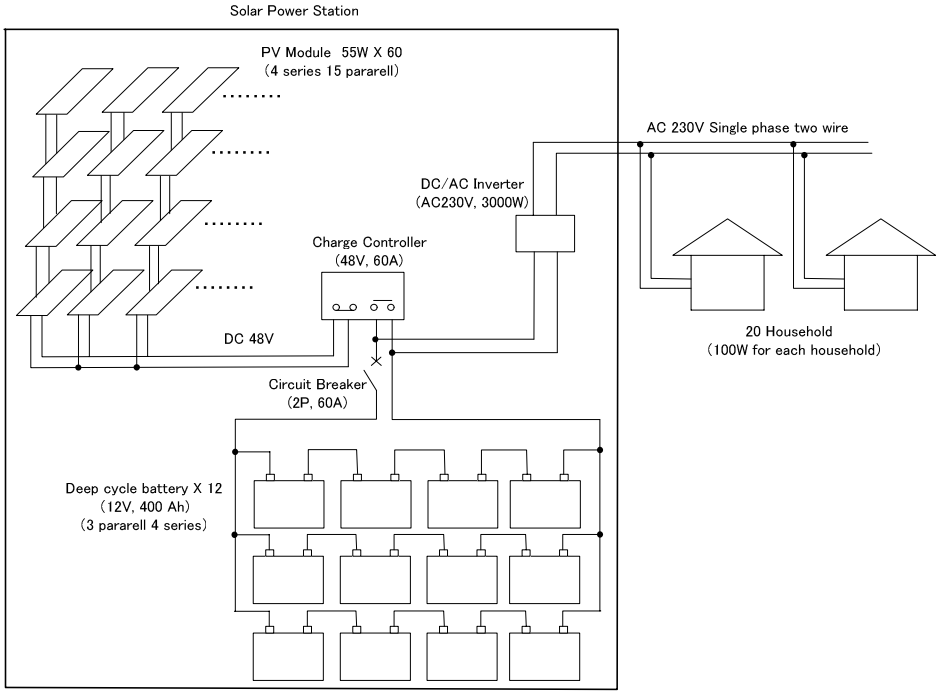


Fig. 5-7 Standard Mini-grid System Configuration

(4) Public Facilities

Taking into consideration the findings of the socio-economic rural survey and field survey of targeted villages in the Pre-Feasibility Study, PV systems are expected to be introduced in following facilities in Nigeria.

1) Schools

Schools are utilized not only for children's lessons, but also for adult education or community meetings in the evening. Potential demand for lighting is high at schools in un-electrified areas where kerosene lamps are presently utilized. Other than lighting equipment, it will be possible to utilize ceiling fans which will improve learning environments in the intense heat, to introduce personal computers and printers as part of IT education, and to utilize televisions and video recorders when adopting audio visual materials, and electric sewing machines for home economics classes.

In addition, since wells are often constructed in school yards in Nigeria as a source of valuable drinking water, not only for children, but also for residents in the communities, a fairly high potential to introduce solar pumping systems utilizing PV exists.

2) Clinics

By introducing PV to un-electrified clinics where kerosene lamps are presently utilized, it will be possible to utilize lighting equipment for medical examinations and treatment at night by utilizing lighting equipment. Although refrigerators for storing vaccines for endemic diseases are available in Nigeria in addition to lighting equipment, if PV is disseminated in the future, it will be possible to introduce more diversified medical equipment such as wireless telephones or blood cell

counters during emergencies.

3) Churches and Mosques

If the village size is medium or larger, there will certainly be a church or mosque, which is a place used for regular community meetings as well as for religious purposes, so the frequency of its utilization is high. It may be possible to utilize lighting equipment and acoustical instruments such as amplification equipment (microphones and speakers) and cassette recorders in those facilities.

4) Street Lights

In addition to problems related to peace and order, such as robbery and theft after sunset, in rural communities women and girls are sometimes attacked by wild nocturnal animals such as snakes and scorpions, and therefore are unable to venture out safely in the evening. Accordingly, from a gender point of view, the living environment will be improved if street lights are installed at major intersections in villages.

5) Solar Pumping System

A PV well pumping system can store potential energy from water by combining it with an elevated water tank (standard capacity: 1,000 gallon) so that batteries used for storing electricity will be necessary and equipment easily maintained. This system is preferable in the early stage of introducing PV electrification. However, technical support from manufactures and builders is vital in securing the maintenance system for a PV system. In Nigeria, systems are in place mainly in the northern semiarid zone. Although AC pumping systems were initially introduced, suspension of operations became a problem due to inverter breakdowns, so a DC pumping system has been more popular in recent years.

As a result of the re-commissioned survey, hand (manual) pumps or diesel engine pumps have been adopted in the targeted villages in the Pre-Feasibility Study. Since the lift head is 100m or less and the standard pumping discharge of the pumps is $25m^3$/day, a DC pumping system will be introduced in this project for easy operation and maintenance for the purpose of providing the minimum drinking water.

5.7 Estimated Project Cost

The results of the estimated project cost are shown as follows by totaling the quantity requested by the targeted villages in the Pre-Feasibility Study for each PV system introduced in 5.6 and applying the unit prices estimated by local PV agents.

It is assumed to be difficult for an ESCO to get enough profit as the quantities to be introduced to the respective villages are small, therefore, a financial analysis is not done. Only an economic analysis was done under the conditions that 50% of the initial investment cost is subsidized by the government as the same as grid electrification.

(1) Jigawa State

A smaller-scale system (55W) of SHS has been requested in Jigawa State and there is a very high possibility for introducing solar pumps for the purpose of securing water resources in the northern part of Nigeria. One (1) village has requested a BCS since ability to pay is lower and expected power consumption is smaller than other villages according to socio-economic survey result.

Table 5-4 Quantity and Reference Prices for PV System Introduction in Jigawa State

	Quantity by vllage						Total Quantity	Estimated Unit Price (NGN)	Total Price (NGN)
	Giginya	Maitsaniya	Jamari	Auramotudu	Kale Hayintara	Dankoshe			
SHS(55W)						20	20	195,000	3,900,000
SHS(110W)		80	190				270	259,000	69,930,000
SHS(165W)							0	434,000	0
BCS					2		2	3,100,000	6,200,000
Mini-Grid			4				4	6,000,000	24,000,000
Solar Pump	1	1		1	1		4	5,500,000	22,000,000
School	1	1	1	1	2	1	7	900,000	6,300,000
Clinic	1	1	1		1	1	5	1,800,000	9,000,000
Mosque	3	5	4		10	1	23	900,000	20,700,000
Street Light	13	15	18	13	40		99	150,000	14,850,000
Total									176,880,000

The economic internal return rate (EIRR) is 38.6%, the environmental net present value (ENPV) is 92,895,000NgN, and the B/C ratio, calculated applying 10% of discount rate following the common way of economic evaluation of the JBIC, WB and ADB, is 2.55, based on the economic analysis and the project is judged to be meaningful.

(2) Ondo State

One might say that the hierarchical groupings of the poor who wish a 55W SHS and the rich who wish a 165W SHS have grown. Right now it is expected to be difficult to introduce Mini-grid system since capacity for village organization for operation and maintenance is not enough. Two (2) villages have requested solar pumps, so the requests are regarded to be appropriate based on the size of each village.

Table 5-5 Quantity and Reference Prices for PV System Introduction in Ondo State

	Quantity by village						Total Quantity	Estimated Unit Price (NGN)	Total Price (NGN)
	Onisere	Oloruntedo	Kajola camp	Fayomi camp	Shegbemi	Tekule			
SHS(55W)	45		25	50	60	15	195	195,000	38,025,000
SHS(110W)		160	10		40		210	259,000	54,390,000
SHS(165W)			10			35	45	434,000	19,530,000
BCS	9					2	11	3,100,000	34,100,000
Mini-grid							0	6,000,000	
Solar Pump	2			1			3	5,500,000	16,500,000
School	1	1	1				3	900,000	2,700,000
Clinic	1					1	2	1,800,000	3,600,000
Mosque, Church	5	9	2	1		10	27	900,000	24,300,000
Street Light	25	20				13	58	150,000	8,700,000
Community Space							0	900,000	0
Total									201,845,000

The economic internal return rate (EIRR) is 34.8%, the environmental net present value (ENPV) is 113,394,000NgN, and the B/C ratio is 2.39, and the project is judged to be meaningful.

(3) Imo State

Of the three types of SHS, a large-scale system (165W) to handle AC load has been requested in Imo State. Also mini-grid system could be introduced for four (4) villages where average energy consumption is higher. However, it is not assumed that almost 100% of rural households, including the poor, will be able to pay necessary charges for maintenance. Thus following figures are compiled based on the estimation of possible demand of PV system as noted in 5.3.

Table 5-6 Quantity and Reference Prices for PV System Introduction in Imo State

	Quantity by village						Total Quantity	Estimated Unit Price (NGN)	Total Price (NGN)
	Umuokpo	Agunume	Umudim	Obibi	Ozara	Obokuwu			
SHS(55W)	480	255	1020				1755	195,000	342,225,000
SHS(110W)							0	259,000	0
SHS(165W)	160					160	320	434,000	138,880,000
BCS	8					4	12	3,100,000	37,200,000
Mini-Grid		19		32	20	16	87	6,000,000	522,000,000
Solar Pump			1				1	5,500,000	5,500,000
School					1		1	900,000	900,000
Clinic	1		1				2	1,800,000	3,600,000
Mosque							0	900,000	0
Street Light	10	20	10	20	20	20	100	150,000	15,000,000
Community Space		1		1		1	3	900,000	2,700,000
Total									1,068,005,000

The economic internal return rate (EIRR) is 41.1%, the environmental net present value (ENPV) is 1,020,069,000NgN, and the B/C ratio is 2.73, and the project is judged to be meaningful.

(4) FCT (Federal Capital Territory)

In the Federal Capital Territory, in a similar manner as Imo State, SHS(55W) and large-scale systems (165) that can handle AC load will be introduced. Solar pumping systems and PV electrification at public facilities such as schools and street lights are most often requested.

Table 5-7 Quantity and Reference Prices for PV System Introduction in FCT

	Quantity by village		Total Quantity	Estimated Unit Price (NGN)	Total Price (NGN)
	Gudun Karya	Yelwan Gawu			
SHS(55W)		15	15	195,000	2,925,000
SHS(110W)			0	259,000	0
SHS(165W)	15		15	434,000	6,510,000
BCS	3		3	3,100,000	9,300,000
Mini-grid		1		6,000,000	
Solar Pump	2	1	3	5,500,000	16,500,000
School	1	1	2	900,000	1,800,000
Clinic	1	1	2	1,800,000	3,600,000
Mosque, Church	5	2	7	900,000	6,300,000
Street Light	10	20	30	150,000	4,500,000
Police office		1		900,000	0
Court		1	1	900,000	900,000
Total					52,335,000

The economic internal return rate (EIRR) is 36.0%, the environmental net present value (ENPV) is 20,235,000NgN, and the B/C ratio is 2.46, and the project is judged to be meaningful.