The Federal Republic of Nigeria
Federal Ministry of Power and Steel (FMPS)
Federal Ministry of Science and Technology (FMST)
Energy Commission of Nigeria (ECN)
Rural Electrification Agency (REA)

The Master Plan Study for Utilization of Solar Energy in the Federal Republic of Nigeria

Final Report

Volume 1 Summary

February, 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

RECS INTERNATIONAL INC.

PREFACE

In response to a request from the Federal Republic of Nigeria, the Government of Japan decided to conduct "The Master Plan Study for utilization of solar energy in the federal republic of Nigeria" and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA dispatched the study team headed by Mr. Mitsuhisa NISHIKAWA of Yachiyo Engineering Co., Ltd. and organized by Yachiyo Engineering Co., Ltd. and RECS International Inc. to Nigeria six times from June 2005 to February 2007.

The study team had a series of discussions with the officials concerned of the Government of Nigeria and conducted related field surveys at the study area. Upon returning to Japan, the study team conducted further studies and compiled the final results in this report.

I hope that this report will contribute to the promotion of the plan and to the enhancement of amity between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Nigeria for their close cooperation throughout the study.

February 2007

Tadashi IZAWA
Vice President
Japan International Cooperation Agency

Mr. Tadashi IZAWA
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

February 2007

Dear Sir
It is my great pleasure to submit herewith the Final Report of "The Master Plan Study for Utilization of Solar Energy in the Federal Republic of Nigeria".

The Study Team that consists of Yachiyo Engineering Co., Ltd. and RECS International Inc. conducted field surveys including pilot projects in Nigeria over the period between June, 2005 and February, 2007 according to the contract with the Japan International Cooperation Agency (JICA).

The Study Team compiled this report, which proposes Master Plan and Action Plan for PV Rural Electrification, Action Plan for Research and Development of Solar Energy Technology, Action Plan for Awareness Raising of Solar Energy, etc, through close consultations with officials concerned of the Government of the Federal Republic of Nigeria and other authorities concerned.

On behalf of the Study Team, I would like to express my sincere appreciation to officials concerned of the Government of Nigeria and other authorities concerned for their cooperation, assistance, and heartfelt hospitality extended to the Study Team.

We are also deeply grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Economy, Trade and Industry, and the Embassy of Japan in Nigeria for their valuable suggestions and assistance during the course of the Study.

Yours faithfully,

Mitsuhisa Nishikawa
Team Leader
The Master Plan Study for
Utilization of Solar Energy in the
Federal Republic of Nigeria

THE MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA

FINAL REPORT
(VOLUME 1 SUMMARY)

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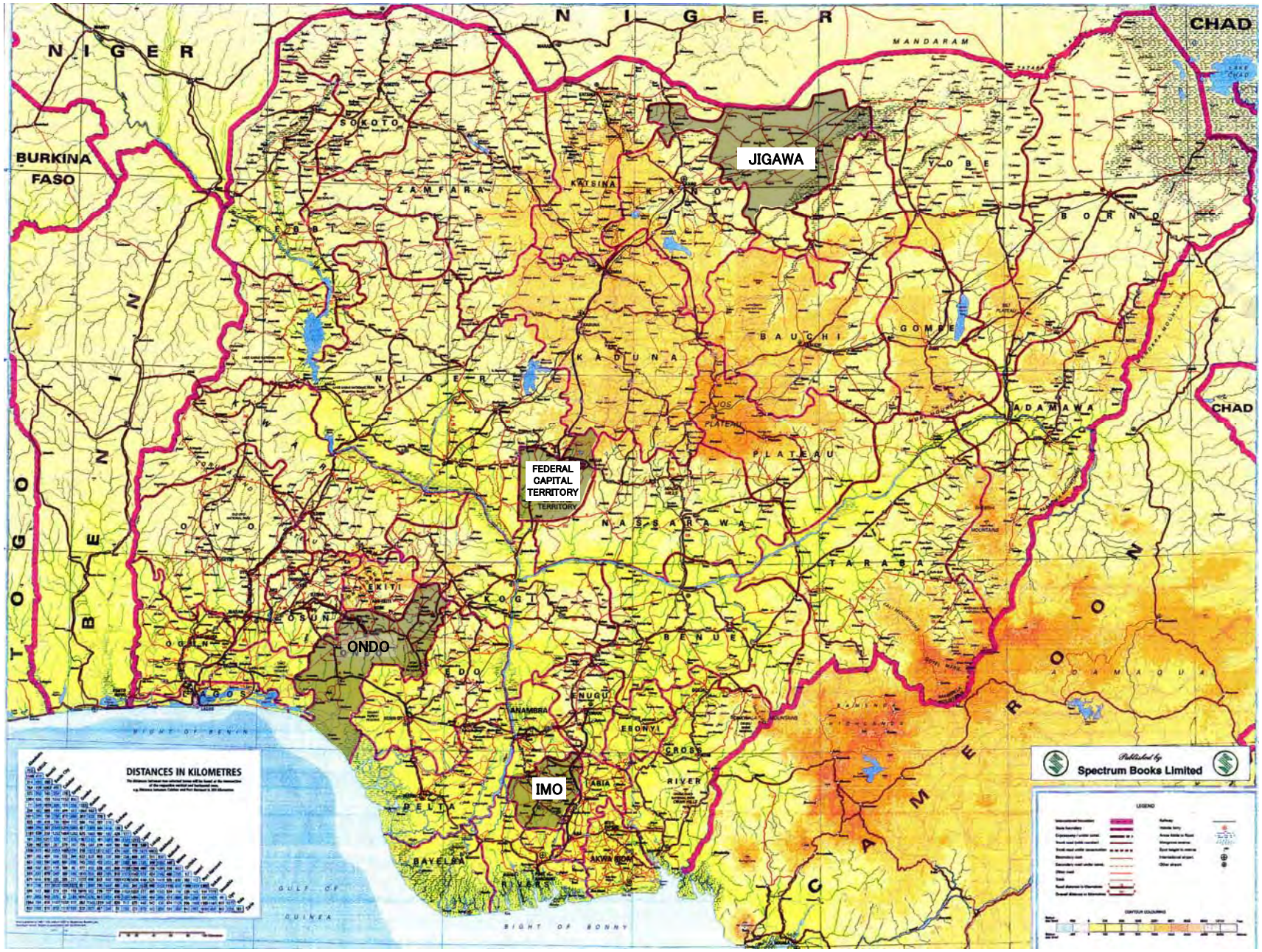

Study Area in the Federal Republic of Nigeria

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ABBREVIATION

B/C Ratio	Benefit/Cost ratio
BCS	Battery Charging Station
BPE	Bureau of Public Enterprises
CD	Capacity Development
ECN	Energy Commission of Nigeria
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FCT	Federal Capital Territory
FIRR	Financial Internal Rate of Return
ENPV	Economic Net Present Value
FNPV	Financial Net Present Value
FMPS	Federal Ministry of Power and Steel

(Federal Ministry of Power and Steel (FMPS) was reorganized to Federal Ministry of Energy on January 2007)

FMST	Federal Ministry of Science and Technology
IEC	International Electrotechnical Commission
IPP	Independent Power Producer
ISO	International Organization for Standards
JAEF	Jigawa Alternative Energy Fund
JICA	Japan International Cooperation Agency
JIS	JAPANESE INDUSTRIAL STANDARD
JWG	Joint Work Group
LGA	Local Government Area
LWG	Local Work Group
NCERD	National Center for Energy Research and Development - the University of Nigeria, NSUKKA, Enugu State
NEDO	New Energy Development Organization
NEPA	National Electric Power Authority
NESCO	National Electricity Supply Corporation (Nigeria) Limited
NERC	National Electric Regulatory Committee
NIMET	Nigeria Meteorological Agency
NPC	National Planning Commission
O&M	Operation and Maintenance
OSEB	Ondo State Electricity Board
PDM	Project Design Matrix
PHCN	Power Holding Company of Nigeria
PURD	Imo State Ministry of Public Utilities and Rural Development
REA	Rural Electrification Agency
REF	Rural Electrification Fund
SELF	Solar Electric Light Fund
SERC	SOKOTO Energy Research Center
SHS	Solar Home System
USAID	United States Agency for International Development
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

CONCLUSIONS AND RECOMMENDATIONS

1. Electrification Policies of Nigeria

1.1 Electrification Target : The National Economic Empowerment and Development Strategy (NEEDS) which commenced in March, 2004 sets an electrification target of providing 75% of the entire population with access to electricity by 2020.

1.2 Rural Electrification : The medium to long-term target for rural electrification set by the FMPS in 2004 under the Rural Electrification Policy envisages that at least 10% of new users will be supplied with electricity using renewable energies.

1.3 Use of Renewable Energies : At present, the FMPS is preparing the Renewable Electricity Policy Guidelines along with the Renewable Electricity Action Programme designed to specify concrete measures in conformity with the said Guidelines.

2. Solar Energy Utilisation Policy

The Renewable Electricity Action Programme adopts the targets shown in the table below for the introduction of renewable energies. According to this table, solar energy is required to supply approximately 18% of the electricity generated by renewable energies.

Introduction Targets for Renewable Energy in Nigeria

(Unit: MW)

Type of Renewable Energy	Introduction Target		
	2007	2015	2016
Mini-Hydroelectric Power	50	100	400 (54.4%)
Solar Energy (PV)	10	20	130 (17.7%)
Wind Power	0	20	100 (13.6%)
Biomass Gas	0	15	105 (13.6%)
Total	60	155	735 (100.0%)

Source: FMPS, “Renewable Electricity Action Programme”

3. Status of the M/P

The status of the M/P is considered to be a medium to long-term master plan for the promotion of off-grid rural electrification using solar energy to materialise the Rural Electrification Policy and the Renewable Electricity Policy Guidelines, etc., both of which are based on the National Economic Improvement and Development Strategy (NEEDS).

4. Actual Introduction of PV Systems by the Government and Donors up to the Present

Implementing Body	Implementation Period	Project Outline
FMST (ECN)	Continual since 1990	Electrification of six villages using an AC mini-grid system; the generating capacity of each system is 10 KW or higher.
		Installation of a 2 – 5 KW system at university laboratories and dormitories, etc. (36 sites)
		Installation of an AV pump for irrigation (1.5 – 2 KW) at 18 sites
		Introduction of a PV refrigerator for vaccine storage (0.45 KW) at 36 sites
		Installation of a radio communication system at 4 sites
FMPS	Equipment procurement stage as of October, 2006	Introduction of a SHS (module: 50 Wp) at 250 households in each of Bauchi State and Katsina State
		Introduction of a mini-grid system (17.5 KW) in Ogun State and Cross River State
		Introduction of a community system (module: 200 Wp to serve 10 11W fluorescent lamps) at 9 sites
		Installation of a street lamp (module: 42 Wp or higher) at 36 sites and a PV pump at 28 sites
Sokoto State	2003	Installation of a PV pump at 8 sites
Lagos State		Installation of a PV pump at 1 site (on a remote island)
USAID	2004	Introduction of SHSs, street lamps, AV pumps and PV systems for public as well as commercial facilities in five villages in Jigawa State
UNDP	2006 – 2007	Planned introduction of a mini-grid system in 6 villages nationwide, supplying electric power for up to 1,000 households, pumps and public facilities
UNIDO	Planning stage	Introduction of a BCS system for individual entrepreneurs using micro-finance
UNICEF		Introduction of AV pumps in Plateau State in addition to the introduction of PV refrigerators in Sokoto State in 2001

5. National PV Rural Electrification M/P (PV Electrification Programme)

(Unit: households)

PV Electrification Programme up to 2010					PV Electrification Programme up to 2020 (Aggregate)				
BCS (760 System)	SHS		Mini-Grid (860 System)	No. of Electrified Households (1.8% of the Total)	BCS (1,210 System)	SHS		Mini-Grid (11,250 System)	No. of Electrified Households (1.8% of the Total)
	RESCOs; VEAs	Direct Sale				RESCOs; VEAs	Direct Sale		
15,200	34,110	3,790	19,200	72,300	24,200	84,810	9,290	225,000	343,000

The number of electrified households is calculated based on the following assumptions.

① 75% of the people in Nigeria will have access to electricity supply by 2020 as planned by the NEEDS.
② At least 10% of new users with access to electricity supply will use a renewable energy in accordance with the Rural Electrification Policy.
③ Among the new users electrified by one type of renewable energy or another, 1.8% will use a PV system as targeted by the Renewable Energy Action Programme.

6. PV Electrification Programme and Funding Demand

When the PV electrification programme is contnually implemented up to 2020 in accordance with the National PV Rural Electrification M/P described above, the total investment amount and amount of subsidy (based on a 50% subsidy rate) will be those shown in the tables below.

Required Investment Amount to Materialise the National PV Electrification Programme

(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

Required Amount of Subsidy to Materialise the National PV Electrification Programme

(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: The Study Team

The annual amount of subsidy will be approximately NgN 1.2 billion at the beginning, followed by a period during which the amount will vary between NgN 1.2 billion and NgN 1.5 billion before starting to decrease in 2017. In 2020, the subsidy will be abolished. The aggregate of the subsidy up to 2020 is NgN 15.6 billion.

7. Present Situation and Problems of PV-Related Private Companies

According to ECN statistics, the number of PV-related private companies in Nigeria was 44 in 1999 and the number is inferred to have increased to approximately 50 today. Of these companies, approximately 70% are believed to have their registered office in Lagos. At present, these companies have experience of selling and installing small systems/equipment but do not conduct regular system maintenance or tariff collection (former PHCN monopolises such work for on-grid electrification projects).

For the promotion of PV rural electrification projects, the fostering of RESCOs (Rural Energy Supply Company) as the leading players is important for the introduction of PV systems by the private sector. For this reason, the Government of Nigeria should make arrangements so that RESCOs can be entrusted to conduct regular system maintenance and tariff collection (including the necessary revisions of the relevant laws) and should also train engineers working for private companies. In the medium to long-term, the public sector should gradually reduce the scope of its businesses to policy planning and project supervision, etc. while examining and introducing measures to maximise the use of the private sector to conduct such businesses as equipment procurement and installation, system maintenance and tariff collection.

8. Recommendations for the Promotion of the National PV Electrification Programme

8.1 Federal government organizations (FMPS, FMST, ECN and REA) acting as the counterparts for the Study and state/local governments in Nigeria must clarify their respective roles, duties and responsibilities and preserve the functioning of the Joint Working Group (JWP) after the formulation of the M/P so that the M/P can be incorporated into the Renewable Electricity Policy Guidelines. They should also cooperate with each other to promote PV rural electrification, raise awareness of, extend and conduct R & D on PV systems and develop human resources.

(1) As the policy planning body as well as supervisory body for the implementation of rural electrification projects, the FMPS should formulate detailed rules for the implementation of rural electrification policies, clarify the situation of project implementation by the REA, state/local governments and RESCOs at the national level, develop standards for the specifications and installation of PV equipment (systems) and establish an equipment certification (type approval) system.

It is also desirable for the FMPS to try to reduce the initial investment amount which is required to introduce PV systems. The relevant measures include the reduction of import duties and VAT on equipment and the reduction of the corporate tax on PV-related private companies. The FMPS should also formulate an environmental management plan and urge the Federal Ministry of the Environment to exempt the operation of PV systems from the subject issues of EIA.

(2) The FMST controls the energy R & D centres at Sokoto and Nsukka to promote the R & D of PV-related equipment and should develop standards for the specifications and installation of PV equipment (systems) in collaboration with the FMPS. The FMST will be responsible

for quality inspection and acceptance testing, etc. At the same time, the FMST should attempt the transfer of manufacturing technologies for the developed products to private companies for the purpose of fostering the PV equipment manufacturing industry and raising awareness of PV systems. The FMST should also gather information and reference materials on the utilisation of solar energy of other organizations and donors with a view to spreading such information, etc. to related organizations and private companies and strengthening the collaboration with donors and international organizations for the extension of PV systems.

(3) The ECN should make efforts to spread the technical know-how on PV systems (on planning, system design, work order placement and work supervision, etc.) which has been accumulated through past projects involving the SHS and mini-grid systems, etc. to the relevant persons of other organizations as well as state/local governments in Nigeria and should also organize technical training courses for engineers and technicians of state/local governments and those of village organizations and RESCOs operating PV systems who are engaged in the operation and maintenance of PV systems.

The ECN should also use its technical know-how on PV systems for the training of engineers of private companies by means of organizing seminars and workshops.

(4) The REA should act as the leading organization for the implementation of both policies for the rural electrification projects formulated by the FMPS and the M/P, secure a stable funding source required for PV electrification with the introduction of a special purpose surcharge of 2% on the electricity revenue and prioritise future rural electrification projects using the Rural Electrification Fund in accordance with the M/P. The REA should try to commence the early operation of the Rural Electrification fund so that village electrification associations and private companies (RESCOs and others) can implement PV rural electrification at the earliest opportunity and also establish a low interest loan system with the cooperation of the PBN and other public financial institutions which have been founded to assist the socially weak.

Furthermore, the REA as the regulatory body for rural electrification projects should prepare safety rules, technical standards and service standards for rural electrification projects which are implemented by village electrification associations and private companies (RESCOs and others).

(5) State/local governments should promote PV rural electrification in their areas in cooperation with the REA in accordance with the rural electrification policies formulated by the FMPS. They should also monitor PV rural electrification projects in progress and collaborate with the higher organization to deal with technical problems which cannot be solved at the local level. If similar rural electrification projects are planned in other villages, state/local governments should extend their operation and maintenance know-how to these villages.

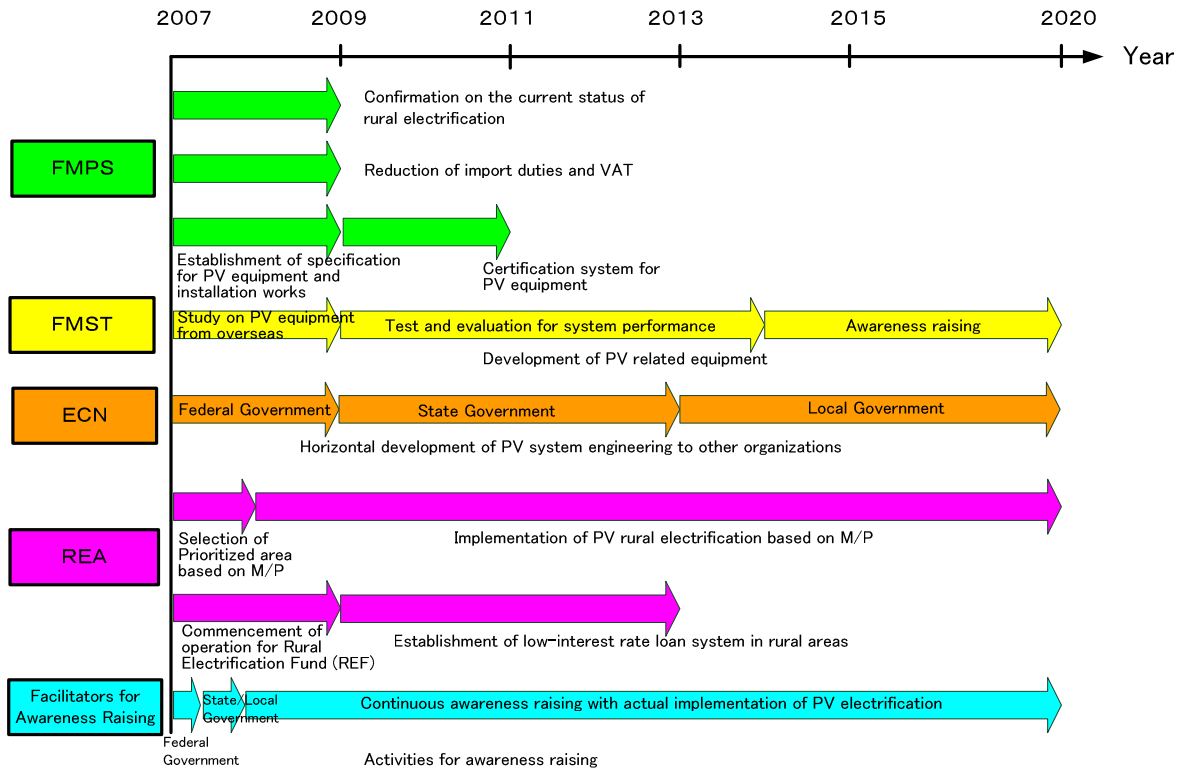
8.2 The FMPS and ECN should introduce measuring instruments and inspection equipment, etc. indicated by the R & D Action Plan in the M/P to the energy R & D centres at Sokoto and Nsukka to promote R & D on the utilisation of solar energy at these centres.

8.3 The Nigerian counterparts (FMPS, FMST, ECN and REA) for the Study should use the log sheet provided by the Study Team to continually monitor the operation and maintenance conditions and the tariff collection situation, etc. of the pilot project which has been implemented using PV equipment loaned by the Japanese side and should make the planning and operation of future PV rural electrification projects reflect the monitoring results.

8.4 The Nigerian counterparts for the Study should establish a facilitator within the JWG in accordance with the Awareness Raising Action Plan in the M/P and mobilise the stakeholders for PV rural electrification. They should also continue awareness raising activities for government officials, private companies and PV equipment (system) users, etc. through information exchange with the media, NGOs and educational/research institutions, etc.

8.5 The Nigerian counterpart for the Study should properly consider gender issues in the implementation of the M/P in collaboration with the Federal Ministry of Women's Affairs and try to establish a unit to consider gender issues in each organization.

In order to realize the M/P, Nigerian counterparts are requested to implement the PV rural electrification in accordance with the following implementation schedule.



Implementation Schedule for PV Rural Electrification

Chapter 1 Background and History of the Study

1.1 Background of the Study

In the Federal Republic of Nigeria (hereinafter referred to as "Nigeria"), some 60% of the people currently lack access to electricity. In rural areas in particular where some 70% of the total population live, some 90% live without electricity. This lack of electricity has many negative impacts on the lives of people, including inability to store vaccines and drugs in a cool place and inability to thresh harvested agricultural crops in addition to progressive forest destruction due to dependence on firewood as the main source of energy in rural areas.

To improve the situation, the Government of Nigeria has been making conscious efforts to build a new power station and to expand/repair existing power stations as well as the transmission and distribution grid via the Federal Ministry of Power and Steel (FMPS), which is the competent ministry for the power sector, and Power Holding Company of Nigeria (PHCN). However, the actual progress has substantially fallen behind that planned because of insufficient budget and manpower. In remote villages which are located far from the existing distribution grid and which have a low density of demand for electricity, electrification by means of distribution line extension (on-grid electrification) is economically difficult, making the strategic introduction of off-grid electrification using dispersed power generation essential.

For this reason, the Government of Nigeria is examining an energy supply programme through the spread of dispersed power generation using renewable energies for remote rural areas which are likely to be left behind conventional on-grid electrification for the medium to long-term. In regard to solar energy (including the use of solar heat) in particular, not only the FMPS but also the Federal Ministry of Science and Technology (FMST) and the Energy Commission of Nigeria (ECN), a subordinate organization of the FMST, are planning its introduction and technical R & D and awareness raising activities on the use of solar energy which is in progress at research facilities in Sokoto and Enugu States. At present, however, the FMPS, FMST and ECN are independently implementing their own pilot projects for the introduction of solar energy and a cross-ministerial approach based on the adoption of a master plan is essential to realise an electrification programme using solar energy for remote rural areas. Meanwhile, the Electric Power Sector Reform Bill prepared by the Bureau of Public Enterprises with the assistance of the World Bank was approved by President Obasanjo in March, 2005 and the Rural Electrification Agency (REA) was set up in March, 2006 as an agency responsible for rural electrification independently from the government. As part of the reform of the power sector, the Nigerian Electricity Regulatory Commission (NERC) has also been set up, illustrating the major changes of the situation surrounding the use of solar energy and rural electrification projects.

In February, 2004, the Government of Nigeria made a request to the Government of Japan to conduct the M/P Study for the Utilisation of Solar Energy (hereinafter referred to as "the Study") to further facilitate efforts to introduce solar energy in view of the changing circumstances. In response,

the JICA conducted the Project Formulation Study for Mining and Manufacturing Industries in September, 2004 and the Preliminary Study in January, 2005 and agreed the basic plan for the project with the Nigerian side. The Study is based on the Scope of Work (S/W) signed on 6th April, 2005 and the Minutes of Meetings (M/M) signed on 7th September, 2004, 25th January, 8th July and 10th October, 2005. The Study has been conducted based on the contents, division of work between the Japanese side and its Nigerian counterpart and the schedule, etc. specified in these documents.

1.2 Purpose of the Study

The Study intends to strengthen the capacity of the Nigerian organizations (REA, FMPS, FMST, ECN and state governments, etc.) which play a principal role in the promotion of the use of solar energy by means of preparing (i) measures for the Government of Nigeria for the promotion of the use of solar energy through the formulation of a master plan for the utilisation of solar energy (hereinafter referred to as "the M/P) and (ii) various recommendations. The results of the Study will be those listed below.

(1) Master Plan for PV Rural Electrification
(2) Solar Energy Technology R & D Action Plan
(3) Action Plan for Raising Awareness of the Use of Solar Energy

1.3 Study Area

The Study Area covers entire Nigeria. However, the Pre-Feasibility Study (Pre-F/S) will only be conducted in Jigawa State, Ondo State and Imo State as well as Abuja Federal Capital Territory while the pilot project will be conducted in Jigawa State, Ondo State and Imo State (added by the M/M signed on 10th October, 2005).

1.4 Basic Policies of the Study

(1) Viewpoint for Technology Transfer

The Study is not simply designed to produce a final report but has the principal purpose of assisting capacity development (CD) for the promotion of the use of solar energy by organizations (such as the REA, FMPS, FMST, ECN and state governments) which play a leading role in the promotion of the use of solar energy. For this reason, the Joint Coordinating Committee (JCC)[1)] and the Joint Work Group (JWG)[2)] were formed and functioned throughout the field survey period. As a result, it was possible for them to act as the counterparts for the technology transfer under the Study, including the planning and monitoring of the pilot project, the implementation of the Pre-F/S, awareness raising activities and guidance on R & D activities, etc. Moreover, it was recommended that the separate roles to be played by the REA set up in

1) Joint Coordinating Committee: The committee was set up to ensure the smooth progress and coordination of the Study with the head of a FMPS bureau acting as the chairperson of the JCC and assuming overall responsibility for the project.
2) Joint Work Group: Subordinate body of the JCC and responsible for practically ensuring the smooth implementation of the daily work. The head of a FMPS section was selected as the group leader.

March, 2006 and other organizations (FMPS, FMST and ECN, etc.) should be clearly established and that the JWG should act as a coordinating body to ensure the consistent promotion of the introduction of solar energy.

In the course of the Study, measuring technologies mainly to check the equipment performance were transferred for the purpose of enabling research institutions in Nigeria to independently conduct the R & D of equipment to use solar energy. The PDCA cycle of such R & D activities is shown in Fig. 1-1. As no measuring technologies to check the performance of trial equipment existed in Nigeria, R & D activities were only at the second stage (D) at the time of the Study's commencement. The principal aim of the transfer of measuring and evaluation technologies under the Study was completion of the first PDCA cycle as such transfer and recommendations based on the check (evaluation) results would enable a move from Do to Check (as shown by arrow ② in Fig. 1-1) and a move from Check to Action (as shown by arrow ③ in Fig. 1-1) respectively. As part of the Study, a R & D action plan was formulated and capacity development work with emphasis on the process from check/analysis to the planning of improvement measures was conducted so that the Nigerian side can perform the second PDCA cycle onwards without external assistance.

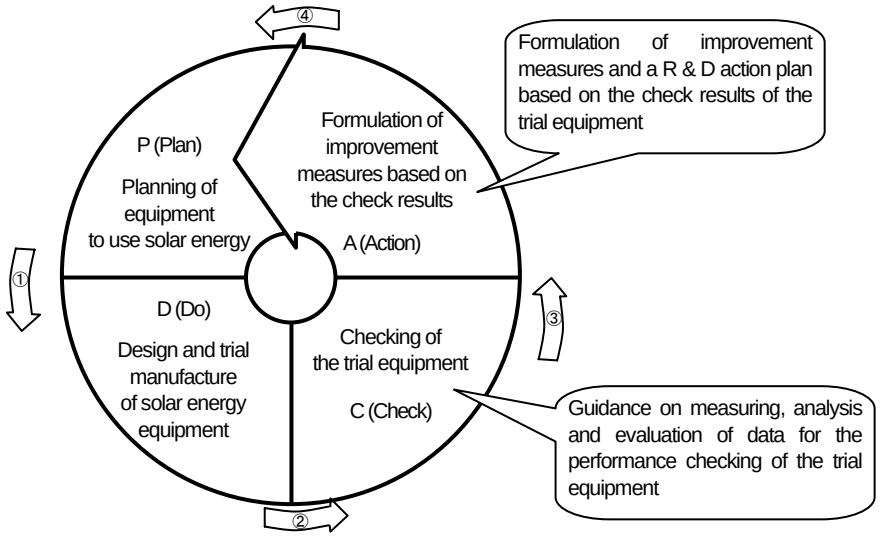


Fig. 1-1 PDCA Cycle for R & D of Solar Energy Technologies

During the study period, counterpart training was conducted in Japan for eight trainees from Nigeria from 29th November to 14th December, 2005 (13 days). This training included visits to observe PV panel manufacturing lines at factories of Sharp and Kyocera in addition to lectures, exercises and the exchange of opinions to enable the trainees to independently solve problems on their return to Nigeria.

(2) Planning of the Pilot Project and Feedback Through Monitoring

During the course of the Study, the pilot project was implemented in Jigawa State, Ondo State and Imo State. The basic components of this pilot project were battery charging stations (BCSs), solar home system (SHSs), public facilities and street lamps. For the planning and implementation of the pilot project, the participatory development technique was employed.

Resident meetings were held at state government offices as well as at the project sites to eradicate any psychological unease among the residents and also to enable the beneficiaries to understand the technical limitations of a renewable energy. After commencement of the operation of the PV system, operation and maintenance data were recorded for the assessment of sustainable maintenance and the assessment results which will provide useful references for similar projects in the future are now incorporated in the M/P. Furthermore, separate maintenance manuals were prepared for engineers, maintenance staff and users to support a cross-sectional maintenance system after equipment installation. The contents of these manuals were explained to the counterparts.

(3) Proposal of Business Models Reflecting the Local Characteristics

For the formulation of a national PV electrification programme, the implementation of multiple business models to satisfy the demand for PV electrification in each area is essential instead of the application of a single business model nationwide given the geographical expanse of Nigeria and the level of autonomy of each state or geopolitical zone. Because of (i) the Nigerian practice of giving the priority for on-grid electrification to areas where both the power demand density and the potential level of payment of the electricity charge are high and (ii) the difficulty of extracting uniform indicators for the comparison of different states, the existing electrification rate was used for the Study to classify the entire country into the following three models. A national PV electrification programme was then formulated by predicting the quantity of PV equipment to be introduced for each model.

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.

・ 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 of which the equipment cost, maintenance cost and charge level are 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. Such a mini-grid system can be incorporated when a distribution line is extended from the existing grid.

1.5 Formulation Process of the M/P

A rural PV electrification programme up to 2020 targeting entire Nigeria and four states (Jigawa, Ondo, Imo and Capital Territory) was formulated under the Study for the purpose of encouraging the governments of these four states and the REA to promote this rural PV electrification programme based on their own initiative. Fig. 1-2 shows the formulation process of the rural electrification programme using PV systems which are described in this Summary and in more detail in the main report.

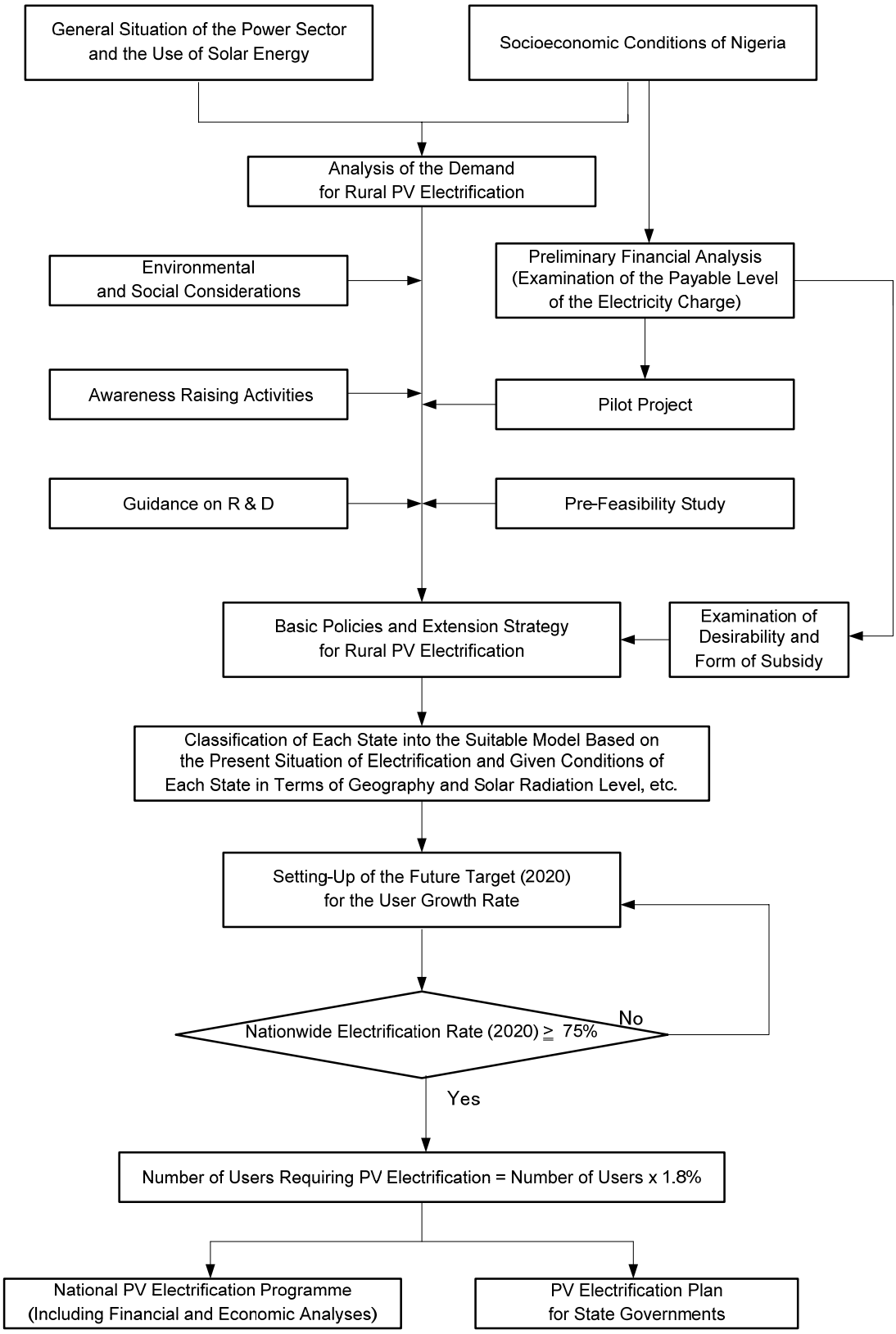


Fig. 1-2 Formulation Process of the M/P

Chapter 2 Basic Study

2.1 Socioeconomic Conditions of Nigeria

2.1.1 Overview

Nigeria achieved independence from Great Britain in 1960. After a military regime which lasted for 16 years, a new constitution was laid down in 1999, followed by the democratic election of President Obasanjo in May of the same year. President Obasanjo is currently in his second term. The international status of Nigeria has been rising in recent years due to the transition to democracy and the commencement of economic reform, etc. President Obasanjo currently holds the position of Chairperson of the African Union while Nigeria is a leading country in the Commonwealth of Nations, the New Partnership for African Development (NEPAD) and the Economic Community of West African States (ECOWAS).

Nigeria consists of 36 states and the Federal Capital Territory (FCT) and is classified into six geopolitical zones. Each state is divided into local government areas (or area councils in the case of the FCT).

2.1.2 Population

The population census held in 1991 recorded a total population of 88,992,000 with a population density of 105 persons/km^2. This 1991 census defined a city as a residential area with at least 20,000 residents. According to this definition, city dwellers account for 36% of Nigeria's total population.

Under colonial rule from 1952/53, population surveys were based on an estimate rather than an actual count. Table 2-1 shows the total population at the time of each population survey and the rate of population growth between two adjacent surveys. Here, the growth rate is calculated using the index method. In the period of 39 years from 1952/53 to 1991, the annual population growth rate of 2.8% is believed to fairly represent the reality.

Nigeria has some 250 ethnic groups, the largest group of which is the Hausa-Fulani (29%) in the north, followed by the Yoruba (21%) in the southwest and the Ibo (18%) in the southeast. Other major ethnic groups are the Ijaw (10%), Kanuri (4%), Ibibio (3.5%) and Tir (2.5%). Some 350 languages are spoken in Nigeria while Islam, Christianity and indigenous beliefs represent 50%, 40% and 10% of the population respectively.

Table 2-1 Total Population at the Time of Population Surveys and Population Growth Rate Between Surveys

Survey Year	Population (million)	Interval (years)		Annual Growth Rate (%)	
		Intervening Years	Period Since 1953	Intervening Years	Based on 1953
1911	16.05	-	-	-	-
1921	18.72	10	-	1.54	-
1931	20.06	10	-	0.69	-
1952/53	30.42	22	0	1.89	-
1963	55.66	10	10	6.04	6.04
1973	79.76	10	20	3.60	4.82
1991	88.99	18	38	0.61	2.82

Source: 1962/63 Census Nigeria and 1991 Population Census

2.1.3 Living Standard

Despite huge human as well as natural resources, poverty is widespread in Nigeria and the country's social indicators suggest that Nigeria is one of the 20 poorest countries in the world. Some 52% of the population are below the poverty line of approximately US$1 per day. The main reasons for the economic stagnation and increased poverty are poor economic management, corruption and excessive dependence on crude oil. To improve the situation, the National Economic Empowerment and Development Strategy (NEEDS), an economic reform programme under the new economic policy of President Obasanjo, commenced in March, 2004 and primarily focuses on the reform of the government and government-related organizations, poverty reduction based on the growth of the private sector other than oil, the creation of wealth and human development.

2.1.4 Economic Activities

The Nigerian economy predominantly relies on the oil sector which accounts for 95% of exports, 76% of government revenue and approximately one-third of the GDP. Although agriculture is the second-largest industry, its growth has lagged behind the population growth. Consequently, Nigeria which has exported food in the past now imports food. The wholesale and retail sector is the third largest sector, accounting for 15.1% of the GDP. Table 2-2 shows the GDP share by sector.

Table 2-2 GDP Share by Sector (2004)

(Unit: NgN million)

Sector	Value	%
Agriculture	**2,578,963**	**31.20**
Crop Production	2,155,133	26.08
Livestock	243,887	2.95
Forestry	51,658	0.63
Fisheries	128,285	1.55
Mining	**2,842,844**	**34.40**
Oil and Natural Gas	2,831,320	34.26
Others	11,524	0.14
Manufacturing	**372,061**	**4.50**
Oil Refining	22,457	0.27
Cement	5,477	0.07
Others	344,127	4.16
Wholesale and Retail	**1,250,337**	**15.13**
Real Estate	**444,688**	**5.38**
Transportation	**358,373**	**4.34**
Land Transportation	337,555	4.08
Air Transportation	3,010	0.04
Transportation-Related Services	16,892	0.20
Others	916	0.01
Finance	**102,953**	**1.25**
Construction	**80,088**	**0.97**
Hotel and Restaurant	**15,649**	**0.19**
Communication	**5,050**	**0.06**
Public Services	**82,230**	**0.99**
Other Services	**131,726**	**1.59**
Total	**8,264,962**	**100.00**

Source: Nigerian Statistical Fact Sheets on Economic and Social Development

In the NEEDS, a new approach to economic revival started by President Obasanjo in 2004, the main focus is placed on government reform, development of the private sector other than oil, poverty reduction through new plans based on the implementation of the Social Charter, the creation of wealth and human development.

2.1.5 Outline of the Target States of the Study

(1) Jigawa State

While the main ethnic groups in Jigawa State are the Hansa and Fulani, some other groups, such as the Manga and Badawa, etc. have a large proportion in some areas. Jigawa State is classified into six areas, each of which is controlled by a traditional chief called the Emir. Although these emirs have no political power, they are still very influential in terms of the preservation of traditions and other aspects of local life.

Jigawa State is ranked bottom in terms of the primary school enrolment rate and is second from the bottom in terms of the English literacy rate. Based on the definition of the literacy rate of "the proportion of people of 15 years or older who can read and write in one language or another", the state's literacy rate is only 51% for men and 22% for women.

The main industry is agriculture and 49% of the working population are engaged in agriculture. The service industry and commerce employ 21% and 15% of the working population respectively. When the scope of the working population is limited to men, 76.5% are engaged in agriculture.

A survey conducted in 2002 sampling 2,000 households found that one important task for local households is the securing of food supply as 60% of the households surveyed stated that they had faced a problem of satisfying the family's food demand in the last one year period. The same survey found that 97.5% of households in rural areas use a kerosene lamp as the lighting source as shown in Table 2-3.

Table 2-3 Proportion of Households Using Different Lighting Sources

(Unit: %)

	Kerosene	On-Grid Connection	Portable Generator	Battery	Firewood	Total
Rural Areas	97.5	1.8	0.2	0.2	0.4	100.0
Urban Areas	59.9	38.4	1.8	0.0	0.0	100.0

Source: Core Welfare Indicator Questionnaire Survey, 2002

(2) Ondo State

Although the Yoruba is the dominant ethnic group in Ondo State, such other ethnic groups as the Akoke, Akure, Ijaw, Ikale, Ilaje, Ondo and Owo, etc. co-exist with the Yoruba. With the presence of many foreigners, the local cultural and art scenes are very diverse.

The primary school enrolment rate in Ondo State is as high as 4th but the literacy rate is ranked in the middle of the table. Ondo State is relatively wealthy, ranking 12th for the household income

and 11th for poverty among all states in Nigeria. The three largest sectors in terms of the working population are commerce (30.9%), agriculture (26.0%) and manufacturing (21.5%). Table 2-4 shows the state of water and electricity supply in Ondo State.

Table 2-4 State of Water and Electricity Supply in Ondo State

Area	Local Government Area	Total No. of Communities*	Communities Receiving Water Supply		Communities Receiving Electricity Supply	
			No.	%	No.	%
Ondo North	Akoko Northeast	12	6	50.0	6	50.0
	Akoko Northwest	18	3	16.7	17	94.4
	Akoko Southeast	8	6	75.0	6	75.0
	Akoko Southwest	14	7	50.0	9	64.3
	Ose	36	6	16.7	13	36.1
	Owo	188	18	9.6	12	6.4
Sub-Total		**276**	46	16.7	63	22.8
Ondo Central	Akure North	130	19	50.0	17	13.1
	Akure South	125	8	6.4	7	5.6
	Idanre	108	20	18.5	NA	-
	Ifedore	157	31	19.7	12	7.6
	Ondo East	80	17	21.3	21	26.3
	Ondo West	202	33	16.3	2	1.0
Sub-Total		**802**	128	16.0	59	7.4
Ondo South	Ese-Odo	243	5	2.1	3	1.2
	Ilaje	302	5	1.7	10	3.3
	Ile-Oluji/Okeigbo	320	56	17.5	5	1.6
	Irele	249	5	2.0	2	0.8
	Odigbo	328	14	4.3	25	7.6
	Okitipura	108	3	2.8	24	22.2
Sub-Total		**1,550**	88	5.7	69	4.5
Total		**2,628**	262	10.0	191	7.3

* A community means a town or village.
Source: Ondo State Socioeconomic Indicators, 2002

As shown in Table 2-4, communities with water supply and communities with electricity supply account for only 10% and 7.3% of the total number of communities respectively. The development of water supply and electricity supply has been particularly slow in Ondo South.

Akure, the state capital, has grown into a major town, attracting people from rural areas and smaller towns. As a result, it is facing such problems as the emergency of slums formed by local income people and unemployment among the same people.

(3) Imo State

The predominant ethnic group in Imo State is the Ibo. The cultural scene of the state is homogenous and Ibo is spoken throughout the state. The local culture and art are quite rich.

The primary school enrolment rate and the literacy rate in Imo State are ranked 5th and 3rd respectively, indicating a high level of local education. The household income in Imo State is in

the middle of the national table. Like Ondo State, Imo State is relatively wealthy as it is ranked the 4th wealthiest on the poverty table. However, the high population density (3rd among all states) means high population pressure on land and forests, etc., resulting in poverty in rural areas. Some people have moved to other states to find employment or farming land. Imo State is endowed with rich underground resources, including oil, natural gas, lead, zinc and limestone.

(4) FCT

The main ethnic groups in the FCT are the Gbagyi, Gwari, Koro and Bassa but the Hausa, Fulani, Igbo and Yoruba, etc. are also sizable as the FCT attracts people from all over Nigeria.

Both the primary school enrolment rate and the literacy rate of the FCT are in the middle of the respective table. While the household income is ranked high at 2nd, poverty is ranked in the middle. Abuja was created in 1976 and became the federal capital in December, 1991.

2.2 General Situation of the Power Sector and Use of Solar Energy

2.2.1 General Situation of the Power Sector

The power sector in Nigeria is under the supervision of the FMPS and the National Electric Power Authority (NEPA) has historically been in charge of the nationwide operation and maintenance of power generating, transmission and distribution facilities In May, 2005, the NEPA was divided into six generating companies, one transmission company and 11 distribution companies and the PHCN was established.

Table 2-5 shows the power generation and sales performance of the PHCN from 2001 to 2005. It can be seen that the installed generating capacity stayed at the same level until 2005 while the peak demand and net system energy demand recorded high average annual growth rates of 8% and 14% respectively, resulting in a shortfall of the electricity supply by the generating facilities owned by the PHCN alone in recent years. Apart from the PHCN, IPPs have their own generating facilities in Nigeria. Because these IPPs have a combined installed generating capacity of 750 MW as of 2006, the available output is just about enough to meet the maximum power demand. However, because of a fairly large potential demand, there is actually a substantial shortage of supply capacity.

Table 2-5 Power Generation and Sales Results of the PHCN

	2001	2002	2003	2004	2005
Installed Generating Capacity (MW)	6,158	6,085	6,119	6,119	6,104
Available Output (MW)	2,525	3,211	3,781	3,410	3,736
Peak Demand (MW)	3,242	3,243	3,479	3,427	3,774
Generated Energy (GWh)	16,841	21,532	22,612	24,132	24,008
Net System Energy Demand (GWh)	9,649	19,098	20,499	21,632	16,458
Total Number of Users (x 1,000)	3,300	4,656	4,805	4,560	4,431

Source: PHCN

The net system energy demand in Nigeria is expected to grow at an average annual rate of 10 – 11% in the 15 year period from 2005 to 2020. For this reason, the Government of Nigeria aims at increasing the installed generating capacity to 10,000 MW, the transmission capacity to 9,340 MVA and the distribution capacity to 15,165 MVA by 2007 in its NEEDS. Table 2-6 show the planned expansion of the generating facilities in the coming years.

Table 2-6 Generating Facilities Expansion Plan in Nigeria (Formulated in 2006)

(Unit: MW)

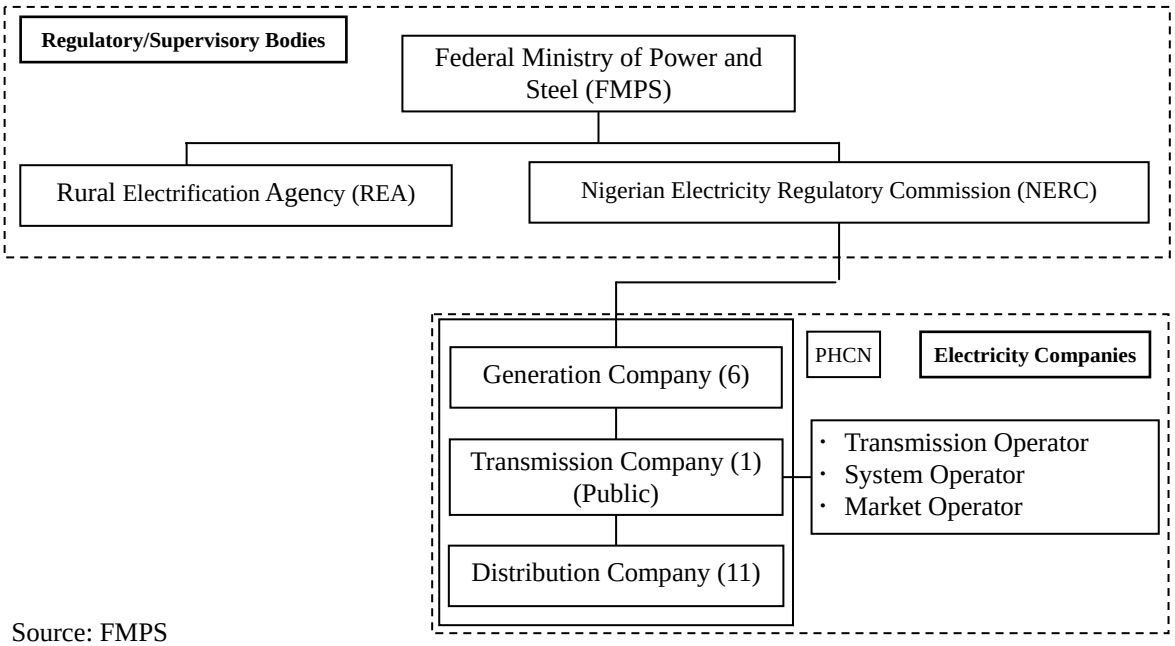
	Dec., 2006	May, 2007	Dec., 2007	Dec., 2008	Dec., 2009	Dec., 2010
Existing PHCN Power Stations (Available Output)	3,357	4,027	4,027	3,880	3,780	3,780
Existing IPP Power Stations (Available Output)	750	750	750	750	750	750
Government Projects (In Progress)	1,001	1,462	1,496	2,511	3,528	4,544
Niger Delta Programme	0	1,315	2,203	2,624	2,624	2,624
IPP Expansion Programme (JV)	0	876	1,820	2,790	2,790	2,790
Other IPPs	90	510	510	1,265	1,365	1,365
Total	5,198	8,940	10,806	13,820	14,837	15,853

Source: PHCN

2.2.2 Reform of the Power Sector and Rural Electrification

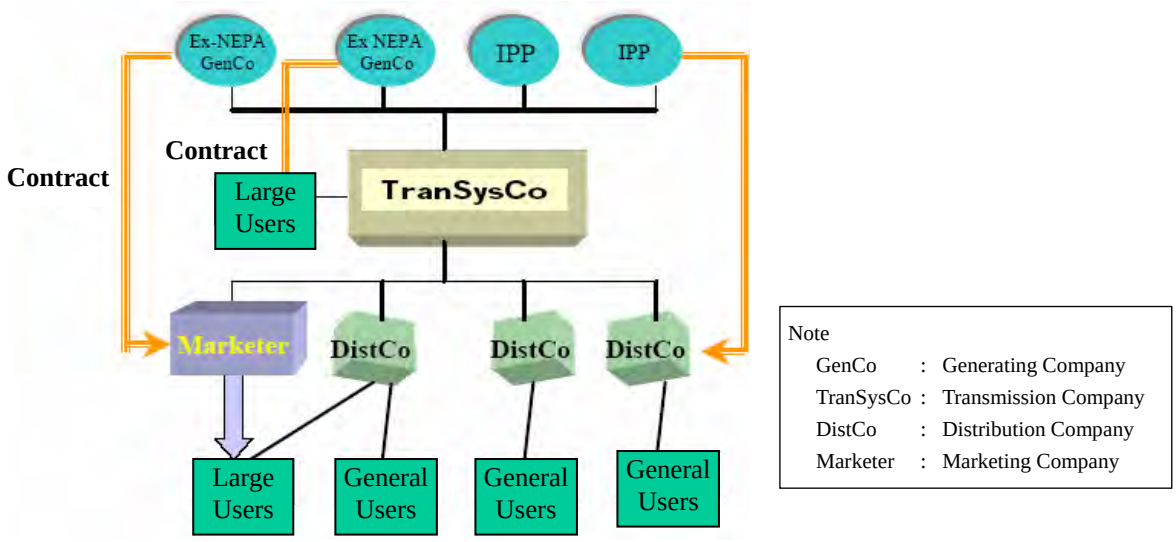
The approval of the Electric Power Sector Reform Bill by President Obasanjo in March, 2005 led to the official effectuation of the Electric Power Sector Reform Act. With the disbanding of the PHCN itself in July, 2006 under the same Act, the generating, transmission and distribution companies as well as IPPs now operate their businesses under the regulatory regime of and with a license issued by the Nigerian Electricity Regulatory Commission (NERC). Liberalisation of the wholesale market (excluding retail operators) for electricity is planned in the coming years. 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 50% subsidised by the federal government at present (a fixed charge system of NgN 304.5/month). Even 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). Fig. 2-1 shows the assumed organization and operating system of the electricity sector after reform while Fig. 2-2 and Fig. 2-3 show the range of electricity companies after reform and the organizational structure of the REA respectively.



Source: FMPS

Fig. 2-1 Organization and Operating System of the Electricity Sector (After Reform)

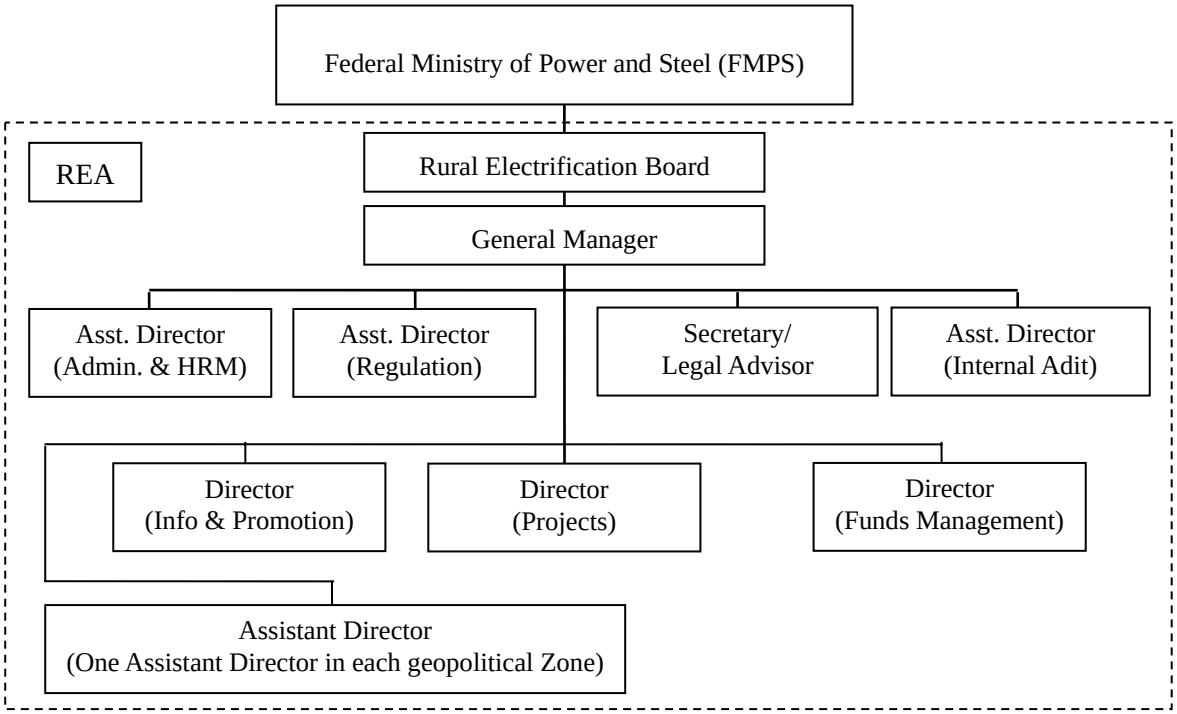


Source: NEPA, "The Power Sector: The Catalyst for Economic Growth for Development", March, 2004

Fig. 2-2 Composition of Electricity Companies After Reform of the Electricity Sector

The REA established as an independent organization from the government is required to select candidate rural electrification projects and to distribute funds in regard to its management of the REF. The REA is preparing policy guidelines to ensure the fair management of the REF for rural electrification. In addition, acting as the regulatory organ for rural electrification projects, the REA also prepares and enforces the minimum safety regulations, technical standards and required standard level of service, etc. The headquarter of the REA is 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. 2-3 Organizational Structure of the REA

2.2.3 Present Situation and Future Targets for the Use of Solar Energy

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 (2005) 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 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. Regarding the potential wind power generation, the mean wind velocity is 4.0 – 5.12 m/s in the north and 1.4 – 3.0 m/s in the south at an elevation of 10 m. 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.

Draft guidelines designed to expand the power supply using renewable energies are being prepared by the FMPS. The Renewable Electricity Policy Guidelines urge electricity supply utilizing renewable energies for (i) an increase of the generating and supply capacity to match the power

demand to support economic and social development, (ii) the diversification of generating sources from the viewpoint of energy security and (iii) an improvement of the electrification rate in rural areas. 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 2-7. 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 2-7 Targets for Use of Renewable Energies in Nigeria

(Unit: MW)

Type of Energy	Target		
	2007	2010	2016
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

The current utilization situation of solar energy is described next.

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.

2.2.4 Assistance of Other Donors for Utilisation of Solar Energy

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 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 geopolitical 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.

Other examples include the introduction of PV refrigerators by the UNICEF in Sokoto State in 2001 and the introduction of borehole pumps in Plateau State but their post-project evaluation results are unknown. Meanwhile, the UNIDO is examining the possibility of introducing BCSs to be operated by individual entrepreneurs using micro-finance and also the productive use of electricity to increase income. However, these are still at the planning stage.

2.3 Present Situation of Environmental and Social Considerations

The Federal Ministry of Environment (FMoE) is responsible for environmental impact assessment (EIA) which is implemented in accordance with the Environmental Impact Assessment Act (Decree No. 86) enacted in 1992 and the guidelines promulgated in 1995. All development projects are classified in one of the following three categories based on the guidelines.

Category 1	Project requiring a full-scale EIA
Category 2	Project requiring a partial EIA mainly featuring environmental impact mitigation measures and an environmental plan (a full-scale EIA is required if a project site is adjacent to an area where special environmental and social considerations are required)
Category 3	Project with “essentially favourable impacts” on the environment (the FMoE prepares an environmental impact statement)

Development projects involving solar energy and other renewable energies are classified in Category 2 and are required to have a partial EIA. Accordingly, the implementation of a partial EIA is required for the implementation of the pilot project under the Study. In compliance with the

guidelines, the FMPS applied to the FMoE for an EIA for the pilot project (November, 2005). As part of this application, the FMPS submitted a summary of the pilot project explaining that PV is not expected to have any serious impacts on the environment as long as the spent batteries are properly disposed of. Following examination of the application documents, the FMoE approved the exemption of the pilot project from an EIA with the condition that an environmental control plan would be submitted (February, 2006). As instructed by the FMoE, the FMPS submitted an environmental control plan for the pilot project.

The summary of the pilot project and the environmental control plan submitted by the FMPS had the following contents.

Contents of the Summary of the Pilot Project

Outline (implementing body, contents, sites and funding source, etc.); background and schedule of the project; present social environment; equipment to be installed; experts to be deployed; expected environmental impacts; mitigation measures

Contents of the Environmental Control Plan

Maintenance bodies; expected environmental impacts; environmental control (implementing body and method); capacity development plan for environmental control

2.4 Present Situation of Energy Research Centres

2.4.1 Outline of Energy Research Centres

In Nigeria, the following two research centres are engaged in R & D on solar energy technologies.

- Sokoto Energy Research Centre (SERC)
- National Centre for Energy Research and Development – University of Nigeria, Nsukka (NCERD)

Both research centres were established as subordinate organizations of the ECN which is controlled by the FMST.

Energy-related R & D activities in Nigeria are geographically divided into those in the north and those in the south. The SERC located in Sokoto is responsible for these activities in the north while the NCERD located in Nsukka is responsible for these activities in the south. The contents of the research work of these two centres are virtually identical. The types of the prototypes made, the timing of commencing the fabrication of the prototypes and actions after the completion of the prototypes are similar at both centres. Also similar are the problems faced by these centres which include a shortage of measuring instruments and a funding shortage.

Although the scale of the two centres is similar, the SERC is more suited to R & D on solar energy because of the larger mean value of solar radiation of 5.92 KWh/m^2/day in Sokoto compared to 4.54 KWh/m^2/day in Nsukka.

(1) Outline of the SERC

The SERC is situated on the campus of Usmanu Danfodiyo University in the city of Sokoto in Sokoto State. It was originally established as a research centre affiliated to the university in 1982 but was transferred to the control of the ECN in 1988.

1) Purposes of Research at the SERC

The research work at the SERC has the following main purposes.

① Research on renewable energies as economical and efficient alternative energies
② R & D on renewable energies for their application to agricultural and industrial activities
③ Training of renewable energy engineers
④ Research on the hybrid application of solar energy and other energies
⑤ Improved efficiency of the utilization of solar energy

2) Organization of the SERC

The staff strength of the SERC is 70, including the Director, and this staff is engaged in R & D activities in five different units. Because of its insufficient size, the budget of the SERC is mainly used to meet the personnel cost, making it practically impossible to fund R & D activities. As a result, all of the measuring instruments for R & D are broken and have not been repaired or replaced.

(2) Outline of the NCERD

The NCERD was established in 1980 as a subordinate organization of the ECN on the campus of the University of Nigeria, Nsukka. The city of Nsukka is located in the savanna belt in the northern part of Enugu State.

1) Purposes of Research at the NCERD

The NCERD was established to conduct basic research on and system development relating to the themes listed below.

① Research on PV
② Development of the means of utilization of solar heat (dryers, water heaters, cookers and chick incubators)
③ Development of biomass and biogas equipment
④ Development of equipment using briquettes
⑤ Research on energy efficiency (energy saving)

2) Organization of the NCERD

The staff strength of the NCERD is 65, including the Director, 26 of which are researchers. R & D activities are conducted by five units as in the case of the SERC. The NCERD cannot satisfactorily conduct R & D due to the shortage, breakdown and aging of its equipment, in turn caused by its insufficient budget.

2.4.2 Common Tasks for Energy Research Centres (SERC and NCERD) in Nigeria

As research centres, both the SERC and the NCERD face common tasks as described below.

(1) Inadequate Research System and Unclear Direction for Research

In view of the lack of clarity regarding the direction for research and the purpose of establishment, both the SERC and the NCERD must re-examine the following issues.

① Both centres must clarify the purposes and contents of their research work to determine the direction for R & D activities and must also formulate a research implementation plan.

② The FMIT, ECN, SERC and NCERD must consult with each other regarding the target persons for human resources development, the methods of such development and the necessary R & D budget size and must jointly strive to obtain the budget to implement training and research work.

③ The FMST, ECN, SER and NCERD must re-organize the two research centres to successfully pursue the two tasks described above.

(2) Insufficient Research Equipment

As both the SERC and the NCERD possess hardly any of the equipment, etc. (measuring instruments, testers, research materials, tools and indoor facilities) required for research work, it is currently impossible for them to continue their R & D activities. To improve this situation, the FMST, ECN, SERC and NCERD must formulate a plan to procure the necessary equipment and materials and work together to secure the necessary budgetary allocation as soon as possible.

(3) Insufficient Experience of Researchers

Many of the researchers are currently inexperienced and have few training opportunities to acquire technical knowledge and skills. To improve this situation, the FMST, ECN, SERC and NCERD must formulate and implement a training plan which includes the participation of local staff in the training sessions organized by other countries and aid organizations.

(4) Insufficient Research Funding

To improve the situation where research work cannot be conducted due to insufficient funding, the FMST, ECN, SERC and NCERD must establish a system which is capable of providing budgetary back-up in line with the purpose, subject and schedule of individual research work.

2.5 Present Situation of Gender Issues and Human Security

2.5.1 Present Situation of Gender Issues

Table 2-8 shows the approach of different government offices in Nigeria to gender issues.

Table 2-8 Present Situation of Gender Issues at Government Offices

Government Office	Approach
Ministry of Women	Established in 1995, the Ministry of Women is promoting the sound development of women's status as well as child protection and the participation of women. Half of the 400 strong staff members and three of the five directors are women.
Ministry of Education	The Ministry of Education is currently formulating the gender policy for the universal basic education (UBE) with the assistance of the UNICEF.
National Statistical Bureau	Since its establishment in 1995, the Gender and Development Unit has been trying to reflect the viewpoint of gender on its data gathering work. The bureau has six staff members (five men and one woman).
NPC	The NPC has a unit (two staff members) in charge of gender issues and has formulated the Mainstreaming of Gender in the State's Economic Empowerment Development Strategy in cooperation with the Ministry of Women.
FMPS	Although the FMPS has neither a unit specialising in gender issues nor a gender policy, staff recruitment and appointment is entirely based on the ability and qualifications of each candidate regardless of gender. Of its 842 staff members, women account for 35%. Of its 130 senior staff members, women account for 26%.
FMST	Although the FMST has neither a unit specialising in gender issues nor a gender policy, staff recruitment and appointment is entirely based on the ability and qualifications of each candidate regardless of gender. Of its 374 staff members, women account for 45%. There is no female director but many expert positions are filled by women.
ECN	Although the ECN has neither a unit specialising in gender issues nor a gender policy, staff recruitment and appointment is entirely based on the ability and qualifications of each candidate regardless of gender. Of its 127 staff members, women account for 13% (15% of 127 expert position are filled by women. There are no women among the 23 engineers). Conscious efforts have been made to include the viewpoint of women in the draft National Energy Master Plan formulated in September, 2006, including the appointment of a representative of the Ministry of Women in the drafting committee. At the NCERD of the ECN, women account for 27% of the 84 staff members (in the case of the 17 researchers, three or 17% are women).
REA	The REA is still in its infancy and is now in the midst of recruiting 98 staff members required to commence its work. The recruitment criteria are the ability and qualifications of each candidate disregarding gender.

Source: The Study Team

2.5.2 Problems Associated with Gender Issues

The Women's Rights Advancement and Protection Alternative, an organization tackling the problem of gender discrimination in Nigeria, has identified the following problems regarding the current approach of government offices to gender issues in its report "Gender Mainstreaming and Future Challenges Towards Gender Equality".

- The level of gender awareness is generally high among government offices and gender has not yet become a central issue of development.
- Of the 19 government offices studied, 16 have a gender officer(s) or a female officer(s). However, their positions are not influential enough to affect policies.
- Government offices do not have sufficient policies and the framework to bring gender issues into the mainstream of society.
- Although there are programmes which target women, they do not necessarily focus on gender inequality.

- While development partners, such as international organizations, clearly indicate the framework to work with gender issues, government offices in Nigeria do not have a suitable mechanism to respond.

The NEEDS of Nigeria adopts the empowerment of people as a principal target. The sub-themes of empowerment include women's empowerment along with poverty reduction, housing supply, creation of employment opportunities, empowerment of young people, welfare of children and reinforcement of the safety net. Some of the targets for women's empowerment are an increase of women's participation in all organizations and functions of society to 30%, enforcement of the provisions of the UN Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), easy access of women to micro-finance and other components of the poverty reduction strategy and increased opportunities for education for women.

2.5.3 Human Security in Nigeria

Although the Government of Nigeria does not use the exact phrase of human security, the NEEDS does consider this issue. The promotion of rural electrification can be considered to be one approach to achieving human security and there is much expectation on the part of the public in this regard. Its contribution to the lives of the people is quite high. The promotion of rural electrification in the coming years is, therefore, important from the viewpoint of improving human security.

The idea of human security should be introduced in Nigeria as a basis for analysis of the present conditions of the country with a view to formulating suitable development programmes and strategies. In this way, it is hoped that human security will be ensured at all stages of development.

Chapter 3 Master Plan

3.1 Socioeconomic Rural Survey

3.1.1 Outline of Socioeconomic Rural Survey

For the formulation of a master plan, it is important for such a plan to reflect the socioeconomic conditions of rural areas. Because of this, a socioeconomic survey was conducted to clarify the present conditions of villages in the three states (Jigawa, Ondo and Imo) and the FCT targeted by the Study. For the selection of these study areas, the local characteristics as well as geopolitical zones in Nigeria were taken into consideration along with the potential of connection to the existing grid by 2020, and Abuja, the capital, was added to the selected states. In the case of Jigawa State, it is hoped that the monitoring results for the SELF Project in progress with the cooperation of the USAID will be utilised for the Study.

Fig. 3-1 shows the flow and status of the Study. The field study was conducted in two stages (i.e. Subcontracted (Recommissioned) Survey 1 and Subcontracted Survey 2), both of which were conducted by a subcontracted local consultant.

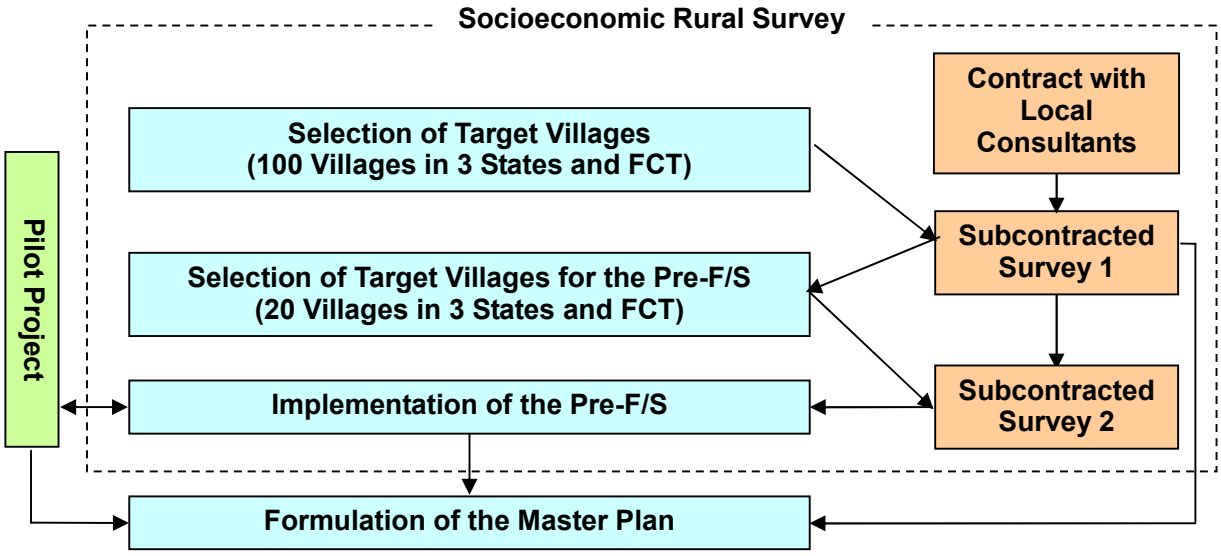


Fig. 3-1 Flow and Status of the Socioeconomic Rural Survey

3.1.2 Findings of Subcontracted Survey 1

(1) Target Villages

The geographical breakdown of the target villages (100 villages in total) of Subcontracted Survey 1 is shown in Table 3-1.

Table 3-1 Target Villages of the Socioeconomic Rural Survey

	Jigawa	Ondo	Imo	FCT
Category A	4	5	9	1
Category B	0	3	0	0
Category C	26	22	21	9
Total	30	30	30	10

Category A : electrified (on-grid)
Category B : electrified (diesel generator)
Category C : unelectrified

(2) Survey Findings for Unelectrified Villages (Category C)

The number of unelectrified villages surveyed was 78.

1) Income Sources

The main income source in all 78 villages is agriculture. Additional sources of income are stock raising (Jigawa), stock raising and commerce (Ondo) and commerce (Imo). Other livelihoods are also mentioned in many villages, including the sale of handicrafts, gainful employment away from the village, employment in public service and transportation by motorcycle.

2) Energy Sources and Costs

Table 3-2 lists the range of common energy sources used in unelectrified villages.

Table 3-2 Common Energy Sources in Unelectrified Villages

Purpose	Source	Remarks
Cooking	Firewood	Widely used and may be collected by oneself or purchased
	Kerosene	Used much less than firewood because of the high cost
Lighting	Kerosene	Widely used
	Palm Oil	Frequently used in Imo State as it can be produced at home free of charge
	Diesel Oil	Used by those possessing an independent diesel generator[1)] but sparingly used because of the high cost of diesel oil
	Dry Cells	Used for torches (at home and for going out at night)
Radio	Dry Cells	Most households have a radio
Other	Diesel Oil	Used by some for an electric fan and television, etc.

1) Independent generator possession ratio (number of owners/number surveyed); 9/130 (Jigawa), 3/110 (Ondo), 12/105 (Imo) and 9/45 (FCT)

Source: The Study Team

Given the present situation, the introduction of PV systems can be expected to replace such energy sources as kerosene for lighting, diesel oil for diesel power generation and dry cells for radios.

Table 3-3 shows the average expenditure for each energy source to determine the trend by state. In Imo State and the FCT, the total monthly expenditure for these energy sources exceeds NgN 3,000, making the utilisation of a fairly advanced PV system possible based on such a monthly expenditure level. In Jigawa State where the monthly expenditure is less than NgN 1,000, either a BCS or the smallest SHS unit appears to be feasible.

Table 3-4 also shows data on the income to determine the relationship between income and energy expenditure. Imo State has the highest ratio of energy expenditure to income of 13.3%. The ratio in the other two states and the FCT varies from 6.5% to 7.7%.

Table 3-3 Replaceable Expenditure by PV System

(Unit: NgN/month)

	Jigawa	Ondo	Imo	FCT
(1) Average Expenditure for Kerosene and Diesel Oil	762	1,451	3,657	2,873
(2) Average Expenditure for Dry Cells for Radios	155	223	148	280
(3) Average Replaceable Expenditure by PV System (1) + (2)	917	1,674	3,805	3,153
(4) Average Income (per Month)	14,077	21,810	28,648	44,012
(5) Ratio of (3) to Average Income (3)/(4) x 100	6.5%	7.7%	13.3%	7.2%

Source: The Study Team

3) Estimated Ability to Pay for PV System

Based on the present energy expenditure, the ability to pay for a PV system was estimated. The surveyed households were then classified into five groups as shown in Table 3-4 based on the ability to pay for a PV system, assuming that 90% of the present energy expenditure would go towards the payment of a PV system. As the table shows, the ability to pay for a PV system corresponds to an installable PV system. For example, if the payment ability is NgN 800/month or more, the household in question is classified in Group 1 for which the introduction of a BCS is possible.

Table 3-4 Cost of Each PV System (First Five Years)

	PV System	Monthly Tariff (NgN)
1	BCS	800
2	SHS 55 W	1,200
3	SHS 110 W	1,600
4	Mini-Grid	2,000
5	SHS 165 W	2,700

Note: For the cost of a BCS, the recharging cost is added to the monthly tariff of NgN 621. Some figures are rounded to the nearest ten.

Source: The Study Team

3.2 Pre-Feasibility Study (Pre-F/S)

3.2.1 Outline of the Pre-F/S

Based on the findings of Subcontracted Survey 1 conducted on 100 villages as part of the socioeconomic rural survey, Subcontracted Survey 2 was conducted on 20 villages meeting the selection criteria listed below. There were six villages each in Jigawa, Ondo and Imo States and two villages in the FCT. Criteria (1) through (4) below had already been used for the selection of the target villages for Subcontracted Survey 1 but were used again as the selected villages did not necessarily meet these criteria. Criterion (1) was used given the situation that many villages have a population of less than 1,000 in Ondo State. Criterion (3) was also eased as the distance to the existing grid is 12 km or less for many villages in Imo State.

1) Population size of 1,000 or more
2) Distance to the existing grid of 20 km or more
3) No electrification plan up to 2020

4) Existence of an active villagers' organization
5) Strong request for the introduction of a PV system

The Pre-F/S was conducted based on the analysis results of the findings of the subcontracted surveys and knowledge obtained in the course of the pilot project with a view to proposing a sustainable solar energy utilisation model(s) and measures to materialise such a model(s). The relation between the Pre-F/S and the subcontracted surveys, etc. is shown in Fig. 3-2.

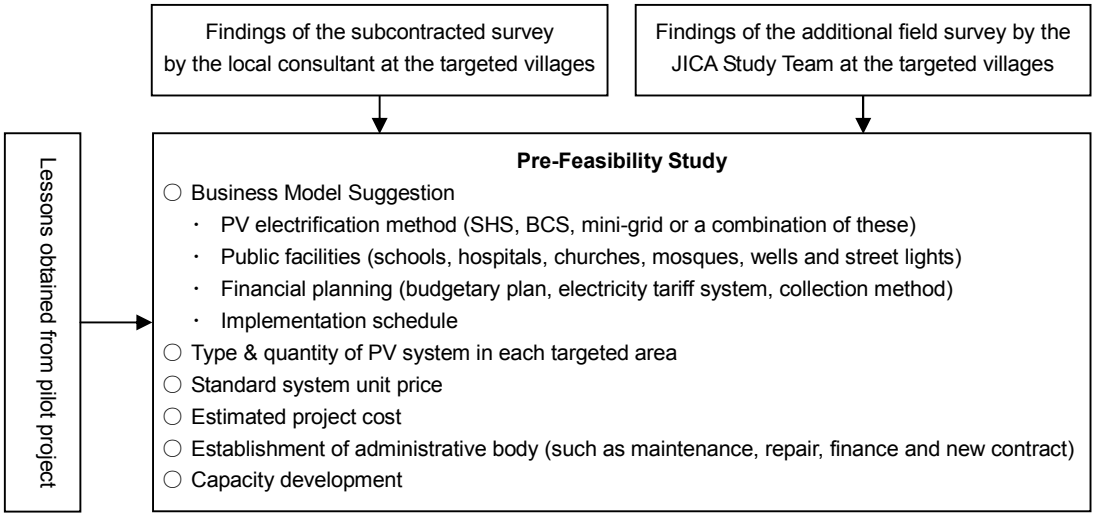


Fig. 3-2 Pre-Feasibility Study Overview

3.2.2 Field Survey Findings

Table 3-5 shows the population, number of households and current energy expenditure, etc. obtained by Subcontracted Survey 2 for the 20 selected villages. These survey findings for the 20 villages do not show any distinctive difference between the target states.

Table 3-5 Present Conditions of the Target Villages of the Pre-F/S

Village	Population	No. of Households	Average Income* (₦/month)	Average Energy Expenditure* (₦/month)			
				Kerosene	Diesel Oil	Dry Cells for Radios	Total
Jigawa State							
Gininya	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							
Onisere	1,500	300	NA	NA	NA	420	-
Oloruntedo	1,200	200	16,333	1,400	0	140	1,540
Kajola Camp	500	60	13,133	1,680	320	NA	-
Fayomi Camp	500	62	22,333	1,400	0	NA	-
Shegbemi	2,300	126	12,017	1,680	0	150	1,830
Tekule	1,200	117	30,833	1,426	260	180	1,866
Imo State							
Umuokpo (Emeabiam)	3,300	1,000	21,600	1,736	0	120	1,856
Agunumee (Nri-Ukwu)	4,000	800	20,800	2,440	0	120	2,560
Umudim (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
Ozara (Mgbee)	3,000	500	19,100	2,680	0	120	2,800
Obokuwu (Mbutu)	8,000	500	57,300	2,624	0	180	2,804
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

* The average income is the result of Survey 1 while the average energy expenditure is the result of Survey 2. Both the respondents and methods used by these two surveys differ but the findings are shown here for reference purposes.

3.2.3 Pre-F/S Implementation Plan

Based on the findings of the socioeconomic rural survey and others, the realistic quantity for introduction was calculated by the following process.

1) It is assumed that ordinary households are willing to pay 90% of their current expenditure for "energy sources replaceable by a PV system" (kerosene, diesel oil and dry cells for radio) for a PV system.
2) The amount which villagers are willing to pay based on assumption (1) above is classified into one of five groups, such as "introduction is impossible if the amount is NgN 800/month or less" and "introduction of a BCS if the amount is between NgN 800/month and NgN 1,200/month", etc.
3) The total number of households is proportioned based on the distribution of the amount which is

willing to be paid for a PV system in each village. In view of the likelihood that some households will choose not to participate in a project, the calculated figures are reduced by 30%.

The estimated project cost for each state is described next based on the cost of each PV system to which the estimated unit cost by a local dealer is applied.

3.2.4 Estimated Project Cost and Economic Evaluation

The estimated project cost based on the planned quantity of each PV system which is calculated on the basis of the process described in 3.2.3 is described here. For this estimation, the estimated unit cost by a local PV dealer is applied.

However, as it was judged to be difficult for an RESCO to secure the profitability of its business in each village because of the small quantity of each system, financial analysis is omitted here. Only economic analysis is conducted based on the assumption that a government subsidy will meet 50% of the initial investment cost as in the case of on-grid electrification.

(1) Jigawa State

In Jigawa State, the preferred PV system is a small-scale SHS (55 W). In northern Nigeria, the potential for the introduction of solar pumps from the viewpoint of securing water supply sources is very high. However, as the findings of the socioeconomic rural survey indicate a low ability to pay among residents and a small average power demand, the introduction of a BCS per village is planned.

Table 3-6 Quantity of PV Systems to be Introduced in Jigawa State and Reference Prices

(Unit: NgN thousand)

System	Quantity to be Introduced by Village						Total Quantity	Estimated Unit Price	Equipment Cost + Installation Cost
	Giginya	Maitsaniya	Jamari	Auramotudu	Kale Heyintara	Dankoshe			
SHS (50 W)						20	20	195	3,900
SHS (110 W)		80	190				270	259	69,930
SHS (165 W)							0	434	0
BCS					2		2	3,100	6,200
Mini-Grid			4				4	6,000	24,000
Solar Pump	1	1		1	1		4	5,500	22,000
School	1	1	1	1	2	1	7	900	6,300
Clinic	1	1	1		1	1	5	1,800	9,000
Mosque	3	5	4		10	1	23	900	20,700
Street Lighting	13	15	18	13	40		99	150	14,850
Total									176,880

The economic evaluation results are an EIRR of 38.6%, an ENPV of NgN 92,895,000 and a B/C ratio (a discount rate of 10% is used in accordance with the customary practice of the JBIC, World Bank and ADB) of 2.55, suggesting that a project on this scale is economically viable in Jigawa State.

(2) Ondo State

The financial status of many residents of Ondo State is somewhere between the poor and the rich and the planned PV systems are primarily the SHS 55 W and SHS 110 W types. The introduction of a mini-grid system is inferred to be difficult at the present stage because the village electrification associations do not have a sufficient maintenance system. Solar pumps have been requested by two villages and the contents of this request are considered to be appropriate given the size of each village.

Table 3-7 Quantity of PV Systems to be Introduced in Ondo State and Reference Prices

(Unit: NgN thousand)

System	Quantity to be Introduced by Village						Total Quantity	Estimated Unit Price	Equipment Cost + Installation Cost
	Onisere	Oloruntedo	Kajola Camp	Fayomi Camp	Shegbemi	Tokure			
SHS (50 W)	45		25	50	60	15	195	195	38,025
SHS (110 W)		160	10		40		210	259	54,390
SHS (165 W)			10			35	45	434	19,530
BCS	9					2	11	3,100	34,100
Mini-Grid							0	6,000	0
Solar Pump	2			1			3	5,500	16,500
School	1	1	1				3	900	2,700
Clinic	1					1	2	1,800	3,600
Mosque	5	9	2	1		10	27	900	24,300
Street Lighting	25	20				13	58	150	8,700
Hall							0	900	0
Total									201,845

The economic evaluation results are an EIRR of 34.8%, an ENPV of NgN 113,394,000 and a B/C ratio of 2.39, suggesting that a project on this scale is economically viable in Ondo State.

(3) Imo State

The subcontracted survey found that there is a request for a large-scale SHS system (165 W) capable of dealing with AC load in two villages. A mini-grid system will be introduced in four villages where the current energy expenditure level is high. However, as it cannot be assumed that 100% of households, including poor households, in these villages can pay the level of tariff necessary to maintain a mini-grid system, the electrification demand is estimated to finalise the quantity to be introduced as shown in Table 3-8.

Table 3-8 Quantity of PV Systems to be Introduced in Imo State and Reference Prices

(Unit: NgN thousand)

System	Quantity to be Introduced by Village						Total Quantity	Estimated Unit Price	Equipment Cost + Installation Cost
	Umuokpo	Agunumee	Umudim	Obibi	Ozara	Obokuwu			
SHS (50 W)	480	255	1,020				1,755	195	342,255
SHS (110 W)							0	259	0
SHS (165 W)	160					160	320	434	138,880
BCS	8					4	12	3,100	37,200
Mini-Grid		19		32	20	16	87	6,000	522,000
Solar Pump			1				1	5,500	5,500
School					1		1	900	900
Clinic	1		1				2	1,800	3,600
Mosque							0	900	0
Street Lighting	10	20	10	20	20	20	100	150	15,000
Hall		1		1		1	3	900	2,700
Total									1,068,005

The economic evaluation results are an EIRR of 41.1%, an ENPV of NgN 1,020,069,000 and a B/C ratio of 2.73, suggesting that a project on this scale is economically viable in Imo State.

(4) FCT

In the FCT, the use of PV systems is requested for solar pumps and such public facilities as schools and street lamps apart from the introduction of SHSs (55 W and 165 W) serving houses.

Table 3-9 Quantity of PV Systems to be Introduced in Imo State and Reference Prices

(Unit: NgN thousand)

System	Quantity to be Introduced by Village		Total Quantity	Estimated Unit Price	Equipment Cost + Installation Cost
	Gudun Karya	Yalwan Gawu			
SHS (50 W)		15	15	195	2,925
SHS (110 W)			0	259	0
SHS (165 W)	15		15	434	6,510
BCS	3		3	3,100	9,300
Mini-Grid		1	1	6,000	0
Solar Pump	2	1	3	5,500	16,500
School	1	1	2	900	1,800
Clinic	1	1	2	1,800	3,600
Mosque/ Church	5	2	7	900	6,300
Street Lighting	10	20	30	150	4,500
Police Station		1	1	900	0
Law Court		1	1	900	900
Total					52,335

The economic evaluation results are an EIRR of 36.0%, an ENPV of NgN 20,235,000 and a B/C ratio of 2.46, suggesting that a project on this scale is economically viable in the FCT.

3.3 Pilot Project

3.3.1 Outline of the Pilot Project

(1) Purposes of the Pilot Project

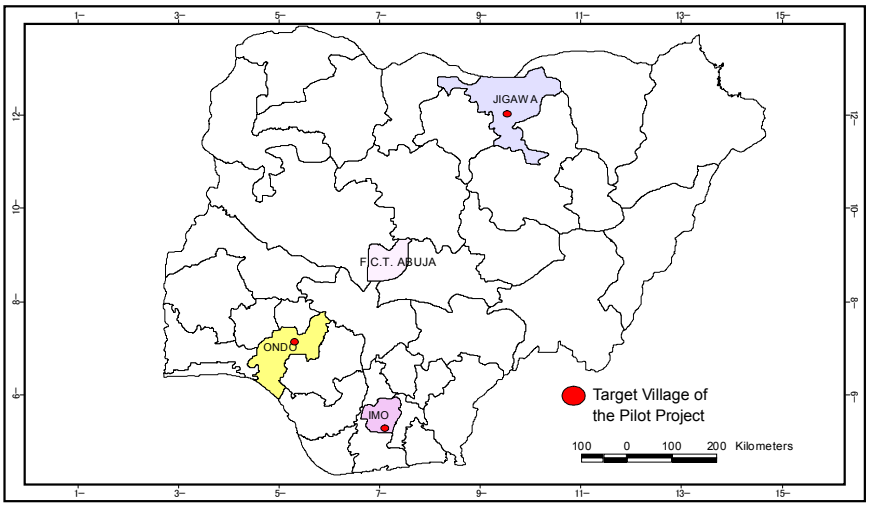
The implementation of the pilot project had the following purposes.

1) Selection and design of appropriate PV systems with due consideration of the continual development of PV systems and establishment of a system operation and management organization as well as a tariff collection system based on the participatory approach
2) Monitoring of PV systems for a period of approximately one year from system installation to evaluate the operation records and to make the formulation of the master plan for the utilisation of solar energy reflect the evaluation results
3) Procurement of small-scale PV systems and equipment using solar heat for the purpose of demonstration and organization of seminars in the target states of the pilot project to raise awareness of the potential to utilise solar energy
4) Capacity building of the counterparts regarding the design, work supervision, operation and maintenance of PV systems through the implementation of the pilot project

(2) Village Selection Criteria

The target areas for the pilot project were selected based on the criteria listed below, taking the local characteristics, geopolitical zone and possibility of connection to the grid up to 2020 into consideration as in the case of the selection of the target villages for the socioeconomic rural survey. As a result, Jigawa State in the north and Ondo State in the southwest were originally selected. Imo State in the southeast was added later because of a strong request by the Nigerian side. Fig. 3-3 shows the selected target areas for the pilot project.

1) Long distance (approximately 20 km or more) from an existing distribution line and no plan for electrification in the immediate future
2) Consent of local residents for PV electrification even though they understand the technological limitations of PV systems
3) Sufficient cash income of local residents to pay the tariff for a PV system
4) Existence of local residents who are already using a battery
5) Availability of distilled water for batteries in a nearby area and an effective means of transporting batteries



Source: The Study Team

Fig. 3-3 Locations of the Target Villages for the Pilot Project

(3) System Installation Plan

The PV systems installed at each pilot project site are listed below.

1) Jigawa State

- BCS and user system : 20 households
- Solar home system (SHS) : 40 households
- Street lighting : 10 lamps
- Public facility : 1 (mosque)

2) Ondo State

- SHS : 60 households
- Street lighting : 10 lamps
- Public facility : 1 (clinic)

3) Imo State

- SHS : 80 households
- Street lighting : 10 lamps
- Public facility : 1 (village hall)

3.3.2 Problems of the Pilot Project and Recommendations

(1) Transfer of Skills

The Study Team conducted the following sessions to transfer skills to the counterparts and others through the project implementation body.

1) Lecture on the procedure to examine PV system specifications using SHS and BCS design examples
2) Explanation of the technically required issues for each type of equipment (system), relevant standards, installation work method and contents of factory and on-site tests using the

technical specifications document for the pilot project

3) Explanation of the outline of the configuration of PV systems and the SHS design process using the PV system manual
4) Demonstration of the wiring for PV systems and the method of using the demonstration kit procured as part of the Study
5) Participation of the counterparts in the training session organized by the Contractor on the use of PV systems
6) Distribution and explanation of the PV system leaflet and SHS handbook prepared by the JICA

However, it cannot be confidently stated that the intended transfer of skills by the Study Team was totally successful because of the non-existence of counterpart engineers who could understand the necessary conditions for the required design, determine the equipment specifications for PV systems and satisfactorily prepare drawings and specification documents. The main reason for such shortcomings appears to be their insufficient practical experience of designing PV systems. A new approach is, therefore, required in the coming years to provide opportunities for these engineers to conduct system design for a similar project under step-by-step guidance.

Meanwhile, it was possible for the counterparts to duly conduct work supervision without external assistance once the key points of supervision were conveyed to them. Nevertheless, the provision of many opportunities for them to experience similar work is still necessary in view of the fact that how the problems of work supervision are identified depends on the engineering ability of each engineer.

(2) Management of Organization

The daily inspection of the PV systems installed under the pilot project is conducted by a technician appointed by the village electrification association organized at a village meeting. As these technicians do not have advanced technical skills, the counterparts of the state/local governments are requested to regularly visit the target villages to provide technical assistance and also to check whether or not the electrification association is properly functioning.

On its part, the village electrification association must collect the tariff from users. However, as of November, 2006, no collection has yet been made in some villages, partly because the amount of the subsidy by the local government has not been finalised. Accordingly, the state/local governments involved in the pilot project and the counterparts of the federal government must provide supervision and guidance for the village electrification associations regarding the question of tariff collection.

(3) Recommendations for Extension of PV Rural Electrification

Based on the field survey results and other relevant information, the Study Team has identified the following problems regarding the extension of PV rural electrification in Nigeria.

1) Low funding capacity of those providing electrification
2) Insufficient manpower to conduct maintenance work in rural areas
3) Insufficient efforts to lower PV equipment prices (high prices due to the insufficient dissemination of PV equipment and import duty, etc.)

For the counterparts in Nigeria to be able to solve these problems and to promote PV rural electrification based on the M/P, the establishment of village electrification associations and the selection of business operators is essential by examining the use of RESCOs and other business models in addition to improving the technical strength, increasing the maintenance staff and implementing PV system awareness raising activities.

3.4 National PV Electrification Programme

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

As the National Rural Electrification Programme formulated by the FMPS in 1981 assumes rural electrification based on extension of the grid, the FMPS intends the finalization of 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 has formulated the Renewable Electricity Policy Guidelines and is in the process of formulating the Renewable Electricity Action Programme as a means 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.

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) 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 tariff" 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 introduction 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 10% of the power demand of new users in the coming years.

3.4.2 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 established in due course.

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 less than 1 MW or of which the distribution capacity is less than 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.

3.4.3 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 tariff, etc. is the key to the successful implementation of a project. With the service model, the ownership of equipment remains with the service provider (Rural Energy Service Company (RESCO); a community-based supplier, a PV supplier or an electric company) which is responsible for equipment maintenance, including the renewal of equipment due to age or damage, and collection of the electricity tariff. 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.

One point which a project implementing body 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.

The reality of a SHS, which is the most common PV system, is that the tariff level will be higher than the level of the on-grid electrification tariff (fixed tariff: 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 tariff level for a PV system can be solved within the entire framework of the power sector (refer to Volume 2, Part 2, Chapter 3 for details of the subsidy system).

3.4.4 Selection of Off-Grid PV Electrification Systems

(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 commercial 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 such 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 during the rainy season as they may be isolated due to the flooding of rivers.

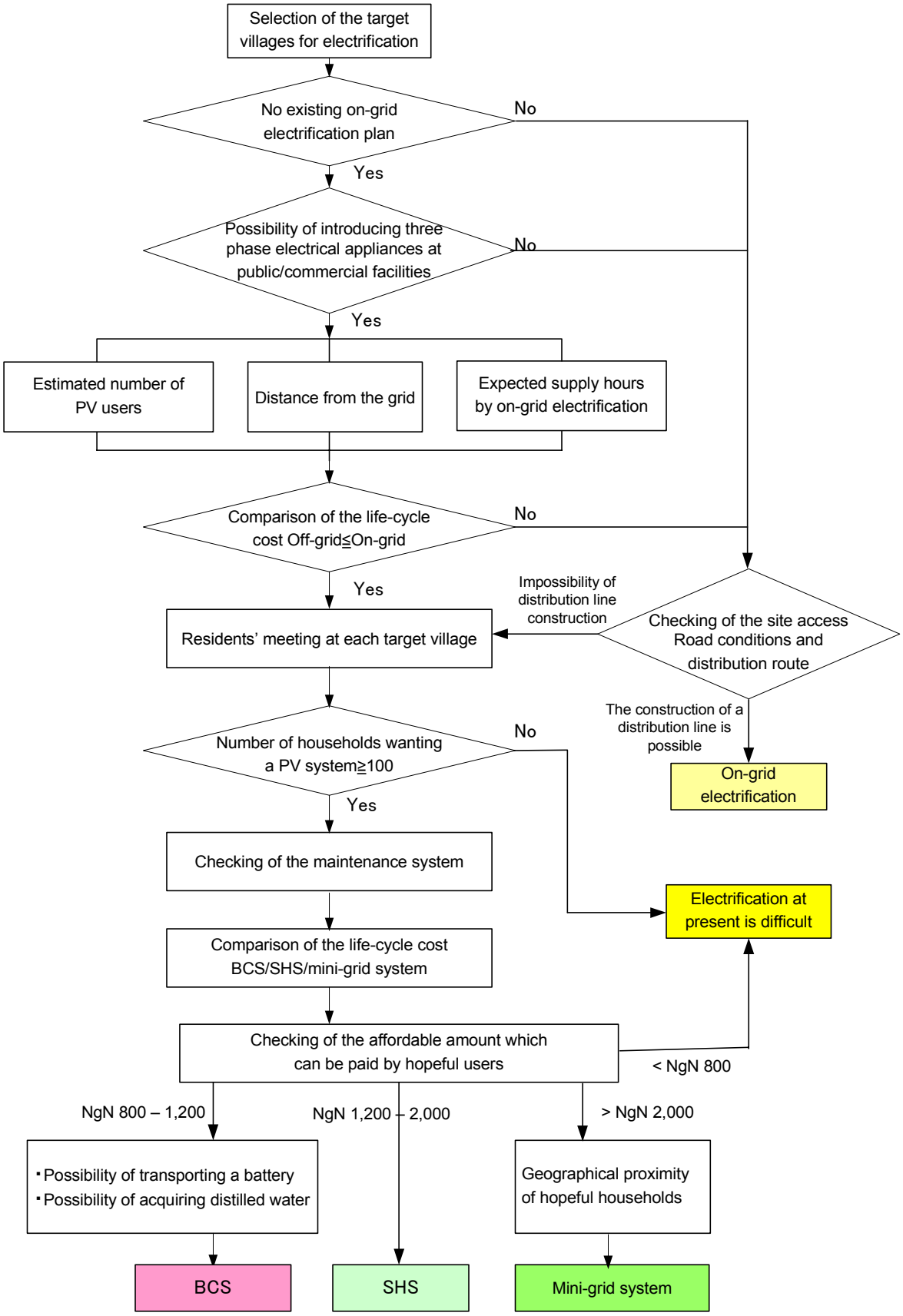
(3) Analysis of the Life-Cycle Cost

It must be confirmed that the life-cycle cost of the planned off-grid electrification is lower than that of on-grid electrification. 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 Tariff at a Residents' Meeting

For the introduction of a PV system, it is essential to check the intentions of local residents in advance by organizing a meeting in the target area. After confirmation of the maintenance system and assigned work of a village electrification association, it is necessary to check the affordable electricity tariff by willing users taking the life-cycle cost analysis results (BCS, SHS and mini-grid) discussed earlier into consideration.

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. 3-4 should be treated as a tool to check an area(s) where the introduction of a recommended system(s) is suitable.



Source: The Study Team

Fig. 3-4 Flow for Selection of Off-Grid PV Electrification System

3.4.5 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 PCHN forecasts that both the peak demand and the annual energy consumption will 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.

3.4.6 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.

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 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 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.

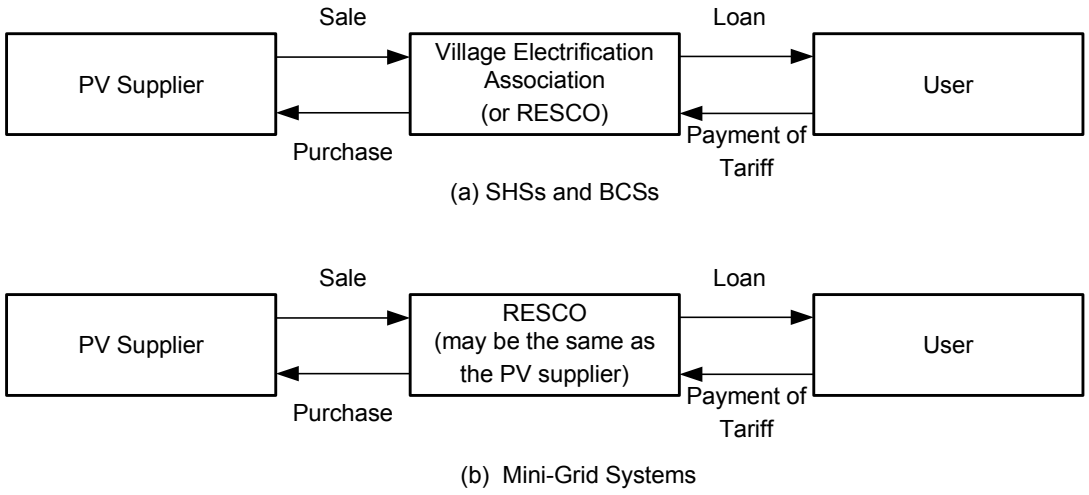
② **SHSs**

The introduction of SHSs led by the 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.

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, private RESCOs are considered to be the principal implementing bodies while excluding community-based (village) electrification associations from the potential implementing bodies.

Fig. 3-5 and Table 3-10 show the relationship between the PV supplier, service provider and users for each of the PV systems described above.



Source: The Study Team

Fig. 3-5 PV Systems to be Introduced and Relationship Between Service Provider and Users

Table 3-10 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

Based on the PV electrification business models described earlier, Table 3-11 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 3-12 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 electricity generated by 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 3-11 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

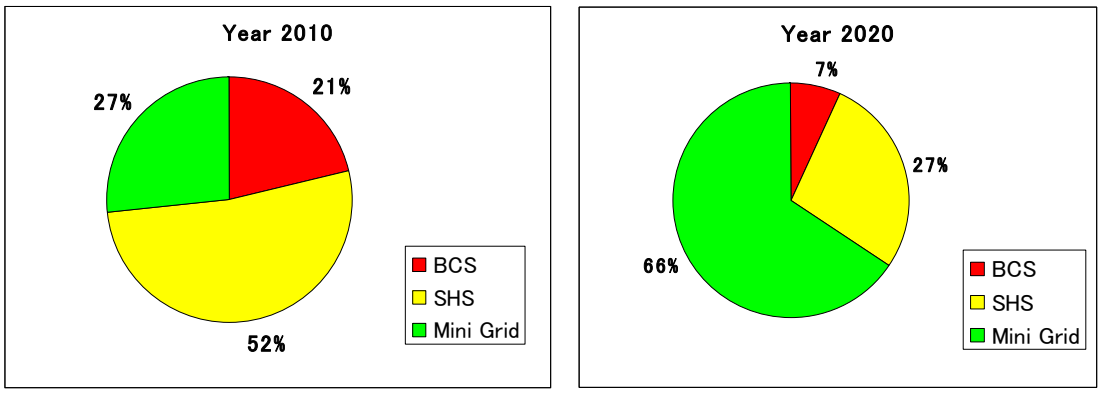
Table 3-12 National PV Electrification Programme

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. 3-6 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. 3-6 Off-Grid PV Systems in Use in 2010 and 2020

3.4.7 Project Implementation Plan

(1) Basic Policies

The introduction of PV systems for a total of some 340,000 households between 2007 and 2020 is planned as shown in Table 3-12. 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.

(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. Meanwhile, personnel of the FMPS, FMST and ECN who are involved in the planning and operation of the pilot project will transfer such required skills as the survey on 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) 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 from Phase 2 onwards.

(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.

(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. 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.

3.4.8 Investment Amount and Subsidy Required to Implement the National PV Electrification Programme and Related Financing Schemes

(1) Investment Amount Required to Implement the National PV Electrification Programme

Table 3-13 shows the calculated investment amount required to implement the National PV Electrification Programme shown in Table 3-12.

The annual investment amount will start at some NgN 2.4 billion and will continue in the range between NgN 2.5 billion and NgN 3 billion. The aggregate investment amount up to 2020 will be approximately NgN 37.6 billion.

Table 3-13 Investment Amount Required to Implement the National PV Electrification Programme

(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: The Study Team

(2) Amount of Subsidy Required to Implement the National PV Electrification Programme

In view of the fact that on-grid electrification receives a subsidy covering 50% of the initial investment amount required, it is expected that 50% of the investment amounts listed in Table 3-13 will be financed by a subsidy. While this 50% subsidy will be provided in the early years, it should be withdrawn when the equipment prices fall to those in the international market. Therefore, the annual amount of the subsidy will be gradually reduced from 2017 to 2020 so that there will be no further subsidy in 2020. In fact, the financial analysis, etc. in Volume 2, Chapter 3 conducts the financial calculations based on the schedule where the subsidy amount is reduced at a later stage, dropping to zero in 2020. Based on this assumption, Table 3-14 shows the amount

of the subsidy to be prepared by the REA.

The annual amount of the subsidy will be approximately NgN 1.2 billion at the beginning, followed by a period during which the amount will vary between NgN 1.2 billion and NgN 1.5 billion before starting to decrease in 2017. In 2020, the subsidy will be abolished. The aggregate of the subsidy up to 2020 will be NgN 15.6 billion.

Table 3-14 Required Amount of Subsidy to Implement the National PV Electrification Programme

(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: The Study Team

(3) Economic and Financial Analyses

The financial internal rate of return (FIRR) and the net present value (NPV) of the National PV Electrification Programme are calculated as shown below.

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

Table 3-15 shows the EIRR, the economic NPV (ENPV) and the B/C ratio (using a discount rate of 10% based on the customary practice employed by the JBIC, the World Bank and the ADB) for each of the mini-grid, SHS and BCS systems.

Table 3-15 FIRR, ENPV and B/C Ratio for Each Type of PV Electrification

	Mini-Grid	55 W SHS	110 W SHS	165 W SHS	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 : The ENPV figure is per household.

Source : The Study Team

As described in the section dealing with the financial analysis, PV systems are virtually non-existent in the power sector of Nigeria. As such, their prices are expected to gradually decline with the spread of the use of such systems. Once this decline starts, it will increase both the EIRR and the ENPV figures.

(4) Institutionalisation of Subsidy for PV Electrification

To stimulate a price decline of PV systems in the future through the wide use of these systems in Nigeria, it may be a good idea to introduce a subsidy system which copies the Project to Facilitate the Introduction of Home PV Systems of the New Energy Development Organization in Japan. In other words, the use of PV systems can be boosted by offering the same rate of subsidy for not only electrification projects implemented by such bodies as private RESCOs and village electrification associations but also for the purchase of PV equipment (systems) by ordinary households in the market for own installation. This arrangement is desirable from the viewpoint of ensuring the fair enforcement of a policy for all people. Although awareness raising as well as public relations activities must be extensively conducted, the market mechanism can be expected to naturally work to assist the spread of PV systems. The provision of a subsidy in Japan rapidly accelerated the installation of grid connection-type home PV systems and the application scope and subsidy rate were gradually reduced in accordance with the diffusion of such systems. This subsidy system no longer exists as PV equipment is now widely used throughout Japan. In Nigeria, it is desirable to introduce a subsidy as a tentative measure which will be gradually reduced/abolished in correspondence with the price decline caused by the wide use of PV equipment in the domestic market.

(5) Adoption and Implementation of Ring-Fenced Tax to Secure the Funding Source for a Subsidy

Another idea is the introduction of a 2% surcharge on the electricity tariff collected in existing on-grid electrified areas to facilitate PV electrification. This tax revenue can create a fund to be used for the implementation of PV electrification projects in unelectrified areas. The setting up of the Solar Energy Utilisation Extension Fund (tentative name) to receive and manage this ring-fenced tax may well be a viable fiscal policy. The income from electricity supply as of 2005 was US$ 687 million nationwide and 2% of this figure is US$ 13.8 million which matches the required annual subsidy amount (NgN 1.2 billion – NgN 1.5 billion) mentioned earlier. If this kind of financial circulation is realized, it can prove to be an effective measure to contribute to the narrowing of the gap not only between urban areas and rural areas but also between the rich and the poor and to the redistribution of income.

(6) Financial Support for Promotion of PV Electrification

Even if 50% of the initial investment cost required for PV electrification is financed by a subsidy, the remaining 50% must be raised from the cash owned by villagers and/or loans.

At present, there is hardly any formal financial services in rural areas in Nigeria and people in rural areas have to rely on informal finance. As such informal finance involves a much higher interest rate than formal finance, the introduction of a policy-based financial support measure is highly desirable as a means of actively promoting PV electrification. Institutions providing formal finance include commercial banks, government banks and a rural sector assistance programme supported by the government. Among these institutions, commercial banks primarily provide loans in urban areas and their presence in rural areas is extremely weak.

Among government banks, the NACB (Nigeria Agricultural and Cooperative Bank) is the principal bank operating in rural areas. The NACB was established by the federal government to assist an increase of agricultural production, to promote socioeconomic development in rural areas and to contribute to improvement of the income and standard of living of the rural populace.

The People's Bank of Nigeria (PBN) was established in 1989 by the federal government to improve access to finance by people or micro-enterprises which found it difficult to use the existing financial institutions. It operates not only in rural areas but also in urban areas and micro-credit is one of the most important loan facilities provided by the PBN. Given the purpose of its establishment, support for women, relief for widows, the elimination of poverty and relief for the handicapped are priority issues for the operation of the PBN.

Meanwhile, although the REA itself has no financing know-how, it must recognize the extreme importance of providing effective financial assistance measures for the target villages for PV electrification if PV electrification projects are to be successfully implemented. Accordingly, the REA should consider establishing a financial assistance programme in collaboration with the PBN so that this programme can support part of the funding for PV electrification.

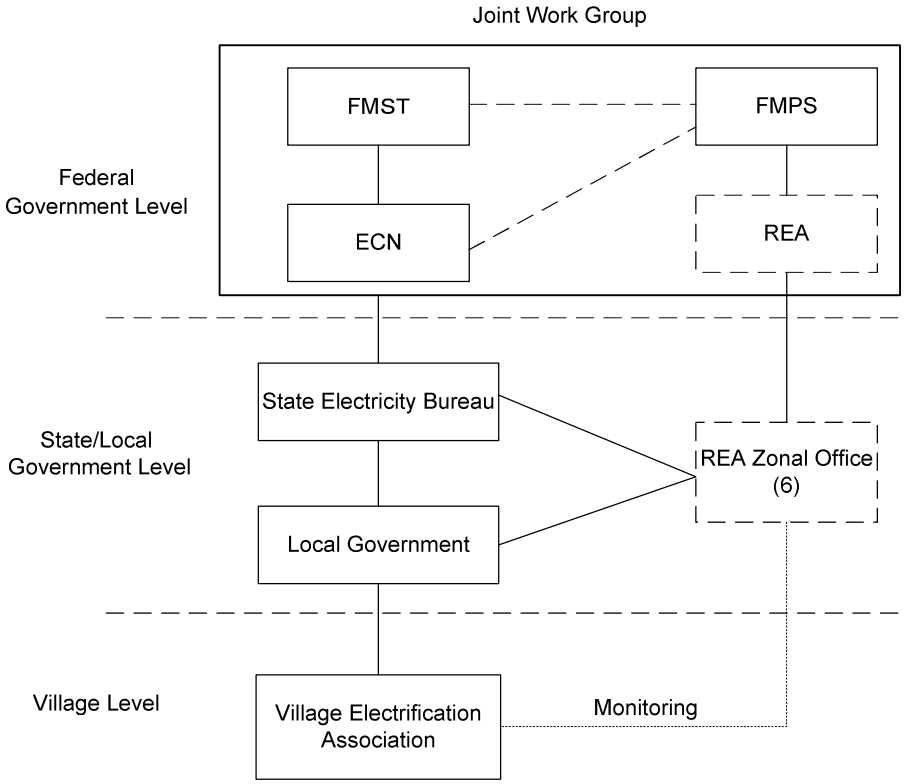
3.4.9 PV Rural Electrification Promotion Measures

(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.

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.

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. 3-7 for the planning and management of projects must be established. For this purpose, it is necessary to clarify the expected roles and goals of each organization involved in PV rural electrification with a view to formulating the necessary CD plan for each organization.



Source: The Study Team

Fig. 3-7 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 tariff as in the cases of the village electrification associations in the pilot project. The formats for the recording of the inspection results, tariff collection and response to breakdowns (trouble-shooting) of PV systems should be shared by all stakeholders.

The types of work described 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 tariff 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 (monitoring) to check whether or not daily and periodic inspections are properly conducted by the maintenance personnel.

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.

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 (Zonal) Offices

The headquarters of the REA is located in Abuja, the capital, and will establish branch (zonal) 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. 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.

- Introduction of quality standards and a type approval system for local products to improve the quality of PV-related products
- 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 and 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 electrification 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 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.

(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 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.

- 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, the high import tariff is an obstacle to the import of PV equipment. 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.

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 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, it is necessary to study (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, while emphasizing the compatibility of the forthcoming local technical standards with the relevant international standards.

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, a quality control system should be established by introducing a certification label to be attached to products which have passed the inspection.

3) Introduction of a PV-Related Equipment Certification System

For the extension of PV-related equipment, it will be necessary to introduce (i) a quality testing system to assess the compliance of equipment with the technical standards mentioned above and (ii) an equipment certification system. 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 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 tariff. 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.

(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. 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.

Another important measure is the training of RESCOs during the implementation process of PV rural electrification projects by the federal government as well as donors. There are many private companies in Nigeria which are capable of conducting the procurement and installation of PV systems and maintenance work business, including regular system inspection and tariff collection, to be conducted by RESCOs should be made accessible by private companies.

What is required is the examination of viable measures to gradually reduce the scope of business 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.

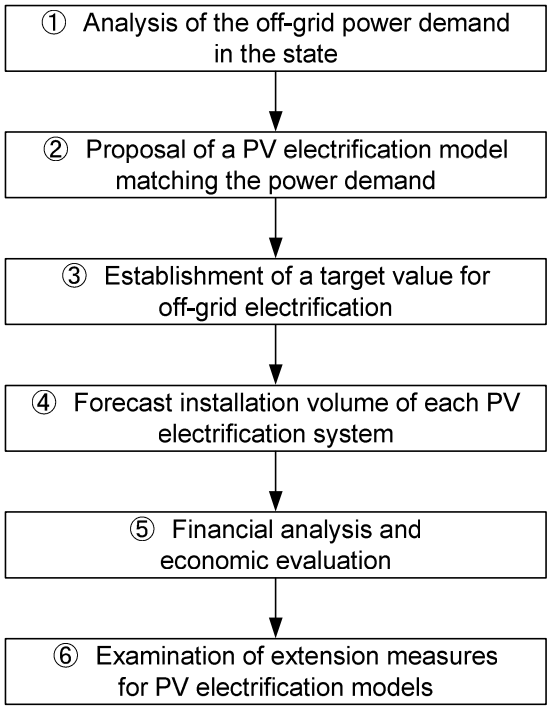
In regard to financial support, promising measures include micro-finance for PV rural electrification projects and soft loans designed to foster SMEs and these measures have frequently been used in Asia and Latin America. As the solar energy-related market size in Nigeria is as small as 100 KW or less, 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.

3.5 PV Rural Electrification Programme for State Governments

3.5.1 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 (commonly called “state governments” in this section) 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 off-grid rural electrification in the coming years, each state government should gather information and data on on-grid electrification and then formulate its own off-grid rural electrification programme. Fig. 3-8 shows the formulation of a PV rural electrification programme by a state government.



Source: The Study Team

Fig. 3-8 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, 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.

3.5.2 Jigawa State

(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% 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.

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 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.

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. Such a poor performance of on-grid electrification widens the geographical scope for off-grid electrification using PV systems.

(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 show that the average energy expenditure (i.e. the total expenditure for kerosene, diesel oil and dry cells) in unelectrified villages is 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.

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 as a short-term measure (up to 2010), 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 poor.

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, 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)

(3) Off-Grid Electrification Targets

To achieve the target electrified household ratio in 2020 under Nigeria's National Energy Policy, Jigawa State will have to provide electricity supply to 560,000 households, i.e. 35% of the 1.61 million households (estimated number of households 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 6,300 households by means of off-grid PV rural electrification will be necessary.

Based on the above analysis, Table 3-16 lists the PV systems of which the introduction in Jigawa State is planned by 2010 and 2020. In regard to SHSs, market penetration based on the model of direct sale by PV companies to wealthy users is forecast and it is assumed that 10% of the newly introduced SHSs will come from such direct sales.

Table 3-16 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

(4) Financial Analysis

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 3-16, 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 3-17 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

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. The significance of this type of organization lies with the need to examine the marginal level of its tariff so that the organization can operate without a cash flow deficit throughout the project life while ensuring the benefits of electrification for villagers.

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 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 expected size of the initial payment per household (Table 3-18), the monthly tariff and the battery charging fee (Table 3-19) are shown in the tables below.

Table 3-18 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 3-19 Monthly Charge and Single Battery Recharging Fee After Installation of a BCS

(Unit: NgN)

Installation year	2007	2008	2009	2010	2011	2012	2013
Monthly tariff (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 tariff (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) 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 3-20 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

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 tariff which is designed not to incur a deficit

is examined. The expected size of the initial payment per household and monthly tariff are shown in Table 3-21.

Table 3-21 Required Initial Cash Payment by Each Household for the Installation of a 55 W SHS and the Monthly Tariff 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 tariff (1-5 year)	1,210	1,160	1,110	1,050	1,000	950	900
Monthly tariff (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 tariff (1-5 year)	850	800	750	700	650	600	550
Monthly tariff (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 400 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 the number of public facilities for which a SHS will be introduced is extremely low, these facilities are not included in the scope of the present analysis.

3.5.3 Ondo State

(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% 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.

The two existing substations (Akure and Ondo), however, 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.

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. Such a poor performance of on-grid electrification widens the geographical scope for off-grid

electrification using PV systems.

(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 with an average expenditure as high as NgN 1,840/month. Given the fact that PV electrification poses certain 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 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.

(3) Off-Grid Electrification Targets

To achieve the target electrified household ratio in 2020 adopted by Nigeria's National Energy Policy, Ondo State will have to provide electricity supply to 1.24 million households, i.e. 99% (the target electrification rate for Ondo State in 2020) of the 1.25 million households (estimated number of households 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. 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.

Based on the above analysis, the mini-grid system is the PV system 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 estimated number of mini-grid systems to be introduced in Ondo State is 110 by 2010 and 495 by 2020 based on the assumption that one system will serve 20 households.

(4) Financial Analysis

< Mini-Grid Projects >

For the implementation of mini-grid based electrification projects in Ondo State, implementation by a RESCO is assumed. The pace of project implementation will correspond to the planned schedule. 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 3-22 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. As shown in the table below, the FIRR and the financial NPV are 17.9% and some NgN 350 million respectively.

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

3.5.4 Imo State

(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 current electrified household ratio of 61% 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 peak demand in

this state, including the suppressed demand, is estimated to be 120 MW, the available supply capacity is only 60 MW, meaning that only some 50% of the peak 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 peak demand at an annual rate of 6.7% and 5.9% respectively indicate the urgent need for facility expansion.

(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 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.

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 tariff 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 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, 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 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)

(3) Off-Grid Electrification Targets

To achieve the target electrified household ratio of 75% in 2020 adopted by Nigeria's National Energy Policy, Imo State will have to provide electricity supply to 1.33 million households, i.e. 96% (the target electrification rate for Imo State in 2020) of the 1.39 million households (estimated number of households 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.

Based on the above analysis, Table 3-23 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 dealers 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.

Table 3-23 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

(4) Financial Analysis

1) Mini-Grid Projects

For the implementation of mini-grid based electrification projects in Imo State, implementation by a RESCO(s) is also assumed instead of the village-based participatory approach for BCS or SHS projects.

Table 3-24 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. As shown in the table below, the calculated 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

2) 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. In Imo State, the level of the demand for electrification is high and it is inferred that 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 high specification SHSs will be installed in Imo State. 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 300 households (55 W for 180 households (60%), 110 W for 90 households (30%) and 165 W for 30 households (10%)).

Table 3-25 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, 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 tariff 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 3-26.

Table 3-26 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 tariff (1-5 year)	1,200	1,140	1,090	1,040
	Monthly tariff (6-20 year)	600	580	550	530
110W	Initial payment per household	38,880	37,135	35,391	33,646
	Monthly tariff (1-5 year)	1,620	1,539	1,472	1,404
	Monthly tariff (6-20 year)	810	783	743	716
165W	Initial payment per household	64,800	61,892	58,985	56,077
	Monthly tariff (1-5 year)	2,700	2,565	2,453	2,340
	Monthly tariff (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.

3.5.5 FCT (Abuja Federal Capital Territory: FCT)

(1) Analysis of the Power Demand

Although the local 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% 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. However, 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. The annual increase rate of the number of users is as high as 12 – 27%. In the case of the peak 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.

(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. Because of restrictions posed by some PV systems 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 tariff is necessary. Given the short distance for grid extension to unelectrified villages, the introduction of a mini-grid system which can be easily relocated once on-grid electrification is realised in the near future is proposed (the same PV electrification model adopted for Ondo State).

(3) Off-Grid Electrification Targets

To achieve the target electrified household ratio of 75% (national average) adopted by Nigeria's National Energy Policy, the FCT will have to provide electricity supply to 200,000 households, i.e. 99% (the target electrification rate for the FCT in 2020) of the 210,000 households. 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.

Based on the above analysis, it is assumed that 20 units of mini-grid systems will have been introduced in the FCT by 2010 and the number of units will increase to 85 by 2020. It is also assumed that a private RESCO will act as the principal project implementing organization in accordance with the REA's policy.

(4) Financial Analysis

< Mini-Grid Projects >

For the implementation of mini-grid electrification projects in the FCT, implementation by an RESCO is assumed. Table 3-27 shows the annually required investment cost for mini-grid systems.

Table 3-27 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

The FIRR and NPV of an RESCO conducting mini-grid electrification in the FCT are calculated. 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

3.6 Maintenance System for Implementation of the Master Plan

The Study Team conducted the basic study, gathering of information related to the PV Rural Electrification Programme and the pilot project in four target areas, i.e. Jigawa State, Imo State, Ondo State and the FCT, in Nigeria. In the villages where the pilot project was implemented, a village electrification association was organized and fostered. In Section 3.6, the analysis results regarding the problems of the maintenance system established by the self-governing body in rural villages to manage the electrification project, their solutions and techniques for the organization of local residents to ensure the smooth operation of a PV system(s) are compiled based on the knowledge obtained through the various activities mentioned above. However, the electrification projects of PV dealers (RESCOs) are omitted from the scope of the analysis.

3.6.1 Traditional Rural Communities and Development Organization

In rural villages in Nigeria, the authority for the management of the village and land is often monopolised by an elders' group led by the village head and democratic discussions among villagers are difficult in many cases. Accordingly, the introduction of new technologies and equipment in a village is extremely difficult without the cooperation of the elders' group. In many villages, the low educational level and slow adaptation to modern technologies prevent the spread of innovative technologies.

Although various types of residents' organizations have been established in rural society in Nigeria, not many are smoothly managed by the residents themselves. Even in the case of organizations established with the guidance of an aid organization, the habitual outcome is the collapse of such organizations with the ending of external assistance.

Compared to elders' groups, young people generally show a positive stance to the introduction of new technologies, such as PV. It is, therefore, desirable to establish a new organization which is mainly composed of young people for the purpose of establishing a system for residents to accept new development efforts while cooperating with the elders' group. In this context, it is essential to ascertain the thoughts of the elders' group and the existing decision-making method in the target villages so that judgements on new development efforts by the residents can be swiftly made without causing any conflict within the villages.

3.6.2 Establishment and Stabilisation of a Maintenance Organization Through the Participatory Approach

(1) Principle of Resident Participation

For the formulation and implementation of a PV rural electrification project with resident participation, it is essential for the higher organization (state or local government) acting as a facilitator in the field to strictly restrict its role to the provision of advice and the creation of an atmosphere in which local residents can freely express spontaneous opinions.

There is an exclusive village society in every village and a counterpart organization is "a stranger" to the villagers to start with. In view of the mentality of local residents, a stance of respecting their initiatives should be adopted. There are several basic principles for the

implementation of PV electrification as listed below.

- Harmonisation of the needs of local residents with the purposes of a PV electrification project
- Respect for the local lifestyle, formulation of a flexible plan whereby a PV electrification project is integrated to local life and the provision of flexible responses in the course of project implementation
- Respect for the initiatives of local residents to promote a PV electrification project
- Checking of the exact capacity of the people in unelectrified villages in advance

One concrete example of the integration of an electrification project to local life is the preparation of an electrification schedule which incorporates festivals and ceremonies based on the agricultural calendar in the project implementation plan so that the project components selected by local residents are placed on the said calendar. Flexible responses, including changes of the planned schedule in response to changes of the natural conditions (disasters and bad weather, etc.) and social conditions (change of the government and strikes, etc.), are required for project implementation.

(2) Roles and Local Residents and the Higher Organization

Local residents and the higher organization have the responsibilities and roles described below.

1) Local Residents

- Local residents are the main actors in the planning and implementation of a project.
- Local residents organize and manage the village electrification association (or committee) which acts as the main body for project implementation.
- Local residents use the installed system properly and maintain system operation records

For the formulation of a project implementation plan, local residents must establish a clear picture of the current situation of their village and examine what they can do themselves (affordable initial investment amount, affordable monthly tariff and free labour contribution during the work period, etc.) It is also necessary for local residents to examine and clarify those things which they expected from the higher organization (subsidy and technical guidance/aid, etc.) and to make the necessary requests. In short, what is necessary is for local residents to act as the main players and to take the initiative at all steps of the project implementation process.

2) Higher Organization (State/Local Government)

- The higher organization is in a position to facilitate the participatory approach at the village level and to assist as well as advise local residents so that local residents can plan and implement a project based on their own initiative.
- The higher organization also plays the role of starting and coordinating a participatory PV electrification project as a facilitator.
- The higher organization provides guidance for local residents so that the latter can organize and manage a village electrification association which acts as the project

implementing body.

- The higher organization regular monitors the electrification project after the completion of the construction work and provides the necessary advice and support for the said association.
- When a problem which cannot be solved by the higher organization alone occurs, this problem should be referred to the federal government for guidance, cooperation and/or assistance.

The higher organization should not make any proposal which forces local residents to accept its opinion at meetings to formulate a project implementation plan and on other occasions. It must restrict its role to increasing the motivation of the participants and to stimulating the fair exchange of opinions among local residents, bearing in mind the fact that "local residents know the local situation better than anyone else".

(3) Organization of a Village Electrification Association

Based on the guidance and cooperation of the higher organization which acts as a facilitator for a PV electrification project, local residents organize a village electrification association while noting the following points.

- In principle, one association should be established in each administrative village.
- The association should have a chairman, vice-chairman, secretary, accounting clerk and liaison (vocal) officer.
- The maintenance staff for the project should be employed under the supervision of the association.
- The organizational structure of the association should be as simple as possible.
- The accounting clerk should collect the maintenance charge from the users and manage it in a bank account.
- The organized village electrification association should be managed noting the following points.
- As the association is the supreme decision-making organ, it is desirable for its officers to be selected from all hamlets.
- The association should constitute an important link between villagers and external organizations (higher organizations, including the federal government and aid organizations, NGOs, related government offices and private companies).
- The chairman should be selected by means of an election by all or mutual voting among the association officers, etc. as proposed by local residents to reflect the collective preference of local residents.
- The association should seek collaboration with the administration.
- The social customs in the area should be respected in the organization of the association and any of its subcommittees.

(4) Roles of Project Maintenance Staff

The project maintenance staff (technician, guard and tariff collector) selected by the village electrification association should, in principle, be stationed in the electrified village to which they are assigned to work and should conduct the following work.

- Recording of operation and maintenance data on the installed PV system and reporting of the said data to the higher organization
- Repair and replacement of equipment which has broken down or reached the end of its life
- Education of users on the appropriate use of the equipment and monitoring of the use of the equipment
- Collection of the maintenance charge from users
- Safe-keeping of the collected charge in a bank account and the management of such charge using an appropriate book-keeping method

(5) Contract with Local Residents

For the implementation of a participatory PV electrification project, it is essential to conclude an equipment lease contract between the village electrification association as the electrification body and individual villagers who are the users. The process of concluding this contract and its contents are explained below.

- A draft contract document should be prepared, requesting the advice/guidance of the higher organization or aid organization involved.
- The contract document will become a formal document when its contents are agreed by each local resident.
- The contract document must clearly state the obligations and responsibilities of each local resident, such as the amount of deposit to be paid by each local resident, monthly charge, equipment maintenance method and method of informing of an equipment breakdown and such obligations and responsibilities of the village electrification association as the repair of broken-down equipment, replacement of consumables and reporting method to the higher organization.

(6) On-Site Short Skill Teaching Course

In cooperation with the village electrification association, the state/local government as the higher organization will organize a short skill teaching course in the following manner to provide guidance on how to use and maintain the equipment and how to compile records for the local residents participating in the PV electrification project. In principle, the trainers will be those responsible for PV electrification of the state/local government and staff members of federal government offices (FMPS, FMST, REA and ECN) and energy research centres may be requested to act as trainers if necessary.

The training materials to be used for this short skill teaching course should be prepared taking the following points into consideration.

- The on-site short skill teaching course should be implemented with two components for each project. These components are an explanatory meeting of the necessary skills and field exercises.
- At the explanatory meeting of the necessary skills, charts with illustrations and key points should be used along with verbal explanations to enhance the visual appeal.
- The field exercises mean the trial of the skills which are explained at the explanatory meeting of the necessary skills and should always follow the said meeting.
- The posters and materials to be used/distributed at the explanatory meeting of the necessary skills should be prepared using simple language for easy understanding and should be kept by local residents after the meeting for the purpose of post-course reference. They should also be used for the extension of technical information to those local residents who did not attend the course.
- At the explanatory meeting, the participants should be encouraged to ask questions to ensure their full understanding of the necessary skills before moving to the field exercise stage.
- During the field exercises, the questions raised by local residents should be properly answered as the occasion arises.
- Local residents should be urged to voluntarily prepare as many tools and materials for the field exercises as possible. For this purpose, they should be informed in advance of the tools and materials required for the field exercises.

3.6.3 Monitoring

(1) Monitoring Method

The usage situation of PV systems must be regularly monitored to ensure the proper use of all PV systems for a long period of time. The recommended monitoring method is described below based on the form prepared by the Study Team for the collection of operation and maintenance records in the pilot project. This form takes the consistency of the records and the illiteracy rate of the system users into consideration.

① Recording of the daily energy consumption of the SHS, BCS and public facility
② Entry of operation and maintenance records on the form by the maintenance person of the village electrification association who visits the user households every day
③ Regular submission of the operation and maintenance records to the higher organization (person in charge at the state/local government)
④ Recording of the spare part and consumable inventory level every month during the period of system use
⑤ Early arrangement of spare part and consumable delivery when the possible long procurement period of these items is likely to cause a shortage

(2) Analysis of the Monitoring Results

The higher organization (state/local government) should conduct the following analyses based on the monitoring records submitted by the village electrification association and provide the necessary recommendations and guidance for the maintenance staff of the said association.

① Technical Aspect

- Analysis of the load pattern (peak demand and duration of use)
- Analysis of the maintenance records (contents of inspection, broken-down equipment/components and trouble-shooting)

② Operational Aspect

- Collection of the charge
- Revenue management

3.6.4 Future Maintenance System

The pilot project monitoring results and analysis results by the Study Team indicate the importance for village electrification associations to carefully note the following points for the successful implementation of the M/P.

① As the maintenance staff of village electrification associations do not have sufficient skill, the establishment of an appropriate support system will be necessary.
② Although the state/local government as the higher organization should primarily be responsible for the establishment of an appropriate support system for village electrification associations, the manpower and technical expertise are both insufficient.
③ It is, therefore, essential for the state/local government to seek the assistance of the federal government.
④ To provide effective assistance, federal government offices (FMPS, FMST, ECN and REA) must reinforce the service and maintenance system through the direct participation of the local governments, village electrification associations and local residents in addition to efforts to build the capacity of each state government.
⑤ It is also necessary to examine the possible regular dispatch of staff members of energy research centres under the control of the ECN as technical advisers to PV electrified villages (the funding source for the travel expenses of these staff members must also be examined).
⑥ The prices of PV systems are extremely high at present and any PV system will constitute a very heavy financial burden for villages until the price declines through the widespread use of such systems. For this reason, the PV tariff and tariff collection system must be carefully determined taking the findings of a detailed socioeconomic survey on the target villages for electrification and the current electricity tariff in nearby electrified villages into consideration.

3.7 Solar Energy Awareness Raising Action Plan

3.7.1 Role of Awareness Raising Activities

Awareness raising activities actually mean that the Government of Nigeria publicises, explains and provides education on the utilisation of solar energy for the purpose of facilitating the utilisation of solar energy. These activities aim at avoiding as well as solving the problems associated with the installation and maintenance of PV systems in the short-term and at creating a better environment for the extension of PV systems in the long-term.

The resulting wide use of solar energy utilisation systems will lead to a fall of the system prices and the further expansion of system usage, creating a virtuous cycle. To achieve such positive results, it is essential to not only spread information and knowledge but also to develop the capacity to coordinate and make the right judgement and the institutional and organizational as well as physical frameworks. Capacity development (CD) is required for people involved in the utilisation of solar energy to fully understand the above requirements and to pursue the realisation of the utilisation of solar energy. Awareness raising activities, therefore, form part of CD, primarily featuring the conveyance of vital information.

3.7.2 Outline of Awareness Raising Activities

Awareness raising activities have their own implementing bodies, receiving bodies and themes and it is essential to consider who conducts what for whom and how.

< Who and When >

Here, such groups as implementing bodies and receiving bodies which have a role to play in awareness raising activities are defined as stakeholders. In reality, these stakeholders are diverse, ranging from government-related groups implementing activities and users and companies, etc. at the receiving end of activities to NGOs, the media and educational/research organizations, etc. For example, while government-related bodies play the principal role of raising the awareness of local residents and the industrial circle, they must be fully prepared to conduct the necessary activities. If the preparations are insufficient, they may find themselves at the receiving end of awareness raising activities. Meanwhile, government officials in such fields as health care, education, agriculture and communication are likely users of solar energy.

< What >

Here, "what" actually means the themes, contents of the information conveyed through awareness raising activities and the details of such activities. The actual contents conveyed correspond to the role and interests of each stakeholder. Some are common for all stakeholders while others are unique to specific stakeholders. The scope of such contents is extremely wide but can be conceptually classified in the following categories.

- Points for which education and motivation are required
- Points which are not understood, not fully understood or incorrectly understood
- Important points which are specific to each stakeholder

・ Impressive as well as interesting examples

One example of a common point is the need for the minimum understanding of what solar energy and PV are by all stakeholders so that any incorrect understanding or expectations can be corrected and the utilisation of solar energy can be accepted in a positive and enthusiastic manner.

< How >

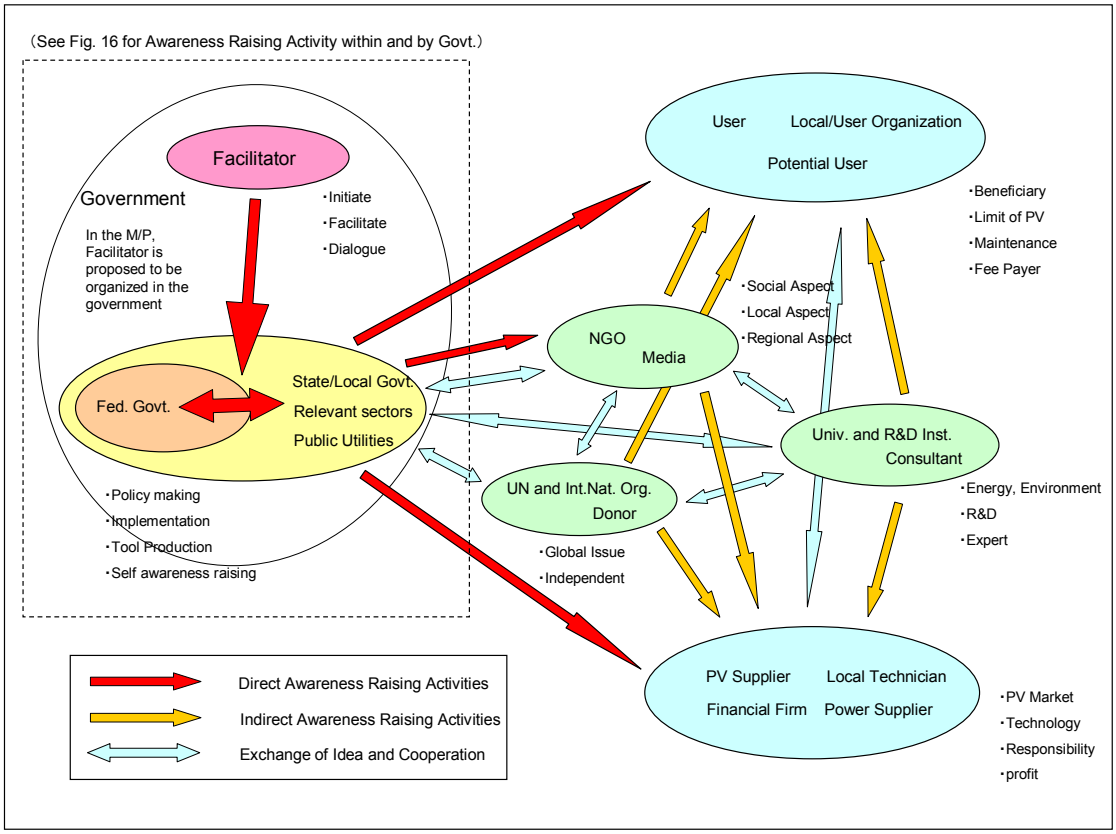
Here, "how" means the method and process. As awareness raising activities are part of CD relying on the conveyance of information, the method to implement these activities means the information conveyance method. In reality, there are many methods. However, from the conventional point of view, there are two methods or stages. The first is to inform as many people as possible of the existence of themes b a simple message using media, etc. The second is to convey information on a specific theme to specific targets. What is essential is the selection of the most appropriate method and media to ensure the maximum effects on the targets for awareness raising.

The addition of a time element, i.e. "when", for implementation to such components of awareness raising activities as the stakeholders, contents and method/process results in concrete actions. The action plan considered here incorporates the following actions.

・ Actions of the government to establish a system to implement awareness raising activities
・ Actions which are themselves awareness raising activities
・ Actions to prepare awareness raising activities
・ Actions designed to promote awareness raising activities by stakeholders other than the government

3.7.3 Stakeholders (Implementing Bodies, Receiving Bodies and Media, etc. Related to Awareness Raising Activities)

The stakeholders related to awareness raising activities and their general relationship are shown in Fig. 3-9. The area in Fig. 3-9 where direct awareness raising activities by the government(s) takes place is the main subject area for the M/P. The relationship between awareness raising activities within the government and those directly implemented by the government is shown in Fig. 3-10.



Source: The Study Team

Fig. 3-9 Stakeholders in Awareness Raising Activities and Their Relationship

3.7.4 Stakeholders Implementing Awareness Raising Activities

Within the framework of the M/P, the Government of Nigeria implements awareness raising activities. The stakeholder who forms the functional core for the launching and promotion of awareness raising activities within the government is defined here as the facilitator with a view to formulating an action plan. This may be called a solar energy awareness raising committee. When an awareness raising strategy is put into action, it starts with the facilitator.

Although the facilitator is positioned on the left-hand side in Fig. 3-9, it is conceptually at the centre, affecting all stakeholders via the government. It is proposed that the section succeeding the JWG under the present Study in an expansive manner be made the facilitator as a realistic plan. If allowed from the organizational point of view, representatives of industry, the financial sector, NGOs, educational/research institutions and the media, etc. should become members of this body acting as the facilitator.

As the first step, it will be necessary for the facilitator to set up a system to implement awareness raising activities in collaboration with such federal government bodies as the FMPS, FMST, REA and ECN, all of which are directly involved in PV rural electrification, other related federal government bodies responsible for health care, education, agriculture and communication, etc. and state/local governments. Thereafter, the facilitator will function to maintain and expand the

implementation system for self awareness raising activities and awareness raising activities within the government and to facilitate the exchange of information between stakeholders to enable the implementing stakeholders to continually promote awareness raising activities in a comprehensive manner.

In addition to the government, educational/research institutions, NGOs and international organizations, etc. will also implement awareness raising activities. It will be the facilitator's job to monitor and coordinate the efforts of various government bodies to promote awareness raising activities.

3.7.5 Target Stakeholders for Awareness Raising Activities

(1) Public Sector

The target stakeholders for awareness raising activities in the public sector include federal government offices related to energy, power, policy planning, finance, education, the environment and gender, state and local governments and sections responsible for public works. While the federal government will basically be the implementing body for awareness raising activities, it can also be the receiving body for the preparation of its actions. Those government offices mentioned above will also find themselves as users. The awareness raising activities of the government for the government will, therefore, be self awareness raising activities. It is essential for the government to be fully aware of its role as the implementer.

Government officials must basically understand all of the issues involves as the implementers of awareness raising activities. These issues are rationalisation of the utilisation of solar energy, the situation of electrification in Nigeria, the global environment, energy, poverty and gender, etc. They must be convinced of what PV can do to deal with these issues. You cannot be expected to convince others if you are not convinced yourself.

(2) Users and Potential Users

User groups include local residents, residents' organizations, companies, public organizations and government organizations, etc., all of which will benefit from electricity supply made available through the implementation of a rural electrification project. Users in existing electrified areas are added to this list as they can also benefit from the utilisation of solar energy in general.

All users must be sufficiently made aware of the limitations of PV systems, the regular maintenance requirements, cost and payment in order to avoid disappointment in addition to their need to have a basic understanding of solar energy and PV systems.

(3) Product Suppliers and Service Providers

This type of stakeholder includes private PV equipment manufacturers/suppliers, companies which install and maintain PV systems, local electricians, village technicians, banks and other financial institutions and private RESCOs, etc. which obtain income from the manufacture and sale of equipment and the provision of services in the course of the implementation of rural electrification projects. Their main business motivation is profit and it is difficult to make them

spring into action with awareness raising activities alone. However, there are many things, including the provision of business ideas, which can be done as part of the general policies. Another critical point for awareness raising is the fostering of corporate morals regarding the importance of product and service quality.

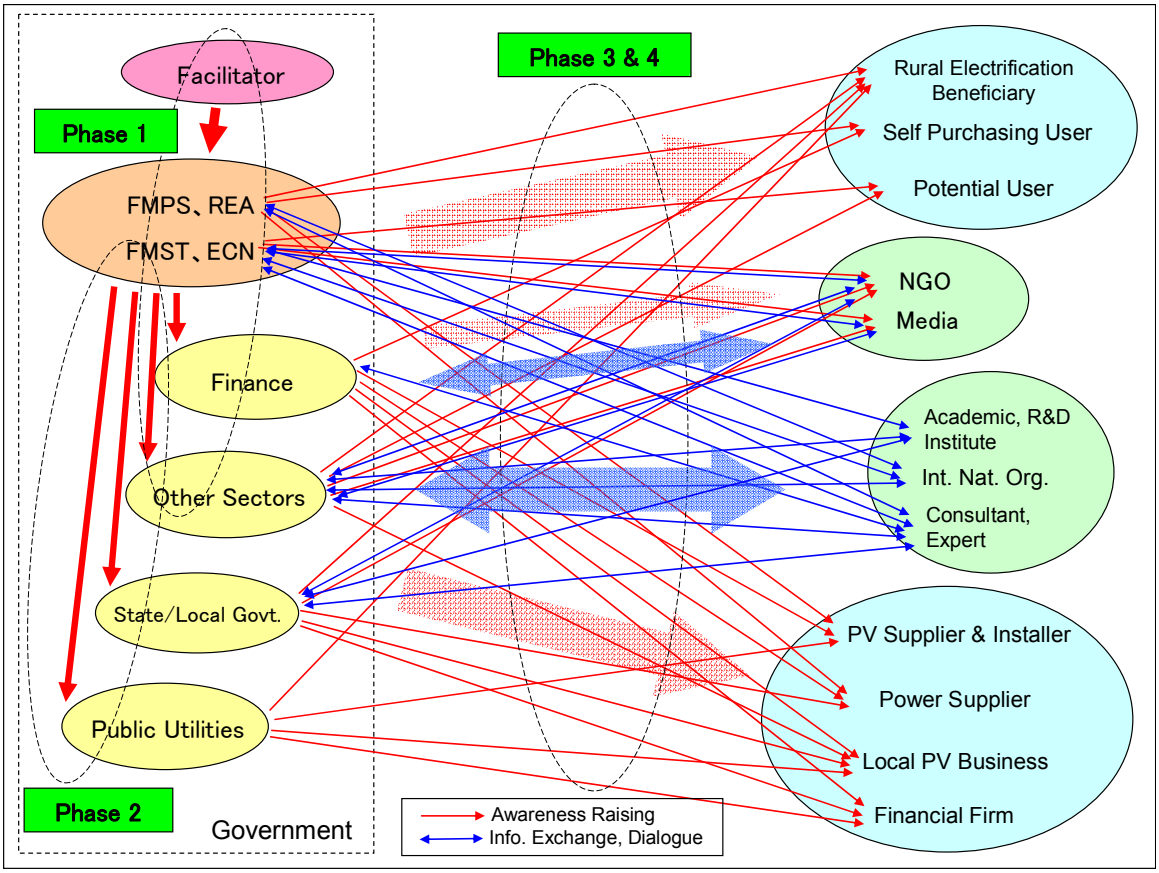
(4) Others

Other stakeholders which are the subjects of awareness raising activities are NGOs and the media, etc. Raised awareness of the importance of the wide uses of PV systems on the part of these stakeholders can be expected to make them act as catalysts to further boost the awareness raising effects.

As targets of awareness raising activities, the position of NGOs is similar to that of self-purchasing users and local governments. In general, it is believed to be possible to conduct more profound awareness raising activities for NGOs. The abilities of NGOs are particularly important to facilitate understanding of the organizational management, PV system operation and maintenance of village electrification associations and the relevant extension activities. Meanwhile, such media as TV, radio, ISP, newspapers and magazines are mainly means of conducting awareness raising activities. NGOs and the media can provide advice on the implementation methods of government-based awareness raising activities for the bodies implementing such activities.

3.7.6 Relationship Between Direct Awareness Raising Activities Within the Government and Those by the Government

As already pointed out earlier, the government is the main body to implement the awareness raising activities, etc. which are dealt with by the M/P. The target stakeholders of these activities are roughly classified into the government itself (self awareness raising), users, private companies and others (NGOs and academic/research institutions). Each target group category can be further divided into sub-groups with different characters. The rural electrification programme currently in progress which incorporates the ongoing reform of the power sector and the roles of each stakeholder within the government are not necessarily clear. Nevertheless, the relationship between the various awareness raising activities as well as information exchange activities of the government are roughly as shown in Fig. 3-10. When the various elements of the government are placed in a single framework, the flow of the awareness raising activities of the government is represented by the five thick arrows in Fig. 3-10 which are also shown in Fig. 3-9.



Source: The Study Team

Fig. 3-10 Relationship Between the Direct Awareness Raising Activities Within the Government and Those by the Government

3.7.7 Awareness Raising Action Plan

Awareness raising activities should preferably be implemented in four phases as shown in Fig. 3-11. Phases 1 involves the building of a system and training (approximately three months) within the federal government and starts after the submission of the M/P. Phase 2 follows Phase 1 in that efforts are made to build a system incorporating both state and local governments and further training (approximately six months). These two phases are preparatory phases and it is desirable for them to be completed prior to the full-scale commencement of actual PV rural electrification projects.

Phase 3 during which full-scale awareness raising activities commence lasts for a long period of time and a concrete plan which reflects the reality is formulated at the beginning of Phase 3. The present action plan describes actions plans which are considered to be feasible at present. Phase 4 features awareness raising activities which target local residents and companies involved in the actual electrification work in the target areas. Phase 4 is implemented in parallel with Phase 3.

Implementing Body	Phase 1 (approx. 3 months) Commencement in 2007	Phase 2 (approx. 6 months)	Phase 3 (Continual Activities)
・ Facilitator ・ Federal Government	・ Formation of the facilitator ・ Building of an internal system ・ Preparation of tools ・ Training		・ General awareness raising by the media, etc. ・ Collaboration with other government bodies, etc. ・ Guidance for state/local governments ・ Information exchange with PV-related companies ・ Information exchange with NGOs and the media ・ Information exchange with international organizations ・ Self awareness raising (awareness creation) activities → Continue

Guidance by the Federal Government ↘

Implementing Body	Phase 1	Phase 2 (approx. 6 months)	Phase 3 (Continual Activities) and Phase 4 (Linked to the Rural Electrification Work of the REA)
・ State Governments ・ Local Governments		・ Building of an internal system ・ Preparation of tools ・ Training	・ General awareness raising for local residents ・ Information exchange with local PV-related companies ・ Information exchange with local NGOs, etc. ・ Collaboration with the federal government ・ Self awareness raising activities ・ Awareness raising activities for the implementation of electrification work (Phase 4) ・ Information exchange with local PV-related companies (Phase 4) → Continue

Source: The Study Team

Fig. 3-11 Different Phases of Awareness Raising Activities

(1) Phase 1: Building of an Internal System by the Federal Government

1) Establishment of the Facilitator

The setting up of a section which succeeds the JWG under the Study in an expansive manner inside the REA and the making of this section the facilitator (a solar energy utilisation awareness raising committee composed of members representing the FMPS, FMST, REA, ECN and others) has already been proposed. Firstly, this proposal must be officially agreed by all related government offices. As the JWG already exists, what is required now is a venue at which meetings, etc. can be held. This agreement must be followed by further agreement regarding the remuneration to be paid to external resource persons and who will pay their travelling and other expenses for the series of workshops discussed below.

2) Workshops Within the Facilitator

After the establishment of the facilitator (at the federal government level at this stage), a series of workshops will be held within the facilitator using the M/P prepared by the Study. The advice of universities and consultants, etc. will be sought for the selection of resource persons. Sufficiently suitable resource persons should be available in Nigeria. The M/P will act as a manual for the selection of these persons.

3) Workshops on Awareness Raising Activities Within the Government

After the understanding awareness raising activities become sufficiently deep within the facilitator, the facilitator itself will act as the resource person to organize an intra-government workshop and will invite government officials to participate from such related sectors as health care, education, agriculture, finance and gender as well as REA officials responsible for the zonal offices.

4) Preparation of Tools for Workshops on Awareness Raising Activities Within the Government

After reaching a sufficiently deep level of understanding, presentation materials, manuals and reference materials will be prepared for their continual use at the workshops on awareness raising activities and other occasions, targeting state and local governments and other related government bodies.

5) Preparation of Tools for Users and Companies

Presentation as well as reference materials for their use at seminars targeting PV system users will be prepared along with user manuals, pamphlets explaining the key issues and leaflets explaining the principal points. Pamphlets, leaflets and a questionnaire for information gathering should also be prepared for distribution to equipment suppliers. These will be used later in Phase 2, Phase 3 and Phase 4. The manual prepared by the Study Team for the pilot project will be a useful reference.

(2) Phase 2: Building of a System Within State/Local Governments

1) Workshops on Awareness Raising Activities Within State Governments

Using the tools prepared in Phase 1, intra-government workshops similar to those held in Phase 1 will be held at each zonal office of the REA, inviting representatives of the related offices of the state governments. The facilitator will dispatch a resource person. Demonstration equipment will be actively used along with solar panels, etc. if this PV equipment is available at the zonal offices. If the resource person travels by car, demonstration equipment may be brought from Abuja.

2) Workshops on Awareness Raising Activities Within Local Governments

Workshops for local government officials will be held by selecting several local governments. The facilitator will dispatch a resource person.

3) Preparation of Tools for State/Local Governments

When the understanding of the key issues within state/local governments reaches a sufficient level, local language versions of the pamphlets and leaflets for users will be prepared. The JICA pamphlet which explains the subject matter using texts as well as illustrations will be a useful reference.

4) Seminars for Users Living in Geographical Area of Each Local Government

Seminar will be held for local residents in the areas which are the targets or potential targets of PV electrification. A local government official in charge of PV electrification will act as the resource person. These seminars will also provide training for young local government officials in charge of PV electrification.

(3) Phase 3-1: Continual Awareness Raising Activities by the Federal Government

1) Continual Self awareness raising and Publicity Activities

The facilitator will regularly organize meetings for members as well as supporting members in the pursuit of continuous self awareness raising and to facilitate the exchange of opinions between the federal government and state/local governments. The activities of the FMST and FMPS, etc. targeting general users, companies and other stakeholders outside the government should use all available means, including information boards, newsletters, media and websites. A website exclusively dedicated to solar energy should be set up in the future.

2) Collaboration Between Different Sectors

The facilitator will also regularly organize meetings involving representatives of related sectors in the pursuit of continuous education and the exchange of opinions. The activities of each sector regarding the utilisation of solar energy will be externally publicised using all available means. The database developed in Phases 1 will be updated and some sections will be made accessible to those outside the government.

3) Collaboration and Exchange of Opinions Involving NGOs, the Media and Educational/Research Institutions

The facilitator will organize workshops targeting NGOs (those focusing on gender, youth and the environment, etc.), the media and educational/research institutions to provide opportunities for the exchange of opinions. The knowledge, etc. obtained through these workshops will be used for a series of awareness raising activities. Information will be gathered at these workshops using a questionnaire.

4) Media-Based Educational Activities Targeting General Users and Companies

Using the materials prepared by the Study Team for TV programmes and self-gathered materials, the facilitator will organize meetings in Abuja and Lagos to explain the plan to produce a TV advertisement and to create a website for general users and companies. Media and IT personnel will be invited to these meetings.

The selection of a production company will be followed by the intensive exchange of

opinions, including the ideas of the production staff. On completion, the website in question will be made accessible by the general public.

5) Gathering of PV Information from the Private Sector Using a Questionnaire

Private companies involved in the PV business will be requested to complete a questionnaire. The obtained information will be incorporated in the database for use for future activities.

6) Educational Activities to Motivate NGOs, the Media and Educational/Research Institutions

Educational activities by means of publicity by federal government offices, the website, promotion video and seminars, etc. will be continually conducted to motivate NGOs, the media and educational/research institutions to start their own activities to spread the utilisation of PV systems.

7) Expert Meeting

Resource persons invited to previous workshops will be gathered for the exchange of opinions on wide-ranging issues. Based on ideas regarding awareness raising at this meeting, various events targeting the public will be organized. An event or conference on World Environment Day may be a good idea if such an opportunity arises. The locations to be considered for these events will primarily be Abuja and Lagos.

8) Awareness Development at State Assembly, etc.

Senior government officials related to PV rural electrification should make efforts to make members of the state assembly and others aware of PV-related policies.

9) Monitoring

Awareness raising activities will proceed through the implementation of various plans and events throughout the country and in all related sectors. The facilitator will monitor their progress along with the extension of PV systems and the progress of rural electrification, etc. and will update the database. The monitoring results will constitute valuable reference materials for not only future awareness raising activities but also for the formulation of an electrification programme.

(4) Phase 3-2: Continuous Awareness Raising Activities by State/Local Governments

1) State/Local Government Seminars for Local Residents

When the blueprint for the selection of the target electrification areas at the local level has been developed to a certain extent, a series of seminars will be held for local residents in these areas. If there is no blueprint, a seminar for general users will be held in the state capital or another suitable location.

If there is already a concrete plan for the target electrification areas and electrification method, etc. at this stage, more concrete actions will be implemented in line with such a plan. These awareness raising activities will also target companies to become Phase 4.

2) Use of a Survey to Formulate an Electrification Programme by State/Local Governments

At the time of a field survey by a state/local government to formulate an electrification programme, investigators will take the leaflets, etc. prepared in Phase 2 with them for distribution to leading figures and knowledgeable persons in the target areas as the distribution of such materials may well be the starting point for awareness raising activities aimed at local residents.

3) Inter-Governmental and Inter-Sectoral Meetings of State/Local Governments

Staff members of the facilitator's branch offices should regularly organize inter-governmental and inter-sectoral meetings to urge the continuation of awareness raising activities and the exchange of opinions. The details and results of these activities should be publicised using such existing means as information boards and newsletters.

4) Introduction of PV Systems by State/Local Governments and Sectors

At the intra-governmental meetings of state/local governments and inter-sectoral meetings, it is important for the staff members of the facilitator's branch offices to actively explain the benefits of introducing small-scale PV systems to local government and other offices, to promote such introduction and to ensure that PV systems are observed by as many people as possible. In regard to the procurement of equipment, the distribution and explanation of the required PV systems using the pamphlet for companies which will have already been prepared at the explanatory meeting of the tender will constitute a useful awareness raising activity.

5) Utilisation of Already Introduced PV Systems and the Pilot Project

State/local governments and related sectors should raise awareness of PV equipment by means of allowing access to observe the working situation of PV systems which have already been introduced, conducting demonstrations using the said systems, establishing demonstration centres and planning tours to pilot project sites.

6) Collaboration and Exchange of Opinions with Local NGOs

If there are any NGOs involved in PV-related sectors and/or residents' organizations (user organizations) in the area, opportunities to exchange opinions should be actively created to raise local awareness of PV systems.

7) Gathering of PV-Related Information in the Private Sector Using a Questionnaire

Local businesses related to PV rural electrification will be requested to complete a questionnaire designed to gather information of their business intentions and other relevant matters. The obtained information will be incorporated in the database for use for future activities.

8) Awareness Raising Activities at Assemblies

State and local governments will make strenuous efforts to raise awareness of PV-related policies at their assemblies as well as other meetings.

9) Monitoring

As in the case of the facilitator, state and local governments should continually conduct the monitoring of various awareness raising activities so that the monitoring results can be used for the next round of activities. They will report the monitoring results to the facilitator from time to time.

(5) Phase 4-1: State/Local Government Activities Targeting Local Residents Prior to the Implementation of PV Electrification

The following activities featuring users and village electrification associations will be implemented as a series of awareness raising activities designed to ensure effective and smooth electrification in the target areas. As far as local residents are concerned, these will not simply be awareness raising activities but will constitute introductory activities to develop a sense of their commitment and for them to create their own organization to operate a real PV system(s) through their participation.

1) Explanation to Village Elders and Knowledgeable Persons

In the target areas for electrification, meetings will be held to explain what the utilisation of a PV system(s) means to the elders or other leading figures and knowledgeable persons as well as NGOs and residents' organization, if any, taking the socioeconomic conditions in the area into consideration. Here, the pamphlets and leaflets already prepared in the local language for users will be used.

2) Explanation to Ordinary Residents

Meetings targeting local residents (residents' meetings) will be held with the participation of elders, other leading figures and knowledgeable persons as a kind of guidance session. The leaflets, etc. prepared in the local language for users will be used to explain PV systems. The level of expectation and understanding among local residents will be assessed based on the opinions and questions put forward in these meetings and this information will be used to establish a maintenance system to be operated by local residents.

(6) Phase 4-2: State/Local Government Activities Targeting Local Business for the Implementation of PV Electrification

The following activities featuring local businesses and local technicians, etc. will be implemented as a series of awareness raising activities to ensure effective and smooth electrification in the target areas. These activities will be conducted in parallel with the activities featuring users, etc. described in Phase 4-1 above.

1) Explanation at the Time of Tender

The pamphlets for businesses will be distributed and explained as part of the tender process for the procurement of PV equipment to raise the level of awareness of PV systems among businesses.

2) Awareness Raising of Businesses at Delivery and Installation Stages

Continuous awareness raising activities will be conducted for businesses which win the

tender to deliver and install PV equipment (PV systems), making the best use of the experience and lessons learned from the pilot project.

3) Awareness Raising of Local Companies and Technicians

Continuous awareness raising activities will be conducted for local companies, technicians and maintenance staff of the village electrification associations who will be responsible for the maintenance, including repair, of the installed PV systems.

3.7.8 Gender Issues in Awareness Raising Activities

In the implementation process of awareness raising activities, gender issues affect not only the stakeholders (implementing bodies, receiving bodies and means) but also the contents and methods of these activities. Awareness raising activities often rely on interchanges between people. While it is important to incorporate the viewpoint of gender in seminars and pamphlets, etc., the participation of women in actual activities is equally important. This point is pertinent for all activities. To be more precise, the following points should be noted.

- The existence of women in the implementing bodies for awareness raising activities (i.e. government, etc.), especially in the facilitator, is essential. This equally applies to related sectors and state/local governments.

- Gender issues which are related to the receiving (target) bodies for awareness raising activities take concrete form when specific actions for specific targets are considered. For example, when a seminar is organized for local residents in a predominantly Muslim area, it may well be difficult for women to attend. In this situation, it may be an idea for a seminar to be organized by women which could be held at a women's centre or the home of a village elder.

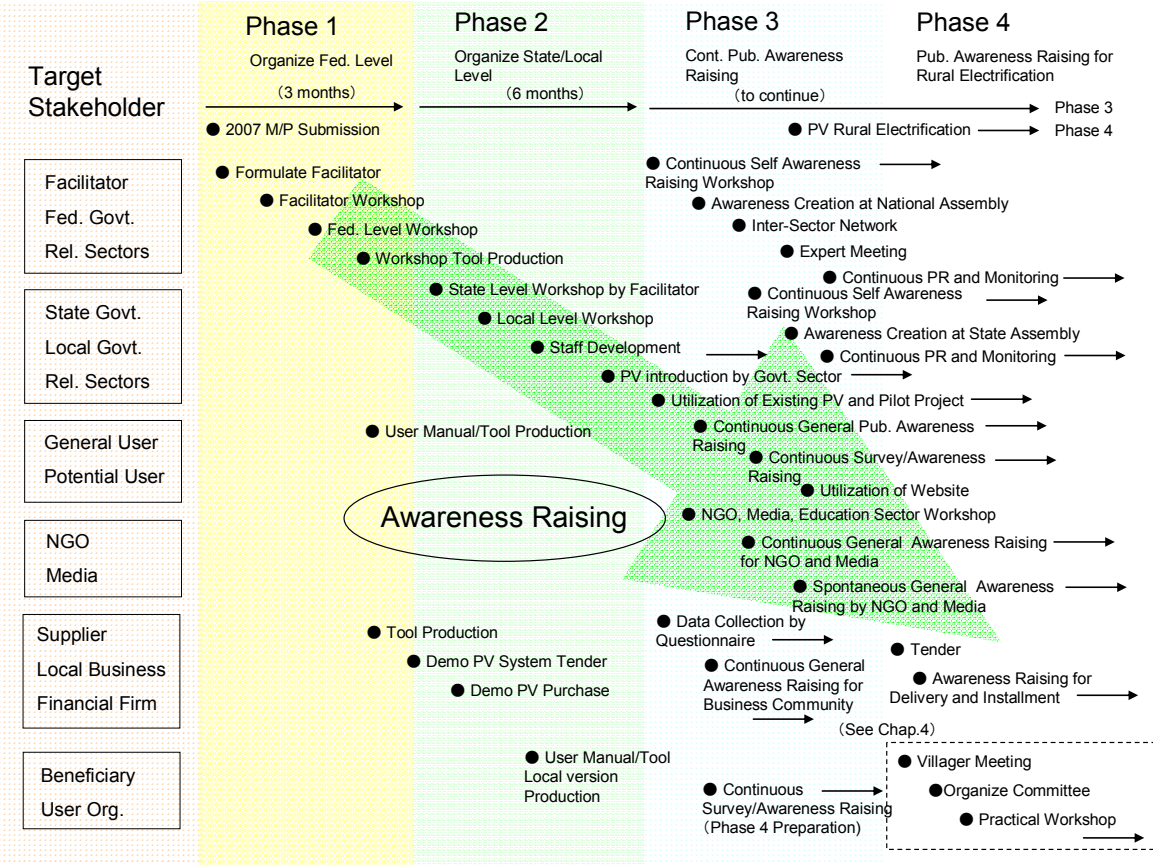
- Gender issues relating to the means and methods of awareness raising activities also take concrete form when a specific action is considered. The seminar by women for women mentioned above is one example. In short, the issue of likely awareness raising effects for women and men must be considered in conjunction with the geographical and social characteristics. To be more precise, gender issues association with the location of the venue for an event and gender issues apparent in print media, etc. must be considered.

- Gender issues regarding the contents of awareness raising activities have already been described in the sections dealing with stakeholders and the contents of awareness raising activities. In short, government officials and all others who are involved in these activities must fully understand the benefits of PV rural electrification for women in the related sectors, especially in health care and the empowerment of women.

3.7.9 Overview of Awareness Raising Activities

Fig. 3-12 shows the general flow of awareness raising activities and actions.

Under the present action plan, the focus of awareness raising activities to implement rural electrification generally moves from the central area to local areas and from the public sector to the private sector with the passing of time. However, from the viewpoint of developing an environment for the wide use of PV systems and expanding the PV market, the role played by the facilitator is important to prompt spontaneous and simultaneous awareness raising activities which involve all stakeholders in all target areas in view of the diversity of these activities.



Source: The Study Team

Fig. 3-12 Awareness Raising Activities

3.8 Solar Energy Technology R & D Action Plan

3.8.1 Solar Cell (PV) R & D Action Plan

(1) Contents and Process of R & D on Solar Cell Units

The accumulation of basic data on sunlight is essential for R & D on solar cells. The Solar Cell Unit of both energy research centres (SERC and NCERD) should procure/introduce the essential measuring instruments to gather basic data and should gradually commence the implementation of the following R & D activities based on their R & D programme.

① R & D and trial manufacture of controllers and inverters, both of which are peripheral devices for PV systems
② Procurement of an existing PV module from abroad and assembly of a SHS system using this module as well as a home-made controller and inverter to improve the technological expertise
③ Establishment of PV equipment inspection standards to raise the inspection level in order to improve the manufacturing standard of equipment and the assembly techniques
④ Transfer of controller and inverter manufacturing technologies to private companies
⑤ Transfer of SHS system assembly techniques and manufacturing technologies to private companies along with a recommendation for the importation of modules and the assembly and sale of SHS systems
⑥ R & D on the configuration of a hybrid system combining other renewable energy and distribution equipment with a view to developing a practical model
⑦ Import of crystal solar cells by the SERC from abroad for R & D on the manufacture, inspection and evaluation of PV modules
⑧ Implementation of R & D by the NCERD on the manufacture, inspection and evaluation of amorphous solar cell modules
⑨ Establishment of a solar cell inspection and approval body

Fig. 3-13 shows the flow of the R & D activities described above.

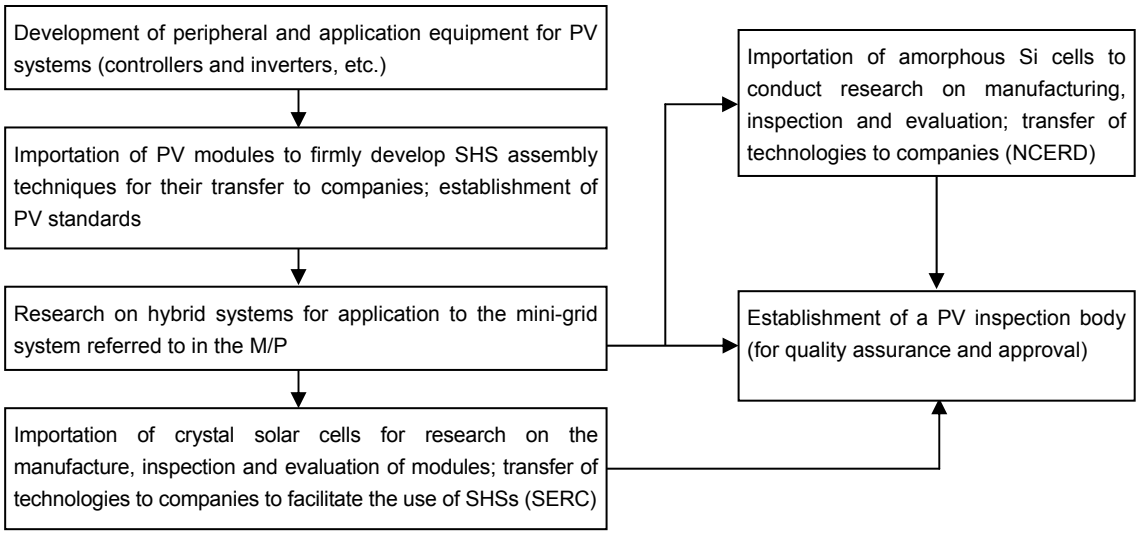


Fig. 3-13 Flow of R & D on Solar Cell Units

(2) R & D Schedule for Solar Cell Units

The programme described here assumed the completion of R & D in three years, followed by different projects, each of which will also be completed in three years. The proposed projects are classified into those subject to common research by the two centres and those subject to different R & D by the two centres. The research contents of each project are described next.

1) 2007 – 2009

① Using an actinometer, obtaining and accumulation of data on the relation between the angle of elevation and quantity of solar radiation and the relation between the annual quantity of solar radiation and the electric energy generated, etc.

② R & D on controllers and inverters

2) 2010 - 2012

① Import of PV modules and R & D on the assembly of SHSs

② R & D on SHS inspection and evaluation techniques

③ Establishment of Nigerian PV standards with the two research centres playing a leading role

④ R & D on hybrid systems between PV and wind power generation, micro-hydropower generation and diesel generation, etc.

3) 2013 - 2015

① Continuation of the research on SHS inspection and evaluation techniques

② Commencement of R & D on modules in 2014

③ R & D on crystal Si modules (SERC)

④ R & D on amorphous Si modules (NCERD)

4) 2016 - 2020

① Continuation of the research on the assembly of PV modules

② R & D on PV module inspection and evaluation techniques

③ Transfer of module assembly, inspection and evaluation techniques to private companies once they have been successfully developed for their wide use

5) Throughout the R & D Period

① Researchers at the research centres will prepare a manual for the use of measuring instruments (explaining handling, use, storage after use, trouble-shooting and repair, etc.)

② Researchers will appoint a manager responsible for measuring instruments. This manager will be responsible for maintaining such instruments in workable condition and will keep a record of those using the instruments.

③ Researchers at the research centres will conduct PV education for local engineers.

④ Researchers at the research centres will prepare a manual (explaining the principles of PV, equipment handling, trouble-shooting and repair methods, etc.) to be used for the education described in ③ above.

Fig. 3-14 shows the time-frame for each R & D item.

Year	Stage 1 (2007 – 2009)	Stage 2 (2010 – 2012)	Stage 3 (2013 – 2015)	Stage 4 (2016 – 2020)
Target of Research Centres	R & D on peripheral devices	System configuration using imported modules	System establishment	Transfer of technology to private companies
Collection of Solar Data	Quantity of solar radiation; angle of elevation →	Preparation of PV standards →		
Controllers and Inverters	Research on foreign products →	Inspection and evaluation of PV systems →	Inspection and evaluation; promotion of the wide use of PV systems →	
Hybrid (Use of In-House Facilities)		Wind power + PV →	Micro-hydropower/ diesel + PV →	Promotion of wide use →
Research on Crystal Modules (SERC)			Study and experiment →	R & D →
Research on Amorphous Modules (NCERD)			Study and experiment →	R & D →

Source: The Study Team

Fig. 3-14 Development Schedule for Solar Cell Units by the SERC and NCERD

(3) R & D Equipment Procurement Plan

1) R & D Equipment Procurement Plan

Table 3-28 shows the procurement plan for the equipment and materials required for R & D. This procurement plan separately applies to the SERC and NCERD.

Table 3-28 R & D Equipment and Materials Procurement Plan

R & D	2007 – 2009			2010 – 2012			2013 – 2015			2016 - 2020		
Equipment and Materials to be Procured	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)
For Research on Controllers	30	250	7,500	30	250	7,500						
For Research on Inverters	30	200	9,000	30	300	9,000						
SHSs (Including Modules, Batteries, Controllers and Lamps, etc.			0	30	104	3,320	30	104	3,320	100	104	10,400
Hybrid Equipment (Controllers and Inverters, etc.)			0	30	1,260	3,780	30	1,260	3,780	50	1,260	6,300
Materials for Research on Controllers			0			0	30	28	840	170	28	4,760
Total Amount (KN)	16,500			23,600			7,940			21,460		
Annual Requirement (KN)	5,500/year			7,870/year			2,650/year			4,300/year		

Source: The Study Team

2) R & D-Related Measuring Instrument Procurement Plan

Table 3-29 shows the procurement plan for the measuring instruments required for R & D. This procurement plan separately applies to the SERC and NCERD.

Table 3-29 R & D-Related Measuring Instrument Procurement Plan

R & D	2007 – 2009			2010 – 2012			2013 – 2015			2016 - 2020		
Instruments, etc. to be Procured	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)
I-V Meter				1	900	900						
Laminator							1	8,000	8,000			
Solar Simulator for Cells							1	14,800	14,800			
Solar Simulator for Modules							1	20,000	20,000			
I-V Meter for Cells							1	6,000	6,000			
Spectroscope							1	4,500	4,500			
I-V Meter for Modules							1	5,000	5,000			
Thunder Shock Tester							1	10,000	10,000			
Meteorological Meter	1		5,000									
Other Small Meters	1 lot		13,000									
Total Amount (KN)	18,000			900			68,300					
Annual Requirement (KN)	6,000/year			300/year			22,870/year					

Source: The Study Team

3) Facility Construction Cost and Operational Expenses Plan

Table 3-30 shows the facility construction cost and operational expenses required for R & D. This plan separately applies to the SERC and NCERD.

Table 3-30 Facility Construction Cost and Operational Expenses Plan

R & D	2007 – 2009			2010 – 2012			2013 – 2015			2016 - 2020		
Cost/Expense Item	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)
New Laboratory (100 m^2)				1	8,000	8,000						
Furniture and Fixtures (Including Power and Other Tools)	1 lot		4,000	1 lot		2,000	1 lot		1,000	1 lot		1,500
Water, Lighting and Heating	1 lot		1,500	1 lot		2,000	1 lot		2,500	1 lot		4,500
Stationary and Various Materials	1 lot		1,400	1 lot		800	1 lot		1,300	1 lot		2,000
Total Amount (KN)	6,900			12,800			4,800			8,000		
Annual Requirement (KN)	2,300/year			4,300/year			1,000/year			1,600/year		

Source: The Study Team

(4) R & D Staff and Personnel Cost Plan

1) Staff Increase Plan

The number of R & D staff (both researchers and assistants) must be increased with the progress of R & D. The average age of researchers working at the SERC and NCERD at present is approximately 33 years, suggesting some 10 years of working experience at these centres after graduation from university. Assistants are either senior high school leavers or recent graduates. Table3-31 shows the staff plan for each centre.

Table 3-31 Planned Increase of Staff Strength

(Unit: persons)

Item	Present	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
Number of Researchers	3	4	5	7	10
Planned Number of Increase		1	1	2	3
Number of Assistants	2	2	4	7	7
Planned Number of Increase		0	2	3	-
Staff Strength	5	6	9	14	17

Source: The Study Team

2) Personnel Cost Plan

In Nigeria, a high salary is paid to researchers working at these research centres in accordance with the government policy. The salary level of researchers is approximately double the salary level of ordinary staff members of the federal government.

Table 3-32 shows the personnel cost plan based on the staff plan (Table 3-31) for each research centre envisaged by the action plan.

Table 3-32 Staff Strength and Personnel Cost Plan

Item	Unit Personnel Cost	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
Number of Researchers	N 170,000/month	4	5	7	10
Total Researcher Cost	(KN)	24,480	30,600	42,840	102,000
Number of Assistants	N 20,000/month	2	4	7	7
Total Assistant Cost	(KN)	1,040	2,820	5,040	8,400
Total Personnel Cost	(KN)	25,920	33,480	47,880	110,400
Annual Personnel Cost	(KN)	8,640	11,160	15,860	22,080

Source: The Study Team

(5) R & D Funding Plan

Table 3-33 shows the R & D funding plan for the Solar Cell Unit of the SERC and NCERD to implement their own R & D. The FMST and ECN must secure the necessary budget for the SERC and NCERD in accordance with the funding plan to proceed with the planned R & D.

Table 3-33 R & D Funding Plan

(Unit: N)

Item	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
R & D Equipment and Material Cost	16,500,000	23,600,000	7,940,000	21,460,000
Measuring Instrument Cost	18,000,000	900,000	68,300,000	0
Facility Construction Cost and Operational Expenses	6,900,000	12,800,000	4,800,000	8,000,000
Personnel Cost	25,920,000	33,480,000	47,880,000	110,400,000
Total	67,320,000	70,780,000	128,920,000	139,860,000
Total Annual Expenses (Each Research Centre)	22,440,000	23,600,000	42,980,000	27,980,000
Total Annual Expenses (Total of SERC and NCERD)	44,880,000	47,200,000	85,960,000	55,960,000

Source: The Study Team

(6) Human Resources Development to Man Solar Cell Unit

The Solar Cell Unit of both the SERC and the NCERD must develop human resources which are capable of implementing self-reliant R & D activities to achieve the research purposes. Although these two research centres have a partnership agreement with a British university for the dispatch of staff at a rate of one person every few years, they are experiencing the problem of those completing their education at the British university deciding not to return to Nigeria. The existing system of sending staff members to study abroad is, therefore, not contributing to human resources development at these centres. The failure of those studying abroad to return to Nigeria is a common problem for human resources development in Nigeria.

Accordingly, the human resources development efforts of the research centres in the future should focus on domestic training, OJT, off-JT, short study abroad, overseas training, cooperation with international organizations, training based on south-south cooperation and collaboration with manpower development bodies (such as the AICAD) in Africa.

① Training at Energy Research Institutes in Developing Countries

While China, India and Thailand, etc. have excellent energy research institutes, the research institutes in Thailand listed below have rich experience of solar energy research. As the conditions of solar radiation and the general environment in Thailand are similar to those in Nigeria, collaboration with these institutes in Thailand to proceed with R & D will prove to be quite fruitful. Along with such collaboration, active efforts should be made to participate in international conferences to obtain useful information. Improvement of the technical expertise of Nigerian researchers to the level where they can present research papers promises better R & D results and will be highly significant for the energy research centres in Nigeria. The research institutes working on solar energy in Thailand are listed below.

- **AIT (Asian Institute of Technology)**

  The AIT is proceeding with the development and standardisation of PV-related equipment in collaboration with neighbouring countries. It also educates PV engineers from neighbouring countries.

- **SERT (School of Renewable Energy Technology)**

  The SERT is conducting research on solar energy and renewable energies in collaboration with energy research institutes in such countries along the Mekong River as Thailand, Vietnam, Cambodia and Laos as well as a research institute in Yunnan Province in China. Many researchers from neighbouring countries study at the SERT and a renewable energy conference is held every year, involving countries in South Asia, India, Pakistan, Nepal and Bangladesh. The NEDO of Japan and the GTZ, etc. also send representatives to this conference.

- **KMUTT (Mongkut University of Technology)**

  The KMUTT conducts R & D as well as training related to renewable energies.

All of the above three universities play a central role in the research and utilisation of solar energy and the establishment of uniform standards, etc. in Asia in collaboration with neighbouring countries and exchanges with the NEDO of Japan.

② Collaboration with the AICAD (African Institute for Capacity Development), the Main Base for Human Resources Development in Africa

The AICAD established by the JICA conducts R & D, training, information management and human resources development, targeting national universities, research institutes, NGOs, SMEs and residents' organizations, etc. in three East African countries (Kenya, Tanzania and Uganda) and also collaborates with similar activities in other African regions.

The head office is located at the Jomo Kenyatta University of Agriculture and Technology in Kenya and research on renewable energies is one of the priority issues. Kenya is closer to Nigeria than Asian and European countries and its economy, culture, living environment and natural environment are similar to those of Nigeria. As the purpose of establishing the AICAD is to contribute to poverty reduction and the vitalisation of socioeconomic activities in African countries, collaboration between the solar energy research centres in Nigeria and the AICAD is both necessary and essential for the development of renewable energies by West African countries.

③ Training by Western Donors and UN Organizations

UN organizations and the aid organizations of Western donors, including the UNDP, USAID, GTZ, SIDA and GEF, conduct training on solar energy using various methods and hope to achieve smooth rural electrification using PV systems by educating PV engineers in African countries.

As the higher organizations of the solar energy research centres in Nigeria, it is important for the FMST and ECN, etc. to properly understand the role to be played by these centres and to send their staff members to training courses, etc. of UN organizations and Western donors to learn how to proceed with energy research, research systems, human resources development methods, fund raising methods and other relevant matters as the supervising bodies of research institutes.

④ Study Abroad in Japan

Researchers at the energy research centres in Nigeria have a strong hope to study in Japan and some have already contacted Japanese bodies based on their search results of the JICA's Home Page. According to the Japanese Ministry of Foreign Affairs, one or two Nigerians are accepted under the government scholarship system run by the Ministry. However, as there is no immediate prospect for this number to increase, it is quite difficult for solar energy researchers in Nigeria to get through this scholarship system.

3.8.2 Research Programme of Solar thermal Utilisation Units

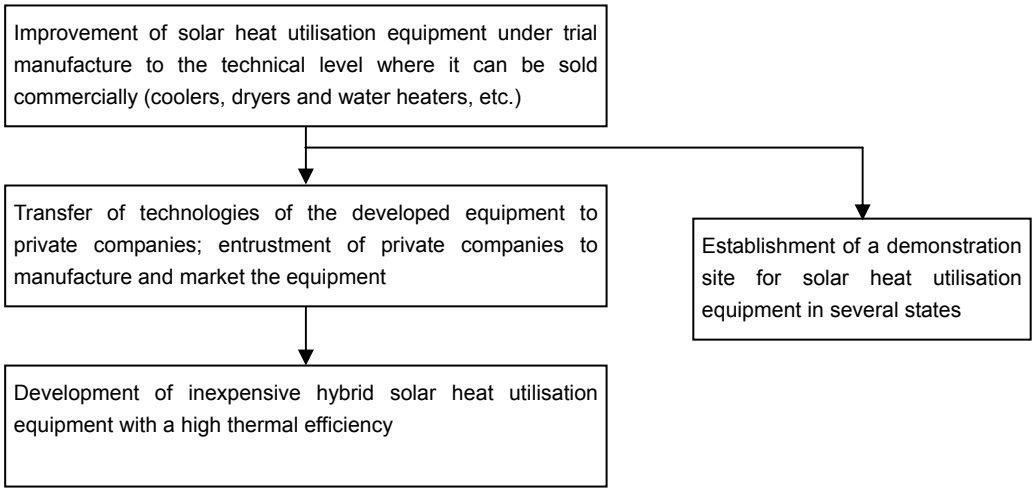
(1) Concrete Contents and Process of R & D by Solar thermal Utilisation Units

These units aim at developing inexpensive solar thermal utilisation equipment with a view to improving the living standard of local residents and reducing the felling of trees as well as the consumption of oil resources.

As in the case of the Solar Cell Units, it is essential for the Solar thermal Utilisation Units to accumulate basic data on sunlight. It will, therefore, be necessary for these units at the SERC and NCERD to gather basic data using the newly introduced measuring instruments and commence the following R & D activities in succession.

① R & D on parabolic cookers
② R & D on dryers
③ R & D on water heaters
④ R & D on water distillers
⑤ R & D on incubators
⑥ R & D on brooders
⑦ R & D on hybrid solar thermal utilisation equipment

Fig. 3-15 shows the flow of the above-mentioned R & D activities.

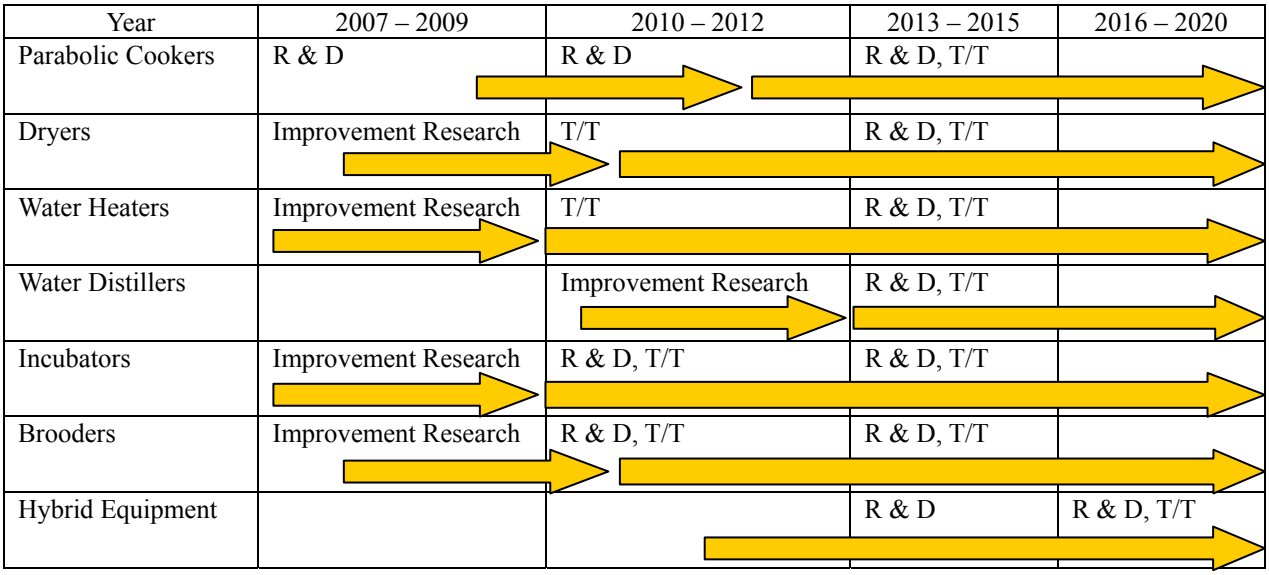


Source: The Study Team

Fig. 3-15 Flow of R & D by Solar thermal Utilisation Units

(2) R & D Schedule for Solar thermal Utilisation Units

In proceeding with the R & D on various types of equipment, the Solar thermal Utilisation Units will determine the ultimate goals, timing of development and period of development. The schedule here is drafted to complete the R & D period in three years and also to complete each project in three years. Fig. 3-16 shows the planned R & D schedule.



Note: T/T = technology transfer

Source: The Study Team

Fig. 3-16 R & D Plan and Schedule for Solar thermal Utilisation Units

(3) R & D Equipment Procurement Plan

1) R & D Equipment Cost

Table 3-34 and Table 3-35 show the plan to procure the range of equipment required for R & D on solar thermal utilisation equipment. From 2007 to 2012, the R & D will feature small equipment. From 2012 to 2020, the R & D will feature medium-size and large equipment which can be used by those engaged in household industries and farmers. The plan here separately applies to the SERC and NCERD.

Table 3-34 R & D Plan for Solar thermal Utilisation Units (1)

Equipment	Unit Material Cost (N)	2007 – 2009		2012 - 2020		Remarks
		Qty	Amount (N)	Qty	Amount (N)	
Cookers	30,000	15	450,000	45	1,350,000	Small parabolic
Dryers	110,000	20	2,200,000	45	4,950,000	Small dryer
Water Heaters	95,000	30	2,850,000	45	4,275,000	Small water heater
Water Distillers	85,000	5	425,000	45	3,825,000	Small distiller
Incubators	130,000	30	3,900,000	45	5,850,000	For 700 eggs
Brooders	100,000	30	3,000,000	45	4,500,000	For 100 chicks
Hybrid Equipment	150,000	0		0		
Total (N)			12,825,000		24,750,000	
Annual Requirement (N)			4,275,000		8,250,000	

Source: The Study Team

Table 3-35 R & D Plan for Solar thermal Utilisation Units (2)

Equipment	Unit Material Cost (N)	2013 – 2015		2016 – 2020		Remarks
		Qty	Development Cost (N)	Qty	Development Cost (N)	
Cookers	40,000	30	1,200,000	50	2,000,000	Medium-size parabolic
Dryers	150,000	30	4,500,000	50	7,500,000	Large dryer
Water Heaters	150,000	30	4,500,000	50	7,500,000	Medium-size water heater
Water Distillers	100,000	30	3,000,000	50	5,000,000	Medium-size (1 m^3) distiller
Incubators	180,000	30	5,400,000	50	9,000,000	For 1,000 eggs
Brooders	400,000	30	1,200,000	50	20,000,000	7 m^2
Hybrid Equipment	150,000	30	4,500,000	50	7,500,000	Example: distiller + water heater
Total (N)			24,300,000		58,500,000	
Annual Requirement (N)			8,100,000		11,700,000	

Source: The Study Team

2) R & D-Related Measuring Instrument Procurement Plan

Table 3-36 lists the main measuring instruments of which the procurement is required for the Solar thermal Utilisation Units to proceed with their own R & D in the coming years. This procurement plan separately applies to the SERC and NCERD.

Table 3-36 Measuring Instruments for Solar thermal Research

Instrument	Unit Cost (N)	2007 – 2009		2010 – 2012		2013 – 2015		2016 - 2020	
		Qty	Amount (KN)	Qty	Amount (KN)	Qty	Amount (KN)	Qty	Amount (KN)
Meteorological Meters	5,000,000	1	5,000					1	5,000
Actinometers	500,000	2	1,000					2	1,000
Portable Actinometers	300,000	3	900					3	900
Spectrometers	3,500,000	1	3,500					1	3,500
Recorders	700,000	3	2,100					3	2,100
Data Loggers	300,000	2	600					3	900
Various Temperature Gauges			1,000						1,000
Precision Scales	200,000	3	600					3	600
Other Meters			1,500						1,500
Total			16,200						16,500
Annual Requirement (N)			5,500						3,300

Source: The Study Team

(4) Facility Construction Cost and Operating Expenses Plan

Table 3-37 shows the plan for the operating expenses which are required for the Solar thermal Utilisation Units to proceed with their R & D activities. This plan separately applies to the SERC and NCERD.

Table 3-37 Operating Expenses Plan for Laboratories

R & D	2007 – 2009			2010 – 2012			2013 – 2015			2016 - 2020		
Cost/Expense Item	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)	Qty	Unit Cost (KN)	Amount (KN)
Furniture and Fixtures (Including Power and Other Tools)	1 lot		2,400	1 lot		2,200	1 lot		2,400	1 lot		6,000
Water, Lighting and Heating	1 lot		1,200	1 lot		2,000	1 lot		1,200	1 lot		1,500
Stationary and Miscellaneous Materials	1 lot		1,200	1 lot		1,100	1 lot		1,200	1 lot		2,000
Total Amount (KN)	4,800			5,300			4,800			9,500		
Annual Requirement (KN)	1,600/year			2,300/year			1,600/year			1,900/year		

Source: The Study Team

(5) Solar thermal Utilisation Equipment Demonstration Site Opening and Operating Expenses Plan

A solar thermal utilisation equipment demonstration site will be opened in each of six geo-political zones for the awareness raising of such equipment in Nigeria. Table 3-38 shows the planned opening time of these sites and their operating expenses.

Table 3-38 Demonstration Site Opening and Operating Expenses Plan

	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
Demonstration Site Opening Cost		21,600,000		
Operating Expenses		11,520,000	17,280,000	28,800,000
Total Amount (N)		33,120,000	17,280,000	28,800,000
Annual Requirement (N)		11,040,000	5,760,000	5,760,000

Source: The Study Team

(6) R & D Personnel Cost Plan

It is planned to increase the number of staff members of each Solar thermal Utilisation Unit in accordance with the progress of R & D as shown in Table 3-39.

Table 3-39 Number of Research Staff Members and Personnel Cost

(Unit: N)

Item	Average Salary (N/month)	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
Number of Researchers		4	5	5	6
Planned Number of Increase		0	1	1	2
Number of Assistants		2	3	3	4
Planned Number of Increase		0	1	1	2
Staff Strength		6	8	8	10
Researchers (N)	170,000	24,480,000	30,600,000	30,600,000	61,200,000
Assistants (N)	20,000	1,440,000	2,160,000	2,160,000	4,800,000

Source: The Study Team

(7) R & D Funding Plan

Table 3-40 shows the R & D funding plan for each Solar thermal Utilisation Units. This funding will be required for both the SERC and NCERD to proceed with the R & D activities based on the present action plan. Both the FMST and ECN must, therefore, secure the annual budget for the SERC and NCERD in accordance with this funding plan.

Table 3-40 R & D Funding Plan

(Unit: N)

Item	2007 – 2009	2010 – 2012	2013 – 2015	2016 – 2020
R & D Equipment and Material Cost	12,525,000	24,300,000	35,100,000	17,500,000
Measuring Instrument Cost	16,200,000	0	0	16,500,000
Facility Construction Cost and Operational Expenses	4,800,000	5,300,000	4,800,000	9,500,000
Demonstration Site Expenses		33,120,000	17,280,000	28,800,000
Personnel Cost	25,920,000	32,760,000	32,760,000	66,000,000
Total	59,445,000	95,489,000	89,940,000	138,300,000
Total Annual Expenses (Each Research Centre)	19,815,000	31,829,700	29,980,000	27,660,000
Total Annual Expenses (Total of SERC and NCERD)	39,630,000	44,869,000	54,200,000	49,560,000

Source: The Study Team

(8) Human Resources Development for Solar thermal Utilisation Units

Both the SERC and NCERD must develop human resources which are capable of implementing and continuing self-reliant R & D activities to achieve the research targets. The details of the human resources development are the same as those described in human resources development for the Solar Cell Units (3.8.1-(6)).

3.9 Environmental and Social Conditions for the Implementation of the Master Plan

3.9.1 Important Points for the Realisation of the Master Plan

The points below require environmental and social consideration in connection with the implementation of the M/P.

① Recycling of waste batteries
② Application for an EIA (environmental impact assessment)
③ Important points from the viewpoint of the social environment

Each point is explained in more detail next.

(1) Recycling of Waste Batteries

Nigeria has an established battery recycling system on a commercial basis and the waste batteries collected by collection companies are sent to domestic recycling facilities or recycling companies overseas for reproduction (Fig. 3-17). As the existence of a waste battery collector has been confirmed in the cities of Kano, Akure and Owerri located near the three pilot project villages respectively, there appears to be a high likelihood of the existence of a similar collector in state capitals and other large cities. Accordingly, the expected general practice for the recycling of waste batteries produced by PV rural electrification projects will be the entrustment of recycling work to these companies.

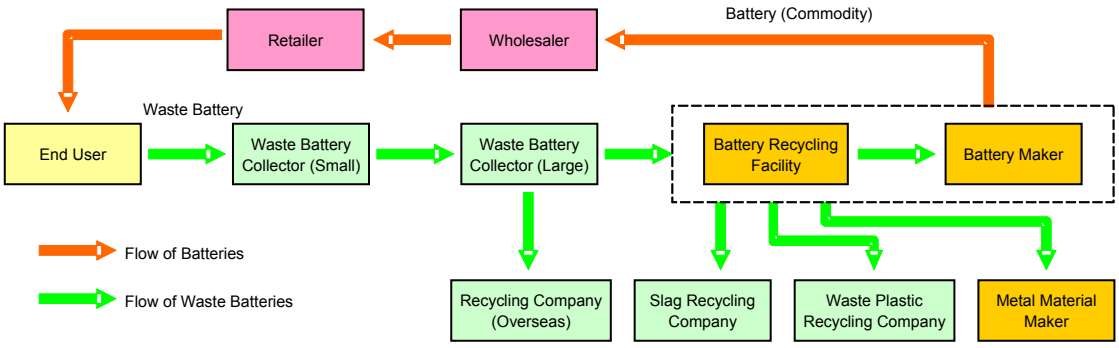


Fig. 3-17 Battery Recycling System in Nigeria

For future PV operation, it will be necessary for the members of a village maintenance organization to understand the importance of recycling waste batteries and to check the existence of a battery collector nearby to ensure the recycling of waste batteries when such an organization is established. In principle, it is desirable for staff members of the REA zonal offices and those in charge of PV electrification at state governments to assume the responsibility for providing appropriate guidance on these matters.

(2) Application for the Implementation of an EIA

As an EIA is conducted by the project implementing body, an application for an EIA is likely to be made by either the state government or local government. However, if the project implementing body is unfamiliar with EIAs, it is likely to find it difficult to fully understand the

procedure involved and to prepare the necessary documents. The provision of the necessary guidance by the REA Head Office is, therefore, desirable via its zonal offices.

Fundamentally, the present set up of the Federal Ministry of the Environment (FMoE) places all development projects relating to renewable energies in Category 2 of the Environmental Impact Assessment Act (No. 86) and, in principle, a partial EIA is deemed to be inappropriate. Reform of the present system is desirable so that only the submission of an environmental management plan is compulsory and a partial EIA is not required in the case of, for example, small-scale PV generation among the various types of renewable energy. The federal government offices involved in PV rural electrification should discuss this matter with the FMoF. These discussions can be suitably initiated and led by the REA or ECN. As an application fee is charged under the present system, it is necessary to clarify which organization is liable for the payment of this fee.

(3) Important Points Regarding the Social Environment

Careful attention should be paid to such aspects of the social environment as the establishment of a consensus and the selection of the target households for the installation of a PV system. It is judged to be appropriate to consider these matters within the framework of establishing and operating a maintenance organization. From the environmental point of view, PV electrification will have the effect of reducing the CO_2 emission from the consumption of fossil fuel. The Rural Electrification and Renewable Energy Development Project, a World Bank project in Nigeria, estimates that a SHS will reduce the CO_2 emission by 120 kg per household per year. The estimated CO_2 reduction by the National PV Electrification Programme using this World Bank figure is 865,101 tons in total by 2040, assuming that each PV system installed from 2007 to 2020 has a life of 20 years.

3.10 Gender and Human Security

3.10.1 Gender

(1) Divided Roles by Gender

The divided roles by gender in the target villages of the Study are outlined in Table 3-41. In each state, the basic pattern is that men are mostly engaged in agriculture (fishing in a small number of villages) which is the main livelihood while women are engaged in housework, childcare and side jobs in addition to a supporting role in farming. Jigawa State is characterised by the fact that women do not work in the farming fields and their work is entirely confined to housework and work around the home, indicating the strong influence of Islam. Because of the basic rule that women in Jigawa State stay at home and within the neighbourhood, water fetching and firewood collection, both of which are usually conducted by women in other areas, are conducted by men. In general, however, the men and women interviewed by the Study Team in several villages consider firewood collection to be women's work as part of their housework even though it is quite hard work, especially for women.

Table 3-41 Divided Roles by Gender in Villages

State	Main Ethnic Group(s)	Men's Roles	Women's Roles
Jigawa*	Hausa	Farming; water fetching; firewood collection; sale of agricultural products in the market	Housework and childcare; processing of agricultural products; sewing; snack making; management of small stores; knitting (mats and hats)
Ondo	Yoruba	Farming; stock raising; firewood collection (few villages); fishing (riverside villages only)	Housework and childcare; water fetching; firewood collection; farming; management of small stores; sale of agricultural products
Imo	Igbo	Farming	Housework and childcare; water fetching; firewood collection; farming; sale of agricultural products
FCT	Koro; Gbagyi; Gwari; Basa	Farming	Housework and childcare; water fetching; firewood collection; processing of agricultural products; farming (harvesting)

Source: Based on the findings of the village socioeconomic survey

* In Jigawa State, women in Kanuri-inhabited villages are engaged not only in housework and childcare but also in farming, water fetching, firewood collection, sale of goods (Kandil Village and Jarmari Village), possession of their own farming land and participation in village activities (Marigadu Village), indicating a very different scope of women's activities compared to Hausa-inhabited villages. In one village where Hausa account for more than 80% of the villagers, women are engaged in farming and the sale of goods while a women's group conducts peanut oil extraction using an extractor (Galadi Village).

(2) Merits of Electrification in the Pilot Project Villages

As part of the process of formulating the M/P, a pilot project involving a PV system was conducted in one village in each of three states. As the SHSs installed at households were the smallest type producing 55 W, the hours during which electricity could be used were limited. To be more precise, two fluorescent lamps could be used for four hours a day and one radio could be used for two hours a day. All of the households have mentioned the merit of using fluorescent lamps which provide a much brighter light. Meanwhile, women listed the following merits.

- Such side jobs as sewing and knitting have become easier to do at night.
- The preparation of beds is easier.
- Feeding children is easier.
- Cooking can be conducted at night.
- The time available to spent time with family members and neighbours has increased.
- Visitors can be received at night.

(3) Other Examples of the Merits of PV

The ex-post report on the SELF Project implemented in Jigawa State with the financial assistance of the USAID and the Jigawa State Government lists various merits of the project as shown in Table 3-42.

Table 3-42 Merits of PV in the SELF Project

Electrification Target	Merits for Both Men and Women (or Those Which Do Not Have a Gender Bias)	Merits for Women
Street lamps (12)	・ The brighter entry points to the village have eliminated problems regarding intruders. ・ Holding meetings at night has become easier. ・ The brighter area around the common water tap has made it easier to obtain water.	・ The business of selling cooked food under street lamps has been made possible
Clinic (lighting and refrigerator to store vaccines)	・ The doctor can receive many patients at night and medical treatment has become easier and safer. ・ Vaccines can now be safely stored for a much longer period.	
School (lighting)	・ An adult class is provided at night and a classroom is available for children to do their homework.	
Pump	・ The work is now much easier compared to manual pumping in the past and queuing is unnecessary. ・ The pumping of groundwater from a deeper borehole is possible with an improved water quality	
Mosque	・ The mosque is used more at night.	
Barber and Tailor, etc.	・ New businesses have been established using the electrified shops.	
Home (SHS)	・ Jobs at home (sewing, etc.) have become quicker.	・ The work efficiency for women who repackage sugar into smaller bags has trebled.
Introduction of Extractor		・ The introduction of a peanut oil extractor has made women's work easier and quicker.

Source: Prepared by the Study Team based on the Solar Electric Light Fund (SELF), "Final Report – Village Electrification Project in Jigawa State"

(4) Possible Contribution to the Empowerment of Women

The empowerment of women means to enable women to participate in the decision-making process as individuals or a social group to obtain the power of self-determination. The JICA has identified nine main gender-related themes, i.e. poverty, economic activities, education, health, the environment, peace, good governance, human rights and information (JICA Guidelines: Mainstreaming Gender Issues: WID). The combination of electrification with a project featuring any of the above themes is expected to contribute to the better empowerment of women as listed below.

1) Economic Activities

① Improvement of the Working Conditions

- Electric lamps are installed as brighter rooms make it easier to do housework with better efficient, reducing the burden of housework on women.
- Basic infrastructure (pump and threshing machine, etc.) is introduced to reduce the burden on women.

- Solar cookers are introduced to reduce the burden of firewood collection on women (which may lead to the prevention of forest degradation caused by firewood collection).

② Women are often involved in such commercial activities as the management of small stores, sale of agricultural products and sale of handicrafts. The increased use of mobile phones by women will make it possible for them to obtain useful information for business expansion and the development of new products.

③ The utilisation of an oil extractor using power generated by a PV system and a solar dryer, etc. will enable the promotion of food processing by women.

2) Education

① Informal education for women which usually takes place at night, including literacy education and vocational training, can be efficiently conducted in a classroom lit by electric lamps. Street lamps will ensure safe passage to and from the school.

② At present, women's centres of which the number exceeds 500 nationwide are said to be facing such operational problems as insufficient facilities and equipment, shortage of instructors, insufficient budget and lack of understanding of gender issues among the public. The use of electric lamps and fans at these centres through their electrification will solve one problem regarding the insufficient facilities.

3) Health Care

① The availability of lighting at village clinics will improve the health care service and childbirth at clinics to a more adequate level.

② The improved working conditions provided by lighting and a refrigerator to store vaccines will make the full-time presence of a doctor and/or nurse possible at rural clinics which currently do not have a full-time doctor and/or nurse.

③ Most families in rural areas currently use kerosene lamps (also palm oil lamps in Imo State) as the light source. These lamps are said to adversely affect the eyes and respiratory system. As women tend to spend a longer time at home than men, they are more liable to these adverse effects. The switch from oil lamps to electric lamps will prevent these adverse effects.

4) Information

① Electrification will increase the opportunity to use a radio and/or TV. Access to movements to help women and the gender situation at home and abroad through programmes will raise the gender awareness of both men and women.

② If electrification leads to the introduction of computers as a hard measure and to computer training for prospective users as a soft measure, there is the possibility of women routinely using the Internet.

(5) Recommendations

1) From Practical Needs to Strategic Needs

One important point from the viewpoint of gender in relation to the formulation of a development plan is to distinguish between the two types of needs of women. There are practical needs for water, medical care and employment which are closely related to daily life. Meanwhile, strategic needs envisage changes of the existing roles assigned to men and women and changes of the existing social, political and economic structures which create the gender gap, subjugating women to men. However, women are often unaware of their segregated status and some time is required for them to become aware of their strategic needs. From this viewpoint, practical needs and strategic needs are completely different needs and the latter should be seen as the development of the former. Talking about the practical needs of women is the first step for women to become aware of gender inequality, from which strategic needs are formed.

2) National Approach

A national approach is necessary to solve gender problems and it is essential for the Ministry of Women Affairs to play the central role in Nigeria. In fact, the Ministry of Women Affairs has expressed interest in the electrification of classrooms used for evening literacy classes for women, the installation of street lamps along the routes to the schools and the electrification of small home industries run by women. What is required is collaboration between the REA and the Ministry of Women Affairs to materialise these plans. In the long-term, the number of women involved in energy policies at all relevant government ministries and agencies should be increased. It will also be necessary to increase the number of men capable of considering gender issues in policy planning as well as implementation.

3) Community-Level Approach

The equal participation of men and women in the decision-making process should be sufficiently considered at the planning as well as implementation stages of a project which affects their daily lives. For example, when a PV maintenance organization is established in a village, a woman (women) should be included among its members. Training on maintenance skills should feature women as well as men. This has two advantages. One is the raising of women's awareness and the other is that women understand the necessity for the installation of street lamps along the route to a clinic as it is generally women who accompany children to the clinic.

To ensure the improved planning of electrification projects which reflect the views of users, the inclusion of the views of women who have much deeper insight into daily life should prove highly significant.

3.10.2 Human Security

(1) What is Human Security?

In its new ODA Charter enforced in August, 2003, the Government of Japan calls for the implementation of ODA incorporating the concept of "human security". The new Mid-Term ODA Policy formulated in February, 2005 defines "human security" as "a concept which places individual persons at the centre and aims at creating a society in which all individuals can live their lives with dignity by means of protecting and the capacity building of individuals as well as local communities which could be threatened or are actually under threat" and places "human security" as "a viewpoint to be adhered to throughout development assistance efforts".

The same policy lists such threats to individuals causing "fear" as conflict, terrorism, crime, violation of human rights, occurrence of refugees, spread of infectious diseases, destruction of the environment, economic crisis and natural disasters and "shortages" associated with poverty, hunger and absence of educational and health care services. In short, the concept of "human security" can be referred to as a framework to create a society in which people can live with peace of mind.

(2) Rural Electrification and Human Security

Table 3-43 shows the perceived benefits of PV by level and field, each of which can be considered a concrete example of "human security".

Table 3-43 Benefits of PV by Level and Field

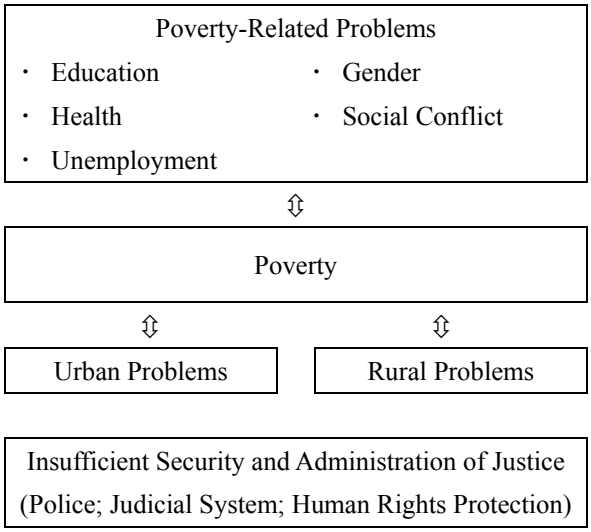
Level	Health, Safety and the Environment	Education, Communication and Information	Livelihood and Economy
Individual/ Household Level	The replacement of traditional kerosene lamps by electric lamps improves the indoor environment (no more soot) and prevents burns and fires.	Evening study and access to information on the radio, etc. become possible.	Income can be increased (longer business hours of stores and livelihood improvement activities in the evening).
Local Community Level	Improved BHN and a better quality of life can be expected because of lighting at public facilities and the cold storage of vaccines, etc. at medical facilities. PV can be considered a means of social development, targeting rural areas which lag behind the development in urban areas.	The improved adult education in the evening will improve the level of education.	The local economy is vitalised due to the creation of added value for processed agricultural products (rice polishing and nut drying, etc.)
National Level	It may become difficult to obtain fossil fuel due to depletion, price hike or political interference, etc. and hydropower generation may decline if the future climate changes, meaning less rainfall, Meanwhile, the use of sunlight as energy is free and unlimited. Its use also means the diversification of generating sources as a part of risk management.	The wide use of radios and TVs will eliminate the increasing information gap in rural areas.	One problem faced by the agricultural sector is population migration from rural areas to urban areas (source: NEEDS). The purpose of such migration is to seek employment or a better income. A better quality of life and increased employment opportunities in rural areas due to electrification may act to prevent population migration.
Global Level	The reduction of the CO_2 emission volume accompanying energy consumption is an important task for assistance for the power sector in developing countries. The promotion of PV which reduces the CO_2 emission associated with power generation is a human security measure from the greater viewpoint of mankind.[1)]		

1) The CO_2 emission levels from solar cell generation and oil-fired thermoelectric generation are calculated as follows: (Source: PV Generation Association Home Page)
CO_2 emission using solar cells: approx. 20 g/KWh
CO_2 emission from oil-fired thermoelectric generation: approx. 200 g/KWh

(3) Human Security in Nigeria

1) Threats to Human Security

Fig. 3-18 schematises the relationship between the various threats to human security in Nigeria.



Source: Prepared by the Study Team based on the NEEDS

Fig. 3-18 Threats to Human Security in Nigeria

2) Approach of the Government of Nigeria

In its National Economic Empowerment and Development Strategy (NEEDS) which is a national strategy adopting a new approach to economic revival, the Government of Nigeria adopts a strategy consisting of three pillars as shown in Fig. 3-19 while recognising the various threats to human security referred to in 1) above.

Empowering People	**Promoting Private Enterprises**	**Changing the Way the Government Works**
Health; Education; Environment; Rural Development; Housing Development; Employment; Youth Development; Safety Nets; Gender and Geopolitical Balance	Security and Rule of Law; Infrastructure; Finance; Sectoral Strategies; Privatisation and Liberalisation; Trade; Regional Integration and Globalisation	Public Sector Reform; Government; Transparency; Anti-Corruption; Service Delivery; Budget and Expenditure Reform

Source: NEEDS

Fig. 3-19 Three Pillars Forming the Needs Strategy and Their Contents

3) Human Security in Nigeria

The NEEDS of Nigeria considers the aspect of human security even though it does not specifically use this phrase. While the current threats to human security are considered to diminish as a result of, for example, an improved school enrolment rate, etc., it is entirely feasible that new types of threats will emerge in different areas. This is equally true for advanced countries. Accordingly, it is highly desirable for the Government of Nigeria to adopt the concept of "human security" and to analyse the situation of the country from such a viewpoint as well as from other viewpoints when formulating a development programme/strategy. In this manner, human security can be expected to be ensured at any time in the future.

Meanwhile, rural electrification can be considered one attempt to improve human security as described earlier and is raising much expectation on the part of rural residents. As its benefits and degree of contribution are very high, it is important for the future promotion of rural electrification to be conducted from the viewpoint that rural electrification is a measure to improve human security.