FEDERAL MINISTRY OF POWER (FMOP)
FEDERAL CAPITAL TERRITORY WATER BOARD (FCTWB)
THE FEDERAL REPUBLIC OF NIGERIA

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR
INTRODUCTION OF CLEAN ENERGY
BY SOLAR ELECTRICITY GENERATION
SYSTEM
IN
THE FEDERAL REPUBLIC OF NIGERIA

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

IL
JR
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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Yachiyo Engineering Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of Nigeria, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Federal Republic of Nigeria for their close cooperation extended to the survey team.

March 2014

Takumi UESHIMA
Director General,
Industrial Development and Public Policy Department
Japan International Cooperation Agency

SUMMARY

① Outline of the Country

The Federal Republic of Nigeria (hereafter referred to as Nigeria) covers an area of 923,773 square kilometers (approximately 2.5 times the size of Japan), has a population of approximately 166.6 million (2012, UNFPA) and per capita GNI of US$1,430 (2012, World Bank), and is one of Africa's foremost countries with the largest production of petroleum and reserves of natural gas and the second highest GDP in the continent. In geopolitical terms, since Nigeria has a complicated mixture of more than 250 ethnic groups including Hausa, Yoruba and Ibo and numerous religions, government administration is carried out in consideration of six geopolitical zones. Concerning crude oil production, Nigeria produces approximately 1,950,000 barrels of oil a day, making it the seventh largest OPEC producer (2012), and it relies on petroleum-related business (including gas) to provide approximately 77 percent of total revenue and 96 percent of total export value (2012). Therefore, the economy of Nigeria is greatly dependent on crude oil production.

② Background and outline of the Project

As the seventh largest producer of oil in OPEC and the ninth largest reserve of natural gas in the world, Nigeria is a major energy resource power; however, energy supply that is based on such fossil fuels is finite. Furthermore, due to the effects of climate change, water flow in the Niger River system is diminishing and power generation at hydropower plants, which constitute important power sources in Nigeria, is falling, thus making it increasingly difficult to realize sustainable energy supply and energy security. As a result, Nigeria is faced with a need to adjust its conventional energy policy based on fossil fuels. Against such a background, Nigeria designated renewable energy as a pillar of sustainable energy supply in the National Energy Plan that was compiled in 2003, while in 2005 it compiled the Renewable Energy Master Plan (revised in 2012), under which it is promoting the introduction of renewable energies such as solar power, wind power, micro hydropower and biomass, etc.

The Government of Japan has established funding schemes such as the Cool Earth Partnership in order to support developing countries that are striving to balance reduction of greenhouse gas emissions with economic growth and contribute to climate stabilization. In view of this policy by the Government of Japan, JICA has made it a policy principle to actively utilize advanced Japanese technologies for clean energy including renewable energy. Within this, there is particular need to make use of photovoltaic power technology, which is an area in which Japan is highly advanced, in international cooperation projects.

Due to the effects of climate change, water flow in the Niger River system is diminishing and power generation at hydropower plants, which constitute important power sources in Nigeria, is falling, thus making it increasingly difficult to realize sustainable energy supply and energy security. As a result, Nigeria is faced with a need to adjust its conventional energy policy based on fossil fuels.

Energy Commission of Nigeria (ECN) formulated ‘Renewable Energy Master Plan (REMP)’ in 2005 and revised it in November 2012. The plan has been promoting the installation of renewable energy such as solar, wind, micro-hydro and biomass. However, introduction of renewable energy is not advancing as expected due to the following impediments: ① the policies, regulations and institutional framework for expanding the renewable energy market do not exist; ② introductory costs are high and it is difficult to raise funds; and ③ there are no regulations concerning technical standards for product quality, and so on.

The preparatory survey was conducted at Umaru Musa Yar’adua University as a project site in 2011. However it has been decided to change the site to Lower Usuma Dam Water Treatment Plant outskirt of Federal Capital Territory due to the deterioration in the security situation. Exchange of Notes on ‘the Project for Introduction of Clean Energy by Solar Electricity Generation System’ was concluded in May 15, 2012.

③ Outline of the Study findings and contents of the Project

JICA dispatched the Preparatory Survey Team to Nigeria from September 14 to October 11, 2013. During this dispatch, the Team reconfirmed the contents of the request and discussed the contents of implementation with related officials on the Nigerian side (Responsible Ministry and implementing agency: the Federal Ministry of Power, and operation and maintenance agency: Federal Capital Territory Water Board), surveyed and investigated the project site and collected related data and materials.

On returning to Japan, based on the data and materials obtained in the field investigation, the Team conducted examination on the necessity of the Project, its social and economic effects and its validity and compiled findings into the Preparatory Survey Report (Draft). JICA dispatched the Team to Nigeria again from March 1 to March 7, 2014 to explain and discuss the Preparatory Survey Report (draft) and reach a basic agreement with the related officials on the Nigerian side.

As a result of the study, the Project will entail the procurement and installation of a photovoltaic system (generation capacity 975 kWp) and related power conditioner, transformer for interconnection, interconnection equipment and 11 kV/415 V distribution lines, etc. at Lower Usuma Dam Water Treatment Plant. Since this photovoltaic system will be the biggest of its kind in Nigeria and will entail grid connection for the first time in that country, the contents have been designed upon giving full consideration to ensure that the system can be operated and maintained without any problems after completion. Moreover, it has been decided to conduct technology transfer concerning operation, maintenance and grid connection to ensure that the Project contributes to the future dissemination of grid-connected photovoltaic systems in Nigeria from now on.

Outline of the Basic Plan

	Components	Quantity or Capacity
Procurement and Installation	1. Photovoltaic system 1.1 Solar photovoltaic arrays 1.2 Junction box 1.3 Collecting box 1.4 Power conditioners 1.5 AC Distribution Panel 1.6 Interconnection Transformer 1.7 Interconnection equipment 2. Data management system 2.1 Data logger including UPS system 2.2 Display system 2.3 Weather monitoring instruments (Pyranometer, Temperature meter) 3. Cables and fitting materials	 975 kWp 1 lot 1 lot Total capacity of the connected photovoltaic modules or more 1 unit Total capacity of the connected photovoltaic modules or more 1 unit 1 set 1 set 1 set 1 lot
Procurement	1. Spare parts 2. Maintenance tools (including high pressure washers)	1 lot 1 lot
Construction	1.Mounting Structures for the photovoltaic arrays 2.Foundations for the photovoltaic arrays 3.Power Conditioner Building	for the photovoltaic arrays of 975 kWp for the photovoltaic arrays of 975 kWp Gross floor area: Approx. 77.5 m^2

④ Project implementation period and rough project cost

In the case where the Project is implemented under the Government of Japan’s Grant Aid scheme, the total project cost will be approximately (**confidential**) yen (Japan’s burden: approximately: (**confidential**) yen, Nigeria’s burden: approximately 7.82 million yen). The main items to be handled by the Nigerian side will be the water pipe branch construction work (0.02 million yen), construction of protection net against vandalism (6.82 million yen based on the estimation by the Preparatory Survey Team. This amount is subject to change according to detail design of protection net construction.), and bank commission fee (Approx. 0.1% of the grant amount). The Project implementation period including the detailed design and the tendering periods will be approximately 19.5 months.

⑤ Project Evaluation

As is indicated below, since the Project will contribute to the realization of Nigeria’s development plans and energy policy as well as benefit the general population, it is deemed to have high relevance as a grant aid undertaking.

(1) Relevance of the Project

1) Beneficiary

This Project will also contribute to the power supply to sole the water utility in Federal Capital Territory, Federal Capital Territory Water Board. Concurrently, through this Project, potable water treated by the photovoltaic system will be supplied to the Federal Capital Territory. The photovoltaic power generation system will contribute to the power supply to approximately 40,000 households.

2) Operation and maintenance capacity

Since the equipment and materials to be procured in the Project can be comfortably operated and maintained under the present Nigerian technical capacity, they will present no particular problems in implementation of the Project. The Federal Capital Territory Water Board organizes Mechanical and Electricity Section under the Distribution Department, and they have experience on the operation and maintenance of power system. Therefore, they will not face difficulties on the operation and maintenance of the photovoltaic system in the future.

3) Urgency

According to the Renewable Energy Master Plan of Nigeria, the goal of installed capacity of clean energy power generation by 2017 is 300 MW whilst the current achievement is 15 MW. It means the achievement rate is merely 5%. Therefore, through the installation of approximately 1,000 kWp of photovoltaic system, the rate will be increased by 6.7%. Furthermore, since this Project will be the first case of the installation of grid-connected photovoltaic system, it is expected to contribute to the similar photovoltaic system in Nigeria in the future.

4) Consistency with Japan's development assistance

The Government of Japan established Cool Earth Partnership mechanism, a funding scheme for developing countries to mitigate the effect of climate change. Since this Project will be implemented in Nigeria, one of Cool Earth Partnership mechanism partner countries, this Project is consistent with Japan's development aid policy. In addition, this Project is considered important from the view that it can utilize Japan's advanced technology in the field of clean energy.

(2) Effectiveness of the Project

Based on the discussion on the effectiveness from quantitative and qualitative views in this section, sufficient effects on the reduction of greenhouse gases and the reduction of electrical expenses are anticipated. Since personnel in charge of operation and maintenance of the photovoltaic system will gain the necessary techniques and knowledge through the soft component, the Project has high relevancy and also enough effectiveness.

The anticipated quantitative effects of Project implementation are as indicated below.

Indicator	Reference value (2013)	Target value (2016)
Net electric energy	0	1,459 MWh
Fossil fuel reduction	0	326,338 Nm^3/year
CO_2 reduction	0	723.5 t
Reduction of payment for the electricity	0	30 million Naira/year

[Source] JICA Study Team

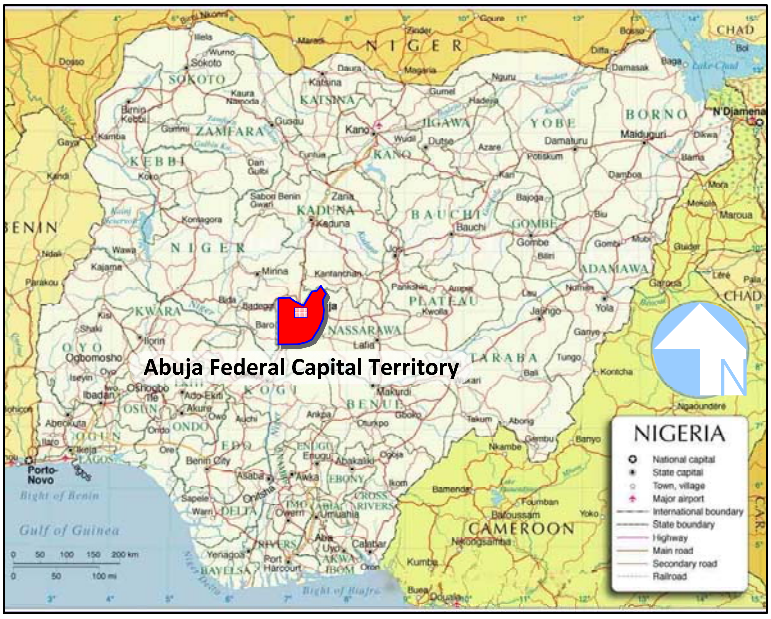
[Notes] The power supplied by the photovoltaic system (1,459 MWh) is projected to contribute to 6% of the estimated power demand of the Plant in 2016 (21,921 MWh).

Electricity tariff is assumed as 21.03 NGN/kWh as of September 2013.

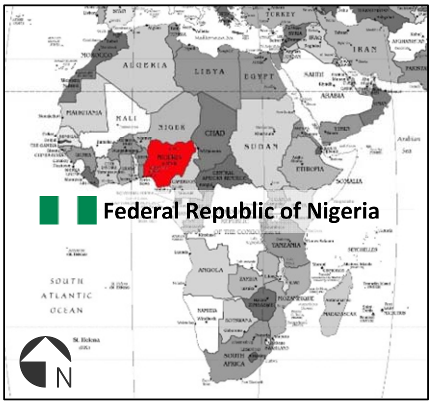
As for the qualitative effects, Project implementation will serve to raise the share of renewable energy out of total power supply as stated on the Renewable Energy Master Plan, enlighten people about photovoltaic generation, contribute to the accumulation of technical know-how on grid-connected photovoltaic systems, and lead to the future dissemination of such technology.

As can be seen above, since implementation of the Project can be expected to impart massive effects, its implementation under the scheme of the Government of Japan is confirmed to be valid. Furthermore, the setup on the Nigeria side in terms of personnel and budget planning is deemed to be sufficient for implementing the Project and conducting post-implementation operation and maintenance.

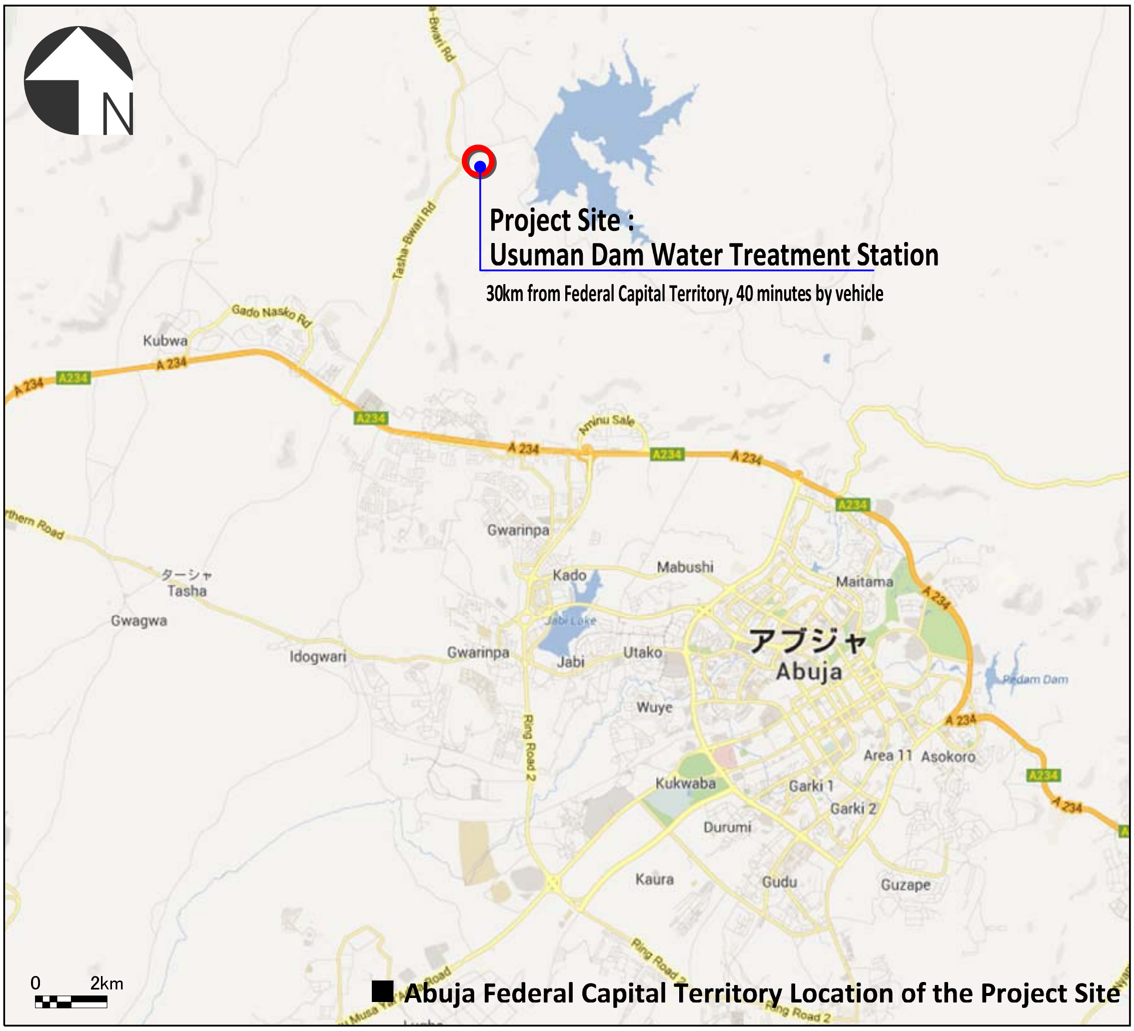
CONTENTS



■ Map of Federal Republic of Nigeria



■ Map of Africa



■ Abuja Federal Capital Territory Location of the Project Site

Preparatory Survey on the Project for
Introduction of Clean Energy by Solar Electricity Generation System
Location of Project Site

Perspective of the Solar Photovoltaic System
(The actual arrangement of PV arrays is subject to change depending on manufacturers.)

LIST OF FIGURES AND TABLES

Chapter 3

ABBREVIATIONS

DISCO	Distribution Company
E/N	Exchange of Note
ECN	Energy Commission of Nigeria
EIA	Environmental Impact Assessment
EIS	Electrical Inspectorate Service Department
FCTWB	Federal Capital Territory Water Board
FMOP	Federal Ministry of Power
FMOST	Federal Ministry of Science and Technology
G/A	Grant Agreement
M/D	Minutes of Discussions
MDGs	Millennium Development Goals
NEEDS	National Economic Empowerment and Development Strategy
NEP	National Energy Policy
NERC	Nigerian Electricity Regulatory Commission
NPC	National Planning Commission
NV20:2020	Nigeria Vision 20：2020
PHCN	Power Holding Company of Nigeria
REMP	Renewable Energy Master Plan
TERI	The Energy and Resources Institute
TOR	Terms of Reference
UMYU	Umaru Musa Yar’adua University

Chapter 1 Background of the Project

1-1 Background of the Request for a Program Grant Aid for Environment and Climate Change

The Government of Japan has established funding schemes such as the Cool Earth Partnership in order to support developing countries that are striving to balance reduction of greenhouse gas emissions with economic growth and contribute to climate stabilization. In view of this policy, JICA has made utilizing advanced Japanese technologies for clean energy including renewable energy a policy principle. Within this, there is particular need to make use of photovoltaic power technology, which is an area in which Japan is highly advanced, in international cooperation projects.

Due to the effects of climate change, water flow in the Niger River system is diminishing and power generation at hydropower plants, which constitute important power sources in Nigeria, is falling, making it increasingly difficult to realize sustainable energy supply and energy security. As a result, Nigeria is faced with a need to adjust its energy policy based on fossil fuels.

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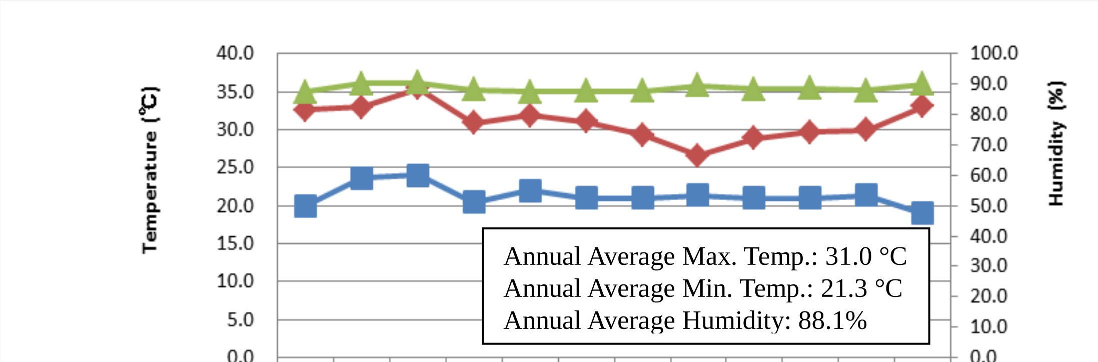
Considering the above background, Nigeria, one of Cool Earth Partnership members, made a request of the project for introduction of clean energy (solar electricity generation system) and thus carrying out of the preparatory survey was decided.

Formerly, the preparatory survey was conducted at Umaru Musa Yar’adua University as a project site in 2011. However it has been decided to change the site to Lower Usuma Dam Water Treatment Plant outskirt of Federal Capital Territory due to the deterioration in the security situation at that site. Exchange of Notes on ‘the Project for Introduction of Clean Energy by Solar Electricity Generation System’ was concluded in May 15, 2012. The grant is amounting to 980 million Japanese yen.

1-2 Natural Conditions

(1) Climatic Conditions

The maximum temperature at Lower Usuma Dam Water Treatment Plant (the Plant) is approximately 33 °C during the dry season, from November to April, and during this season, daily maximum temperatures of some days even exceed 40 °C. On the other hand, the daily maximum temperature during the rainy season, from May to October, is around 30 °C. and the lowest daily maximum temperature was recorded in August and it was slightly over 26 °C. The range of humidity throughout year is between 88% and 91%. Figure 1-2.1 shows the annual average temperature and humidity.

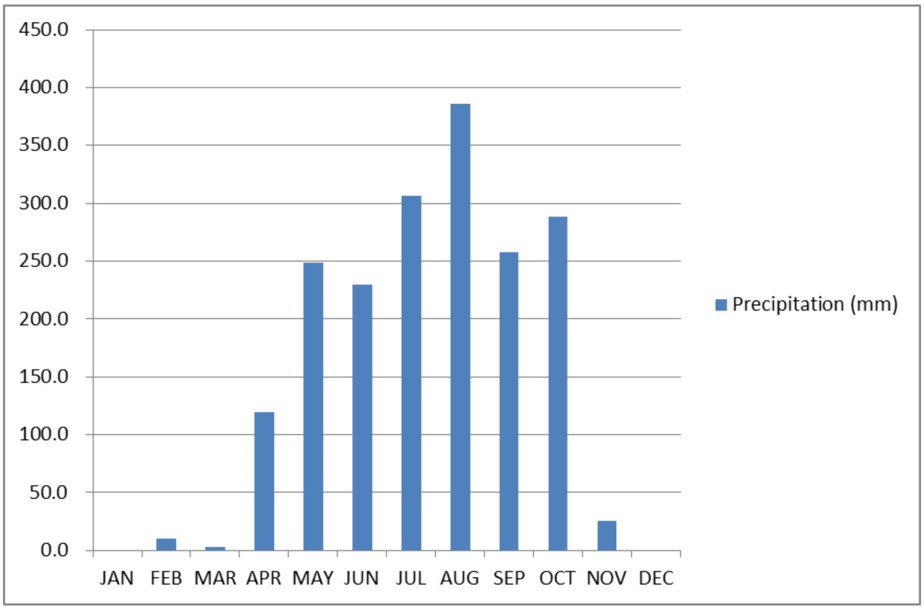


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Daily Max. Temp.	32.6	33.0	35.5	30.9	31.8	31.0	29.3	26.6	28.9	29.6	30.0	33.1
Daily Min. Temp.	20.0	23.7	24.0	20.4	22.0	21.0	21.0	21.3	21.0	21.0	21.3	19.0
Average Humidity	87.5	90.2	90.4	88.1	87.4	87.6	87.7	89.6	88.4	88.7	88.0	89.9

[Source] Lower Usuma Dam Water Treatment Plant

Figure 1-2.1 Annual temperature and humidity of Lower Usuma Dam Water Treatment Plant (2010-2012)

The precipitation during dry season at the Plant is low and it concentrates during rainy season. Figure 1-2.2 shows the monthly precipitation at the Plant from 2010 to 2012.



[Source] Lower Usuma Dam Water Treatment Plant

Figure 1-2.2 Monthly precipitation at Lower Usuma Dam Water Treatment Plant (2010-2012)

(2) Irradiation Conditions

1) Horizontal solar irradiation

Table 1-2.1 shows the solar irradiation data in Abuja issued by four different sources: Nigeria Meteorological Agency, NASA, Nigerian Building and Road Research Institute and Meteonorm in Switzerland. As the table indicates, values of each data are different.

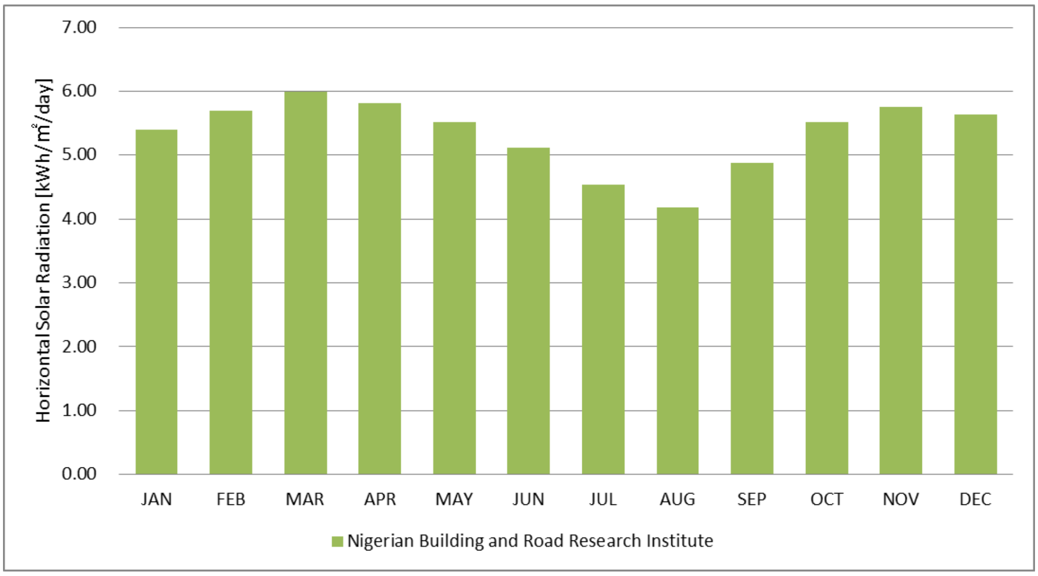
NASA's data are collected with an indirect manner. In case of other countries, NASA's data tend to be higher than the measured data by 10%. The data of Nigeria Meteorological Agency are even higher than that of NASA. Meteonorm's annual total value is slightly higher than that of NASA. The data of Nigerian Building and Road Research Institute show the lowest among these four data. Since the data are the safest, the data of Nigerian Building and Road Research Institute are going to be utilized. Figure 1-2.3 shows the data of horizontal solar irradiation.

Table 1-2.1 Horizontal solar irradiation

(Unit: kWh/m²/Month)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Nigeria Meteorological Agency	216.69	195.72	200.88	174.6	158.1	138.6	136.09	140.74	152.7	172.36	197.4	213.9	2098
NASA	182.28	170.52	194.37	181.8	172.98	151.5	137.64	129.89	141.9	164.61	179.4	181.66	1989
Nigerian Building and Road Research Institute	167.4	159.6	185.69	174.3	171.12	153.3	140.43	129.58	146.4	171.12	172.5	174.84	1946
Meteonorm	181.04	173.88	194.99	183	184.14	171.9	156.86	148.8	145.8	178.87	177.9	167.09	2064

[Source] JICA Study Team



[Source] JICA Study Team

Figure 1-2.3 Solar irradiation in Abuja

2) Tilt-angle solar irradiation

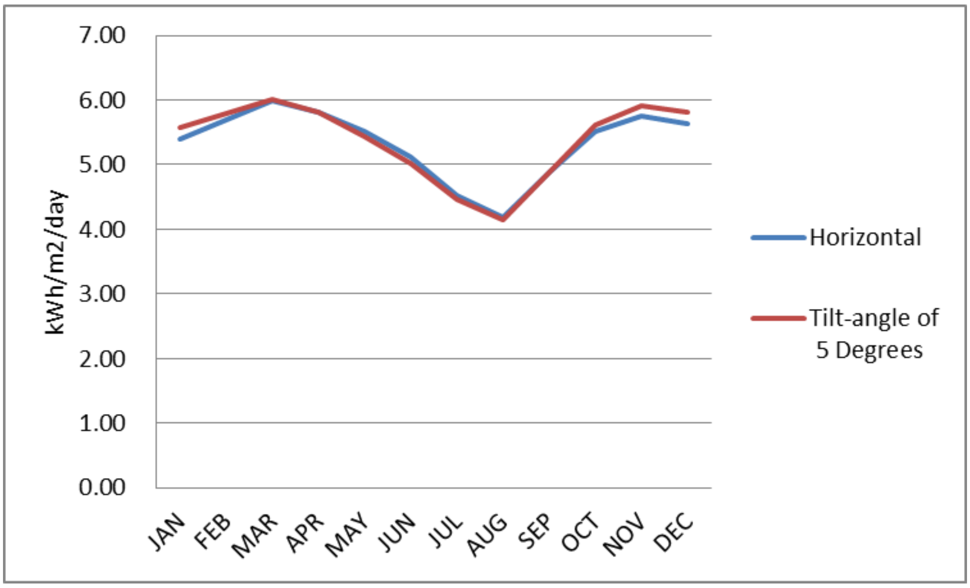
Referring to the data of horizontal and tilt-angle solar irradiation simulated by Meteonorm, the tilt-angle solar irradiation is calculated based on the horizontal solar irradiation data of Nigerian Building and Road Research Institute. Appropriate angle of solar modules is 5–10 degrees considering that the project site is situated at the latitude of N 9° 11'. Monthly horizontal solar irradiations and solar irradiations with tilt-angle 5 degrees are shown in Table 1-2.2 and Figure 1-2.4. The difference of solar irradiation is 14 kWh/m^2/year. Based on the data, the estimated power generation will be discussed in 'Chapter 3 Project Evaluation'.

Table 1-2.2 Horizontal solar irradiation and the solar irradiation with tilt-angle 5 degrees

(Unit: kWh/m^2/month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Horizontal	167.4	159.6	185.7	174.3	171.1	153.3	140.4	129.6	146.4	171.1	172.5	174.8
5 Degrees	172.9	162.4	186.6	174.3	168.3	150.6	138.6	128.7	146.4	174.0	177.3	180.1

[Source] JICA Study Team



[Source] JICA Study Team

Figure 1-2.4 Comparison of solar irradiation

1-3 Environmental and Social Consideration

(1) Legal structure concerning Environmental Impact Assessment in Nigeria

In Nigeria, Environmental Impact Assessment (EIA) is implemented by the Federal Ministry of Environment (FMOE) based on the Environmental Impact Assessment Act No. 86 (Decree No. 86) enacted in 1992. The EIA procedure shall be imposed on every development project regardless of whether it is public or private. FMOE classifies the development project into three categories:

Category 1: Projects that require a full-scale EIA

Category 2: Projects that require implementation of a partial EIA based on environmental impact mitigation measures and environment planning (a full-scale EIA is required in cases where the project site is located near areas that need special environmental and social consideration).

Category 3: Projects that impart an essential beneficial impact on the environment (an Environmental Impact Statement is prepared).

Generally, EIA is processed based on the following procedure:

1) Project implementing agency submits the EIA Registration Form together with the project proposal to the FMOE. The items that need to be stated in the form includes project title, implementing agency, location, project outline, sources of required materials, sector, forecasted project life, EIA implementer (consultant, etc.,)
2) After FMOE scrutinizes the submitted documents, FMOE will carry out the field survey. Subsequently, FMOE determines the category of the Project.
3) The Project implementing agency prepares Terms of Reference (TOR) for the implementation of EIA based on the determination.
4) The Project implementing agency will carry out the EIA after the TOR is approved by FMOE. After the EIA, the draft EIA report will be submitted to FMOE.
5) FMOE will decide of whether to approve or disapprove the draft EIA Report.
6) After the environmental mitigation monitoring is carried out by FMOE or other organization, the project implementing agency will submit the final EIA Report.

(2) Environmental Impact Assessment for the Project

Renewable energy development projects including those for photovoltaic energy are classified as Category 2 out of the aforementioned three categories; in other words, they are deemed to be projects that have medium level impacts and require partial EIA. Accordingly, a partial EIA will be necessary in the Project too.

However, when JICA implemented a pilot project under the Master Plan Survey for Solar Energy Utilization in Nigeria in 2007, FMOE stated that there was no need to implement either a full-scale EIA or partial EIA as it was forecasted that the photovoltaic power generation would create no major environmental impacts provided that the used batteries were properly disposed. In the Project, although there will be some minor environmental impact during the preparatory works (site reclamation), the photovoltaic system will not use batteries and there will be no major impacts in line with the disposal of used batteries. Accordingly, similar to the abovementioned pilot project, there is a strong likelihood that the EIA will be waived. In case that the Environmental Impact Assessment is required by FMOE, the assessment shall be referred to IEE instead of EIA. Furthermore, since sufficient time is secured for the Environmental Impact Assessment process until the commencement of the project implementation, it will hardly affect the project implementation schedule.

In line with the above procedures, the following procedure will be followed:

1) FMOP registers the project to FMOE (Registration fee: 50,000 naira).

2) FMOE scrutinizes the submitted document and informs the result to FMOP.

3) In case that FMOE requires the implementation of EIA FMOP will prepare the TOR and get approval from FMOE.

4) Based on the TOR, EIA implementing agency designated by FMOP carries out the assessment.

5) FMOP takes it into consideration in proceeding the procedures and discussions with FMOE that the FMOE stated that there was no need to implement either a full-scale EIA or partial EIA when FMOP and JICA implemented a pilot project under the Master Plan Survey for Solar Energy Utilization in Nigeria in 2007.

Chapter 2 The Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Goal

Impacts of climate change are observed in the energy sector of Nigeria. One example is the decrease of power generation by hydroelectric plants caused by the decrease of water flow of Niger River. Considering the difficulties being faced in securing the stable power supply, changing the energy policy from the conventional fossil fuel to other sources is getting important.

Energy Commission of Nigeria (ECN) formulated 'Renewable Energy Master Plan (REMP)' in 2005 and revised it in November 2012. The plan has been promoting the installation of renewable energy such as solar, wind, micro-hydro and biomass. However, introduction of renewable energy is not advancing as expected due to the following impediments: (1) the policies, regulations and institutional framework for expanding the renewable energy market do not exist; (2) introductory costs are high and it is difficult to raise funds; and (3) there are no regulations concerning technical standards for product quality, and so on.

Considering the above background, Nigeria, one of Cool Earth Partnership members, made a request of the project for introduction of clean energy (solar electricity generation system) and thus conducting the preparatory survey was decided.

2-1-2 Outline of the Project

The Government of Japan has established funding schemes such as the Cool Earth Partnership in order to support developing countries that are striving to balance reduction of greenhouse gas emissions with economic growth and contribute to climate stabilization. In view of this, JICA has made utilizing advanced Japanese technologies for clean energy including renewable energy a policy principle. Within this, there is particular need to make use of photovoltaic power technology, which is an area in which Japan is highly advanced, in international cooperation projects.

The purpose of this Project is to install grid-connected photovoltaic system with 975 kWp of generation capacity at Lower Usuma Dam Water Treatment Plant (the Plant) to fulfill the overall goal on the Renewable Energy Master Plan in conformity with 'Cool Earth Partnership' of Japan. The components of the main equipment are shown in Table 2-1-2.1.

Formerly, the preparatory survey was conducted at Umaru Musa Yar'adua University as a targeted site in 2011, however, due to the deterioration in the security at that site, it has been decided to change the project site to Lower Usuma Dam Water Treatment Plant outskirt of Federal Capital Territory.

Exchange of Notes on 'the Project for Introduction of Clean Energy by Solar Electricity Generation System' was concluded in May 15, 2012. The grant amount is 980 million Japanese yen.

Table 2-1-2.1 Component of the main equipment

	Components	Quantity or Capacity
Procurement and Installation	1. Photovoltaic system	
	1.1 Solar photovoltaic arrays	975 kWp
	1.2 Junction box	1 lot
	1.3 Collecting box	1 lot
	1.4 Power conditioners	Total capacity of the connected photovoltaic modules or more
	1.5 AC Distribution Panel	1 unit
	1.6 Interconnection Transformer	Total capacity of the connected photovoltaic modules or more
	1.7 Interconnection equipment	1 unit
	2. Data management system	
	2.1 Data logger including UPS system	1 set
	2.2 Display system	1 set
	2.3 Weather monitoring instruments (Pyranometer, Temperature meter)	1 set
	3. Cables and fitting materials	1 lot
Procurement	1. Spare parts	1 lot
	2. Maintenance tools (including high pressure washers)	1 lot
Construction	1. Mounting Structures for the photovoltaic arrays	for the photovoltaic arrays of 975 kWp
	2. Foundations for the photovoltaic arrays	for the photovoltaic arrays of 975 kWp
	3. Power Conditioner Building	Gross floor area: Approx. 77.5 m^2

[Source] JICA Study Team

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

Based on the request from the Government of Nigeria, the Project aims to procure and install a photovoltaic system on the Project site inside Lower Usuma Dam Water Treatment Plant (The Plant) located about 40 km far in the northwest from Abuja City of Nigeria.

Photovoltaic system shall be installed together with mounting structures at the following two areas (total 8,800 m^2).

- Area on the top slab of existent water tanks (No.3 and No.4)
- Open space between existent No.3 and No.4 water tanks

The Project will install the grid-connected photovoltaic system (975 kWp) to provide supplemental power supply to the Plant adding to the commercial power supply from the Abuja Electricity Distribution Company (Abuja DISCO). It was agreed by Nigerian and Japanese sides that the system does not include batteries as a result of the limitation of battery capacity, its high replacement cost. The photovoltaic system is comprised of electrical equipment such as solar photovoltaic modules, connection box, collection box, power conditioner, step-up transformer and interconnection equipment.

2-2-1-2 Policy regarding Natural Environmental Conditions

(1) Temperature and humidity conditions

The target area is a hot region with daily maximum temperature ranging between 25 and 35 °C throughout the year. A power conditioner and other equipment that contain precision instruments will be installed inside a building (Power Conditioner Building) to be constructed in the Project and it will be necessary to plan the building specifications, etc. so that the equipment is protected from the outside temperature and dust.

(2) Rainfall conditions

Since large amounts of concentrated rain fall during the rainy season around the Project site, it will be necessary to take steps to ensure that the rainwater does not infiltrate into the photovoltaic panel installation area.

However basic infrastructures such as drainage facility, road pavement etc. have been already provided at the all the installation areas for photovoltaic system and power conditioner. Therefore, it is not necessary to plan.

2-2-1-3 Policy regarding Socioeconomic Conditions

Socioeconomic infrastructure development in Nigeria for its citizens' daily necessities, such as roads, power, and water service, has been steadily making progress.

In particular, given the frequent power outages in the Federal Capital Territory and its surrounding areas, improvement in the electrical power situation is highly anticipated due to investment focused in construction of power stations and expansion of transformer substations.

When taking a long-term outlook on the social and economic conditions of Nigeria, the photovoltaic system installed through the Project should be able to contribute to improving the power situation. To this end, the Team must consider not only the equipment aspects, such as the provision of materials and equipment, but also organize the implementation of soft components, such as the transfer of technology through design and planning.

2-2-1-4 Policy regarding the Construction Situation / Procurement Conditions

Abuja has not only local construction companies, but also a number of foreign construction companies as well ranging from small to large scale with a wide variety of work performance. However, it would be hard to say that the situation is satisfactory in terms of quality control, or the number of engineers and skilled workers who possess advanced technological skills and expertise in process management leading to a complete construction.

For this reason, in carrying out foundation and installation work for the photovoltaic system in the Project, consideration should be given to allow for the reliable transfer of equipment management, and technologies related to quality and processes, under the supervision of the Japanese engineers who possess technological skills and expertise.

2-2-1-5 Policy regarding Utilization of Local Contractors

The Team has verified that it is feasible to conduct all site work for the Project, including steel processing, plating, assembly, and the calibration and testing of the machinery and tools, etc., using local contractors and laborers under the guidance of Japanese engineers, who bring relevant construction management skills and technological know-how. To this end, Japanese personnel shall be appointed to supervise and manage the Project. Further, since it will be necessary to support the photovoltaic arrays to withstand the harsh local environment, and take into account experiences to date with defect inspections for the Environment and Climate Change Program, the mounting structures shall be procured from Japan.

It is possible to procure all construction materials and equipment locally, and extra consideration will be given to the proactive use of local products. However, the reality is that imports are relied on due to the wide variation in quality and market supply levels of domestically produced steel and rebar. For this reason, when procuring steel and rebar to be used in structural applications, it is essential to carefully inspect their quality, origin, etc.

2-2-1-6 Policy regarding Operation and Maintenance

There are no large-scale photovoltaic systems in the Plant. Power is being supplied from Abuja DISCO across 33 kV overhead dual lines to the electrical room on the premises of the plant, where it is stepped-down to 11 kV through 11 kV switching equipment in order to provide power to No.3 and No.4 Water Treatment facilities. In the event of a power supply interruption from Abuja DISCO, two back-up diesel engine generators rated at 1,000 kVA capacity have been installed. The operation and maintenance of the diesel engine generators is performed by 5 technicians. Although an operation and maintenance system for the photovoltaic system is in place, they do not possess sufficient knowledge and technical skills.

Consequently, it is imperative to plan to adequately transfer knowledge and technical skills related to not only for operation but also maintenance of the completed photovoltaic system through the soft components to the department responsible for the operation and maintenance.

Through the soft components, the Project will transfer basic technology related to grid connection with an emphasis on interconnected operation with the Plant's existing electrical distribution system, as well as consider of how to make the Project's photovoltaic system operate more efficiently and effectively, through suggestions for the operation and maintenance systems after it becomes operational.

2-2-1-7 Policy regarding the Grading of Facilities and Equipment

While bearing in mind the conditions described above, the procurement and installation scope and technical level of Project equipment will be formulated as the following principle.

(1) Policy regarding the scope of facilities and equipment, etc.

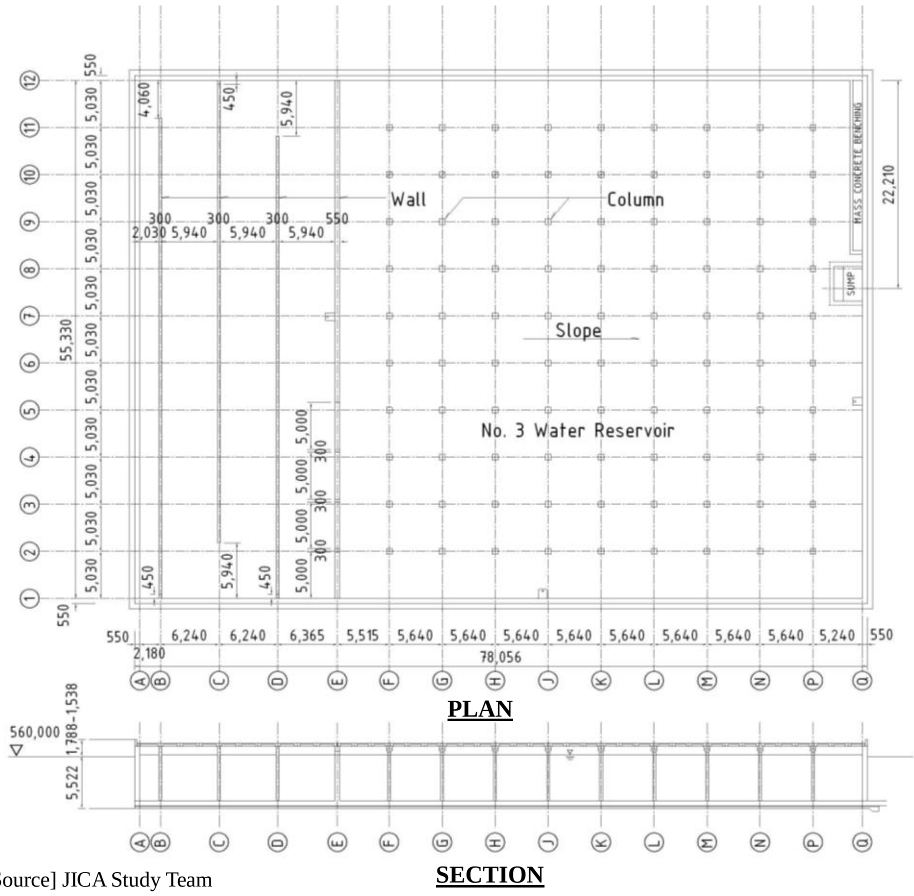
In order to realize a design that is both technically and economically appropriate, standard items of equipment and materials that comply with IEC and other international standards shall be adopted as far as possible. The number of models and methods shall be minimized to promote compatibility and the minimum required equipment mix, specifications and quantities shall be selected.

Furthermore the following items shall be carefully taken into consideration because most of photovoltaic panels will be installed on the top slab of existent No.3 and No.4 water tanks.

1) Dimensions and features of existent water tanks

Characteristics of the existing tanks' shape and structure are summarized below.

- The existing tanks are watertight structures supported directly by the foundation and arranged in line-symmetrical to the middle of the passageway located between No.3 and No.4 tanks as an axis. The planar view as well as cross-sectional shape and dimensions are as shown in Figure 2-2-1-7.1.



[Source] JICA Study Team

Figure 2-2-1-7.1 Existent No.3 Water tank

- The top slab of the existing tank where the photovoltaic system will be mounted has pre-cast concrete panels laid and covered with 6 cm of waterproof concrete with a waterproof membrane applied to the surface.
- In order to protect the waterproof membrane against solar heat and ultraviolet light, as well as to prevent weeds from taking root, 10 cm of crushed stone has been laid. The load, including the above mentioned pre-cast concrete panels, is being supported by a reinforced concrete external wall, an internal flow guide wall, pillars and beams.
- Installed on the top slab of each tank is a manhole to inspect the tank interior, injection pipes to introduce chemical agents, and ventilation pipes.

2) Points of attention regarding design

The following 3 points are cited as particularly important matters to note concerning the design of the Project.

- The aggregate weight of the photovoltaic system and mounting structure, including the reinforced concrete foundation, is relatively lightweight at 90 kg/m² when calculated as distributed load. However, since the existing tanks are critical structures and of waterproof construct, there is a need to minimize the load exerted on them.
- It is important to take precautions to avoid exceeding the stress limits of the original design so that reinforcement of the existing structural members is not required, not only in terms of load, but also in (compressive, tensile, shear) stresses exerted on the structural members of the top slab (walls, pillars, beams, and pre-cast concrete panels).
- It is essential in this Project to take special precautions to ensure not to interfere with the tank's functionality or the Plant's operation and maintenance works.

3) Policy regarding installation on the upper portion of the top slab

In this Project, the installation of the photovoltaic system, mounting structure, and base will be carried out, along with consideration of the above mentioned structural features of the existing tanks.

In particular, in regards to the need to ‘minimize the load exerted on the tanks, the load increased by the structures of the Project is equivalent to half the weight of the "10 cm of crushed stone" laid on the top slab. Thus, 5 cm of the existing crushed stone shall be removed.

As for the stresses exerted on each structural member that constitutes the tank, by logically arranging the foundation that supports the photovoltaic system and mounting structure into a suitable configuration, they will be installed so as not to exceed the stress limits of the original design.

In addition, care shall be taken so as not to impede the existing equipment on the top slab, such as the various pipes, and to ensure clear passage along the inspection manhole walkway and surrounding workspaces.

(2) Policy regarding level of technology

Concerning the specifications of photovoltaic system instruments procured in the Project, in consideration of the technical level of the operation and maintenance department that will operate and maintain the equipment after installation, care shall be taken to avoid a complicated system composition and specifications.

2-2-1-8 Policy regarding Implementation/Procurement Methods and Implementation Schedule

Equipment procured in Japan and other third countries will primarily be transported to Nigeria by sea., Since the equipment will need to be carried overland for approximately 800 kilometers from the port of landing at Lagos to the Project site, it will be necessary to give ample consideration to safety and period of time when transporting the equipment.

Regarding preparation of the implementation schedule, the following items shall be sufficiently taken into consideration.

1) Since the work will take place on-site at the water treatment plant, the maintenance of the existing facilities, times, and time periods should be understood in advance. Care must be taken not to interfere with operations, maintenance, or the functionality of existing facilities.

2) Since the photovoltaic system, mounting structure, and foundation will be mounted on the top slab of existing tanks, they must adhere to upper load limits in the original design. In order to comply with these limitations, it is necessary to establish appropriate construction method selection and construction processes, including temporary construction work.

3) There is a need to be aware from historical data, the time and duration of dry and rainy seasons, as well as amounts of rainfall, and care shall be taken to avoid as much as possible concrete and earthwork during rainy season, which typically peak between May and October.

4) Approximately half of Nigeria's population is Muslim. There is concern over reduced efficiency of site work due to religious practices carried out during working hours and Ramadan, which lasts for one month (once a year). It is said that the number of Muslims in the capital area is less than in northern areas; however, it has been decided to set the construction schedule after taking into account the actual conditions.

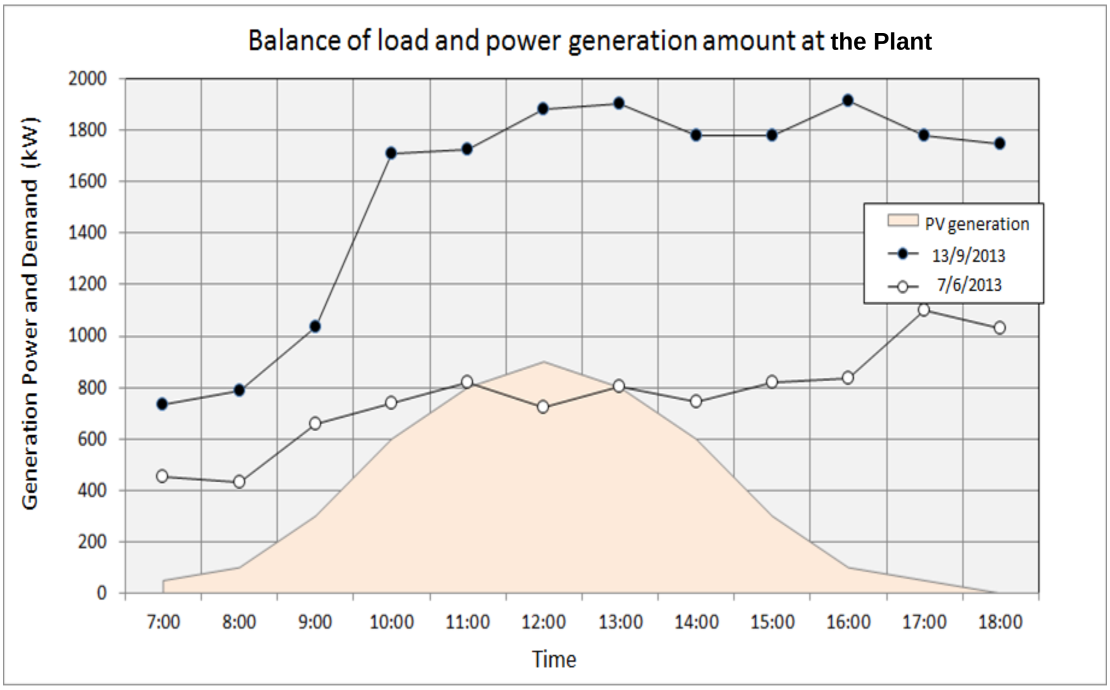
2-2-2 Basic Plan (Construction Plan / Equipment Plan)

2-2-2-1 Preconditions

(1) Power demand of the target facility

Power to the Plant is supplied via 33 kV distribution system of Abuja DISCO, 11 kV roadside distribution lines and private generating equipment.

The Team verified power demand at the Plant between November 1st, 2012 and September 17th, 2013 over the 11 kV trunk lines at the premises (total of 3 feeders). Based on this, the daily load curve during the day time period over two days is shown in Figure 2-2-2-1.1. It also shows the amount of solar power as an estimated amount of power generated if a 975 kWp photovoltaic system will be installed.



[Source] JICA Study Team

Figure 2-2-2-1.1 Example of commercial power load curve during day at Lower Usuma Dam Water Treatment Plant

It was identified from Fig. 2-2-2-1.1 that there are days that reverse power flow to the power distribution system occurs and days it does not occur during weekdays.

Thus, if 975 kWp photovoltaic system is installed in the Project, and if the load remains constant at the Plant, reverse power flow to the grid could be generated.

However, Federal Capital Territory Water Board has explained that reverse power flow to the grid is not expected when the photovoltaic system goes into operation from the following points of view:

- No.3 and No.4 water treatment facilities were built in response to a surge in demand for water service in the Federal Capital Territory, however, they are currently doing test-runs and the load is light. By the time this Project's photovoltaic system starts operation, No.3 and No.4 water treatment facilities (total throughput of 20,000 m^3/hr) will be running at full capacity in addition to No.1 and No.2 water treatment facilities (total throughput of 10,000 m^3/hr), which are currently running at full capacity.
- Currently at the Plant facilities, the load is controlled according to the demand for water service. However, when the photovoltaic system goes online, the plant's operations will be adjusted in such a way that after tanks are balanced, the plant's load peak time-slot will be matched to the time-slot in which the photovoltaic system reaches its peak power.

(2) System and technical examination regarding grid connection

1) Legal systems and regulations concerning

Nigeria currently has the following two legal systems concerning private power generation and grid connection.

(a) NERC (Nigeria Electricity Regulatory Commission) Regulation R-0108

Regulation R-0108 targets private generation systems with output of higher than 1,000 kW for authorization. As the Project system is less than 1,000 kW, it is not subject to this regulation, however, since NERC needs to confirm the technical specifications, installation site and safety measures of private generating systems, it advises operators to submit an application for authorization that includes the equipment specifications even when output is less than 1,000 kW. Additionally, when selling surplus power to distribution companies, it is necessary to obtain a license when output is more than 1,000 kW; however, when it is less than 1,000 kW, it is only necessary to notify NERC.

(b) Systems and regulations for private power generation and grid connection based on NERC distribution code

The Distribution Code for the Nigeria Electricity Distribution System

The NERC distribution code is applied when rotating generators with capacity of 50 kW or more are connected to the grid. When making applications, it is necessary to indicate the generating plan details (generating capacity, minimum stable load, reactive power, voltage, current, etc.).

The above systems and regulations exist with respect to private generation and grid connections; however, there are no systems and regulations concerning grid connection of renewable energy. Since the output of the photovoltaic system in the Project is less than 1,000 kW and entails no rotating generator equipment, it has been confirmed that the above regulations will not be applicable.

(3) Matters concerning introduction method of the grid-connected photovoltaic power generation systems

Hypothetical introduction methods of the grid-connected photovoltaic system when the Project is implemented are shown in Table 2-2-2-1.1. Rows (1) and (2) represent introduction in the form of power company equipment. Rows (3), (4), and (5) represent introduction as equipment outside of the power company, such as installation on the premises of another private sector company or installed as citizen-owned equipment.

As a result of discussions with the Nigerian side, in the current plan the Federal Capital Territory Water Board shall be the owner and will take responsibility for the operation and maintenance of the Project site as an electric facility of Lower Usuma Dam Water Treatment Plant. The operation and maintenance of the photovoltaic system shall be funded through savings of electricity charges brought about by the introduction of this Project's photovoltaic system.

The Project is to be implemented in the form of (4). In this introduction form, since the owner of the building and the owner of the photovoltaic system are one and the same, their responsibility for its operation and maintenance management is clear. Moreover, since the Project site is a water treatment plant which provides water to the Federal Capital Territory, meaning the entrance is restricted to staff members, it can be said that this form is ideal from the point of view of operations and maintenance.

It should be noted that the Lower Usuma Dam Water Treatment Plant has 33 kV power receiving equipment, an 11 kV on-premise power distribution network, and low voltage equipment, and that engineers with knowledge and skills in electrical facilities are working at the site. Thus, for operation and maintenance of the photovoltaic system, the policy for technology transfer is that it shall be carried out through soft components as part of the Project.

Table 2-2-2-1.1 Matters concerning introduction method of the grid-connected photovoltaic power generation systems

No.	Introduction method	Installation site	Photovoltaic system owner	Characteristics, challenges, requirements, etc.
(1)	Power company installs the photovoltaic system in its own facility as its own equipment.	Power company facility, etc.	Power company	・ Since the company itself installs the photovoltaic system and surrounding equipment, design work related to the photovoltaic system installation is straightforward. ・ There is flexibility regarding the location of the photovoltaic system installation.
(2)	Power company rents the roof of an independently owned building and installs its photovoltaic system.	Facility not owned by power company	Power company	・ Design work related to the PV installation is straightforward. Installation site restrictions and rent fees should be expected. ・ Requires discussions about facility operations management and security aspects. ・ Need to consider electricity charges taking into account the rent fee.
(3)	A facility owner installs a photovoltaic system as its own power source and sells surplus energy back to the power company	Third party's building, etc.	Facility owner, etc.	・ Since it would be continually used privately, there would be little reverse power flow of surplus energy, thus little impact on the power distribution lines. ・ Fair standards (a guideline, etc.) need to be established for technical requirements concerning installed equipment, such as safeguards, which are needed when connecting to the grid. Or alternatively, separate discussions with the power company would be necessary. ・ A surplus power buyback program would need to be prepared.
(4)	A facility owner installs a photovoltaic system as its own power source, and uses all of the energy on the premises. [Applied to the Project]	Facility not owned by power company	Facility owner, etc.	・ Reverse power flow to the grid would not be generated ・ Fair standards (a guideline, etc.) need to be established for technical requirements concerning installed equipment, such as safeguards, which are needed when connecting to the grid. Or alternatively, separate discussions with the power company would be necessary.
(5)	A party other than the power company, such as a facility owner, installs the photovoltaic system with the goal of supplying wholesale electric power to the power company.	Facility not owned by power company	Facility owner, etc.	・ If a large-scale photovoltaic system is to be interconnected to existing power distribution lines, voltage cut-out equipment needs to be considered in advance. ・ Wholesale power trading systems need to be prepared.

[Source] JICA Study Team

(4) Matters concerning laws and regulations necessary for the introduction of a grid-connected photovoltaic system

The "technical aspects" and "systemic aspects" concerning the introduction of a grid-connected photovoltaic system are shown in Table 2-2-2-1.2. Issues to be considered have been selected.

Table 2-2-2-1.2 Issues to be considered regarding legislation at the time the grid-connected photovoltaic system will be introduced

Issues to be considered	
Technical aspects	Power quality: Presence or absence of regulations (voltage, frequency, flicker, harmonics) impacting the existing grid power by the photovoltaic system to be introduced.
	Grid safeguards: Important matters and special considerations for ensuring safety, such as protective relays, which should be equipped for interconnection.
	Interconnection method: Classification of interconnection voltage classes (low voltage interconnection or high voltage interconnection) and requirements for interconnection equipment.
Systemic aspects	Regulatory approval for power generation equipment installation, installation companies, and regulations concerning reverse power flow.
	Method of power metering the grid-connected photovoltaic system and method of handling power production and fees.
	Operation and maintenance organization and structure for the photovoltaic system to be introduced.

[Source] JICA Study Team

Note that Japanese power conditioners, commonly available on the market, minimize harmonic distortion. Thus, with respect to the specifications of equipment utilized in this Project, equipment which conforms to Japanese guidelines on harmonic suppression shall be requisitioned.

Basically, the power generated by the photovoltaic system is not expected to be high enough to produce reverse power flows; however, in the off-chance it occurs, we have verified that there would be no problems in terms of systemic aspects, as it would flow into the power distribution lines via consumer-side equipment

With respect to the operation and maintenance system, since this will be a large-scale photovoltaic system in Nigeria, it was planned to build a framework which includes the power distribution company which had jurisdiction over the Lower Usuma Dam Water Treatment Plant, while transferring skills and knowledge concerning operation and maintenance through soft components.

(5) The need to augment the power distribution system

There are two items that should be taken into account when considering the need to augment a power distribution system after a grid-connected photovoltaic system is introduced: (1) the power distribution equipment located on the upstream side of the point of interconnection (transformers, power distribution lines) will not be overloaded, and (2) the voltage of the power distribution lines at the interconnection point does not deviate from the control reference range.

1) The need to augment the power distribution equipment of the upper system (transformers, power distribution lines)

(a) Distribution transformer capacity

At the Plant, power is distributed inside the premises after receiving 33 kV power from the power distribution company, then stepping it down to 11 kV near the power reception point. After drawing power in via 11 kV power distribution lines to each water treatment facility on the premises, it is stepped down to low voltage and the power is then supplied to each load system. The capacity of the 33/11 kV transformer at the power reception point is 5,000 kVA. Since there are plans to connect to 1,000 kWp grade capacity on the 11 kV-side of No.3 and No.4 water treatment facilities in the photovoltaic system of this Project, there is no need to augment the 33/11 kV transformer at the power reception point

If Japan's Program Grant Aid for Environment and Climate Change scheme is utilized, since work can continue until the remaining amount becomes less than 3%, it is estimated that the capacity of the photovoltaic system could be over 1,000 kWp depending on bidding results. Taking into account operational and equipment constraints of the Plant, an 11 kV interconnection will be used, as above. However, at No.3 and No.4 water treatment facilities, the step down capacity to low voltage is 1,000 kVA. Thus, if using a low voltage connection, it may be necessary to consider augmenting the arrangement, as appropriate.

In view of the above, if a low voltage connection is used and it becomes necessary to augment the distribution transformers to add capacity to the photovoltaic system, there may be a conflict with the original design concept. In this case, portions of the original construction design will need to be modified or replaced when the added portion is built. In addition, the electrical equipment in No.3 and No.4 water treatment facilities, just put into operation in 2013, may need to be replaced, making the plan inefficient. From this perspective, an 11 kV interconnection would be the reasonable choice.

(b) Distribution line capacity

The 33 kV power distribution lines leading from the upper transformer substation that supply electric power to the Plant consist of two branch lines: the Usuma Dam dedicated line, and the Buwari supply line, as shown in Table 2-2-2-1.3. However, the Buwari supply line has not been used since the Usuma Dam dedicated line opened, hence power is only being received via one line.

As shown in Table 2-2-2-1.3, the power cable used in the Usuma Dam dedicated line is 150 mm² ACSR cable, following the IEC standard adopted in Nigeria. In contrast, power cable standards in Japan follow the JEC standards. 150 mm² ACSR cable is not defined in this standard and thus not used. For that reason, the use of 120 mm², which is less forgiving than 150 mm² cable, will be considered.

120 mm² ACSR cable has an allowable current value of approximately 380 A. In contrast, the reverse power flow current value at maximum solar power output is about 20 A (estimating an approximate 1,000 kWp final equipment capacity). For that reason, there is no need to augment the existing distribution line.

Table 2-2-2-1.3 Specifications of upper power distribution lines

Transformer substation of target site area	Voltage Classes	Line type	Allowable current value
No. 4 Abuja power transmission (Dutse Alhaji) substation	33 kV	Lower Usuma Dam Water Treatment Plant dedicated line	150 mm² (ACSR)
		Buwari feeder branch line	150 mm² (ACSR)

[Source] Prepared by the JICA Study Team based on feedback from FMOP and cable data of Japanese manufacturer

2) Voltage of the power distribution lines at the interconnection point shall not deviate from the control reference range.

This section verifies that the voltage received by the nearest public consumer from the Plant will fall within the allowable voltage range along with the 33 kV distribution line. The value of voltage of the nearest low-voltage consumer from the Plant will be verified by the simplest but most severe condition; that is, the reverse power flow from the Plant to the nearest substation will occur without any existence of load along with the distribution line. To conduct the verification, the voltage of bus-bar of the substation will be set as the base value (33 kV).

33 kV distribution line supplies the electricity to the Plant form the upper substation and its length is 10 km and the conductor is 150 mm^2 of ACSR. Since this type of conductor is not used in Japan, this section discusses with the assumption of 120 mm^2 of ACSR which gives more severe condition. Line resistance of 120 mm^2 of ACSR is 0.233 Ω/km. Since the power factor generated by the solar photovoltaic system is one, it is not necessary to consider the reactance.

As discussed above, the voltage of the upper substation (33 kV distribution system) is regarded as being uniform since the bus-bar capacity is regarded as infinite in comparison with the maximum output of photovoltaic system, 1,000 kWp. The voltage rise is calculated as follows:

$$V_S = V_R + \sqrt{3}\,R\,I$$

$$\Delta V = V_S - V_R$$

$$= \sqrt{3}\,R\,I$$

$$= \sqrt{3} \times 2.33 \times 20$$

$$= 80.7\ (V)$$

$$V_S = 33000 + 80.7$$

$$= 33080.7\ (V)$$

Where, V_S: Reverse voltage at the Plant, V_R: Voltage received at the upper substation (33,000 V), R: Resistance of 10 km of ACSR (Ω), I: Reverse current (A), ΔV: Voltage rise (V)

Hence, the ratio of voltage rise at the Plant ε (%) is calculated as follow:

$$\varepsilon = (V_S - V_R) / V_S \times 100$$

$= 80.7/33080.7 \times 100$

$= 0.244\ (\%)$

As a result, the influence of voltage fluctuation caused by the reverse flow is slightly observed at the voltage of the Plant side. Low voltage at the nearest consumer from the Plant is calculated in the same way.

$V_R' = (1 + \varepsilon/100)\ V_R$

$= (1 + 0.244/100) \times 240$

$= 240.6$ (V) [Allowable range: 252-228 (V)]

Where, V_R': Low voltage after the voltage rise at 33 kV side, V_R: Low voltage value without the reverse power flow from the photovoltaic system, ε : Ratio of voltage rise

The result of the above calculation is shown in Table 2-2-2-1.4. The rise of the low voltage at the nearest public consumer is 240.6 V. According to the JEAG9701-2001 of Japan, values of the receiving voltage of the nearest general consumer should be within 240 V±12 V (±5%).

In conclusion, the voltage rise at the general consumer will be 240.6 V at maximum and it is far below the allowable value, 252 V. Thus, there is no need of augmenting the distribution line.

Table 2-2-2-1.4 Study results of interconnection point and power distribution line voltage values for nearby typical low-voltage consumers

Length	Distribution voltage	Size	Resistance	Reverse current from the PV	Reverse voltage at the Plant	Voltage rise	Voltage at the nearest consumer to the Plant
10 km	33 kV	120 mm^2	0.233 Ω/km	20.0A	33080.7 V	80.7 V	240.6 V

[Source] JICA Study Team

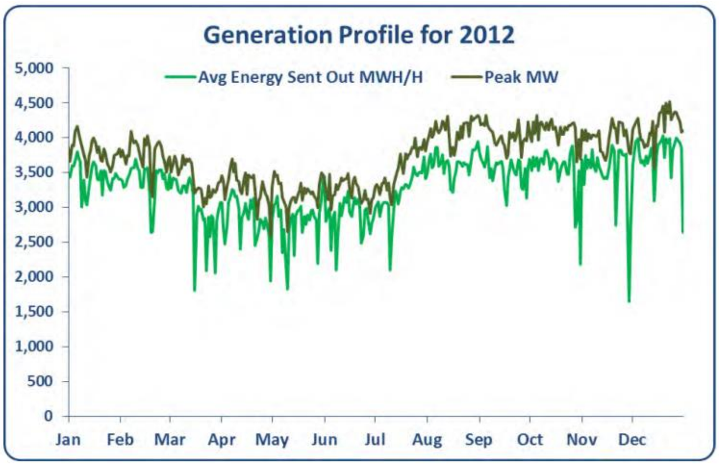
(6) Capacity of the grid-connected photovoltaic system

Given the scale of the system in Nigeria, the impact of the equipment in this Project is very low in terms of frequency stability. However, the 1,000 kWp installed-capacity grid-connected photovoltaic system scheduled in this Project shall be re-verified to determine the feasibility of installing it onto the existing system.

It shall be evaluated assuming the most difficult condition, being the power generation equipment connected to a system operating normally under light load while performing governor-free control. Nigeria has no clear frequency reference values. Thus Japan's strict frequency deviation target value of 50 ± 0.15 Hz (± 0.3%) for power quality shall be used to study the installable capacity of the grid-connected photovoltaic system.

As an overview of the scale of the system in Nigeria, Fig. 2-2-2-1.2 shows peak power (in MW) from January to December 2012, as well as average power transmission amounts per hour (MWh/h). Maximum peak power during the period shown was 4,517.6 MW (recorded on

December 23, 2012), and the lowest value of average power transmission per hour was 1,500 MWh per hour.



[Source] Presidential Task Force on Power (Jan.2013) Year in Review 2012

Figure 2-2-2-1.2 Peak power in 2012 and average power transmission amounts

As shown above, in light-load times during the time zone in which the peak is estimated to occur during the day, demand is estimated at 1,500 MW. Assuming that the speed variation rate of power supply equipment connected to a system is typically 3 to 4 percent for thermal or hydroelectric power equipment, an instantaneous load variation permissible system would follow the following equation.

1,500 MW × (permissible frequency fluctuation rate 0.3% / speed variation rate 4%) = 112.5 MW

In other words, it has been determined that no frequency stability problems will occur, even if the tripping of 100 MW-class thermal or hydroelectric power equipment and output fluctuation due to changes in sunlight on the photovoltaic system occur simultaneously in this Project.

(7) Prerequisites regarding choosing specifications of major hardware

This Project under the Program Grant Aid for Environment and Climate Change strikes a balance between the aim to contribute to the prevention of global warming and the aim to promote the products of Japanese companies. Thus, it is important that multiple Japanese companies bid on, and participate in the project. Prerequisites regarding choosing specifications of major equipment shall be determined taking into account the suitability of each piece of equipment, natural environment and power situation of Nigeria, and installation space.

1) Solar photovoltaic modules for Lower Usuma Dam Water Treatment Plant

The Plant is situated at north latitude 9 degrees and the climate is divided into rainy season and dry season. Violent squalls occur during the rainy season, while the dry season is dominated by sand storms from the Sahara Desert. Maximum mean temperature is 31.0 °C and the natural environment is extremely harsh. Preconditions for selecting the module specifications in the Project are the existence of past performance, reliability and durability. The module shall be also be selected with due consideration to the local footprint and natural environment. The specifications indicated in Table 2-2-2-1.5 have been selected for the Project.

Table 2-2-2-1.5 Module Specifications

Specifications	Conditions
Country of manufacture	Japan (all parts including cells shall be made in Japan)
Module type	Mono-crystalline, multi-crystalline Silicon Type or, Tandem type of Crystalline Silicon and Amorphous Silicon
Reference technical standards	JIS, IEC or equivalent
Module output	No less than 250 W Measurement conditions (AM: 1.5, temperature 25 °C, solar irradiation 1000 W/m^2)
Total output	975kWp or more (Considering the budget limitation)
Module conversion efficiency	No less than 14.5%
Module weight	Weight per module: 15 kg-20 kg
Size	According to maker specifications

[Source] JICA Study Team

2) Junction box and collecting box

Nigeria is subject to very harsh natural conditions. The seasons are divided into the rainy season and dry season. In the rainy season, violent squalls occur, while in the dry season, sand storms blow off the Sahara Desert. In particular, fine sand from the Sahara infiltrates gaps in buildings, junction boxes and collection boxes, etc. Since the junction boxes and collection boxes will be installed outdoors, it will be necessary to protect them from this wind, rain and sand. The protection class shall be set at IP45 or higher in order to protect the junction boxes and collection boxes from the harsh environment, high temperatures, high humidity, sand and squalls, etc. Japanese products are equally matched in terms of reliability and quality and can be used in the natural environment of Nigeria. For detailed equipment specifications, see Section 2-2-2-3 Equipment Plan.

3) Power conditioner

Since the power conditioner is the heart of the grid-connected photovoltaic system, any troubles or operating errors can impact the entire system operation. Furthermore, a review of the plant's operation records has shown that power quality is not as stable as in Japan. Thus, due consideration will be given when establishing the set point range and time range of protection systems for the interconnection while assuming the use of a power conditioner of general specifications available in the market. Natural conditions in Nigeria are harsh and the power supply situation is subject to frequent power interruptions. The power conditioner will be installed indoors away from the wind and rain, however, it is still possible that the fine Sahara sand will infiltrate the building and have a negative impact on instruments. The protection class shall be set at IP20 or higher in order to protect instruments from the natural environment. For detailed equipment specifications, see Section 2-2-2-3 Equipment Plan. The location of the power conditioner building is shown in outline design drawing G-01

4) Transformer

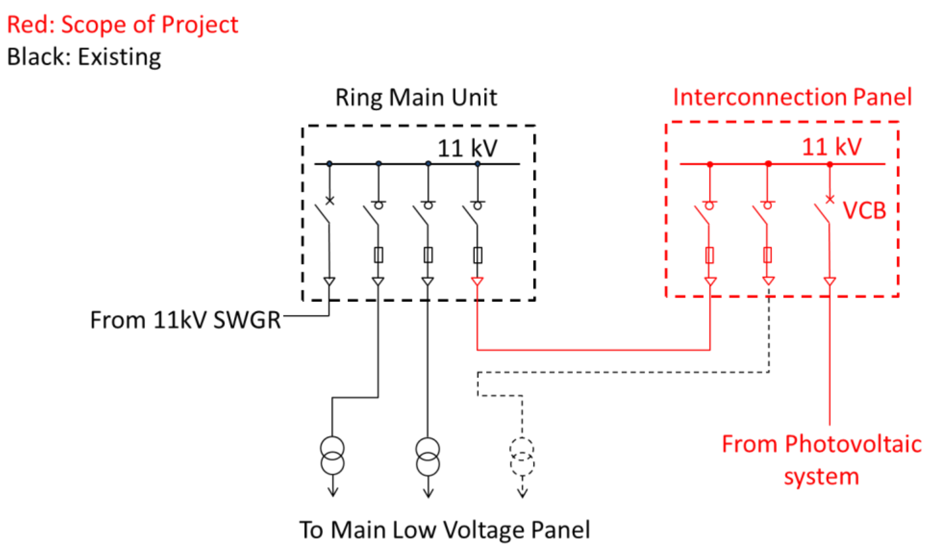
The transformer is used to step-up the AC power converted in the power conditioner according to the voltage of the distribution grid. The transformer will be installed in a building close to the power conditioner room. Terminals on the 11 kV side will be divided over five voltage stages in 5% taps (11 kV±10%) in order to conform to voltage fluctuations on the grid side. For detailed equipment specifications, see Section 2-2-2-3 (1) Equipment Plan.

5) Interconnection equipment

Interconnection equipment is the panel for connecting power that has been stepped up by the transformer by 11 kV from the power conditioner to the existing equipment.

The Federal Capital Territory Water Board explained that the requirement for connecting the existing electrical system on the premises to the photovoltaic system of this Project is the connection on the 11 kV side, not between the low voltage side and electrical equipment of No.3 and No.4 water treatment facilities. Since the low voltage bus of the electrical equipment for No.3 and No.4 water treatment facilities is complicated and contains interlock logic, there is concern about incorrect operation by the Plant operators if the photovoltaic system is connected to the low voltage bus. Further, due to constraints at the target site, the distance between the photovoltaic system and interconnection point is over 200 m. Thus, assuming a general sized cable available at market is used, there will be an extremely substantial loss from voltage drop, etc.

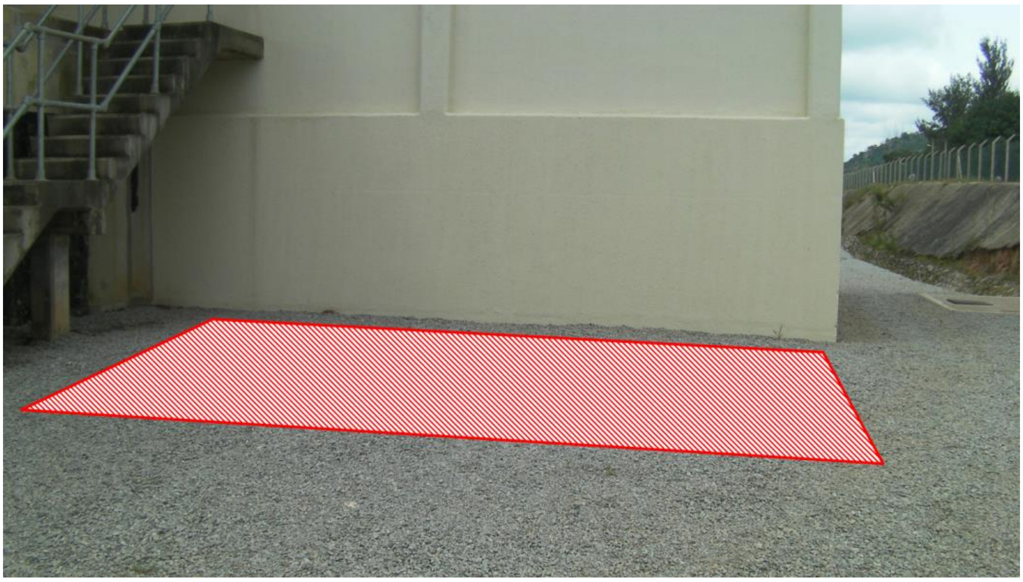
Also, in discussions with the Federal Capital Territory Water Board taking into consideration the below points, it has been explained that in connecting the photovoltaic system to the existing 11 kV system, there is a requirement to adopt the interconnection method shown in Fig. 2-2-2-1.3



[Source] JICA Study Team

Figure 2-2-2-1.3 Interconnection method between the photovoltaic system and 11 kV system

- For the 11 kV switching equipment of No.3 and No.4 water treatment facilities, in addition to the two feeders for the existing transformer banks (of 1,000 kVA each), one feeder for transformer bank expansion has been secured in preparation for expansion of the facilities based on the anticipated future growth of water service demand. If a photovoltaic system acting as an auxiliary power source with no load tracking capabilities is connected here, this configuration will restrict the original design's concept of future use of this feeder for the additional transformer bank that acts as a stable power supply. The Federal Capital Territory Water Board has explained that adopting the interconnection method shown in Fig. 2-2-2-1.3, to secure feeders for future expansion of the existing transformer bank, is a requirement in connecting the photovoltaic system to the existing 11 kV system.
- Nigeria has a harsh natural environment, and frequent and repeated power outages occur. The panel is installed outdoors and the equipment will be adversely impacted by fine sand from the Sahara. The protection class shall be set at IP45 or higher in order to protect the equipment from the surrounding natural environment. Detailed equipment specifications are listed in Section 2-2-2-3 Part (1), "Overview of the Basic Plan." The location is shown in outline design drawing G-01; the space is shown in Fig. 2-2-2-1.4.



[Source] JICA Study Team

Figure 2-2-2-1.4 Interconnection equipment installation space

6) Data logger and display system

The data logger and display system will be installed in the existing central monitoring room to display the operating status of the photovoltaic system. When reverse power flow looks likely to occur, the Plant load shall be increased. In order to contribute to raising awareness of Nigerian People on the Japanese products, monitoring LCDs shall be Japanese products. Detailed equipment specifications are listed in Section 2-2-2-3 Part (1), "Outline of the Project." The display device locations are shown in outline design drawing G-01.

2-2-2-2 Overall Plan

The scale and specifications of facilities and equipment in the Project shall be planned according to the following conditions.

(1) Site and climate conditions

Table 2-2-2-2.1 Site and Climate Conditions

Item	Condition
a. Altitude	560.0 m
b. Ambient temperature (maximum)	35.5 ˚C
c. Ambient temperature (minimum)	19.0 ˚C
d. Relative humidity	88.1%
e. Maximum wind velocity	40.0 m/s
f. Particulate	Take into consideration

[Source] Federal Capital Territory Water Board

(2) Electric system conditions

Distribution voltage : (incoming voltage) 3 phase 3 wire, 33 kV
: (in-plant voltage) 3 phase 3 wire, 11 kV
: (low voltage) 3 phase 4 wire, 415/240 V

Frequency : 50 Hz

Maximum short circuit capacity : 11 kV system, 12.5 kA (1 sec)

Grounding system : 11 kV system, direct grounding

Grounding resistance : 10 Ω or less, 3 phase 3 line, 33 kV

Coloring : IEC standards (red, white, blue, black)

(3) Facilities planning conditions

The Project site is on the premises of the Lower Usuma Dam Water Treatment Plant, in a formerly hilly area which was reclaimed by excavating soil. The site is surrounded by a net fence with security spikes, has a gated entrance, has a security guard booth, and since it has also been outfitted with drainage facilities, it has been determined that there is no need to construct any new outside structures or drainage facilities for the Project.

However, since most of the photovoltaic system will be mounted on the upper portion of the top slab of No.3 and No.4 tanks (approximately 1.8 m above ground), load constraints must be inevitably observed regardless of whether the construction is temporary or permanent. In carrying out work on the tanks, which are large-scale and important structures, it is essential to develop a suitable construction plan not only to avoid adverse effects on the tanks, but so work under the supervision of the Japanese engineers can progress without impeding maintenance, and to ensure the completion of the work without industrial or personal accidents.

In addition, as there are numerous pipes and cables buried in the water treatment plant, appropriate protective measures shall be taken to avoid damaging them through earthwork or vehicle loads. At the same time, in light of the construction taking place in the unique environment of a water treatment plant, a plan that gives ample consideration to environmental and sanitary aspects and to maintaining an organized site at all times shall be developed.

Since there is no existing structure within the Plant to house the step-up transformer, power conditioner and other electrical equipment, a power conditioner building shall be erected on the site (single-story, approximately 5.0 m×15.5 m).

For the power conditioner building, from the fact that the average annual temperature is as high as 31 °C, a structure that shields the interior from the hot outside air is to be built. Thus, a structure with a suspended ceiling shall be constructed to reduce as much as possible the effects of heat from the roof. At the same time, it shall be planned in a way that the area's characteristic Harmattan dry and dusty sand clouds do not infiltrate the structure.

For power supply, outdoor interconnection transformers shall be installed next to the new power conditioner building and power will be stepped-up to the 11 kV. 11 kV cable shall be cable-routed to the 11 kV Ring Main Unit installed in the existing electric room via the newly installed interconnection equipment, then power will be provided by connecting to the bus of the existing circuit breaker panel.

2-2-2-3 Equipment Plan

(1) Outline specifications of equipment

The photovoltaic equipment to be procured and installed by the Japanese side under the Project shall be based on JIS and IEC standards and specifications. Also, when selecting the facilities and equipment for the photovoltaic grid-connected system, the minimum number of specification items shall be sought and standard design models shall be adopted in order to facilitate installation and shorten the installation period. Table 2-2-2-3.1 shows the outline of the basic plan, procurement quantity and the outline specifications of the main equipment. Since the system varies by makers, the numbers of junction boxes, collecting boxes and power conditioners are not yet decided.

Table 2-2-2-3.1 Outline of the Project

	Components	Quantity or Capacity
Procurement and Installation	1. Photovoltaic system	
	1.1 Solar photovoltaic arrays	975 kWp
	1.2 Junction box	1 lot
	1.3 Collecting box	1 lot
	1.4 Power conditioners	Total capacity of the connected photovoltaic modules or more
	1.5 AC Distribution Panel	1 unit
	1.6 Interconnection Transformer	Total capacity of the connected photovoltaic modules or more
	1.7 Interconnection equipment	1 unit
	2. Data management system	
	2.1 Data logger including UPS system	1 set
	2.2 Display system	1 set
	2.3 Weather monitoring instruments (Pyranometer, Temperature meter)	1 set
	3. Cables and fitting materials	1 lot
Procurement	1. Spare parts	1 lot
	2. Maintenance tools (including high pressure washers)	1 lot
Construction	1. Mounting Structures for the photovoltaic arrays	for the photovoltaic arrays of 975 kWp
	2. Foundations for the photovoltaic arrays	for the photovoltaic arrays of 975 kWp
	3. Power Conditioner Building	Gross floor area: Approx. 77.5 m^2

[Source] JICA Study Team

Table 2-2-2-3.2 Solar Photovoltaic Module Specifications

Equipment	Specifications	Required Specifications
1. Solar photovoltaic modules	Applicable standard	IEC and equivalent standards, protection class IP65 or higher
	Environment of use	Tropical, sandy area, no more than 1,000 m
	Ambient temperature	+31.0 °C
	Installation method	Above ground installation
	Type	Mono-crystalline, Multi-crystalline Silicon Type or, Tandem-type of crystalline silicon and Amorphous silicon
	Module efficiency	14.5% or higher
	Module capacity	250 W/1 or more

[Source] JICA Study Team

Table 2-2-2-3.3 Solar Photovoltaic Module Mounting Structure Specifications

Equipment	Specifications	Required Specifications
2. Solar module mounting structure	Support method	Steel frame
	Environment of use	Tropical, sandy area
	Material	SS400 hot dip zinc finish or equivalent quality

[Source] JICA Study Team

Table 2-2-2-3.4 Junction Box Specifications

Equipment	Specifications	Required Specifications
3. Junction box	Structure	Outdoor, wall hanging type, protection class IP45 or higher
	Environment of use	Tropical, sandy area
	Ambient temperature and humidity	+40 °C or less, 85% or less
	Maximum input voltage	Maximum power voltage (V_{pm}) of a string or more
	Input circuits	Number of sub-array unit parallel lines or more
	Input current	Module nominal shorting current (I_{SC}) per circuit or higher
	Output circuits	1 circuit
	Output current	Module nominal shorting current (I_{SC}) or higher
	Internal devices	- Wiring circuit breaker: Number of circuits - Reverse flow prevention diode: Each string - Induced lightning protector: All output circuits

[Source] JICA Study Team

Table 2-2-2-3.5 Collecting Box Specifications

Equipment	Specifications	Required Specifications
4. Collecting box	Structure	Outdoor, wall hanging type, protection class IP45 or higher
	Environment of use	Tropical, sandy area, no more than 1,000 m
	Ambient temperature and humidity	+40 °C or less, 85% or less
	Maximum input voltage	Maximum power voltage (V_{pm}) of a string or more
	Input circuits	Condensed number of junction boxes or more
	Input current	Junction box output current or more
	Output circuits	1 circuit
	Output current	Sub-array nominal short circuit current x Number of input circuits or more
	Internal devices	- Wiring circuit breaker: Number of circuits - Induced lightning protector: All input and output circuits, between wires, between earth

[Source] JICA Study Team

Table 2-2-2-3.6 Power Conditioner Specifications

Equipment	Specifications	Required Specifications
5. Power conditioner	Structure	Indoor, aboveground vertical standing type, protection class IP20 or higher
	Environment of use	Tropical, sandy area, no more than 1,000 m
	Ambient temperature and humidity	+40°C or less, 85% or less
	Main circuit system	Self-exciting voltage
	Switching system	High frequency PWM
	Insulation system	To be specified. Isolation transformer shall be installed, if necessary.
	Cooling system	Forced air cooling
	Nominal input voltage	To be specified
	Input operation voltage range	The string maximum output voltage (V_{pm}) and nominal open voltage (Voc) shall be within range.
	Input circuits	The number of collecting boxes or more
	Output electricity system	3φ3W or 3φ4W
	Rated output voltage	AC415 V or adjust to voltage on the transformer low voltage side
	Rated frequency	50 Hz
	AC output current distortion factor	General current 5% or less, each sub-wave 3% or less
	Power control system	Maximum output follow-up control
	Rated power conversion efficiency	93% or more
	Control functions	- Automatic start/stop - Automatic voltage adjustment - Input/output over-current adjustment - Output adjustment
	Grid-connected protective functions	- Over voltage (OVR), Under voltage (UVR), Over frequency (OFR), Under frequency (UFR) All permanent values, with timed variation
	Islanding operation detection function	- Active type - Passive type

[Source] JICA Study Team

Table 2-2-2-3.7 Interconnection Transformer Specifications

Equipment	Specifications	Required Specifications
6. Grid-connection transformer	Applicable standard, Structure	JIS, IEC Standards, Outdoors, vertical standing type
	Environment of use	Tropical, sandy area
	Ambient temperature and humidity	+40 °C or less, 85% or less
	Capacity	1,250 kVA
	Primary voltage	Adjust to the output voltage of the power conditioner
	Secondary voltage	3φ3W AC11 kV
	Frequency	50 Hz
	Insulation class	Type A
	Connection method	Dyn11

[Source] JICA Study Team

Table 2-2-2-3.8 Interconnection equipment Specifications

Equipment	Specifications	Required Specifications
7. Interconnection equipment	Applicable standard, Structure	IEC or equivalent standards, Outdoor, aboveground vertical standing type, protection class IP45 or higher
	Environment of use	Tropical, sandy area
	Ambient temperature and humidity	+40 °C or less, 80% or less
	Rated voltage	AC12 kV or more
	Number of phases	3φ3W
	Rated current	630 A or more
	Bus wire shorting current	25 kA or more (1 sec)
	Input circuits	1 circuit
	Connection method	Underground
	Self-contained instruments	- Lightning arrestor - Load break switch with fuse - Vacuum circuit breaker (fixed) - Meter current transformers - Meter transformers - Operation transformer - Other auxiliary instruments
	Control power supply	AC110 V
	Operating conditions	- Direct manual operation by electrical interlock
	Measurement and protective devices	- Over-current relay (3 phase protection) - Ground-fault over-current relay - Under-voltage relay

[Source] JICA Study Team

Table 2-2-2-3.9 Instrumentation Specifications

Equipment	Specifications	Required Specifications
8. Instrumentation	Pyrometer Applicable standard Sensitivity	 ISO9060 Second class or equivalent 7-14 mV/(kW・m^2))
	Thermometer Type Shape Temperature range of use	 Measurement resistor Pt100 With basic shelter -40 °C - ＋100°C
	Signal Converter Structure Material Input signals Output signals Power source Housed equipment	 Outdoor, IP45 or more SS400 hot dip zinc finish or equivalent quality Pyrometer (0-10 mV), thermometer (Pt100 Ω) 4-20 mA×2 AC240 V Pyrometer signal converter, thermometer signal converter, wiring circuit breaker, induced lightning protector
	Data Management System Data measuring method - Measurement cycle - Data collection items Used devices Software specifications	 6 seconds Inclined plane solar intensity, temperature, generated electric energy PLC Data-processing device, data logger, PC for the operation of Data Management System, and UPS Instantaneous value display, graph and form display; Power conditioner operating status, trouble information display; Power conditioner protective device setting information storage

[Source] JICA Study Team

(2) Facility Configuration Plan

Solar photovoltaic modules (975 kW) will be installed within the Lower Usuma Dam Water Treatment Plant approximately 200 m from the front gate to the right on No. 3 tank and No. 4 tank, as well as in the space between them covering a total of approximately 8,800 m^2. Given that the solar photovoltaic module installation location is on top of an existing structure, it is necessary to create a plan that takes precautions against damaging the existing structure. The layout of panels and major equipment are shown in the outline design drawings G-01 and G-02 in Section 2-2-3. The DC power generated by each module is collected via junction box and collecting box and then connected to the power conditioner, which is a DC-AC converter. The power conditioner shall be housed in a newly constructed building at the solar photovoltaic module installation site. Low voltage wiring on the output side will be stepped-up by the transformer located next to the building, and then the power will be transmitted to interconnection equipment to connect to the existing 11 kV Ring Main Unit.

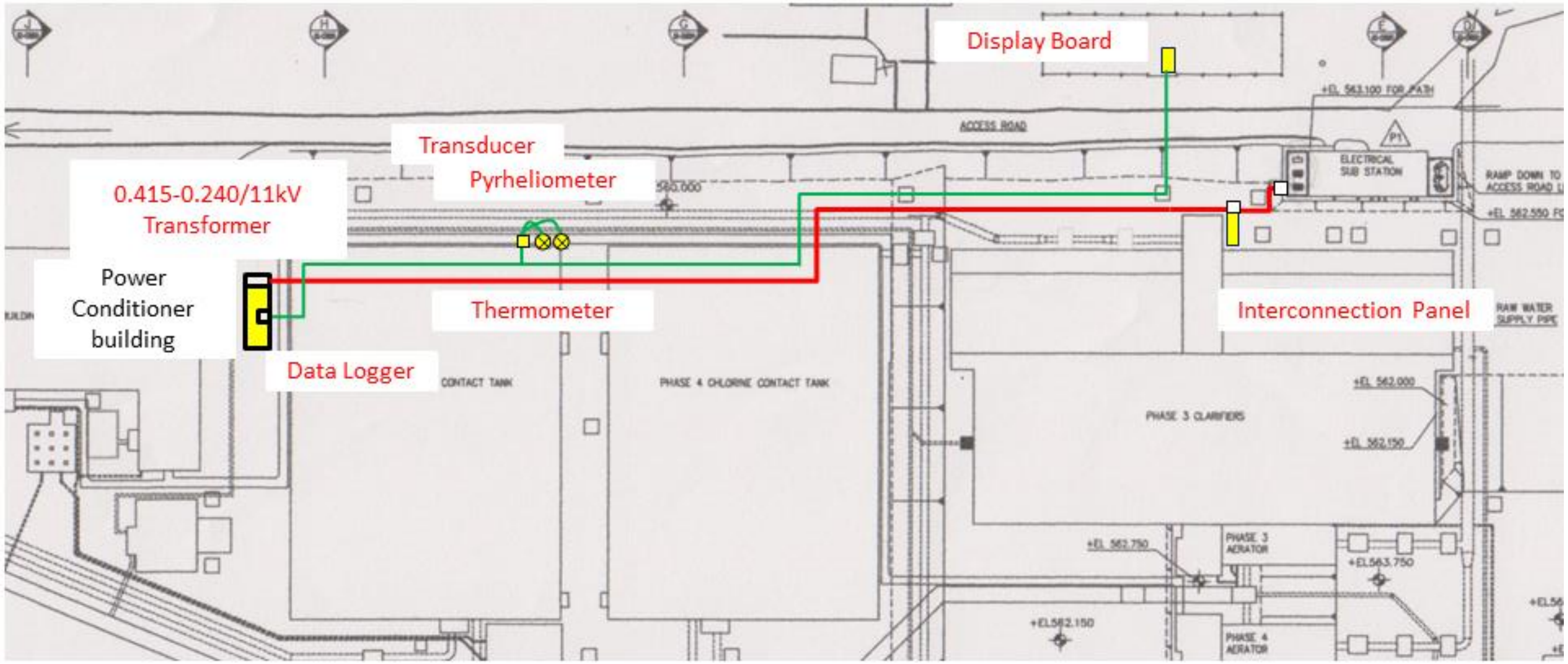
Since data from pyrometer, thermometers, and other power production data will be sent to the display devices and the data logger installed in the existing central monitoring room, existing empty pipes shall be used for the communication cables so that components may be connected without disrupting the existing building.

2-2-3 Outline Design Drawing

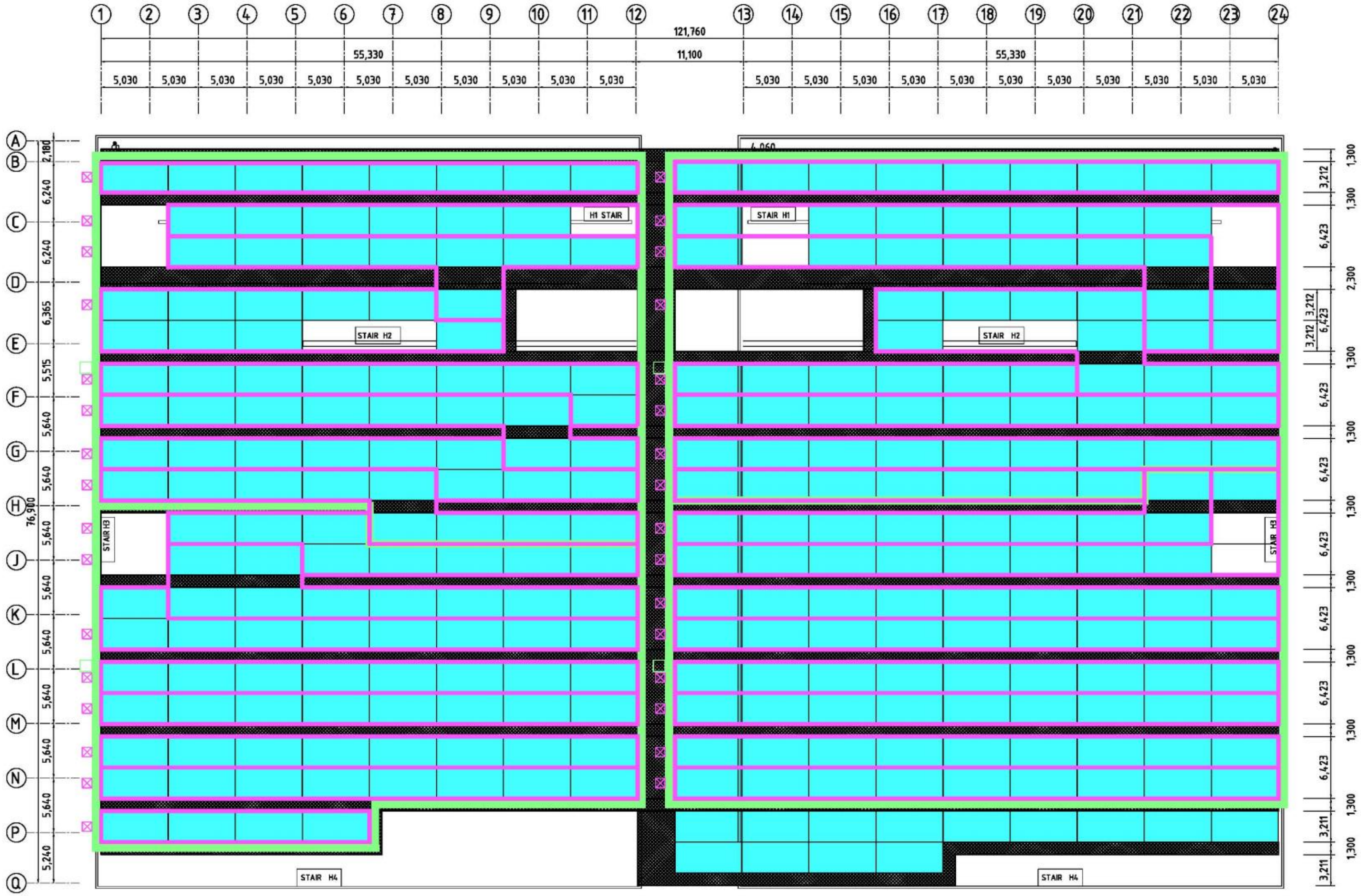
Outline design drawings of the Project are shown after the next page. See the list in Fig. 2-2-3.1

Table 2-2-3.1 Outline design drawing list

Drawing number	Drawing name
G-01	GENERAL LAYOUT OF THE PROJECT SITE
G-02	LAYOIUT OF THE PHOTOVOLTAIC ARRAYS
E-01	SINGLE LINE DIAGRAM OF THE PHOTOVOLTAIC SYSTEM OF 975 kWp
A-01	MOUNTING STRUCTURE FOUNDATION (1) TYPICAL SECTION ON TANK
A-02	MOUNTING STRUCTURE FOUNDATION (2) TYPICAL SECTION AT CENTRAL PASSAGE
A-03	POWER CONDITIONER BUILDING (1) LOCATION , SECTION
A-04	POWER CONDITIONER BUILDING (2) PLAN , ELEVATION , SECTION
A-05	POWER CONDITIONER BUILDING (3)FINISHING SCHEDULE, FITTING LIST
A-06	POWER CONDITIONER BUILDING (4) FACILITIES PLAN

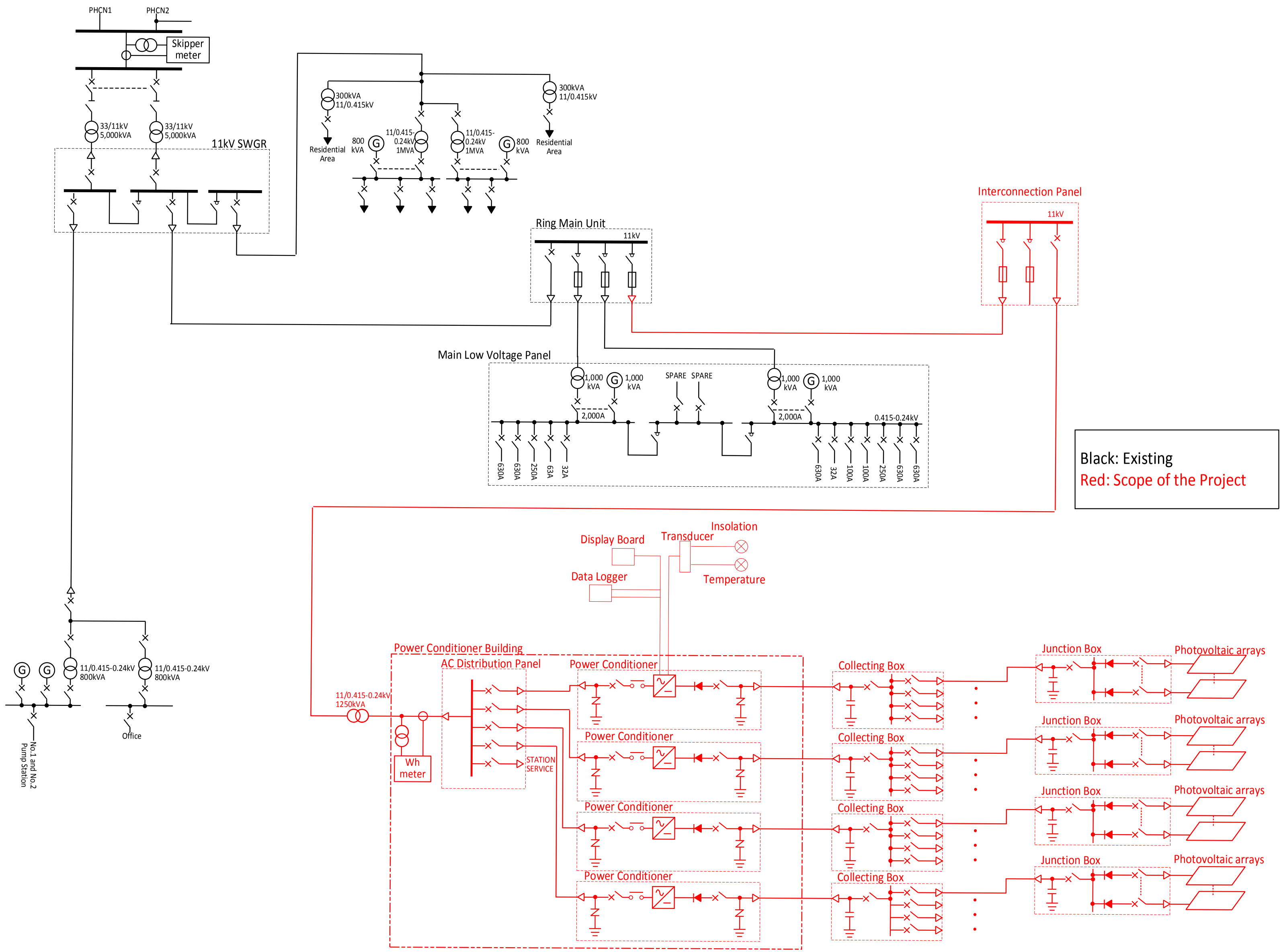


G-01 GENERAL LAYOUT OF THE PROJECT SITE



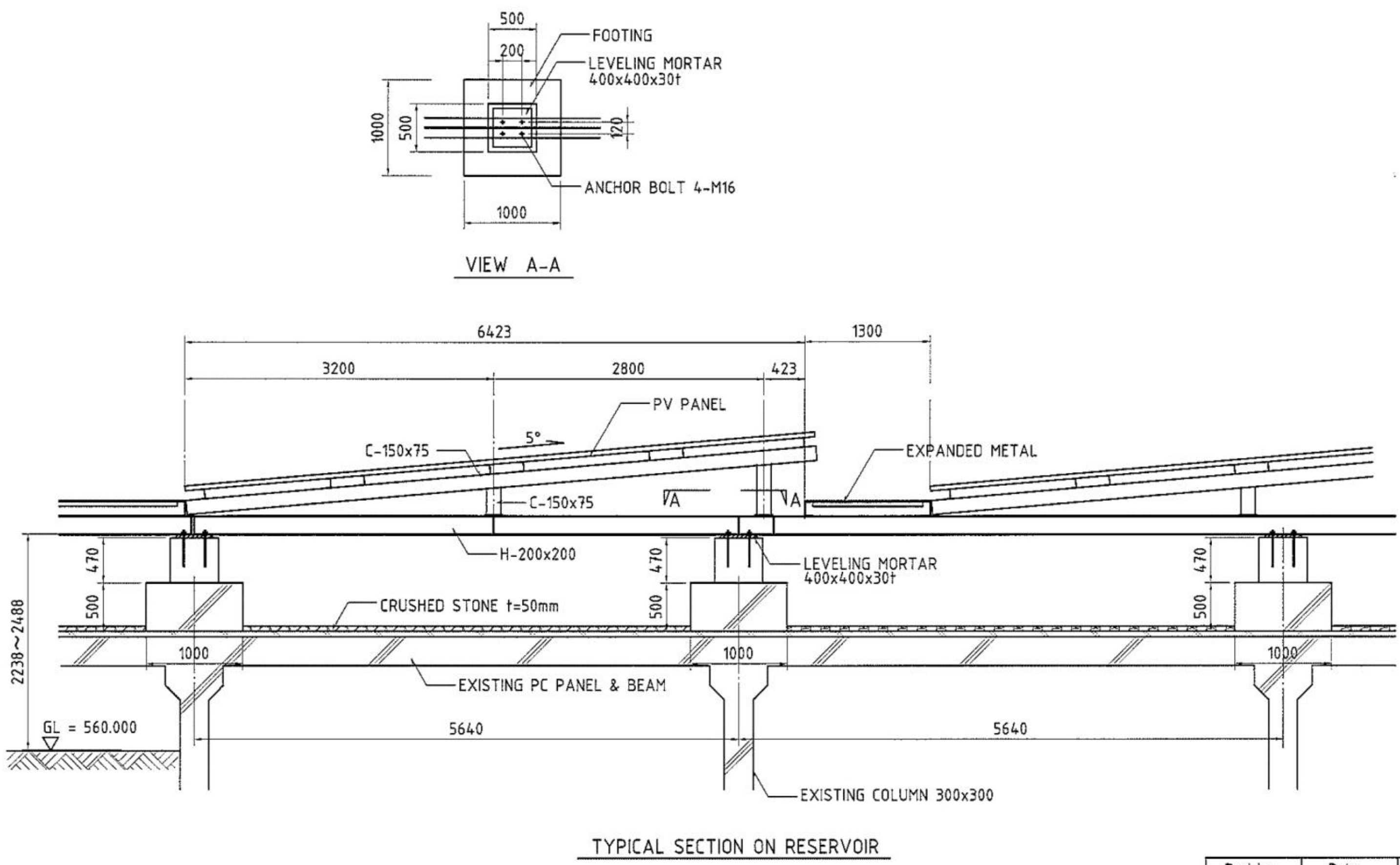
G—02 LAYOUT OF THE PHOTOVOLTAIC ARRAYS

(The actual arrangement of PV arrays is subject to change depending on manufacturers)



E—01 SINGLE LINE DIAGRAM OF THE PHOTOVOLTAIC SYSTEM OF 975 kWp

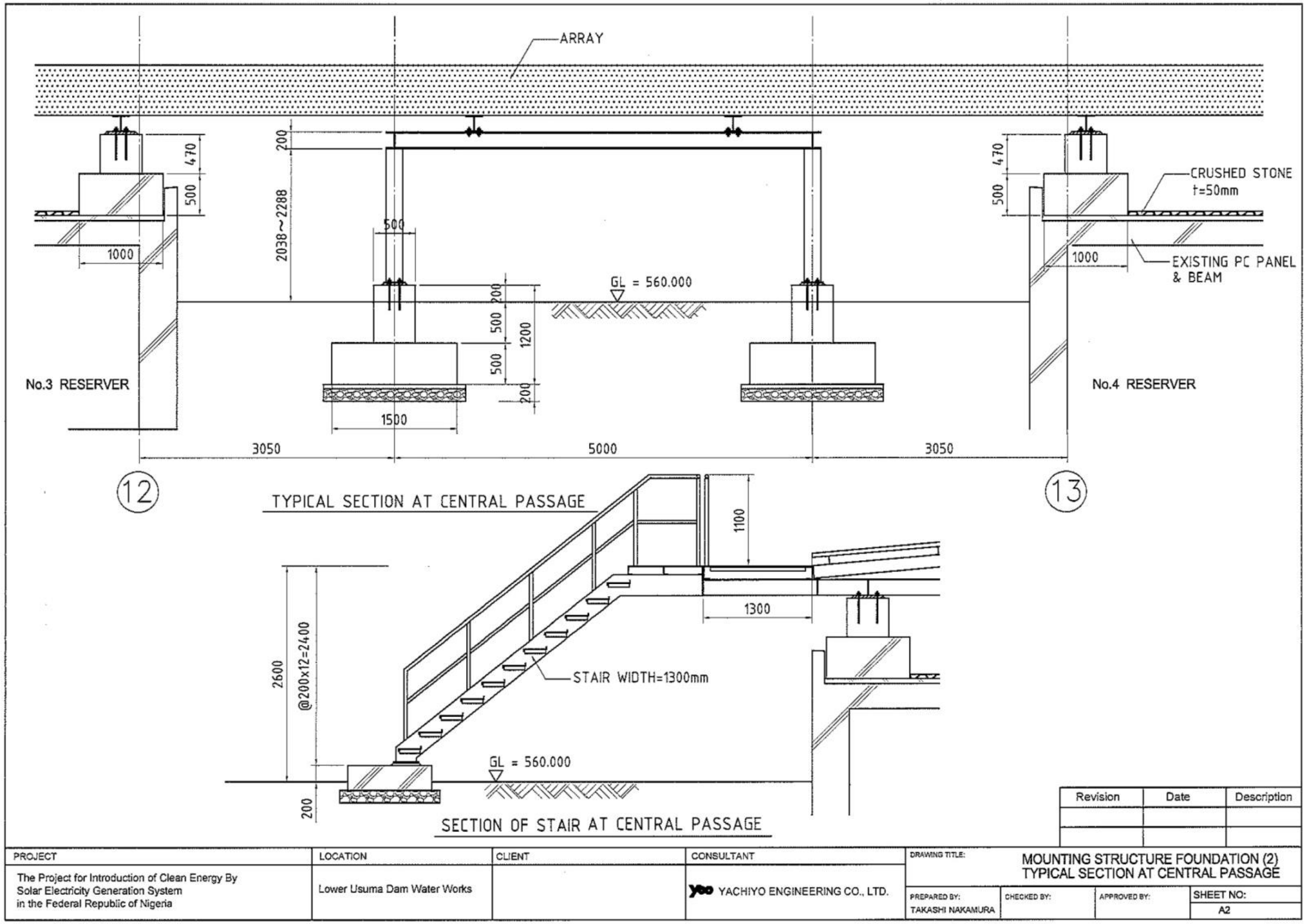
(The actual number of Power conditioner is subject to change depending on manufacturers)



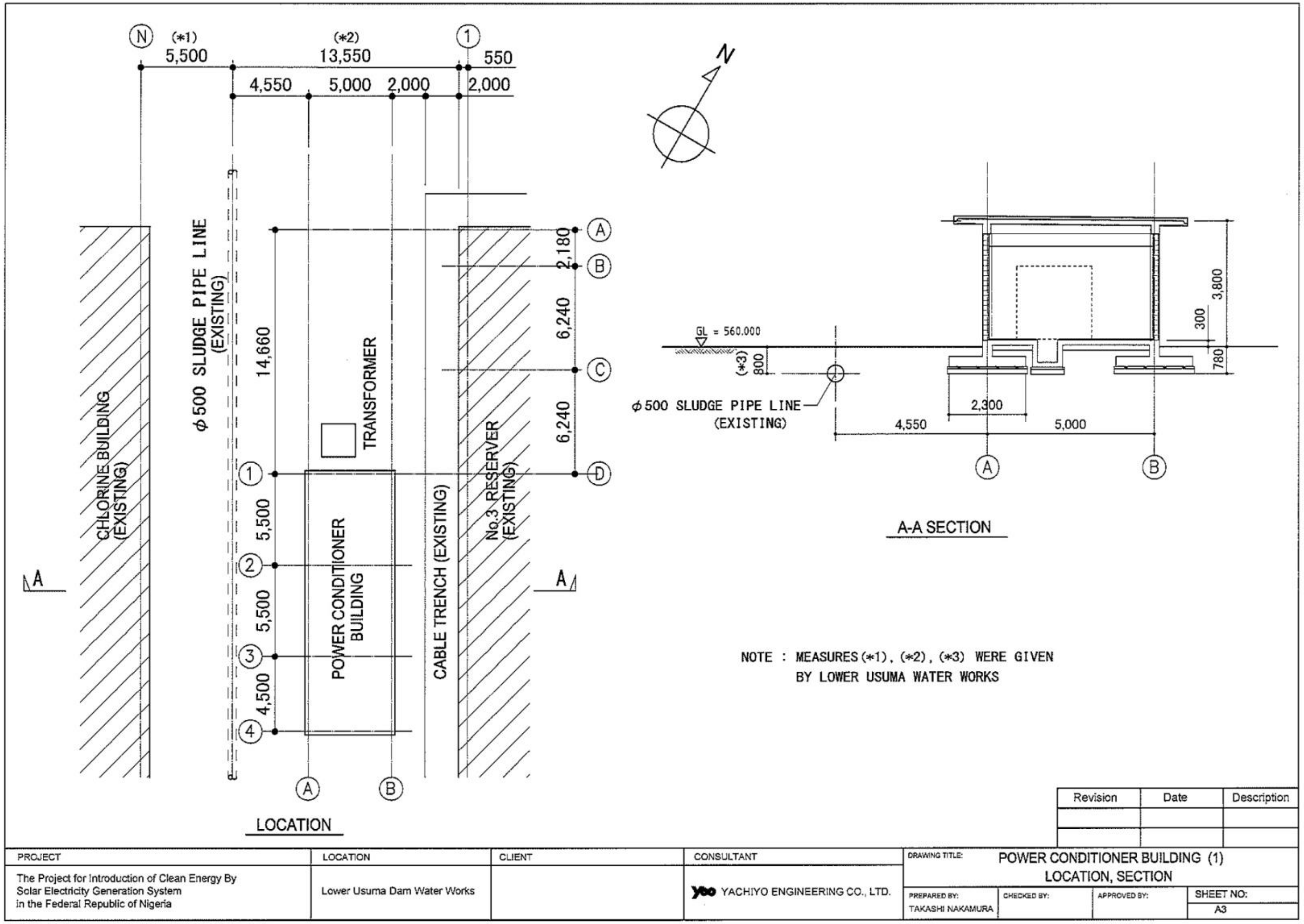
Revision	Date	Description

PROJECT	LOCATION	CLIENT	CONSULTANT	DRAWING TITLE:			
The Project for Introduction of Clean Energy By Solar Electricity Generation System in the Federal Republic of Nigeria	Lower Usuma Dam Water Works	.	YACHIYO ENGINEERING CO., LTD.	MOUNTING STRUCTURE FOUNDATION (1) TYPICAL SECTION ON RESERVOIR			
				PREPARED BY: TAKASHI NAKAMURA	CHECKED BY:	APPROVED BY:	SHEET NO: A1

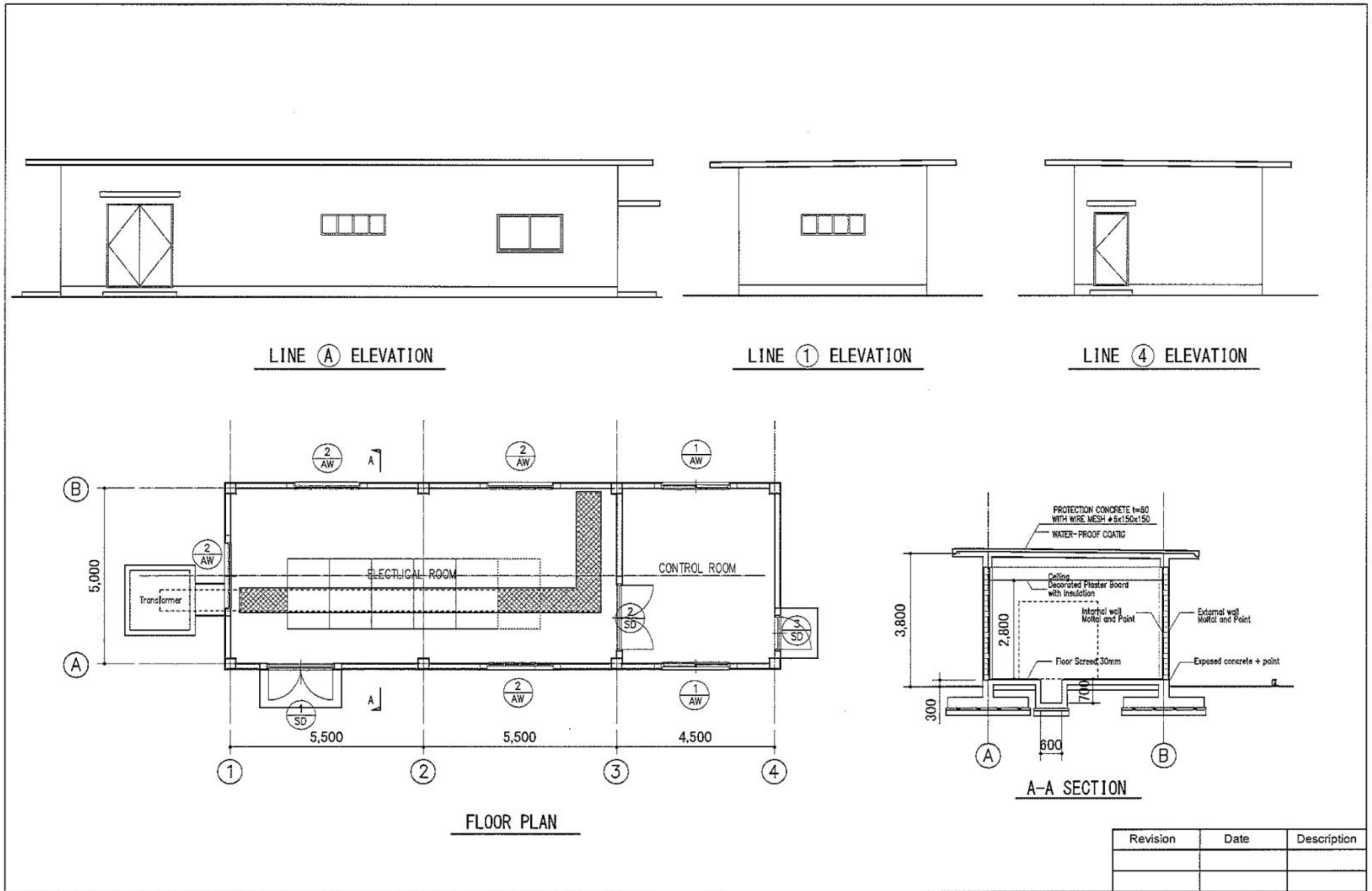
A-01 MOUNTING STRUCTURE FOUNDATION (1) TYPICAL SECTION ON TANK



A-02 MOUNTING STRUCTURE FOUNDATION (2) TYPICAL SECTION AT CENTRAL PASSAGE



A-03 POWER CONDITIONER BUILDING (1) LOCATION, SECTION



Revision	Date	Description

PROJECT	LOCATION	CLIENT	CONSULTANT	DRAWING TITLE: POWER CONDITIONER BUILDING (2) PLAN, ELEVATION, SECTION
The Project for Introduction of Clean Energy By Solar Electricity Generation System in the Federal Republic of Nigeria	Lower Usuma Dam Water Works		YACHIYO ENGINEERING CO., LTD.	PREPARED BY: CHECKED BY: APPROVED BY: SHEET NO: A4

A-04 POWER CONDITIONER CUILDING (2) PLAN, ELEVATION, SECTION

GENERAL

BUILDING AREA	77.5 m2
TOTAL FLOOR AREA	77.5 m2
UNDER GROUND STRUCTURE	REINFORCED CONCRETE CONSTRUCTION
UPPER GROUND STRUCTURE	REINFORCED CONCRETE CONSTRUCTION

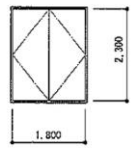
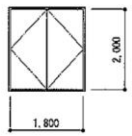
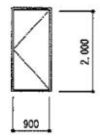
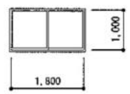
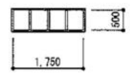
EXTERIOR FINISHING SCHEDULE

LOCATION	SPECIFICATION
ROOF	PROTECTION CONCRETE t=80mm WITH WIRE MESH φ6x150x150 WATER-PROOF COATING
WALL	150THK CONCRETE BLOCK WITH MORTAR EP PAINT FINISH
BASEBOARD	EXPOSED CONCRETE EP PAINT FINISH
CANOPY	TOP : MORTAL STEEL TROWEL EP PAINT FINISH UNDER : EXPOSED CONCRETE EP PAINT FINISH

INTERIOR FINISHING SCHEDULE

ROOM NAME	FLOOR	BASEBOARD	WALL	CEILING	REMARKS
CONTROL ROOM	MORTAR STEEL TROWEL DUSTPROOF PAINT FINISH	MORTAR STEEL TROWEL FINISH H=100mm	MORTAR STEEL TROWEL EP PAINT FINISH	DECORATED PLASTERBOARD t=9.5 LIGHT IRON SUSPENDED FRAME CEILING SYSTEM CH=3000	AIR-CONDITINOR,VENTILATION FAN 100THK GLASSWOOL INSULATION ON CEILING
ELECTLICAL ROOM	MORTAR STEEL TROWEL DUSTPROOF PAINT FINISH	MORTAR STEEL TROWEL FINISH H=100mm	MORTAR STEEL TROWEL EP PAINT FINISH	DECORATED PLASTERBOARD t=9.5 LIGHT IRON SUSPENDED FRAME CEILING SYSTEM CH=3000	VENTILATION FAN 100THK GLASSWOOL INSULATION ON CEILING

FITTING LIST

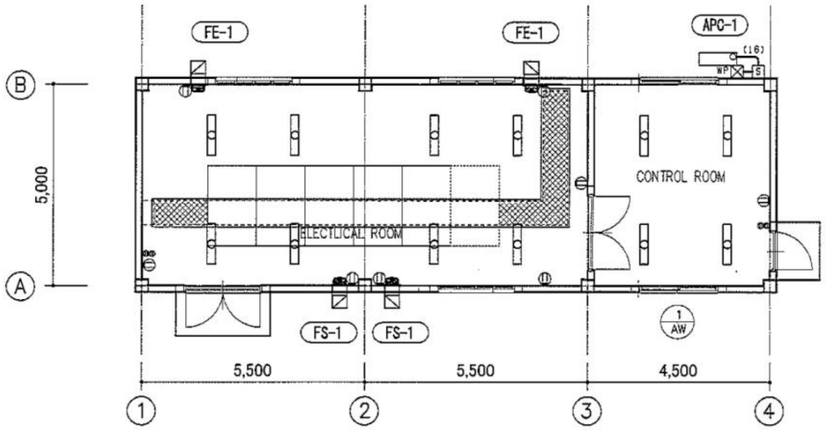
MARK No.	1/SD X 1	2/SD X 1	3/SD X 1	1/AW X 2	2/AW X 3
ELEVATION					
TYPE	DOUBLE SWING DOOR	DOUBLE SWING DOOR	SINGLE SWING DOOR	SLIDING WINDOW	FIXED WINDOW
MATERIAL・FINISH	STEEL・ OIL PAINT	STEEL・ OIL PAINT	STEEL・ OIL PAINT	ALUMINUM・ ELECTRO COLOR	STEEL・ OIL PAINT
GLASS	—	—	—	FLOAT GLASS t=5mm	FLOAT GLASS t=5mm
HARDWEAR	HINGE, LEVER HANDLE, DOOR CLOSER, KEYLOCK	HINGE, LEVER HANDLE, DOOR CLOSER, KEYLOCK	HINGE, LEVER HANDLE, DOOR CLOSER, KEYLOCK	CRESCENT, READY-MADE HARDWEAR	READY-MADE HARDWEAR
REMARK				ALUMI GRILL, MOSQUITO NET WINDOW	

Revision	Date	Description

PROJECT	LOCATION	CLIENT	CONSULTANT	DRAWING TITLE:
The Project for Introduction of Clean Energy By Solar Electricity Generation System in the Federal Republic of Nigeria	Lower Usuma Dam Water Works		YACHIYO ENGINEERING CO., LTD.	POWER CONDITIONER BUILDING (3) FINISHING SCHEDULE, FITTING LIST

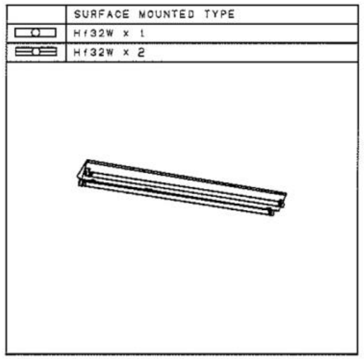
PREPARED BY:	CHECKED BY:	APPROVED BY:	SHEET NO:
			A5

A-05 POWER CONDITIONER CUILDING (3) FINISHING SCHEDULE, FITTING LIST



FLOOR PLAN

SYMBOL	DESCRIPTION	QTY	SPECIFICATION	LOCATION
ACP-1	WALL MOUNTED TYPE HEAT-PUMP SYSTEM AIR CONDITIONER	1	COOLING CAPACITY : 10.0 kW COMPRESSOR POWER : 4.1 kW INDOOR FAN POWER : 250 W OUTDOOR FAN POWER :100 W POWER : 1 PHASE - 240 V - 50 Hz	CONTROL ROOM
FE-1	WALL MOUNTED TYPE PROPELLER SUPPLY FAN	2	CAPACITY : 200DIA x 552m3/H x 50Pa x 25W POWER : 1 PHASE - 240 V - 50 Hz ASSEMBLY : MOTORIZED TYPE SHUTTER	ELECTRICAL ROOM
FS-1	WALL MOUNTED TYPE PROPELLER SUPPLY FAN	2	CAPACITY : 200DIA x 510 m3/H x 40Pa x 25W POWER : 1 PHASE - 240 V - 50 Hz ASSEMBLY : MOTORIZED TYPE SHUTTER	ELECTRICAL ROOM



LEGEND
1. RATED VOLTAGE : 1φ 240V-50Hz
2. STARTER (FLUCRESCENT LANP) : GLOW STARTER
3. POWER FACER : HIGH POWER FACTOR

⊖ SOCKET OUTLET 2P+E 250v 15A/ 2-GANG

SWITCH 1P10A×2 (W/PLATE)

Revision	Date	Description

PROJECT	LOCATION	CLIENT	CONSULTANT	DRAWING TITLE:
The Project for Introduction of Clean Energy By Solar Electricity Generation System in the Federal Republic of Nigeria	Lower Usuma Dam Water Works		YACHIYO ENGINEERING CO., LTD.	POWER CONDITIONER BUILDING (4) FACILITIES PLAN

PREPARED BY:	CHECKED BY:	APPROVED BY:	SHEET NO:
TAKASHI NAKAMURA			A6

A-06 POWER CONDITIONER CUILDING (4) FACILITIES PLAN

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The Project will be implemented based on the Government of Japan's Program Grant Aid for Environment and Climate Change scheme. The Project received approval by the Government of Japan, and the two countries' governments signed the Exchange of Notes (E/N) and the Grant Agreement (G/A) in 2012. The procurement agent will be recommended to the Nigerian side by the Government of Japan, while Federal Ministry of Power (FMOP) will be responsible and implementing organization to ensure that the contract (tender and equipment procurement) is appropriately and smoothly executed.

(1) Implementation Setup

Following the completion of the Preparatory Survey, the Government of Nigeria will entrust selection and contracting of the works consultant and suppliers to the procurement agent. Also, the implementation design and works supervision consultant and suppliers will implement their respective duties upon binding contracts with the procurement agent.

(2) Responsible Ministry

The responsible ministry will be the Federal Ministry of Power (FMOP). The contact department and agencies will be the Electrical Inspectorate Service Department.

(3) Implementing Organization

The implementing organization for the Project is also FMOP. The Project will be implemented as a Program Grant Aid for Environment and Climate Change undertaking based on the procurement agency contract that is concluded between FMOP (the responsible government agency on the Nigerian side) and the Japanese procurement agent.

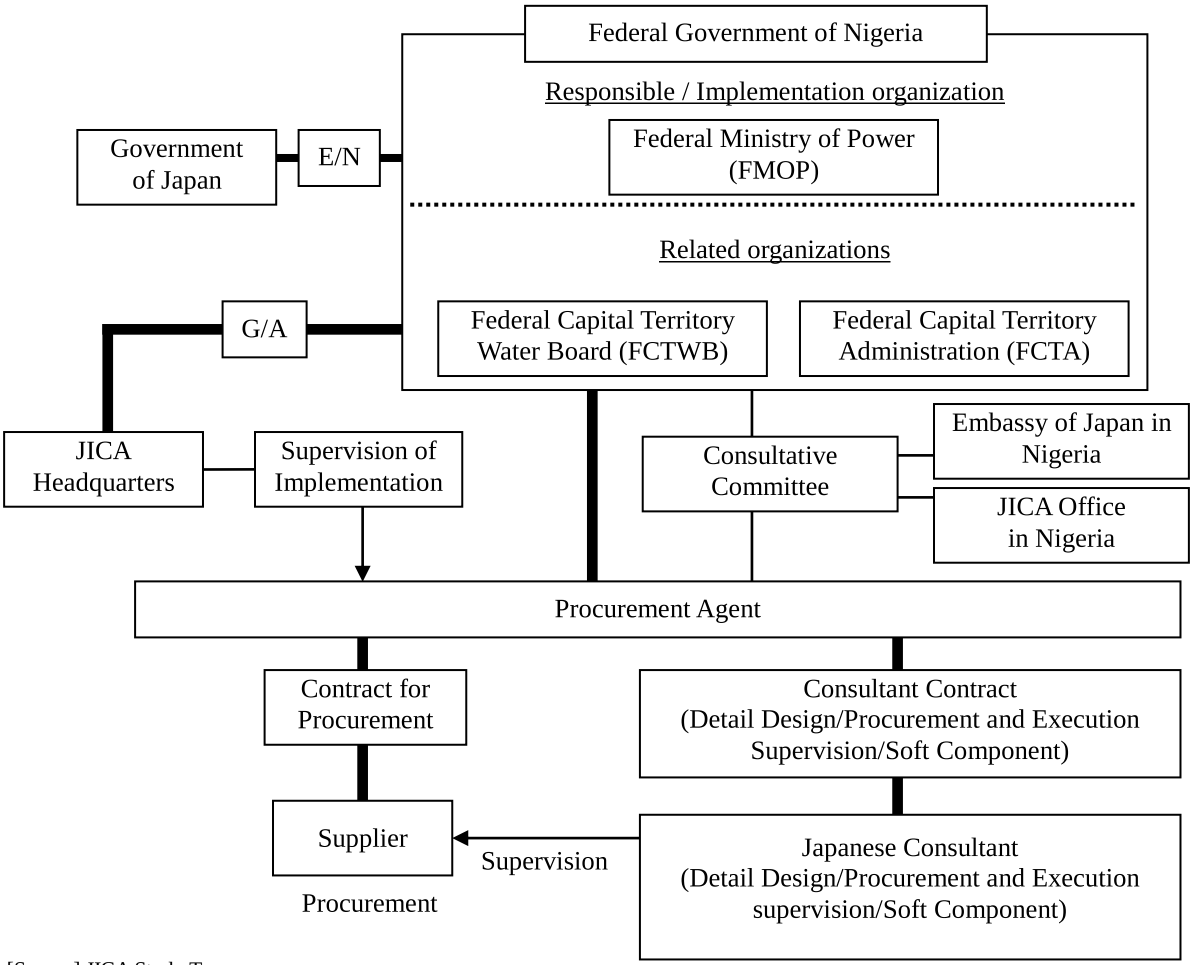
Other related agencies on the Nigerian side are as indicated below, and it will be necessary to fully share information and coordinate with each agency in the implementation stage. Federal Capital Territory Water Board (FCTWB) is not only a direct beneficiary but also the operation and maintenance agency of this photovoltaic system. Also, Federal Capital Territory Administration will secure necessary budget for the operation and maintenance to assist FCTWB's operation and maintenance activities.

- Federal Capital Territory Water Board (FCTWB)
- Federal Capital Territory Administration (FCTA)

When coordinating with each agency, it has been confirmed that the Electrical Inspectorate Service Department of FMOP will act as the primary contact.

Also, the main agencies on the Nigerian side and the Government of Japan will establish an intergovernmental conference composed of representatives from each agency/government to discuss the items that require confirmation at government level.

The Project implementation setup is shown in Figure 2-2-4-1.1.



[Source] JICA Study Team

Figure 2-2-4-1.1 Implementation Setup

(4) Procurement Agent

1) Implementation Contents

The procurement agent will prepare the tender documents for equipment procurement, thereby initiating the tender management proceedings and procurement operations for the Project. The procurement agent, which will be recommended to the Nigerian side by the Government of Japan, will implement and execute general supervision to ensure that the Project components are appropriately and smoothly implemented.

Concerning tender work supervision, the procurement agent will prepare documents concerning the Agent Agreement, bank arrangements and contracts pertaining to tender, and it will distribute the tender documents and conduct duties pertaining to the tender, evaluation and contracting of suppliers.

In the area of works management, the supervisor dispatched by the Japanese procurement agent will conduct fund management including payments, expenditure planning in the event where excess funds arise, confirmation of implemented contents and reporting of progress to both governments, as well as maintain constant discussions, coordinate with and report to the Nigerian side.

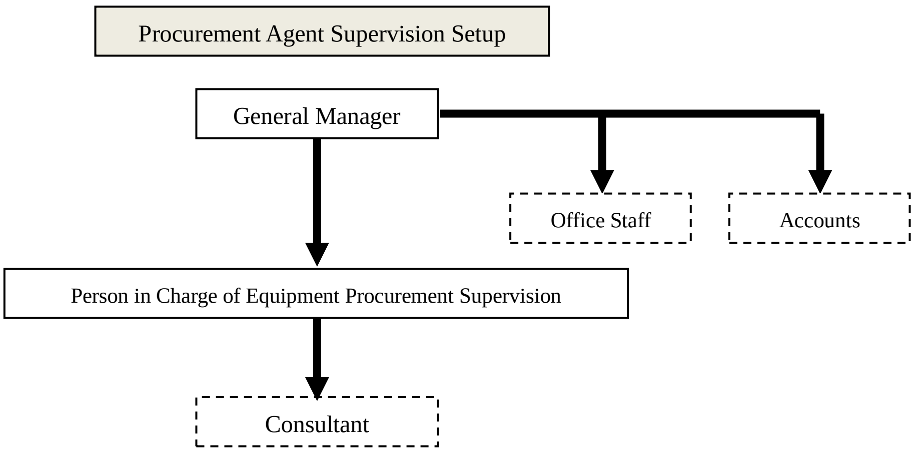
2) Implementation Setup

- Tender work management period

The procurement agent will compile the tender documents, confirm equipment specifications and evaluate the tendering firms; however, since the international competitive tender for equipment procurement is likely to be complicated, the agent will recruit local auxiliary personnel. Moreover, since it will be necessary to receive and answer technical questions on the tender contents and appropriately evaluate the technical proposals of tenderers, the Japanese consultant will assist in the technical affairs.

- Works supervision period

The procurement agent will conduct general management during the works execution period, however, this will only comprise checking of key points and will be conducted under the works supervision of the Japanese consultant.



[Source] JICA Study Team

Figure 2-2-4-1.2 Procurement Agent Supervision Setup

(5) Construction supervision and procurement supervision consultant

The consultant that will be in charge of detailed design and work supervision will conduct detailed design and supervise the quality of work, schedule, safety etc. of the facilities construction, confirm quality, functions, performance and quantities in the equipment procurement, and check for exterior damage during the transportation of equipment after the consultant for this Project close a contract with procurement agency. If it discovers any problems, it will immediately prepare a report and discuss countermeasures with related officials. Moreover, the consultant in charge of construction supervision will assess the performance of the contractor’s works.

(6) Contractor and equipment supplier

The contractor selected by the procurement agent by the tender must fully understand and promptly and certainly execute the contents of the contracts. The consultant that will conclude the Agent Agreement with the procurement agency will supervise the contractor during the work implementation period.

2-2-4-2 Implementation Conditions

(1) Construction situation in Nigeria

It is possible to secure operators (workers) for construction works in Nigeria, however, skilled operators and technicians who possess expertise in the areas of schedule, quality and safety control, etc. are limited. Accordingly, it will be necessary for the Japanese contractor to dispatch engineers and skilled workers from Japan as the need arises.

Meanwhile, since Nigeria has no prior experience of photovoltaic system installation works on the scale of those proposed in the Project, and highly skilled technicians are required in order to install equipment and carry out adjustment and testing, etc. after installation, it will be difficult to utilize local personnel other than laborers. Accordingly, when implementing the installation work, it is desirable that the Japanese contractor procures local laborers and works equipment and dispatches engineers from Japan. Moreover, the Japanese engineers will conduct technology transfer in the shape of OJT for Nigerian engineers during the installation period.

(2) Implementation planning conditions

1) In Nigeria, because there is frequent rainfall during the rainy season from May to October, it will be necessary to compile the implementation plan so that excavation and high voltage cable terminal processing work does not arise during this period.

2) In carrying out work on the tanks, which are large-scale and important structures, load limits shall be set regardless of whether the construction is temporary or permanent. Efforts shall be taken to avoid adverse effects on the tanks and precautions shall be taken to avoid interfering with the Plant's operation and maintenance management.

3) As there are numerous pipes and cables buried in the Plant, it is essential that appropriate protective measures be taken to avoid damaging them.

4) The Plant's yearly, monthly, weekly, and daily operation and maintenance plans should be studied in advance and ample consideration should be put into not interfering with regular work at the Plant.

5) When conducting connecting works with existing equipment, it will be necessary to

compile the implementation plan so that power interruptions are kept to a minimum.

6) Work shall be organized to strictly comply with environmental and sanitary aspects of the water treatment plant and a clean worksite shall be maintained at all times.

(3) Utilization of local equipment and materials

The aggregate, cement and reinforcing bars, etc. required for building the foundations of the mounting structure for the solar photovoltaic modules can be procured in Nigeria, although it will be necessary to implement management and supervision of quality and deadlines. Accordingly, when compiling the implementation plan, locally procurable equipment and materials shall be utilized as far as possible for the foundation works.

(4) Safety measures

Although the target site of this plan is in the suburbs of Federal Capital Territory, in implementing the Project, strict compliance with the JICA Nigeria office safety manual. shall be observed, and security measure costs incurred for deployment of armed police and vehicles shall be suitably appropriated.

It should be noted that concerning armed police deployment in the implementation of Japanese side assistance projects, unlike in the Preparatory Survey stage, a per diem rate for armed police through JICA Nigeria office does not apply, thus this point should be duly noted so as not to create an impractical security plan.

Operation and maintenance at the existing facilities of the Project site are carried out on 24-hour basis. Therefore, it is crucial to ensure safe passage of management personnel and management patrol vehicles. Proper stationing of construction vehicle traffic control personnel, working safety observers, etc. shall be exercised, and all reasonable measures shall be taken to ensure their safety.

In addition, Japanese construction supervision consultants and contractors will be commuting daily from Abuja. Precautions shall be taken to ensure they will not be targeted by criminals, such as ensuring they do not commute at the same time.

(5) Tax Exemptions

In order to receive exemptions of customs duties and taxes on the Project equipment, the contractor will need to give advance notification to the Ministry of Finance via the Federal Ministry of Power. It is possible to receive exemptions on duties and domestic taxes, however, it has been confirmed that this is not an advance rebate system but rather a total exemption scheme whereby the implementing agency in Nigeria avoids any tax burden.

(6) Transportation

Equipment carried to Nigeria by sea is usually landed and undergoes customs clearance at the international port of Lagos. Customs clearance is carried out at the port; however, in Nigeria it is compulsory for incoming goods to undergo landing inspections by third party inspection companies. Since the customs clearance procedure including this inspection takes at least two weeks, the transportation plan will be compiled with this in mind. There are around three transport companies that transport goods from the port to inland locations and some of these have worked on grant aid projects in the past. Therefore, there should not be a problem regarding inland transportation. Equipment transported from Japan will be packed in such a way that it can withstand the long sea voyage, landing at port, inland transportation to the Project site and storage.

2-2-4-3 Scope of Works

Details on responsibility allocation between Japan and Nigeria under the Environment and Climate Change Program are shown in Table 2-2-4-3.1

Table 2-2-4-3.1 Major undertakings to be taken by each party

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side	
			FMOP	FCTWB
1	to secure [a lot] /[lots] of land necessary for the implementation of the Project and to clear the [site]/[sites];		● Arrangement	● Securement
2	To construct the following facilities			
	1) The power conditioner building	●		
	2) The gates and fences in and around the site		●	
	3) The parking lot (if necessary)		●	●
	4) The road within the site	N/A		
	5) The road outside the site (if necessary)		●	●
3	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the [site]/[sites]			
	1)Electricity			
	a. The distributing power line to the site (Securement of interconnection point of the PV system)		● Arrangement	● Securement
	b. The drop wiring and internal wiring within the site (Wiring of the equipment of the Project after the interconnection point)	●		
	c. The main circuit breaker and transformer (The main circuit breaker and transformer for the interconnection)	●		
	d. The connection point of electricity for the installation and construction work beside the Project site		● Arrangement	● Securement
	2) Water Supply			
	a. The city water distribution main to the site (Securement of connection point of the water system of the Project)		● Arrangement	● Securement
	b. The supply system within the site (Water line and taps for maintenance of the PV arrays)	●		
	c. The connection point of electricity for the installation and construction work beside the Project site		● Arrangement	● Securement

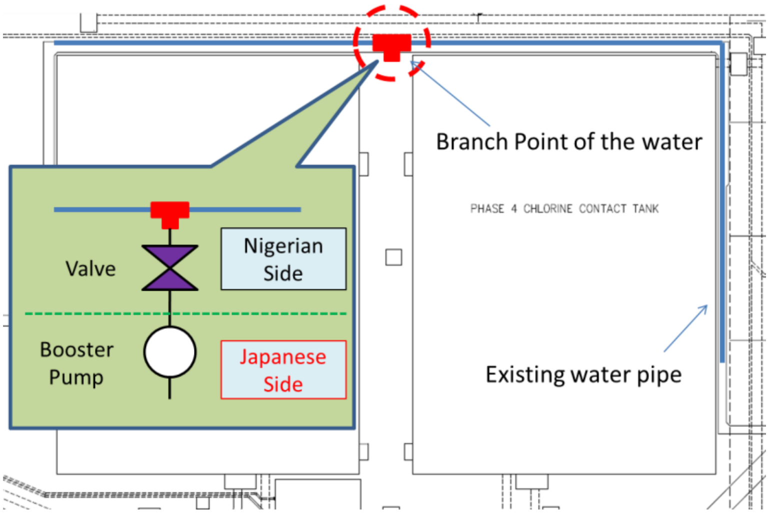
No.	Items	To be covered by Grant Aid	To be covered by Recipient Side	
			FMOP	FCTWB
	3) Drainage			
	a. The city drainage main (for storm sewer and others to the site)		● Arrangement	● Securement
	b. The drainage system (for toilet sewer, common waste, storm drainage and others) within the site	N/A		
	4) Gas Supply			
	a. The city gas main to the site		N/A	N/A
	b. The gas supply system within the site	N/A		
	5) Telephone System			
	a. The telephone trunk line to the main distribution frame/panel (MDF) of the building		N/A	N/A
	b. The MDF and the extension after the frame/panel	N/A		
	6) Furniture and Equipment			
	a. General furniture		●	
	b. Project equipment (Procurement and installation of the equipment of the Project)	●		
	c. Procurement of materials for final connection of the equipment of the Project to the 11kV system at the interconnection point	●		
	d. Implementation of scheduled outage of the 11kV system, and final connection work of the equipment of the Project to the 11kV system		● Arrangement	● Implementation
4	To bear the following commissions applied by the Japanese bank for banking services based upon the B/A:			
	1) Payment of bank commission		●	
5	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products			
	1) Marine (Air) transportation of the Products from Japan to the recipient country	●		
	2) Tax exemption and custom clearance of the Products at the port of disembarkation		●	
	3) Internal transportation from the port of disembarkation to the project site	●		
6	Securement of area for temporary storage and offices		● Arrangement	● Securement
7	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the products and the services [be exempted] / [be borne by the Authority without using the Grant]		●	
8	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work		● Arrangement	● Support
9	To maintain and use properly and effectively for the facilities that are constructed and the equipment that is provided under the Grant		● Monitoring	● Implementation
10	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project		●	●
11	To give due environmental and social consideration in the implementation of the Project.		●	
12	Countermeasures against vandalism		●	●

[Notes] B/A : Banking Arrangement, N/A: Not Applicable
Though each work to be covered by the Nigerian side shall be carried out by each authority mentioned above with independence, other related parties in Nigeria support the authority for smooth implementation of the Project.

[Source] JICA Study Team

(1) Securing the water supply connection and valve

The Federal Capital Territory Water Board has explained that they will install the water supply connection and valve for cleaning the solar arrays before construction work begins. Layout of the water supply connection and valve is shown in Fig. 2-2-4-3.1.

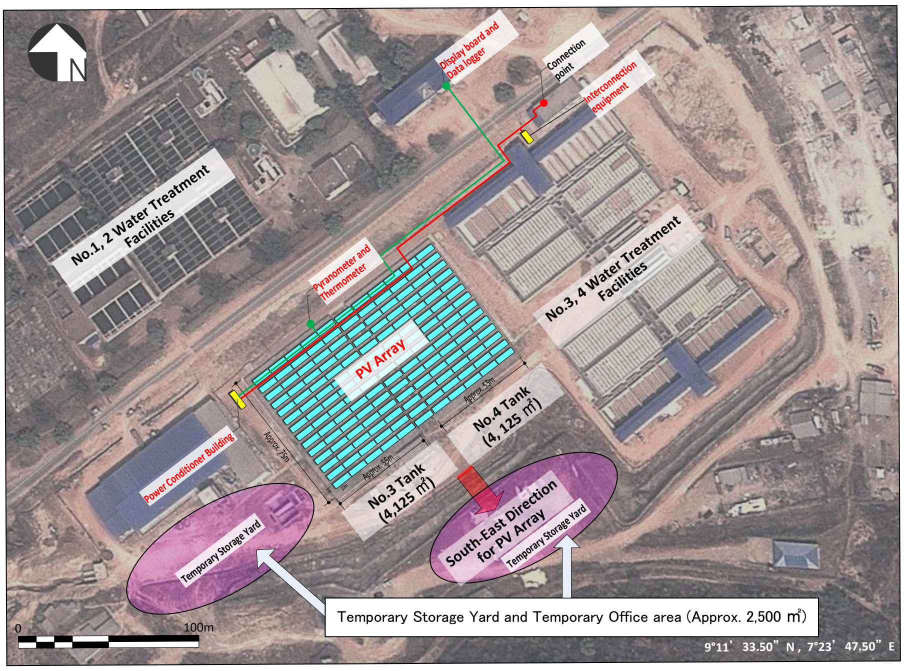


[Source] JICA Study Team

Figure 2-2-4-3.1 Layout of the water source for cleaning of the PV Arrays

(2) Securing temporary storage and temporary office sites

The Federal Capital Territory Water Board will secure temporary storage and temporary office sites. As shown in Fig. 2-2-4-3.2, the land to be used has an approximate area of 2,500 m² located southwest of the solar arrays.



[Source] JICA Study Team

Figure 2-2-4-3.2 Temporary Storage Yard and Temporary Office area

(3) Vandalism countermeasures

The photovoltaic arrays of the Project will be installed on the top slab of No.3 and No.4 tanks at the Lower Usuma Dam Water Treatment Plant on the southeast side of the main road. The main road is on the Lower Usuma Dam Water Treatment Plant premises, separated by the main gate of the Plant. It is not, however, completely inaccessible to the general public or the comings and goings of general traffic. Accordingly, it is necessary to carefully review measures to prevent vandalism, such as stone throwing at, or the theft of, the solar arrays at the pre-project stage.

2-2-4-4 Consultant Supervision

Based on the scheme of the Government of Japan's Program Grant Aid for Environment and Climate Change, the consultant will organize a consistent Project Team to smoothly conduct the detailed design and construction supervision work according to the principles of the outline design. The consultant will permanently assign at least one engineer to the Project site during the construction supervision stage in order to conduct schedule control, quality control, performance control and safety control. Furthermore, an expert in Japan will attend factory inspections and pre-shipping inspections of equipment and materials manufactured in Japan with a view to ensuring that no troubles occur following delivery of materials and equipment to Nigeria.

(1) Basic Concept of Construction Supervision

The basic concept of construction supervision by the consultant will be as follows: to supervise the works progress to ensure they finish within the designated period, and to supervise and instruct the contractor to ensure that the quality, performance and delivery times specified in the contract are secured and the site works are executed safely.

(2) Schedule Control

The consultant will compare progress with the implementation schedule in the contract every month or every week in order to adhere to the delivery deadline given in the contract. In cases where delays are predicted, the consultant will warn the contractor, to present a plan of countermeasures and offer guidance to ensure that the works and equipment delivery are completed within the contract period. The comparison of the planned schedule and actual progress will be carried out according to the following items.

1) Confirmation of works performance (manufacture of equipment and materials in plant and performance of building and civil engineering works on site)
2) Confirmation of equipment and materials delivery (Photovoltaic system, and building and civil engineering works equipment and materials)
3) Confirmation of temporary installation works and construction machinery preparations
4) Confirmation of yield and actual numbers of engineers, skilled workers and laborers, and state of preparation.

(3) Quality and Performance Control

Supervision will be carried out based on the following items to determine whether the manufactured, delivered and installed equipment and materials and constructed facilities satisfy the required quality and performance stated in the contract documents.:

1) Checking of shop drawings and specifications of equipment and materials
2) Attendance of plant inspections of equipment and materials and checking of plant inspection results
3) Checking of packing, transportation and on-site temporary storage methods
4) Checking of shop drawings and installation guidelines of equipment and materials
5) Checking of trial operation, adjustment, testing and inspection guidelines of equipment and materials
6) Supervision of equipment and materials site installation works and attendance of trial operations, adjustments, tests and inspections
7) Checking of equipment installation work drawings and shop drawings with site performance

In cases where doubts arise over quality and performance, the consultant will immediately demand the contractor to make amendments, revisions or corrections.

(4) Safety Control

Discussions will be held and cooperation sought with responsible officers of the contractor and safety control will be exercised during the construction period in order to prevent industrial accidents and accidents affecting third parties. Important points to consider in safety control on the site are as follows:

1) Establishment of safety control regulations and appointment of manager
2) Prevention of accidents through implementation of periodic inspections of construction machinery
3) Planning of the works vehicles and construction machinery operating routes and thorough enforcement of slow driving
4) Encouragement of laborers to utilize welfare measures and vacations
5) Prevention of theft of equipment and assignment of guards

(5) Works Supervisor

The contractor will implement the procurement and installation of photovoltaic equipment and materials, and the distribution and communications equipment, cables, etc. In order to implement these works, the contractor will employ a subcontractor(s) in Nigeria. Therefore, since the contractor will need to ensure that the subcontractor(s) complies with the works schedule, quality control, performance and safety measures prescribed in the contract, it will dispatch an engineer who has experience of similar projects in overseas countries to provide guidance and advice on the site.

2-2-4-5 Quality Control Plan

The consultant's construction supervisor will carry out supervision and checking based on the following items to ensure that the contractor secures the quality of Project equipment and materials and the execution and installation performance stipulated in the contract documents (technical specifications and implementation design drawings, etc.). In cases where doubts arise over quality and performance, the construction supervisor will immediately demand that the contractor make amendments, revisions or corrections.

(1) Checking of shop drawings and specifications of equipment and materials

(2) Attendance of plant inspections of equipment and materials and checking of plant inspection results

(3) Checking of packing, transportation and on-site temporary storage methods

(4) Checking of shop drawings and installation guidelines of equipment and materials

(5) Checking of trial operation, adjustment, test and inspection guidelines of equipment and materials

(6) Supervision of site installation works of equipment and materials and attendance of trial operations, adjustments, tests and inspections

(7) Checking of facilities shop drawings against work performance on site

(8) Checking of as-built drawings

In cases where doubts arise over quality and performance, the consultant will immediately demand the contractor to make amendments, revisions or corrections.

2-2-4-6 Procurement Plan

The main equipment such as solar photovoltaic modules and power conditioner to be procured and installed in the Project are not manufactured in Nigeria. The supplier of photovoltaic equipment and main equipment in the Project shall be from Japan, based on the intent of the Japanese Program Grant Aid for Environment and Climate Change project. When Japanese product will be selected, it will be necessary to take local conditions, ease of operation and maintenance by local engineers, and existence of the post-installation setup for procuring spare parts and responding to breakdowns, etc. into account. Specifications of the equipment in the tender document will be revised to reflect the actual conditions of the equipment procured through similar projects under the Program Grant Aid project scheme in western African countries.

In consideration of the above points, the origin of the equipment and materials in the Project will be as follows:

(1) Locally procured equipment and materials

Equipment and materials for the civil and building works such as cement, sand, concrete aggregate, reinforcing bars, timber, gasoline, diesel oil, works vehicles, cranes, trailers and other temporary installation equipment

(2) Equipment and materials procured in Japan

Solar photovoltaic modules, power conditioner, grid-connection transformer, display unit, wiring materials, etc.

(3) Equipment and materials procured from third countries

Circuit breaker panel, wiring materials, etc.

2-2-4-7 Operational Guidance Plan

Guidance on initial equipment controls and operation will basically be conducted by the Contractor as OJT (on the job training). In order to install and operate the grid-connected photovoltaic system (grid-connected photovoltaic system), the site electrical engineers must have ample knowledge on photovoltaic power generation. Therefore, OJT regarding the guidance on initial equipment controls and operation will be executed for two weeks after the testing adjustment.

After contract with the contractor, it will take 6 months to prepare design drawing of equipment and to fabricate the equipment, and 3 months for transportation the equipment to the site. Installation works will take about 9 months from the start to the delivery including Trial operation and adjustment. 13 months will be needed in total.

The soft component is to be implemented at three stages by the consultant during the installation works period of approximately 9 months. Photovoltaic system operators must receive training under the soft component, as is described in detail in Section 2-2-4-8 (Soft Component Plan). In the soft component training, trainees will take part in classroom and practical training covering preparation of Operation and Maintenance (O/M) manuals, basics of photovoltaic systems and characteristics of grid-connected photovoltaic systems. Moreover, operators will use the grid-connected photovoltaic system to learn about methods and important points in installation via training during the installation works.

The operators will first learn basic know-how on photovoltaic power generation and then acquire practical operating technology from the Japanese engineers (installation engineers). It is currently scheduled for initial inspections and trial operation to begin 14.5 months after agreement.

(1) Initial operation guidance plan

The grid-connected photovoltaic system operators have already learned the basics of solar photovoltaic cells and grid-connected photovoltaic systems.

The operators will implement the following items together with the installation engineers:

- Inspections, checks and measurements on completion of the grid-connected photovoltaic system and at the start of the operations
- Trial operation methods
- Routine inspections following the start of operation

1) Inspections, checks and measurement guidance before the start of operation

- The inspection, check and measurement items to be implemented before operation are described in detail in Section 2-4 (2) (Periodic Inspection Items). The results of inspections, checks and measurements will be recorded.
- Main inspection and check guidance
  The installation engineers will conduct technology transfer of the following items to the operation managers.

(a) Solar photovoltaic module and array inspections

In the construction stage, thoroughly check for any damage or breakage that may have occurred during transportation. Check for cracking, fractures and discoloration of the surface glass will be conducted as well.

(b) Checking of wiring and cables

Since the service life of photovoltaic systems is long, damage or twisting of power lines and cables during the installation can lead to decline of insulation resistance and dielectric breakdown. Parts that cannot be checked after the installation works have been finished will be recorded. In routine inspections and periodic inspections, check for signs of damage will be conducted visually.

(c) Confirmation of connecting terminals

Screws of power conditioners. sometimes become loose during transportation. Temporary wiring is sometimes left unfinished, while cases that have been loosened for testing, etc. are sometimes left as they are. Check for any loose screws on terminal sections before operation. Also, make sure there are no terminals with mistaken polarity (positive polarity is P or +, and negative polarity is N or -) or mistaken wiring between DC and AC circuits.

(d) Inspection of other peripheral instruments

Check other peripheral instruments will be conducted by visual inspection.

(2) Measurement guidance and safety measures guidance

The operation manager will check that the installed solar photovoltaic modules are operating correctly and are maintaining performance levels before the start of operation. The operation managers and work assistants will receive guidance regarding safety measures on the handling of solar photovoltaic arrays from the installation engineers before the start of actual work.

1) Safety measures

Before the start of work, it is important to observe the following points regarding safety measures (clothing and electrical shock countermeasures):

(a) Clothing

- Wear helmets, sneakers and hip bags.

(b) Shock prevention

- Detach one end of solar photovoltaic cell strings before the start of work
- Wear low voltage insulated gloves
- Use insulated tools
- Do not work when it is raining.

2) Solar photovoltaic array inspection: Confirmation of voltage and polarity and measurement of short circuit currents

① Confirm that the solar photovoltaic modules have been correctly installed and that voltage is being generated as described in the specifications.
Make sure that the positive and negative polarities are not confused by checking each string with a voltmeter.

② Measurement of short circuit current
Measure the solar photovoltaic modules by ammeter to make sure that short circuit current flows as specified in the specifications.

3) Insulation resistance measurement

Insulation resistance testing will be implemented in order to confirm that it is acceptable to turn on power to the photovoltaic system. Insulation resistance will be measured after the construction (before the start of operation), during periodic inspections and when identifying and repairing malfunctioning areas during accidents. Measured resistance values will be recorded. When the used voltage is 300 V or higher, insulation resistance should be at least 0.4 MΩ.

4) Ground resistance measurement

Grounding of electrical devices is important in order to protect human lives and property from accidents and fires caused by ground faults. Grounding works are divided into four types, i.e. A, B, C or D. Types A, C and D grounding works are implemented on uncharged areas such as the metal armor of electrical devices and cables. Type B installation works are implemented on the low voltage side cable ways of transformers for stepping down ultra-high and high voltage to low voltage. High voltage metal external boxes and low voltage exterior boxes exceeding 300 V are reduced to 10 Ω or less, however, 500 Ω or less is acceptable in cases where a device is installed for breaking current within 0.5 seconds when ground faults occur.

(3) Adjustment of permanent values and stabilization times of instruments before the start of operation

The operation manager and installation engineers will jointly adjust the permanent values and stabilization times of instruments in the grid-connected photovoltaic system.
The major permanent values and stabilization times will be as follows:

- Confirmation of permanent values of protective relays
- Confirmation of closing holdback time in cases of AC power restoration
- Confirmation of system stoppage time in cases of DC power loss
- Confirmation of system stoppage time in cases of AC power loss

After configuring the permanent values and stabilization times, the system operation will be carefully confirmed. For details refer to Section 2-4 (2) (Periodic Inspection Items).

(4) Operation Guidance Plan

Once the grid-connected photovoltaic system goes into operation, unlike diesel engine generators, there is no need to conduct system controls. The grid-connected photovoltaic system automatically operates every day, however, if it is stopped for some reason, it will need to be switched on after checking. At the start of operation, since problems are apt to occur in the semiconductors and photovoltaic modules, it will be necessary to conduct inspections every day. At the start of the operation of the grid-connected photovoltaic system, the operation managers and installation engineers will patrol the installation site and learn the inspection areas and techniques.

1) Creation of operation manual

The operation managers will create their own operation manual based on the technology they learn from the installation engineers.

2) Creation and storage of routine inspection records

Routine inspection items are described in detail in Section 4-1 (Routine Inspection and Periodic Inspection Items). The operation manager will record routine inspection results in notebooks and archive them. Keeping records will make it possible to detect changes in the instruments.

3) Solar irradiation and generated electrical energy checks

The operation manager will check the amount of solar irradiation and generated electrical energy. Through doing this, it will be possible to detect changes when problems occur in the solar photovoltaic modules and power conditioner, etc.

4) Panel cleaning

The operation manager will always monitor for dirt on panels during the routine inspections. It will be especially necessary to clean the panels every day when the Harmattan blows during the dry season.

2-2-4-8 Soft Component Plan

(1) Background of the necessity of soft component

In National Energy Plan formulated in 2005, the Government of Nigeria placed renewable energy as one of sustainable energy supply and is implementing the promotion of renewable energy such as photovoltaic generation, wind generation, small hydroelectric generation and biomass. However, the plans are not progressing as scheduled due to insufficient condition of policies, regulation, difficulty on the large fund procurement for initial investment and so forth.

The Plant, Mechanical and Electricity Section under the Distribution Department, have 2 mechanical technicians 9 electrical technicians, 5 operators, and 1 plumber in total, a personnel of 17 members is in charge of the operation and maintenance of overall facilities. This Section will owe the responsibility of the operation and maintenance of the photovoltaic system.

Although the Mechanical and Electricity Section has the knowledge and experience of general electrical facilities, they hardly have the knowledge and techniques specifically for the photovoltaic system. Therefore, as a component of the Project, Japanese side will dispatch two Japanese consultants to organize and implement the soft component workshop aiming to providing the skills and knowledge on the maintenance of the photovoltaic system. To contribute to the achievement of the Renewable Energy Master Plan it is desirable that other public organizations will also dispatch participants to the workshop.

(2) Current issues

Difficulties to operate and maintain the photovoltaic system at the Plant is summarized as follows:

- The operation and maintenance setup regarding grid-connected photovoltaic systems is unclear.
- Technical knowledge concerning the basics of photovoltaic system is scant.
- Technical know-how concerning the operation of grid-connected photovoltaic system is scant.

- Technical knowledge concerning the maintenance of grid-connected photovoltaic system is scant.
- Maintenance concepts and knowledge on methods regarding grid-connected photovoltaic systems are scant.
- Ability to respond to troubles in grid-connected photovoltaic system is limited.

Improvement regarding these issues is as shown in Table 2-2-4-8.1

Table 2-2-4-8.1 Current issues and proposed countermeasures

Current issue	Proposed countermeasure	Soft component feasibility
· The operation and maintenance setup regarding grid-connected photovoltaic systems is unclear.	・ Mechanical and Electricity section takes the initiative in establishing a maintenance setup within the section	・ Make recommendations on the optimum maintenance setup and examine and discuss jointly with the related agencies.
· Technical know-how concerning the operation of grid-connected photovoltaic system is scant.	・ Prepare an operation and maintenance manual for the grid-connected photovoltaic system.	・ Support manual preparation and implementation guidance.
· Technical knowledge concerning the basics of photovoltaic system is scant	・ Prepare a maintenance manual on electricity technology for the grid-connected photovoltaic system.	・ Support manual preparation and implementation guidance.
· Maintenance concepts and knowledge on methods regarding grid-connected photovoltaic systems are scant.	・ Implement operation and maintenance technical training concerning the grid-connected photovoltaic system. ・ Implement training on monitoring methods, periodic inspection methods and other aspects of monitoring.	・ Implement technical training on an appropriate grid-connected photovoltaic system. ・ Implement technical training on proper monitoring.
· Ability to respond to troubles in grid-connected photovoltaic systems is limited.	・ Include contents of troubleshooting in the operation and maintenance manual. ・ Conduct implementation guidance and enlightenment activities on the manual to ensure that maintenance is appropriately conducted.	・ Support manual preparation and implementation guidance ・ Ditto

[Source] JICA Study Team

(3) Soft component objective

The objective of the soft component is to facilitate the sustained and smooth operation and maintenance of the grid-connected photovoltaic system based on the operation and maintenance manual with equipment owned by the organization responsible for operation and maintenance, i.e. Federal Capital Territory Water Board.

(4) Method for confirming the degree of attainment of outputs

The implementation process will be divided into three stages as shown in Table 2-2-4-8.2, and categories 1 to 3 will be implemented in order. The outputs from each stage will be confirmed and evaluated as shown below.

- Category 1: Evaluation and guidance on the operation and maintenance manual on items 1.1 and 1.2 in Table 2-2-4-8.2
  Guidance on the experiment and measurement with solar photovoltaic modules on items 1.3 – 1.4 in Table 2-2-4-8.2
- Category 2: Interview and evaluation of the practical work on items 2.1 – 2.4 in Table 2-2-4-8.2
- Category 3: Interview and evaluation of the practical work on items 3.1 – 3.5 in Table 2-2-4-8.2

Table 2-2-4-8.2 Contents of soft component training

Category	Specific Implementation Contents
1. Operation and maintenance setup building	1.1 Clarification of the responsibilities of operation and maintenance personnel 1.2 Principles and basic knowledge on photovoltaic system 1.3 Characteristics and protection of grid-connected photovoltaic system 1.4 Issues on the installation of the grid-connected photovoltaic system
2. Technical training	2.1 Operation management 2.2 Maintenance management 2.3 Evaluation of operation and maintenance system 2.4 Trouble shooting
3. Monitoring	3.1 Optimization of monitoring methods 3.2 Routine inspections 3.3 Evaluation items 3.4 Reporting of monitoring results 3.5 Preparation of operation and maintenance manual

[Source] JICA Study Team

(5) Input to the soft component

Following contents will be carried out to instruct the operation and maintenance method for the equipment:

1) Contents of the soft component

Personnel of the Plant hardly have knowledge on the operation and maintenance of photovoltaic systems. Thus the soft component aims to transfer the knowledge and techniques including basic principle of photovoltaic system, operation and maintenance, and monitoring. The method includes the classroom training, practical training (preparation of manuals by the participants) and practical training with the actual equipment which will be installed such as photovoltaic arrays, measuring instruments and tools

Although it is presumed that the reverse power flow from the Plant to the national grid is not going to occur, the contents of the reverse power flow will be a part of soft component, considering that the grid-connected photovoltaic system with reverse power flows will be installed to Nigeria in the future.

2) Explanation to the Nigerian side

When implementing the soft component, it will be essential to have the participation of the Plant, Federal Capital Territory Water Board, which is the organization responsible for operation and maintenance of the photovoltaic system. The consultant shall stage a workshop in order to ensure that the local side thoroughly understands the objectives, implementation contents and activity schedule, etc. of the soft component. In addition to the Plant (FCTWB), the participants will include related officials of the Federal Ministry of Power and Abuja DISCO. With respect to the officials other than those from the Plant, the technology transfer will aim to promote the understanding of the operation and maintenance setup and responsibilities for the grid-connected photovoltaic system and to contribute to the promotion and dissemination of grid-connected photovoltaic systems in Nigeria in the future. The Project equipment will be newly installed and it will be necessary to build the operation and maintenance setup from scratch. Accordingly, the soft component will be commenced before the start of the installation works and will proceed in order from the basics up.

3) Photovoltaic System Operating Committee (provisional name)

Before the start of the Project, Federal ministry of Powerr will promptly establish the Photovoltaic System Operating Committee (provisional title) with the objectives of securing the smooth implementation of the soft component and sustained operation after the soft component is finished. This committee will hold regular meetings during the Project to ensure that the Project equipment is operated and maintained smoothly on a sustained basis. At the same time, Photovoltaic System Working Group, comprised of staffs of the Plant who will have the direct responsibility of the operation and maintenance of the system, will be established. After the completion of the Project, Photovoltaic System Operating Committee will instruct the Photovoltaic System Working Group to operate and maintain the system smoothly. The Photovoltaic System Working Group will report the operation and maintenance to the

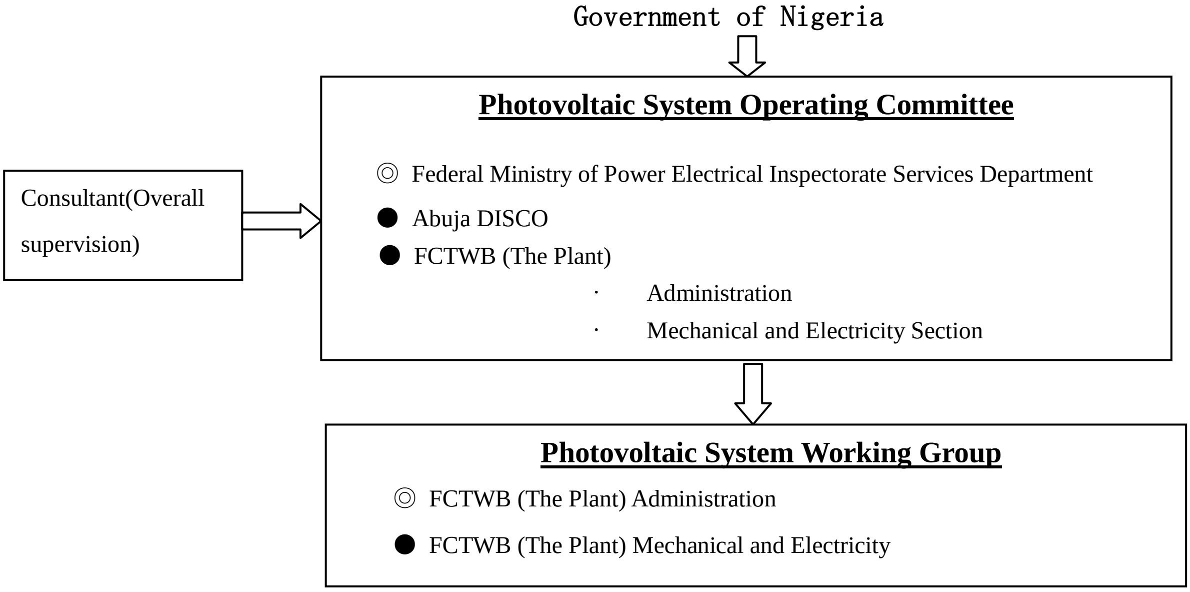
Committee and follows the guidance and advices if necessary.

The office of the Photovoltaic System Operating Committee will be located in the Plant. FMOP will be the head of this Committee and FCTWB and Abuja DISCO will be the member. Each member shall belong to suitable departments to the Project and one or two members from each agency will form the Committee. The system of the Committee is shown in Figure 2-2-4-8.1.

The Photovoltaic System Operating Committee and the Photovoltaic System Working Group will manage the system based on the Table 2-2-4-8.3 and have a discussion on the following issues for the dissemination of the system in Nigeria.

i) Difficulties on the operation and maintenance of grid-connected photovoltaic system
ii) Influence of the grid-connected photovoltaic system on the operation of the national grid and electrical quality
iii) Challenges for the dissemination of the grid-connected photovoltaic system in Nigeria
iv) Legal regulation to disseminate the grid-connected photovoltaic system in Nigeria
v) Technical criteria to disseminate the grid-connected photovoltaic system in Nigeria (including the discussion on the reverse power flow)

The Photovoltaic System Working Group will be established under the Photovoltaic System Operating Committee and implement the operation and maintenance of the photovoltaic system under the guidance and instruction of the Committee.



[Source] JICA Study Team

Figure 2-2-4-8.1 Photovoltaic System Operating Committee Implementation Setup (Proposed)

Table 2-2-4-8.3 Photovoltaic System Operating Committee Implementation Setup (Proposed)

	Japanese Consultant	Photovoltaic System Operating Committee	Photovoltaic System Working Group
Project organization	2 members	5 – 10 members	3 – 5 members
Project operation method	Management of overall progress	Overall work management	Actual maintenance
Orientation on the Project contents	Explanation	Hosting	Hosting and participation
Operation and maintenance manual	Advice	Draft check	Draft preparation
Operation and maintenance follow-up	Management and guidance	Report of the operation and maintenance	Report of the operation and maintenance
Report destination (s)	Embassy of Japan in Nigeria and JICA	Japanese consultant	Photovoltaic System Operating Committee

[Source] JICA Study Team

4) Preparation of maintenance manual

During the soft component, the Photovoltaic System Working Group will discuss with Japanese consultant and prepare the draft operation and maintenance manual. The consultant will evaluate the manual and provide the feedback. The Group will complete the preparation of the manual based of the feedback. Also, the manual shall include the trouble shooting.

(6) Soft component implementation schedule

The implementation is as shown in Figure 2-2-4-8.2 and each category indicated in Table 2-2-4-8.2 will be treated in order. The timing of commencing each category is considered as follows:

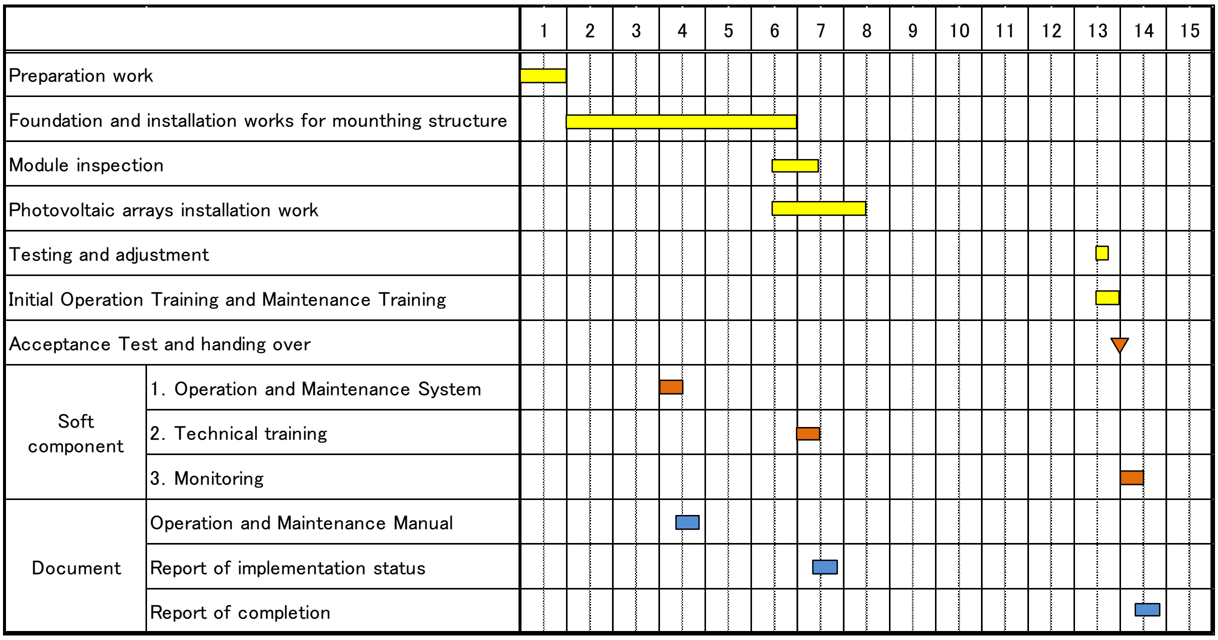
Category 1: Since supporting the establishment of the maintenance setup and clarifying the setup before installation will arouse interest among the related parties, this will be implemented before the equipment is installed.

Category 2: Inspection and operation of the system will be instructed with the actual equipment. Also, the content of operation and maintenance manual which should be noted prior to the commencement of the system will be instructed. This category will be carried out during the period of the photovoltaic array installation.

Category 3: Since this category will confirm Nigerian side’s capability to operate and maintain the system, it will be carried out after the acceptance and handing over of the system.

(7) Soft component schedule (Draft)

The soft component schedule is shown in Figure 2-2-4-8.2



[Source] JICA Study Team

Figure 2-2-4-8.2 Soft component schedule

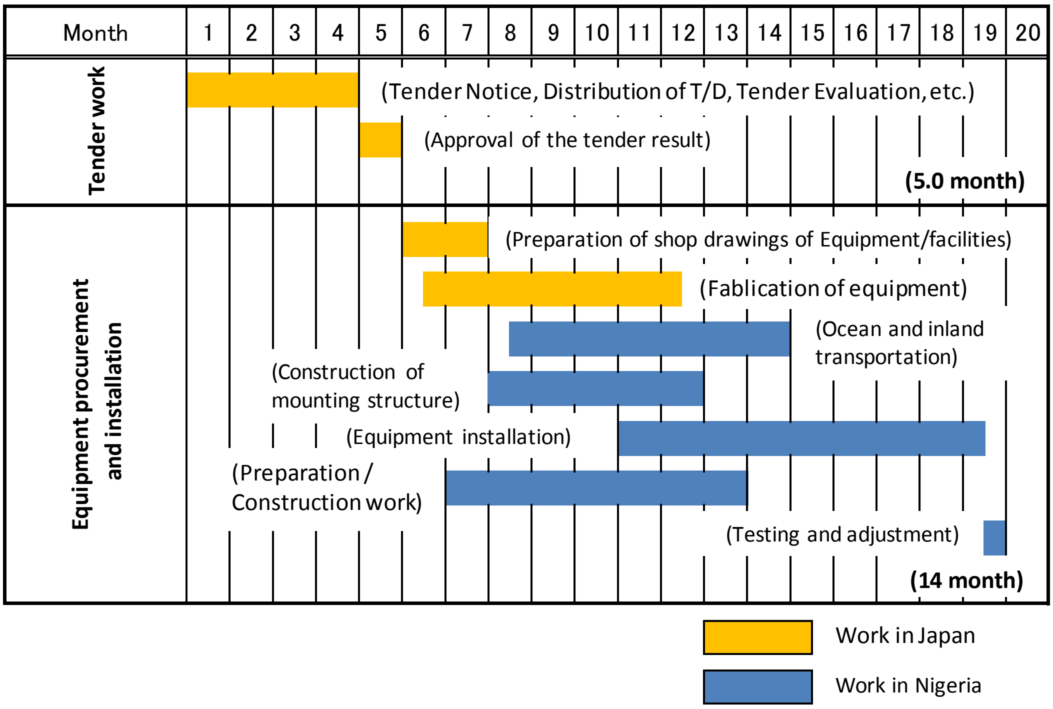
(8) Responsibilities related to the soft component on the Nigerian side

The followings are responsibilities on the Nigerian side related to the soft component.

- The Plant will organize the Photovoltaic System Operating Committee
- The Plant will provide the conference rooms, needed for implementing the soft component.
- The Plant will provide necessary personnel for the soft component
- Photovoltaic System Operating Committee will prepare the operation and maintenance manual in close cooperation with the Japanese consultant
- The Plant will operate and maintain the grid-connected photovoltaic system properly in line with the operation and maintenance manual
- The Plant will submit performance reports to the Japanese consultant for a certain period based on the operation and maintenance manual

2-2-4-9 Implementation Schedule

The Project implementation schedule was compiled as Figure 2-2-4-9.1 shows based on the scheme of the Government of Japan's Program Grant Aid for Environment and Climate Change.



[Source] JICA Study Team

Figure 2-2-4-9.1 Project Implementation Schedule

2-3 Obligations of Recipient Country

When it comes to implementing the Project, in addition to the scope of works on the Nigerian side indicated in Section 2-2-4-3 Scope of Works, items to be implemented or borne by the Nigerian side are as follows.

1) To provide information and materials necessary for the Project
2) To secure tax exemption and customs clearance and the speedy unloading of products for the Project at the port of unloading in Nigeria
3) To exempt Japanese nationals from taxes and tariffs, etc. which are ordinarily levied in Nigeria on products and services supplied based on authorized contracts
4) To attend equipment and materials inspections on site and to appoint an engineer and skilled workers as counterparts for the transfer of operation and maintenance technology
5) To secure a disposal site for excavated earth, sewage, waste oil and recovered equipment and materials during the works period (if necessary)
6) To secure the safety and provide guidance and education to local residents, employees etc. during the works period
7) To take the minimum required power interruption countermeasures when connecting the Project equipment and existing equipment.

2-4 Project Operation Plan

(1) Basic Policy

Although Lower Usuma Dam Water Treatment Plant, which is the target site in this project, is not a power company, the Plant will conduct operations and maintenance under the basic principle that it provides a safe and stable water supply to the Federal Capital Territory. The Plant has diesel generators as a distributed power supply, which differs from a photovoltaic system in that they have high temperature mechanical sliding parts, as well as even higher operation and maintenance technology. The Plant also operates and maintains 33 kV and 11 kV high voltage wires installed on its premises. Thus, once a certain level of technical competence is confirmed, the operation and maintenance of the photovoltaic system can be carried out problem-free through soft components.

The policy of this Project is that it shall be organized in such a way that the operation and maintenance plan is formulated efficiently and competently, and can move smoothly and quickly to the operation and maintenance stage once construction is completed.

(2) Routine Inspection and Periodic Inspection Items

Routine maintenance and inspections will be essential in order to ensure the sustainable operation of the grid-connected photovoltaic system. Operation managers will basically implement the following three types of inspections:

- Inspections and checking on completion of the grid-connected photovoltaic system and before the start of operation
- Routine inspections following the start of operation
- Periodic inspections after operation

1) Inspection items on system completion and in periodic inspections

The items inspected on completion of the system and in periodic inspections are almost the same. Table 2-4.1 shows the inspection items and measurement items. For details on the system completion inspection and checking, see Section 2-2-4-7 (Operational Guidance Plan).

2) Routine inspections

Unlike other generating facilities, the grid-connected photovoltaic system requires no special controls following the start of operation such as start up and turns off.

The grid-connected photovoltaic system automatically starts operating every day once the sun rises to a certain point. If the grid-connected photovoltaic system stops for some reason, it is necessary to investigate the cause and restart it by manually pushing the start switch. In the initial stages of operation, since troubles sometimes occur in the semiconductors and photovoltaic power modules, it is necessary to implement inspections of operational status every day. In the initial stage, during Initial Operation Training and Maintenance Training, the operation managers shall patrol the photovoltaic power installation site with the Japanese engineers, installation engineers to learn the inspection areas and techniques.

The photovoltaic equipment can be automatically operated without any operating personnel, although performing routine inspections makes it possible to quickly discover system abnormalities.

Routine inspections will be implemented as visual checks every day for the first month after the start of operation. After that, these inspections can be implemented around once per week; however, it will be necessary to check and wipe away dust from panels every day during the dry season. Table 2-4.1 shows the inspection items.

Table 2-4.1 Routine Inspection Items

Inspection target	Inspection Item
Solar photovoltaic array	- Surface dirt, damage - Mounting structure corrosion, rust - External wiring damage
Junction box	- External box corrosion, rust - External wiring damage
Power conditioner	- External box corrosion, rust - External wiring damage - Noise, odor during operation - Blockage of the ventilation outlet filter - Installed environment (humidity, temperature, etc.)
Grounding	- Wiring damage
Power generation situation	- Confirmation of normal operation and records of generated electrical energy and amount of solar irradiation - Checking of instrumentation and displays

[Source] JICA Study Team

The operation manager shall strictly observe the following three points when implementing routine inspections:

- Preparation and archiving of routine inspection records

  The routine inspection items are indicated in Table 2-4.1 (Routine Inspections). After checking the items indicated in the table, the operation manager will record the results and keep them. Through keeping records in this way, it will be possible to detect changes in the equipment.

- Solar irradiation and generated electrical energy check

  The operation manager shall constantly check the amount of solar irradiation and generated electrical energy. By doing so, the operation manager will be able to detect any changes when troubles arise in the solar photovoltaic modules and power conditioners.

- Panel cleaning

The operation manager will constantly monitor the panels for dirtiness in the routine inspections. In particular, the panels shall be cleaned every day during the Harmattan season in the dry season.

3) Periodic inspections

Table 2-4.2 shows the general periodic inspection items and measurement items. Periodic inspection entails stopping the system after a certain period in order to inspect the instruments and measure the items shown in the table. The first periodic inspection will be implemented five years after the start of operation.

Table 2-4.2 Periodic Inspection Items

Inspection Target	Inspection Item	Measurement/Test
Solar photovoltaic array	- Surface dirt, damage - External wiring damage - Mounting structure corrosion, rust - Grounding wire damage, ground wire looseness	- Insulation resistance measurement - Open voltage measurement (when needed)
Junction box, collecting box	- External box corrosion, rust - External wiring damage, connecting terminal looseness - Grounding wire damage, ground wire looseness	- Insulation resistance measurement
Power conditioner	- External box corrosion, rust - External wiring damage, connecting terminal looseness - Grounding wire damage, grounding wire looseness - Noise, odor during operation - Blockage of the ventilation outlet filter - Installed environment (humidity, temperature, etc.)	- Insulation resistance measurement - Surface operation check - Protective function test
Grounding	- Wiring damage	Grounding resistance measurement

[Source] Design and Installation of Photovoltaic Power Generating Systems

① Periodic Inspection Contents

(a) Always record and archive the results of the inspections and checks shown in Table 2-4.2

(b) Major inspection and check items

- Solar photovoltaic module and array inspection
  Thoroughly check for broken or damaged panels. Check for cracking, fractures and discoloration of the surface glass.
- Checking of wiring and cables
  Check for any damage or twisting of power lines and cables.
- Confirmation of connecting terminals
  Check for any loose screws on terminal sections, and also check the polarity of screws.
- Inspection of other peripheral instruments

Check for abnormalities in other peripheral instruments by visual inspection.

4) Grid-connected photovoltaic system inspection sheet

The grid-connected photovoltaic system at the Project will be a high-voltage grid-connected system. As such, in addition to the inspections described in Table 2-4.2 inspections will be conducted while referring to high voltage grid-connected inspection items and judgment criteria as shown Table 2-4.3. Care is needed because standard values differ according to the manufacturer. Inspection records should be kept with the operation record.

Table 2-4.3 Inspection Items and Judgment Criteria for the High Voltage Grid-Connected Photovoltaic System (Inspection date: Inspector:)

Instrument, etc.	Inspection Item		Judgment Criteria	Remarks	Inspector
Solar photovoltaic cells	Dirt on glass		Glass should not be dirty		
	Frame damage, deformation		The frame should not be damaged or deformed.		
	External wiring, dirt, damage		External wiring should not be dirty or broken.		
Mounting structure	Rust, scratching		There should be no rust or scratching.		
	Mounting structure fixing		There should be no loose bolts.		
	Fixing of solar photovoltaic cells and mounting structure		There should be no loose bolts.		
	Grounding of mounting structure		The mounting structure should be grounded.		
	Attachment of structures		Structures should be attached tightly.		
Operation/ Stop	Power conditioner	Grid-connected operation	Operation should be conducted with the 'Operate' switch.		
		Operation/Stop	Operation should be stopped with the 'Stop' switch.		
Operation/ Stop	Commercial power supply	Power interruption	The power conditioner should stop instantaneously.		
		Power resumption	The power conditioner should resume operation automatically after ( ) seconds on the resumption timer.		
Junction box	Terminal box loose screws		There should be no loose screws.		
	Wiring connections (polarity)		There should be no confusion between + (plus) and – (minus) in wiring.		
	Grounding works		Equipment should be certainly grounded.		
	Rust, dirt		There should be no rust or dirt.		
	Insulation resistance measurement Voltage DC1000 V		Insulation resistance between the solar photovoltaic cells + (plus) and ground should be at least 1MΩ.	MΩ	
			Insulation resistance between the solar photovoltaic cells – (minus) and ground should be at least 1 MΩ.	MΩ	
	Solar photovoltaic cell open voltage measurement	Open voltage in case of ( ) series	Voltage should be less than DC (-)V	PV1 PV2 PV3 PV4	
		Voltage fluctuation	Fluctuation should be less than ( )V (determined by the system)	V	

Instrument, etc.	Inspection Item	Judgment Criteria	Remarks	Inspector
Power conditioner	Terminal box loose screws	There should be no loose screws.		
	Wiring connections (polarity)	There should be no confusion between + (plus) and – (minus) in wiring. The AC output RST should be correctly wired.		
	Terminal box loose screws	Equipment should be certainly grounded.		
	Protective relay configuration	Confirm that configuration is as designed.		
	Noise	Separate TVs and radios by at least 3 m.		
	Ventilation	Are the ventilation ducts open?		
	Combustible objects in the vicinity	Are there no flammable objects nearby?		
	Grid voltage measurement	Voltage between RTs should be no more than AC( )V ± ( )V.	Between RS Between ST Between TR	

[Source] Design and Installation of Photovoltaic Power Generating System

5) Adjustment of permanent values and stabilization times of instruments before the start of operation

The operation manager will configure the following instruments and check that the instruments operate as configured before resuming operation.

The operation manager will adjust the permanent values and stabilization times of instruments in the grid-connected photovoltaic system. The main permanent values and stabilization times are as follows.

① Confirmation of permanent values of protective relays

Confirm the permanent value and stabilization time of the installed power conditioner.

② Confirmation of closing holdback time in cases of AC power restoration

After confirming the power conditioner, close the breaker on the DC side. If there is no problem with the display, close the breaker on the AC side and measure the time until grid-connected operation starts.

③ Confirmation of system stoppage time in cases of DC power loss

Turn the breaker on the DC side off during power conditioner operation and make sure that the power conditioner stops safely.

④ Confirmation of system stoppage time in cases of AC power loss

After performing item turn the DC side breaker on and turn the AC side breaker off while in the operating state, and make sure that the power conditioner completely stops.(Note: Since there are differences between manufacturers, refer to the manufacturer specifications).

(3) Spare Parts Purchasing Plan

Since the photovoltaic system contains no internal operating parts, it is basically a maintenance-free. It experiences no breakdowns as a result of abrasion and friction, etc.; however, because it uses an inverter, there is a possibility that failure will occur in the semiconductors. Since semiconductor faults appear during initial operation, it is considered to be normally operating if no initial troubles arise. However, this does not mean that failures cannot be caused by natural disasters and fires or that there will be no degradation or wear caused by long-term use. It is, therefore, necessary to keep needed spare items and instruments.

1) Equipment replacement intervals and inspection contents

Equipment wears down and eventually loses its functions over time. The state of degradation in photovoltaic power modules can be judged to some degree through measuring output characteristics, however, it is difficult to discern degradation in many other instruments. According to the preventive maintenance philosophy for preserving system reliability, parts are changed before they break down. Table 2-4.4 shows the recommended replacement intervals and inspection contents of major instruments for reference. Depending on the system, there is concern that costs will become higher, however, spare parts will be supplied in the Project.

Table 2-4.4 Replacement Intervals and Inspection Contents of Major Equipment (Recommended cases)

Part Type	Recommended Replacement Interval	Inspection Contents
Solar photovoltaic modules	20-30 years	External appearance and voltage measurement
Junction box	20 years	Malfunction
Circuit breaker	10-15 years	Malfunction
Collecting box	10-15 years	Malfunction
Power conditioner	10-15 years	Malfunction
Low voltage panels	10-15 years	Malfunction
Interconnection transformer	20 years	Temperature increase
Interconnection equipment	10-15 years	Malfunction
Fuse	7 years or 50,000 hours	Meltdown
Air conditioner	10-15 years	Malfunction, reduced performance

[Source] JICA Study Team

2) Spare parts storage

Breakages and failures of main items of equipment in photovoltaic systems frequently lead to suspension of system functions. When troubles occur, it is desirable to promptly conduct repairs or replace the problem equipment, and the system can be quickly restored if replacement equipment is kept on hand. However, since it is expensive to store of expensive parts or large quantities of parts, it is necessary to determine the types and quantities of spare parts upon considering the equipment characteristics, economy and time required for system recovery, etc. Table 2-4.5 shows the types and quantities of spare parts that are recommended for storage in the Project.

Table 2-4.5 Spare parts to be procured

Equipment	Quantity
Solar photovoltaic modules	3% of all the PV modules
Junction box	2
Collecting box	1
Vacuum Circuit Breaker (VCB) (630 A, 25 kA)	1
Electromagnetic contactor	Each 1 of all types
Wiring circuit breaker	Each 1 of all types
Fuse	6 phases
Auxiliary relay	Each 1 of all types
Cables and wires	3% of all types

[Source] JICA Study Team

3) Spare parts procurement plan

The recommended replacement intervals of the major items of equipment in the grid-connected photovoltaic system are as indicated in Table 2-4.4. Costs arise when major items of equipment are replaced, and it is necessary to budget for these every year. However, in the Project, spare units will be procured for all the main instruments that comprise the photovoltaic system. The service life of the air conditioner in the Power Conditioner Building is 10-15 years, and since no spare air conditioner will be procured in the Project, it will be necessary to budget for replacement of this in the 10th year after start of operation. Air conditioners and other items can be purchased in Abuja.

Table 2-4.6 Replacement Intervals and Costs of Replacement Parts

Part	Replacement Interval	Quantity	Cost
Air conditioner	10~15 years	1	700,000 Naira

[Source] JICA Study Team

4) Testing equipment and maintenance tools procurement plan

Necessary testing equipment and maintenance tools will be procured in this Project. The list is shown in Table 2-4.7

Table 2-4.7 Test Equipment and Maintenance Tools

Part	Quantity
Digital Multi Meter	1 lot
Insulation Resistance Tester	1 lot
Voltage Detector	1 lot
Clamp Meter	1 lot
Earth Resistance Tester	1 lot
Phase Rotation Tester	1 lot
Electrical Tool Set	1 lot
Combination Tool Set	1 lot

[Source] JICA Study Team

5) High-pressure washer purchase plan

The replacement interval for the high-pressure washer needed to clean the large-scale photovoltaic arrays is shown in Table 2-4.8. A budget must be appropriated for replacement of pressure washers in the 5 year after construction is completed.

Table 2-4.8 Replacement Intervals and Costs of Booster Pump

Part	Replacement Interval	Quantity	Costs
High-pressure washer	5-7 years	4	1,255,000 Naira

[Source] JICA Study Team

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

In the event this Project is implemented through Japan's Grant Aid, the total cost will be approximately 980 million yen. The cost breakdown of both parties, based on division of construction responsibilities between Japan and Nigeria as indicated above, is estimated based on the cumulative cost terms shown below. Note that the estimated project cost shown here is a provisional value; it is not necessarily intended to indicate the maximum amount of grant on Exchange of Notes, and will be further scrutinized at the time this Project is being considered for implementation.

(1) Costs to be borne by the Nigerian side: US$ 78,254.77- (approximately 7.82 million yen)

The contents and costs to be borne by the Nigerian side are as follows:

1) Payment of commission for the bank: US$ 9,806.86 (Approx. 0.1% of the grant amount)
2) Pipe branch construction work: US$ 200.14
3) Construction of protection net against stone-throwing: US$ 67,897.52

*) Item 3) is the estimated amount for the construction of protection net to avoid vandalism by the Preparatory Survey Team. This amount is subject to change according to detail design of protection net construction.

(2) Estimation criteria

1) Estimation point:	October 2013
2) Exchange rate:	US$1 = 99.93 yen (Mean value from July 2013 to September 2013)
3) Works and procurement period:	The detailed design and equipment procurement and installation period is as shown in the implementation schedule.
4) Other points:	The Project will be implemented according to the scheme of the Program Grant Aid for Environment and Climate Change.

2-5-2 Operation and Maintenance Cost

Main equipment of the photovoltaic system procured in the Project is composed of Japanese product, and this is especially true in the grid-connected system here since it does not use batteries. However, since the system will be installed overseas, it will not be possible to respond to any problems as quickly as compared to the case of installation in Japan. Implementation of routine inspections and periodic inspections needed for operation and maintenance helps in quickly discovering system failures and troubles and is useful for improving operation methods. Also, keeping manuals and operating records on hand is an effective means of enhancing system maintenance. Moreover, establishing a setup for storing and supplying replacement parts and so on enhances the system reliability. Maintenance is important for ensuring the long-term operation of grid-connected photovoltaic systems. Key points in maintenance are the replenishment of instruments at times of failure and implementation of routine inspections. The special condition in the Project site is the fine sand that is carried by Harmattan winds during the dry season. When the Harmattan is blowing strongly, the back window of a sedan car can become so covered in dust that it can no longer transmit light. During the dry season, it will be important to clean photovoltaic panels on a daily basis. The important points in maintaining the grid-connected photovoltaic system are indicated below.

(1) Important maintenance points

1) Implementation of periodic inspections and maintenance

Periodic inspections and maintenance are the basic requirement for ensuring the stable and long-term operation of photovoltaic systems. Early detection of system failures and troubles is important for improving operation methods and conducting preventive maintenance.

2) Preparation of manuals

Compiling the contents of operation and maintenance work into manuals is effective for engineers to conduct their work smoothly and improving the efficiency of system maintenance.

3) Maintenance of operating records

Operation managers keep records of photovoltaic system inspection and maintenance conditions and any failures, troubles or problems in the system. Such records prove useful in identifying failure-prone points, and preventing reoccurrence of problems. Furthermore, records are fed back to manuals and education of engineers and can be used for improving the content and efficiency of maintenance technology.

4) Equipment replenishment

It is desirable to use locally procurable equipment and materials in the system as much as possible. However, if imported products or products that are locally hard to procure have to be used from the viewpoints of reliability and cost, it is necessary to establish a system for promptly supplying them when needed.

5) Staff education at the Plant

Since the staff will be directly or indirectly involved in maintenance of the photovoltaic system, they will need to be educated. It will be possible to operate the photovoltaic system more effectively if staff members at the Plant understand the system. Operation managers must carry out this education for the staff.

(2) Equipment replenishment

Photovoltaic modules are said to have a service life of 20 years or more, while the other component equipment and materials have shorter life. The long-term stable operation of the system depends on the rapid replacement of such equipment and materials. Description of the replacement intervals, inspection contents, spare parts storage methods, etc. is given in Section 2-4 (3) (Spare Parts Purchasing Plan).

(3) Operation and maintenance cost

In addition to the equipment described above, personnel expenses are also required in order to maintain the grid-connected photovoltaic system. Regarding personnel costs, staff members of the Plant will conduct operation and maintenance of the system in addition to the regular duties.

1) Personnel expenses

Panel cleaners will be employed throughout a year. The cleaners will clean panels every day.

Table 2-5-2.1 Annual Employment Costs

Employed number	Employed period	Employed days	Rate / day	Employment cost (year)
2 people	January - December	365 days	3,686.96 N	2,691,480.66 N

[Source] JICA Study Team

2) Equipment replenishment costs

Table 2-4.4 shows the necessary equipment and estimated service lives for operating the grid-connected photovoltaic system over the long term. These instruments are expensive, however, replacement parts will be supplied when installing the system. Federal Capital Territory Water Board will need to bear the cost of replacing the air conditioner in the power conditioner building.

(4) Operation and maintenance cost

Table 2-5-2.2 shows the operation and maintenance costs of the grid-connected photovoltaic system. The annual cost of the grid-connected photovoltaic system is approximately 3,341,580 N (20,460 US$)

Table 2-5-2.2 Operation and Maintenance Cost

	Annual cost (N/year)	Remarks
Employment cost	2,691,500	Panel cleaners: 2 people (1 year)
Equipment cost	70,000	Cooler (1 year)
Electricity charge (*1)	276,300	Power conditioner building High-pressure washer
Others (contingencies)	303,780	10%
Total	3,341,580	

Note: Electricity charge calculation

- Power conditioner room , High-pressure washer, etc. is estimated as 8.0 kW/hour (assuming room temperature of 27-35°C).
- Electricity usage: 365 x 9 x 0.5 x 8.0 ＝ 13,140kWh / year (assuming 50% conduction rate), 9 hours per day, conduction rate 50%
- Electricity tariff: 21.03 N/kWh

[Source] JICA Study Team

Chapter 3 Project Evaluation

3-1 Preconditions

Preconditions of the Project implementation are considered as (i) Permission of the usage of land for the installation of photovoltaic arrays, (ii) Acquisition of the approval of the environmental assessment, and (iii) Tax exemption and custom clearance when unloading the equipment and materials at the port. As stated below, since Nigerian side processes required procedure, there are no special concerns.

(i) Permission of the usage of land for the installation of photovoltaic arrays

The photovoltaic system will be installed at the Usuma Dam Water Treatment Plant managed by the Federal Capital Territory Water Board, Operation and Maintenance Agency of the Project. Since the Federal Capital Territory Water Board had a desire to install the solar photovoltaic system, the installation site was secured smoothly.

(ii) Acquisition of the approval of the environmental assessment

Complying with the Nigerian Environmental Impact Assessment procedure, Federal Ministry of Power has submitted the registration form and the project proposal to the Federal Ministry of Environment with the close cooperation of the JICA Study Team. Since this Project will contribute to the mitigation of the global warming, it will certainly obtain the approval.

(iii) Tax exemption and custom clearance when unloading the equipment and materials at the port

Federal Ministry of Power, the Responsible Ministry and Implementing Agency, has previously implemented several projects under Japan's Grant Aid scheme. However, these processes did not implemented smoothly in previous projects; thus the Japanese side needs to continue the proper follow-up.

3-2 Necessary Inputs by Recipient Country

The Nigerian side must fully meet the following requirements.

(1) Prior to the Commencement of the Installation Work

1) The Nigerian side is required to appropriate the necessary budget to cover the Project cost for the Nigerian side without delay so that the work to be completed by the Nigerian side before the start of the Japanese work will be duly completed.

2) The Nigerian side is required to consult and coordinate with the Japanese contractor and the local stakeholders whenever necessary to check any impacts on or interference to planned route of transportation of materials, temporary stock yard on site, and underground public utility systems (water supply pipes, sewers and broadcasting/telephone lines) on and around the project site before the start of the Japanese work.

3) Area on the top slab of No.3 and No.4 water tanks and the space between these tanks and

designed area where the Power Conditioner Building will be constructed, needs to be kept as they were when the Field Surveys of this Project were carried out.

4) The spare feeder of the existing 11 kV Ring Main Unit needs to be kept as it is.

5) Data transmission line will be delivered from the Power Conditioner Building to the existing Administration Building where data management system and data display system are installed using the empty space of the existing conduit. This conduit will bypass the main road in the Plant. Therefore, the designed empty space for this Project needs to be kept as it is.

6) The photovoltaic system is designed not to operate in parallel with the existing emergency generators; the power conditioners need to stop their operation. Thus, empty spaces of the output terminal which will transmit the operation signal to the power conditioners need to be kept available.

7) The water valve needs to be installed to the existing water pipe which will distribute the water for cleaning the photovoltaic arrays before the start of the Japanese work.

(2) During the Construction Work and After the Commencement of Operation

1) The Nigerian side needs to routinely monitor the temporary storage yard to prevent the theft of equipment and materials.

2) The Nigerian side is required to swiftly appoint engineers to participate in the soft component workshop under the Project so that these engineers can spread their newly acquired knowledge and skills to other non-participating engineers.

3) The Nigerian side shall undertake all the procedures necessary for the conveniences of the concerned persons from Japan

4) The photovoltaic system will be installed along the main road in Usuma Dam Water Treatment Plant. Since local pupils use this road to go to schools, there may be vandalism actions, such as stone throwing. The Nigerian side needs to take necessary countermeasures to prevent such actions.

3-3 Important Assumptions

The following assumptions are crucial to produce and sustain the expected outputs and effects of the Project.

(1) Regarding the Overall Goal

- The renewable energy policy of Nigeria will not be changed.
- The politics and economy of Nigeria will remain stable.

(2) Regarding the Project Targets

- The operation and maintenance of the photovoltaic system will be continually conducted in a proper manner.
- The budget required for the operation and maintenance will be secured.
- The security of the photovoltaic system will be secured.

(3) Regarding the Project Outputs

- Current climate pattern will remain as it is.
- The photovoltaic system will be fully operated.

3-4 Project Evaluation

3-4-1 Relevance

As is indicated below, since the Project will contribute to the realization of Nigeria's development plans and energy policy as well as benefit the general population, it is deemed to have high relevance as a grant aid undertaking.

(1) Beneficiary

This Project will also contribute to the power supply to sole the water utility in Federal Capital Territory, Federal Capital Territory Water Board. Concurrently, through this Project, potable water treated by the photovoltaic system will be supplied to the Federal Capital Territory. The photovoltaic power generation system will contribute to the power supply to approximately 40,000 households.

(2) Operation and maintenance capacity

Since the equipment and materials to be procured in the Project can be comfortably operated and maintained under the present Nigerian technical capacity, they will present no particular problems in implementation of the Project. The Federal Capital Territory Water Board organizes Mechanical and Electricity Section under the Distribution Department, and they have experience on the operation and maintenance of power system. Therefore, they will not face difficulties on the operation and maintenance of the photovoltaic system in the future.

(3) Urgency

According to the Renewable Energy Master Plan of Nigeria, the goal of installed capacity of clean energy power generation by 2017 is 300 MW whilst the current achievement is 15 MW. It means the achievement rate is merely 5%. Therefore, through the installation of approximately 1,000 kWp of photovoltaic system, the rate will be increased by 6.7%. Furthermore, since this Project will be the first case of the installation of grid-connected photovoltaic system, it is expected to contribute to the similar photovoltaic system in Nigeria in the future.

(4) Consistency with Japan's development assistance

The Government of Japan established Cool Earth Partnership mechanism, a funding scheme for developing countries to mitigate the effect of climate change. Since this Project will be implemented in Nigeria, one of Cool Earth Partnership mechanism partner countries, this Project is consistent with Japan's development aid policy. In addition, this Project is considered important from the view that it can utilize Japan's advanced technology in the field of clean energy.

3-4-2 Effectiveness

Based on the analysis on the effectiveness from quantitative and qualitative views in this section, sufficient effects on the reduction of greenhouse gases and the reduction of electrical expenses are anticipated. Since personnel in charge of operation and maintenance of the photovoltaic system will gain the necessary techniques and knowledge through the soft component, the Project has high relevancy and also enough effectiveness.

(1) Quantitative effects

The anticipated quantitative effects are shown in Table 3-4-2.1.

Table 3-4-2.1 Quantitative effects of the Project

Indicator	Reference value (2013)	Target value (2016)
Net electric energy	0	1,459 MWh
Fossil fuel reduction	0	326,338 Nm^3/year
CO_2 reduction	0	723.5 t
Reduction of payment for the electricity	0	30.7 million Naira

[Source] JICA Study Team

Note: The power supplied by the photovoltaic system (1,459 MWh) is projected to contribute to 6% of the estimated power demand of the Plant in 2016 (21,921 MWh).
Electricity tariff is assumed as 21.03 NGN/kWh as of September 2013.

1) Anticipated power generation

Power generated by the photovoltaic system is calculated as follow:

$E_p = H_A \times K \times P_{AS}$ [kWh/day], where E_p [kWh/day] is generated power, H_A [kW/(m^2・day)] is the solar irradiation on arrays, P_{AS} [kW] is array output in the normal condition and K is the total design factor.

975 kWp will be applied to P_{AS} (Array output) since the Project assumes the power generation capacity will be between 975 kWp. Tilt-angle solar irradiation datum in the '1-2 Nature condition' will be applied to H_A.

Total design factor is defined as follows:

$K = K_d \times K_t \times \eta_{INV}$, where K_d is DC correction coefficient, K_t is temperature correction coefficient and η_{INV} is inverter efficiency.

- K_d has been set at 0.9 and includes correction for loss caused by dirt on the surface of photovoltaic cells and fluctuations in solar intensity, and correction for disparities in photovoltaic cell characteristics.

- K_t is a correction coefficient for fluctuations in conversion efficiency due to rises in the temperature of photovoltaic cells caused by sunlight. It is defined as the formula below.
  $Kt = 1 + \alpha (Tm - 25) / 100$
  Where, α: Maximum output temperature coefficient (%・°C -1) = -0.5 (%・°C -1) [Crystalline -type], T_m: Module temperature (°C) = T_{av} + ΔT, T_{av}: Mean monthly temperature (°C), ΔT: Module temperature increase (°C) = 18.4 (°C)

- η_{INV} is assumed to be 0.94.

Based on the above condition, the power generation by month is calculated as shown in Table 3-4-2.2. The annual power generation would be 1,459 MWh.

Table 3-4-2.2 Monthly power generation by the photovoltaic generation system

(Unit: MWh)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
129	121	139	130	125	112	103	96	109	129	132	134	1,459

[Source] JICA Study Team

2) Anticipated annual reduction of fossil fuels by the clean energy

By applying the emission factor by fuel listed on Table 3-4-2.3, the reduction of greenhouse gases by the photovoltaic power generation system will be calculated as follows:

(i) Calculation of power generated by photovoltaic system [MWh/year].

(ii) Amount of thermal generation [GJ/year] which will be offset by the photovoltaic system will be calculated as follow:

Power generation [MWh/year] × 3,600 [GJ/(1000MWh)] ÷ Thermal efficiency of generation

(iii) Annual reduction of fossil fuels is calculated as follow:

Offset amount of thermal generation [GJ/year] ÷ Amount of thermal

Table 3-4-2.3 Emission factor by fuel

Fuel	Amount of thermal	Emission factor
Coal	25.7 GJ/t	0.0247 tC/GJ
Crude oil (excluding NGL)	38.2 GJ/kl	0.0187 tC/GJ
Diesel Oil	37.7 GJ/kl	0.0187 tC/GJ
A Heavy Fuel Oil	39.1 GJ/kl	0.0189 tC/GJ
Natural Gas (excluding LNG)	43.5 GJ/10^3Nm^3	0.0139 tC/GJ

[Source] Ministry of the Environment / Ministry of Economy, Trade and Industry (May 2013) Calculation and Reporting manual on Greenhouse Gas Emissions (Ver 3.4)

It is calculated by applying 37% as thermal efficiency of generation based on the fact that the major thermal power generation in Nigeria is gas turbines, the reduction of fossil fuel is calculated to be 326,338 Nm3/year as follows:

- Offset amount of thermal generation [GJ/year]: 1,459 × 3600/1000 ÷ 0.37 = 14,195.7 GJ/year
- Annual reduction of fossil fuels [Nm^3/year]: 14,195.7 × 1000/43.5 = 326,338 Nm^3/year

3) Anticipated annual reduction of greenhouse gases by the clean energy

Annual reduction of greenhouse gases [t] by the photovoltaic power generation system will be calculated as follow:

- Offset amount of thermal generation [GJ/year] × Emission factor [tC/GJ] × 44/12

Hence, the annual reduction of greenhouse gases is calculated to be 723.5 t as follow:

- 114,195.7 × 0.0139 × 44/12 = 723.5 t

4) Reduction of payment for electricity

Electricity tariff applied for the Plant is 21.03 Naira/kW at a metered rate. After the installation of the photovoltaic system of the Project, the reverse power flow from the Plant to the national grid will not be generated '(1) Power demand of the target facility' under the 'Section 2-2-2-1 Preconditions'. In case that all the power generated by the photovoltaic system will be consumed within the Plant, the payment for the electricity will be reduced as indicated in Table 3-4-2.4, and thus the payment for electricity amounting to approx. 30 million Naira will be reduced. The expense for the operation and maintenance of the photovoltaic power generation system is estimated to be approximately 3 million Naira, the sustainability of this system is considered to be high.

The above stated electricity expenses to be reduced is calculated based on the data obtained by JICA Study Team.

Table 3-4-2.4 Reduction of payment for electricity to Abuja DISCO

(Unit: million Naira)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2.71	2.54	2.92	2.73	2.63	2.36	2.17	2.01	2.29	2.72	2.78	2.82	30.68

[Source] JICA Study Team

(2) Qualitative effects

Qualitative effects of the Project is indicated in Table 3-4-2.5

Table 3-4-2.5 Qualitative effects

Current conditions and problems	Project countermeasures	Degree of Project effects and improvement
1. Renewable Energy Master Plan states that the goal of installation capacity of renewable energy will reach 300 MW by 2017. However, the installed capacity of solar photovoltaic system was approximately 15 MW as of 2012.	Installation of 975 kWp of grid-connected photovoltaic system to Lower Usuma Dam Water Treatment Plant	The photovoltaic system to be installed by the Project will be mega-solar class and it will contribute to advancing the numerical goal of the installation of renewable energy. In addition, since grid-connected photovoltaic system has not yet been installed, this Project will be meaningful from the view that it provides the first case of grid-connected photovoltaic system.
2. Large scale solar photovolataic system such as mega solar system has not yet installed in Nigeria and data collection system regarding solar irradiation and actual power generation has not yet been developed.	Data management system including meteorological devices shall be procured and installed.	Through the procurement and installation of the data management system, proper operation and maintenance of the system will be secured. The system will not only provide the basic data required for the formulation of relevant solar photovoltaic plans such as solar irradiation, but also clarify the acutual operation ratio of solar photovoltaic system. Moreover, the technology transfer on the utilization of the data through the soft component will contribute to the installation of solar photovoltaic system in Nigeria.
3. Nigeria's development of legal system on dispersed power sources is underway.	The legal system will be developed through the soft component.	The photovoltaic system of this Project will be the first large-class photovoltaic system in Nigeria. The project implementation agency will be the Federal Ministry of Power. Through the soft component, staffs of FMOP will develop their knowledge based on Japan's Grid-Interconnection Code.
4. Although the promotion of renewable energy use is one of major goal of the energy policy in Nigeria, people are not familiar with photovoltaic system and thus the enlightenment of the system is lagging behind. Dissemination of photovoltaic systems is indispensable to the smooth policy implementation.	The Project will provide opportunities to people of Nigeria to visit and learn the photovoltaic system at the Plant which is located just outskirt of the Federal Capital Territory.	The project site is located nearby Abuja and it takes 30 to 40 minutes by car. Since, photovoltaic arrays will be arranged on and around No.3 and No.4 tanks which are located along the main road within the Plant, it will be easy for people to observe the system. (Perspective is attached at the beginning of this report.)

Current conditions and problems	Project countermeasures	Degree of Project effects and improvement
4. Personnel capable of operation and maintenance of photovoltaic system are scant in Nigeria.	Personnel will be able to gain necessary techniques through the soft component which will be carried out as a part of the Project.	As a component of the Project, soft component workshop will be held in Nigeria by consultant and photovoltaic system technician dispatched from Japan so as to properly transfer the technique and knowledge on the operation and maintenance of the photovoltaic system. Participants of the workshop shall be for not only personnel who will be in charge of operation and maintenance of the system, but also staffs of Abuja DISCO and Federal Ministry of Power. Through the participation from these organizations, personnel such as those who are in charge of policy formulation on the installation of photovoltaic system will enhance their techniques and knowledge on the promotion of dispersed clean energy power system. Therefore, it will contribute to promote the installation of clean energy and development of technical standard in Nigeria such as grid-connection code.