Noguchi Memorial Institute for Medical Research
University of Ghana
The Republic of Ghana

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

OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey on the project for Introduction of Clean Energy by Solar Electricity Generation System in the Republic of Ghana, and organized a survey team headed by Mr. Kyoji FUJII of Yachiyo Engineering Co., Ltd. between December 2009 and October 2010.

The survey team held a series of discussions with the officials concerned of the Government of Ghana, and conducted field investigations. 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 Ghana for their close cooperation extended to the survey team.

October 2010

Kyoko KUWAJIMA
Director General,
Industrial Development Department
Japan International Cooperation Agency

Summary

SUMMARY

(1) Overview of Ghana

The Republic of Ghana (hereafter referred to as Ghana), situated in the west of the African Continent, has a land area of approximately 239,000 km^2, population of approximately 23.9 million (2008, according to the UNFPA) and per capita GNI of US$670 (2008, World Bank).

Ghana has a typical primary commodity-dependent economy, relying on agriculture and mining; its three top exports are cacao, gold and timber, and the economy is thus prone to changes in international market conditions and the weather. When Ghana was confronted with economic difficulties from the late 1970s to the early 1980s, it attempted to conduct economic reconstruction based on structural adjustment from 1983 with support from the World Bank. As a result, it achieved a mean GDP growth rate of 5 percent from the late 1980s and earned respect as a model of structural adjustment in Sub-Saharan Africa. However, with the onset of the 1990s, the economy was once again plunged into recession due to decline in the international prices of gold and cacao and sudden inflation in the price of petroleum, which is the country's primary import. In response, the government applied for debt relief based on the Expanded HIPC (Heavily Indebted Poor Countries) Initiative in March 2001 and embarked on economic reconstruction based on fiscal austerity. Ghana subsequently maintained sound fiscal management as its basic policy and its economy recovered to a growth rate of approximately 6 percent in 2007. In 2009, due to the impact of the global financial crisis and recession, the real GDP growth rate fell to 4.5 percent.

(2) Project Background

Until the mid-1990s, Ghana obtained its domestic electricity supply and also exported electricity to neighboring Cote d'Ivoire and Togo from hydroelectric power generated by utilizing the abundant water resources provided by Lake Volta, which is an artificial lake. However, since Ghana has become unable to satisfy the growing domestic power demand through hydroelectric power alone, it has recently responded by promoting construction of thermal power plants and sharing electricity with Cote d'Ivoire via international interconnected grid. Furthermore, climate change has triggered frequent droughts in recent years and the generation capacity of Akosombo Hydroelectric Project has been declining. In response, the Government of Ghana has adopted diversification of energy sources and promotion of renewable energy as policy targets and is striving to strike a balance between improving the energy supply situation and mitigating environmental loads.

According to the Strategic National Energy Plan 2006-2020 (SNEP) that was compiled in 2006, the target is to raise the share of renewable energy out of total generating plant capacity to 10 percent by 2020, and the introduction of renewable energies such as biomass, wind power, solar power and hydropower, etc. is being advanced in line with this. Ghana has previously advanced the introduction of small-scale independent PV systems not connected to the grid in order to supply electricity in non-electrified areas, however, it has so far not introduced any large-scale grid-connected PV systems.

The Government of Japan has established fund support systems such as the Cool Earth Partnership and Hatoyama Initiative in order to support developing countries striving to balance greenhouse gas reductions with economic development and thereby contribute to climate stabilization. In line with this policy, JICA has been charged with actively utilizing Japanese advanced technologies in the field of clean energy including renewable energy; in particular it is required to utilize photovoltaic power generation technology, in which Japan has an extremely advantageous position, in international cooperation projects.

It was against such a background that the Ministry of Foreign Affairs implemented a survey of needs regarding environmental program grant aid utilizing photovoltaic power in Cool Earth Partner nations. As a result, a request was received from the Government of Ghana, and the preparatory survey for cooperation concerning the introduction of clean energy using photovoltaic power was implemented.

The Project aims to procure and install a grid-connected photovoltaic system with output of 315 kWp at the Noguchi Memorial Institute for Medical Research (NMIMR) attached to the University of Ghana.

(3) Outline of the Survey Findings and Contents of the Project

JICA dispatched the preparatory survey team to Ghana from December 6 to December 12, 2009 (the first site survey) and from March 12 to March 30, 2010. During these visits, the team reconfirmed the contents of the request and discussed the contents of cooperation with related officials in Ghana (responsible agency: University of Ghana, implementing agency: Noguchi Memorial Institute for Medical Research), surveyed the project site and collected related data.

On returning to Japan, the survey team examined the necessity of the Project, its social and economic impacts and validity based on the site survey data, and they compiled the findings into the preparatory survey report (draft). JICA dispatched the third site survey (outline explanation) team to Ghana from August 1 to August 7, 2010 in order to explain and discuss the preparatory survey report (draft) and reach a basic agreement with the Ghanaian authorities.

As a result of the survey, the Project will entail the procurement and installation of a photovoltaic system (output 315 kWp) and related transformers, 415 V circuit breakers, 415 V distribution lines and distribution line equipment on the target site of Noguchi Memorial Institute for Medical Research of the University of Ghana. Since the said photovoltaic system will be the biggest of its kind in Ghana and will be connected to the grid, which is very unusual in that country, ample consideration shall be given in design to ensure that operation and maintenance following completion can be conducted smoothly. Moreover, to ensure that the Project contributes to the future dissemination of grid-connected photovoltaic equipment in Ghana, transfer of technology will be carried out concerning operation and maintenance and grid connection in the soft component.

Outline of the Basic Plan

	Procurement and installation of the following photovoltaic system equipment	Quantity
Equipment procurement and installation	PV module	315 kW
	PV module frame	1 set
	Junction box (quantity varies according to the maker)	1 set
	Collecting box (quantity varies according to the maker)	4 or more
	Power conditioner	4
	Step-up transformer	1
	Display unit	1 set
	Instrumentation	1 set
	Wiring materials	1 set
	Grounding works materials	1 set
Equipment Procurement Plan	PV system replacement parts, maintenance tools and test apparatus	1 set

(4) Project works period and rough project cost

In the event where the Project is implemented under Japan's Grant Aid Scheme, it is estimated that the rough project cost will be approximately (***confidential***) yen (the Government of Japan's share: approximately (***confidential***) yen, the Government of Ghana's share: approximately 910,000 yen). The main items that will be borne by the Ghana side will be the cutting of plants and trees on the PV panel installation site (approximately 300,000 yen) and the payment of commission fees regarding the fund transfer to a Japanese bank (approximately 610,000 yen). The Project works period including the implementation design will be approximately 12 months.

(5) Project evaluation

Based on the validity and efficacy of the Project described below, the relevance of grant aid implementation is judged.

[Relevance]

- Benefitting population

  Project implementation will enable employees (approximately 220) of Noguchi Memorial Institute for Medical Research to receive power supply from PV generation. Moreover, the reduction in emissions of greenhouse gases enabled by PV generation will benefit all the people of Ghana.

- Contribution to stable operation of public welfare facilities

  In addition to contributing to power supply for Noguchi Memorial Institute for Medical Research (a public welfare facility), the Project will aid in the dissemination and public education of renewable energy.

- Operation and maintenance capacity

  Since the equipment and materials to be procured in the Project can be comfortably operated and maintained under the present technical capacity in Ghana, they will present no particular problems regarding implementation of the Project.

- Contribution to development plans in Ghana

  The project will contribute to the national energy policy and strategic national energy plans being implemented by the Government of Ghana.

- Government of Japan's Grant Aid Scheme

  The Government of Japan's Grant Aid Scheme will not hinder implementation of the Project. Moreover, since the Project contents and schedule are feasible for implementation under the Grant Aid Scheme, the Project can be implemented without any major difficulty.

- Necessity and superiority of Japanese technology

  In the Project it will be possible to utilize Japanese advanced technology in the field of clean energy including renewable energy. In particular, it will be possible to utilize extremely superior Japanese technology in the field of photovoltaic power generation.

[Efficiency]

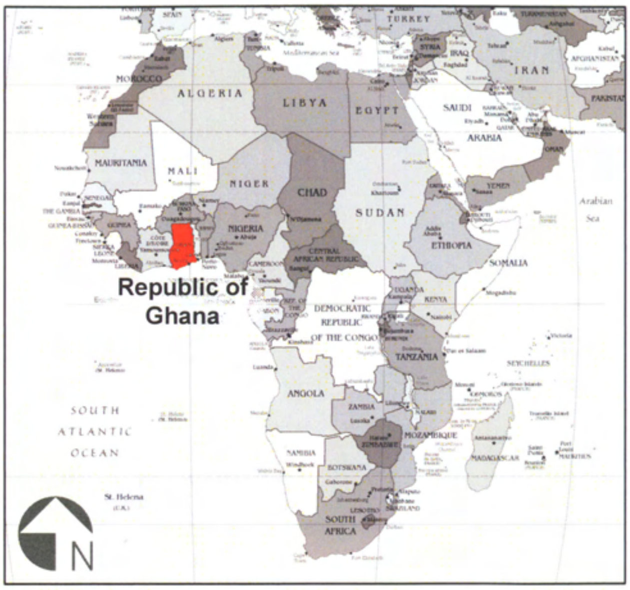
In terms of quantitative effects, power generating plant capacity based on renewable energy (biomass, photovoltaic power, micro-hydropower, etc.) will increase from 1,000 kW in 2009 to 1,315 kW in 2015, while CO_2 emissions will be reduced by 220t /year as a result of such power generation.

In terms of qualitative effects, the Project will disseminate knowledge about photovoltaic power generation, impart technical know-how and experience on large-scale grid-connected PV systems and contribute to the future dissemination of PV systems, etc.

Accordingly, since Project implementation will have major anticipated effects and contribute to realizing the energy policy of Ghana, it is deemed to be relevant for implementation under the Government of Japan’s Grant Aid Scheme. Moreover, the Ghanaian side is deemed to possess adequate personnel and budget capability to host the Project and handle the operation and maintenance of equipment after its completion.

CONTENTS

■ Map of the Republic of Ghana



■ Map of Africa

■ Map of the Requested Site in Accra

Map of the Requested Site for Installation of PV Panels in the Republic of Ghana

List of Tables and Figures

Chapter 2

Abbreviations

ＢＣＳ	Battery Charging Station
ＤＡＣ	Development Assistance Committee
ＤＡＮＩＤＡ	Danish Development Agency
ＥＣ	Energy Commission
ＥＣＧ	Electricity Company of Ghana
ＥＩＡ	Environmental Impact Assessment
Ｅ／Ｎ	Exchange of Notes
ＥＰＡ	Environmental Protection Agency
Ｇ／Ａ	Grant Agreement
ＧＤＰ	Gross Domestic Product
ＧＥＤＡＰ	Ghana Energy Development and Access Project
ＧＥＦ	Global Environmental Facility
ＧＮＩ	Gross National Income
ＧＰＲＳ	Growth and Poverty Reduction Strategy
ＨＩＰＣ	Heavily Indebted Poor Country
ＩＤＡ	International Development Association
ＩＥＣ	International Electrotechnical Commission
ＩＭＦ	International Monetary Fund
ＩＳＯ	International Organization for Standards
ＪＥＡＣ	Japan Electric Association Code
ＪＩＣＡ	Japan International Cooperation Agency
ＪＩＳ	Japanese Industrial Standards
ＭＤＧｓ	Millennium Development Goals
ＭＯＥ	Ministry of Energy
ＭＤＲＩ	Multilateral Debt Relief Initiative
ＮＥＤ	Northern Electricity Department
ＮＥＰ	National Energy Policy
ＮＥＳ	National Electrification Scheme
Ｏ&Ｍ	Operation and Maintenance
ＯＤＡ	Official Development Assistance
ＯＪＴ	On the Job Training
ＰＲＳＰ	Poverty Reduction Strategy Paper
ＰＵＲＣ	Public Utilities Regulatory Commission
ＰＶ	Photovoltaic
ＲＥＳＰＲＯ	Renewable Energy Service Project
ＳＨＥＰ	Self Help Electrification Project
ＳＨＳ	Solar Home System

SNEP	Strategic National Energy Plan
UNDP	United Nations Development Program
UNFPA	United Nations Population Fund
VRA	Volta River Authority

CHAPTGER 1 BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

1-1 Background of the Project

Until the mid-1990s, the Republic of Ghana (hereafter referred to as Ghana) obtained its domestic electricity supply and also exported electricity to neighboring Cote d'Ivoire and Togo from hydroelectric power generated by utilizing the abundant water resources provided by Lake Volta, which is an artificial lake. However, since Ghana has become unable to satisfy the growing domestic power demand through hydroelectric power alone, it has recently responded by promoting construction of thermal power plants and sharing electricity with Cote d'Ivoire via international interconnected grid. Furthermore, climate change has triggered frequent droughts in recent years and the generation capacity of Akosombo Hydroelectric Power Plant has been declining. In response, the Government of Ghana has adopted diversification of energy sources and promotion of renewable energy as policy targets and is striving to strike a balance between improving the energy supply situation and mitigating environmental loads.

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The Government of Japan has established fund support systems such as the Cool Earth Partnership and Hatoyama Initiative in order to support developing countries striving to balance greenhouse gas reductions with economic development and thereby contribute to climate stabilization. In line with this policy, Japan International Cooperation Agency (hereinafter referred to as JICA) has been charged with actively utilizing Japanese advanced technologies in the field of clean energy including renewable energy; in particular it is required to utilize photovoltaic power generation technology, in which Japan has an extremely advantageous position, in international cooperation projects.

It was against such a background that the Ministry of Foreign Affairs implemented a survey of needs regarding Program Grant Aid for Environment and Climate Change utilizing photovoltaic power in Cool Earth Partner nations. As a result, a request was received from the Government of Ghana, and the preparatory survey for cooperation concerning the introduction of clean energy using photovoltaic power was implemented.

The Project aims to procure and install a grid-connected photovoltaic system with output of 315 kWp at the Noguchi Memorial Institute for Medical Research (hereinafter referred to as NMIMR) attached to the University of Ghana.

1-2 Environmental and Social Consideration

(1) Regulatory Regime concerning Environmental Impact Assessment, etc.

According to the Ghana Environmental Assessment Regulations, 1999, Legislative Instrument (LI) 1652, it is obligatory to conduct an Environmental Impact Assessment (EIA) if any one of the following five cases is applicable when constructing electric power facilities.

① Construction of steam power plant
② Construction of dam and hydropower plant
③ Construction of combined cycle power plant in a national park
④ Construction of an atomic power plant
⑤ Construction of transmission lines

Since the Project entails the installation of a photovoltaic system and none of the above five cases apply, there will be no need to implement an EIA.

However, on visiting the Environmental Protection Agency (EPA), since it was explained that it would be necessary to obtain an environmental permit from the EPA prior to implementing the Project, it was decided to take the following procedure.

(1) The Noguchi Memorial Institute for Medical Research submits an EIA registration form to the EPA (submitted on March 24, 2010, registration No. AC/GAR/CE/258). The commission for registration and permission is notified by the EPA a few days later, and this is paid by the NMIMR.

    The main items that need to be specified on the EIA registration form are as follows:
    - Project outline
    - Expected environmental impacts

(2) The EPA reviews the environmental impacts based on the submitted project information and decides on the necessary procedures for securing environmental permit. The review findings and procedures are notified to the NMIMR. (Environmental Permit for the Project was issued by the EPA on 11th August 2010, permit No. 2150).

The validity of the Environmental Permit is 18 months from the date of permission and if the Project is not completed within 18 months, the permission must be renewed.

(2) Expected Environmental Impacts

This project is categorized as "Category C" project which has nil or minimal negative impact on natural and social environment under JICA's Guideline for Environmental and Social Considerations. Since the planned photovoltaic system will not use batteries, there will be no major environmental impacts arising from the disposal of waste batteries.

When preparing the site, it will be necessary to conduct leveling, tree cutting (or relocation) and removal of anthills, however, all of these activities entails only minimal environmental impacts.

CHAPTGER 2 CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Superior Objectives and Project Objectives

In Ghana, the development of a diverse mix of energy sources has been raised as a goal of energy policy in order to achieve stable energy supply and energy security. The introduction of renewable energy sources is being advanced as one of the methods for realizing this goal.

In accordance with this policy, Ghana intends to increase the ratio of renewable energy in electric power supply to 10 percent by 2020. The Project aims to contribute to the realization of this target for renewable energy introduction and, as a measure for addressing climate change (mitigation measure) by the Ghanaian government, to reduce consumption of thermal power generation fuels and emissions of greenhouse gases through conducting photovoltaic power generation.

2-1-2 Outline of the Project

The Project aims to install a grid-connected photovoltaic system at the Noguchi Memorial Institute for Medical Research (NMIMR) attached to the University of Ghana with a view to realizing the above objectives. Through doing so, it is hoped to increase the ratio of renewable energy in electric power supply and reduce greenhouse gas emissions. The scope of cooperation within this will include the procurement and installation of PV (Photovoltaic) generating equipment.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

Based on the request, the Project intends to procure and install a photovoltaic system (output 315 kWp) and related transformers, 415 V circuit breakers, 415 V distribution lines and distribution line equipment on the target site of Noguchi Memorial Institute for Medical Research of the University of Ghana. Since the said photovoltaic system will be the biggest of its kind in Ghana and will be connected to the grid, which is very unusual in Ghana, ample consideration shall be given in design to ensure that operation and maintenance following completion can be conducted smoothly. Moreover, to ensure that the Project contributes to the future dissemination of grid-connected photovoltaic equipment in Ghana, transfer of technology will be carried out concerning operation and maintenance and grid connection in the soft component.

The Project photovoltaic system will supplement electricity supply to the NMIMR via the distribution facilities of the Electricity Company of Ghana (ECG) installed on the grounds of the University of Ghana. The connection point between the ECG distribution system and the University of Ghana is an 11 kV distribution line, however, because Ghana has no regulations for the grid connection of generating equipment, design will be carried out according to grid connection regulations in Japan.

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

(1) Temperature and Humidity Conditions

Temperatures are high and vary between 26°C and 33°C throughout the year. Out of the equipment to be procured in the Project, precision instruments such as power conditioner will be installed inside buildings (power conditioner room) to be constructed under the Project in order to prevent the equipment being affected by outside temperatures. Moreover, when planning the specifications of buildings, it will be necessary to design air conditioning and ventilation to ensure that room temperatures do not exceed the permissible temperature of precision instruments, i.e. 40°C taking the heat from equipment into account.

(2) Rainfall

Since heavy rain in Ghana is concentrated in the rainy season, drainage facilities, etc. shall be designed around solar panel installation areas to ensure that rainwater doesn’t infiltrate the panels (see 2-2-3 Outline Design Drawings).

2-2-1-3 Socioeconomic Conditions

The Project site is NMIMR located inside the grounds of the University of Ghana in the capital Accra, and the entrance to the university is placed under around-the-clock guard. Moreover, since Accra has stable civil order, there should be no major problems regarding photovoltaic equipment installation works and laying of distribution cables.

Furthermore, because roughly 80 percent of people in Ghana are Christians, it should be noted that there are numerous public holidays around special festivals such as Christmas when planning the implementation schedule.

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

Large-scale construction projects for commercial facilities and office buildings are routinely conducted in the capital Accra and there are numerous general contractors that are able to perform such works including electrical works. However, since works contractors range in scale from small to large, it will be necessary to display ample consideration regarding implementation period and quality.

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

Since there are local offices of foreign affiliated general construction firms as well as local contractors in Accra, it is relatively easy to secure manpower, transporting vehicles and construction machinery and materials in Ghana, and it will be possible to contract the building works, foundation works and distribution line installation works in the Project to local contractors.

Meanwhile, local contractors have experience of solar panel installation works and related equipment installation works but they have not experienced the scale planned in the Project; moreover, highly skilled technicians are required in order to implement installation and conduct adjustment and testing afterwards. Accordingly, it will be necessary to dispatch engineers from Japan and/or the third country in order to conduct quality control, technical guidance and schedule management.

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

NMIMR receives electricity supply from the ECG via the distribution equipment within the University of Ghana, and it also has a diesel generator for use in case the ECG power supply is interrupted. Since NMIMR does not possess photovoltaic generating equipment, the institute’s operation and maintenance staff have no experience or know-how about managing such systems. Therefore, in the Project, it will be necessary to conduct appropriate technology transfer for the Maintenance Department in charge of operating and maintaining the photovoltaic equipment.

In Ghana, approximately 1 MW of photovoltaic systems comprising mainly solar home systems (SHS) have been installed mostly in non-electrified rural areas, however, large-scale photovoltaic systems have only been introduced in two cases. These are, ① the 50 kW system (a grid-connected system but currently the inverter is broken down) that was installed on the offices of the Ministry of Energy (MOE) under assistance from the Government of Spain in 1998, and ② the 4.5 kW solar tracking photovoltaic system that was installed on the car park of the Energy Commission (EC) offices under assistance from the Government of Germany in 2008. Accordingly, even the MOE and EC, which are responsible for energy and electric power policy in Ghana, and power companies such as ECG do not possess operation and maintenance technicians with sufficient knowledge and experience of photovoltaic systems. Furthermore, Ghana possesses no technical standards or regulations, etc. concerning the grid connection of photovoltaic systems. In order to conduct technology transfer for operation and maintenance of Project equipment, a PV[1)] System Operating Committee (provisional title) will be established to provide appropriate technology transfer regarding photovoltaic system (including grid connection system) operation and maintenance. At the same time, the roles of each member will be defined in order to ensure that the introduced photovoltaic system can be continuously operated without any hitches.

Furthermore, since the equipment installed in the Project will be operated in tandem with grid power supplied by ECG, an appropriate maintenance manual concerning grid-connected operation (including a reverse flow system) will be provided in the soft component to facilitate the effective and efficient operation of the installed equipment.

2-2-1-7 Policy regarding Grading of Facilities and Equipment, etc.

Taking into account the conditions described above, the scope and technical level of equipment procurement and installation in the Project will be compiled based on the following basic policy.

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

In order to realize a design that is both technical 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 shall be minimized to promote compatibility and the minimum required equipment mix, specifications and quantities shall be selected.

(2) Concept regarding technical levels

Concerning the specifications of photovoltaic system instruments procured in the Project, in consideration of the technical level of the Maintenance Department of NMIMR that will manage 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 Ghana by sea. The distance from the port of Tema to the Project site is only around 30 km; moreover, since road

1) PV: The abbreviation for Photovoltaic, this refers to photovoltaic cells.

conditions between the port and site are good, there shouldn't be any problems concerning the overland transportation of equipment.

Noguchi Memorial Institute for Medical Research (NMIMR, the Project target site) was constructed under grant aid from the Government of Japan, and Japanese doctors, etc. are still stationed there to conduct research work. In particular, the animal experiment block requires a constant electricity supply for maintaining ventilation and the sanitary environment. Accordingly, when carrying out the installation works, it will be necessary to carefully explain the works methods to institute personnel, to jointly compile a detailed implementation schedule, and to confirm the methods for minimizing power interruption times when connecting the photovoltaic system to the existing power grid.

Regarding the implementation schedule, since the heaviest rainfall in the Project target area occurs between May and July, it will be necessary to plan excavation and backfilling work, etc. outside of this time frame.

2-2-2 Basic Plan (Equipment Plan)

2-2-2-1 Preconditions

(1) Power demand of the target facilities

The main building and auxiliary buildings of NMIMR receive power supply from the commercial power grid and a private generator (in case grid power is interrupted).

The Survey Team measured distribution voltage, frequency, peak power and load factor inside the Institute using a digital multi meter from March 16 through March 26, 2010. Figure 2-2-2.1 shows the typical load curves for weekdays and holidays, and Table 2-2-2.1 gives an outline of the measurement results. Since power load ranges from a peak of 400 kW during weekdays to a minimum of around 150 kW on holidays (daytime), it is assumed that the power load of the NMIMR while the photovoltaic system is generating power will be in the range of 150~400 kW. Commercial power supply interruptions hardly occurred at all during the survey.

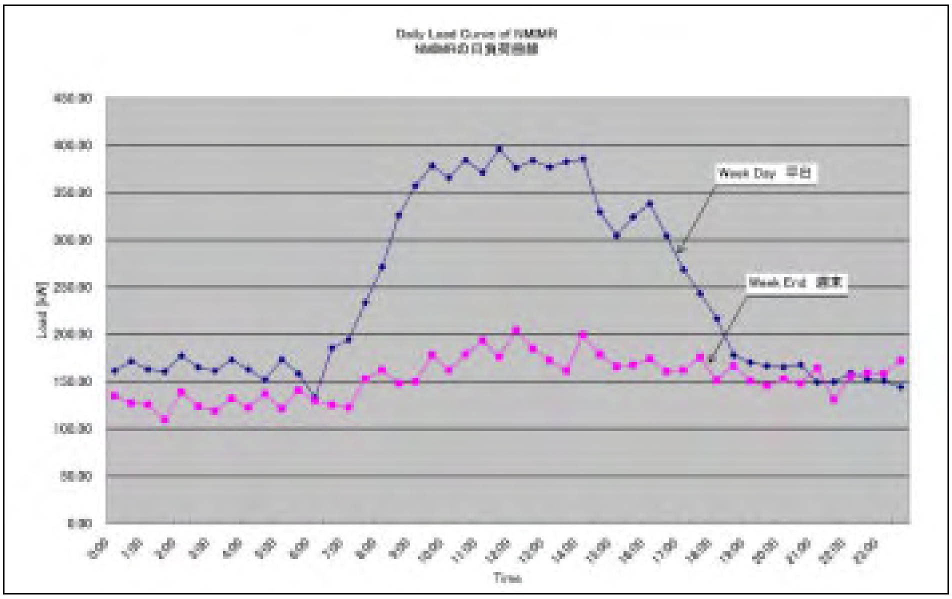

Figure 2-2-2.1 Daily Load Curve of NMIMR

Table 2-2-2.1 Electric Power Quality and Load Measurement Results

Item		Measured Value	ECG Operating Standard
Distribution voltage (V)		395~418	400±10%
Frequency (Hz)		49.8~50.5	50±5%
Peak power (kW)	Week day	400	-
	Holiday	200	-
Load factor (%)		Measured value: 0.90~0.94 (*) Estimate value: Around 0.8	0.9 or more

(*) Measured values of the load factor are between 0.90~0.94 due to malfunctioning of the power factor converter, however, the actual load factor is estimated to be around 0.8.

According to the above measurement findings, since peak power is 400 kW (500 kVA assuming a power factor of 0.8) with respect to distribution equipment capacity of 415/240 V (transformer capacity 750 kVA) inside NMIMR, the power distribution equipment has ample spare capacity.

Compared to the ECG operating standards, the distribution voltage and frequency are within the control values, however, the power factor exceeds the control level because there is no capacitor for improving power factor on the 415 V side.

Power load in NMIMR on Saturdays and Sundays drops to around 40~50 percent of the weekday level. It has been calculated that the photovoltaic generating capacity will be 315 kWp and that photovoltaic output based on the measured solar irradiation could exceed the power load of NMIMR.

1) Measured solar irradiation

Measurement area : Inside NMIMR

Measured date : March 19, 2010 (Friday), clear with cloud

Measurement equipment : Simple pyranometer

Table 2-2-2.2 Flat and Incline Surface Solar Irradiation at NMIMR

Measured surface	Time	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	Actinometer
Horizontal	Wh/m^2	327.5	354.0	447.5	607.0	249.5	817.5	850.5	868.5	890.5	893.0	831.5	645.0	652.5	501.0	474.5	136.5	87.5	162.5	99.5	19.5	9,916
5 degrees south-facing incline	Wh/m^2	305.0	397.0	477.5	667.0	250.5	871.5	905.5	912.5	918.5	936.0	856.0	646.0	697.5	531.0	490.0	151.0	94.5	182.5	94.5	23.0	10,407

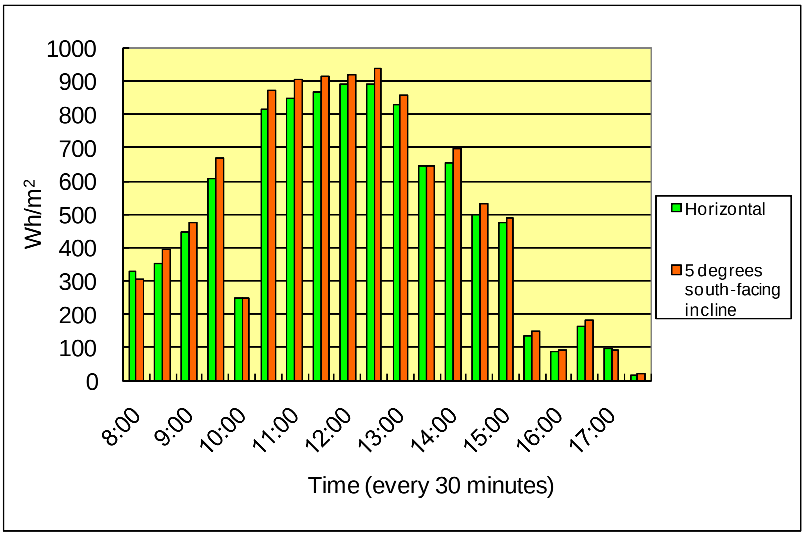

Figure 2-2-2.2 Solar Irradiation Measurement Results (March 19, 2010)

The monthly average flat surface solar irradiation in Accra is 4~6 $kWh/m^2/day$. Since the value measured on March 19, 2010 was 9.9 $kWh/m^2/day$, it is guessed that weather was fine and solar irradiation conditions were especially good on this day.

2) Power load and photovoltaic power output

Using the solar irradiation measurement results from March 19, photovoltaic power output was calculated and comparison was made between power load and photovoltaic power output at NMIMR. The results are shown in Tables 2-2-2.3 and 2-2-2.4 and Figures 2-2-2.3 and 2-2-2.4.

Table 2-2-2.3 Power Load and Generated Electricity Balance at NMIMR (Saturday)

Time	Unit	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00
Load Mar.20(Sat)	kW	161.9	141.9	149.9	171.2	161.9	178.4	193.1	176.2	204.4	184.7	172.5	161.4	199.1	176.6	165.8	167.3	173.7	160.5	162.0
Generated output	kW	64.1	83.5	100.3	140.2	52.6	183.2	190.3	191.7	192.9	196.7	179.9	135.8	146.5	111.5	103.0	31.7	19.8	38.3	19.8
Surplus power	kW	0.0	0.0	0.0	0.0	0.0	4.8	0.0	15.5	0.0	12.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

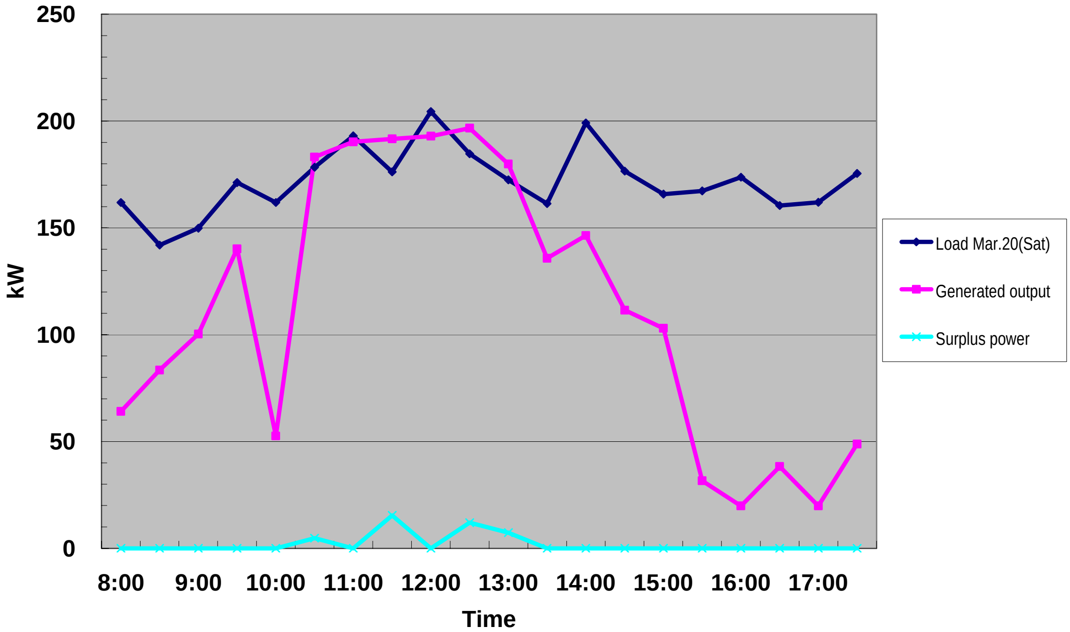

Figure 2-2-2.3 Power Load and Generated Electricity Balance at NMIMR (Saturday)

Table 2-2-2.4 Power Load and Generated Electricity Balance at NMIMR (Sunday)

Time	Unit	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00
Load Mar. 21 (Sun)	kW	124.3	130.4	134.6	135.7	166.4	169.2	156.1	177.2	173.3	176.6	176.6	168.3	168.1	193.4	206.5	202.1	228.5	184.1	182.7
Generated output	kW	64.1	83.5	100.3	140.2	52.6	183.2	190.3	191.7	192.9	196.7	179.9	135.8	146.5	111.5	103.0	31.7	19.8	38.3	19.8
Surplus power	kW	0.0	0.0	0.0	4.5	0.0	14.0	34.2	14.5	19.6	20.1	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

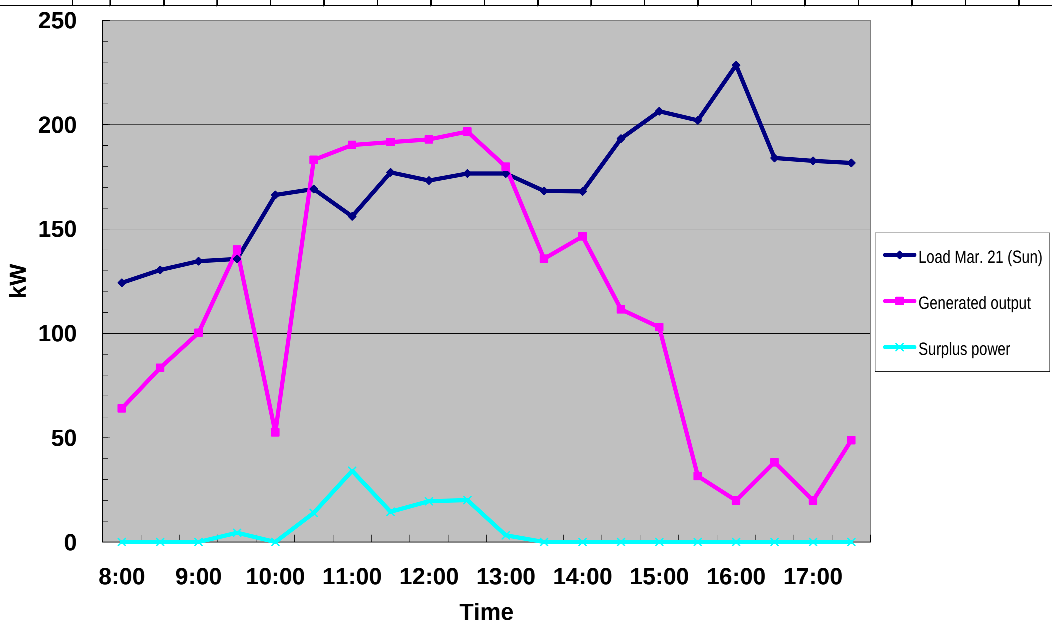

Figure 2-2-2.4 Power Load and Generated Electricity Balance at NMIMR (Sunday)

According to the above results, there are periods during the low power load Saturdays and Sundays when the photovoltaic power output is greater than the power load, and it is possible that maximum excess power of around 35 kW will be generated. In such cases, the excess photovoltaic power generated at NMIMR will be supplied to the University of Ghana via the campus distribution system. The University of Ghana receives 11 kV power from the ECG grid and distributes this to each facility on campus, however, because the university's contract power is around 5,000 kVA (estimate), which is sufficiently large to accommodate the scale of photovoltaic power generation and excess power, the excess power will be consumed inside the campus and there will be no occurrence of reverse flows to the ECG distribution grid.

(2) Systems and technical examination regarding grid connection

1) Legal systems and regulations concerning grid connection

The only legal system concerning private power generation and grid connection in Ghana at the present time is the Grid Code, which requires a license in order to retail privately generated electricity to third parties. There are currently no regulations or technical standards relating to reverse flows. It has been confirmed with the MOE that the Project grid-connected PV system will not be subject to any regulations during introduction.

There are no legal systems or regulations concerning connection of renewable energy to the power grid. The Renewable Energy Bill of Ghana was compiled by the Energy Commission in 2009 and submitted to the Cabinet in March 2010.

The RE Bill aims to promote the development and utilization of renewable energy, to diversify energy sources in order to improve energy security, to promote electrification using renewable energy and to prepare controls, etc. The main contents are as follows.

① Licensing system for operating renewable energy businesses

Applicants hoping to establish a renewable energy business submit the application form to the Commission, which decides whether to grant permission upon examining technical data, national security, public safety, food safety, health and environmental issues based on the application. Licenses are divided according to the five fields of production, transportation, storage, construction and repair.

(Commission here refers to the Commission stipulated in Section 4 of the Energy Commission Act 1997 (Act541)).

② Feed-in Tariff

This system is established in order to retail electric power generated from renewable energy. It comprises items concerning the renewable energy purchasing obligation, feed-in tariff prices and grid connection.

a Power companies must purchase a set ratio of electricity generated from renewable energy.

b The PURC (Public Utilities Regulatory Commission) decides the said ratio jointly with the Energy Commission.

c Power companies must not determine the feed-in tariff price until the PURC decides the purchase price.

③ Upgrading of transmission and distribution lines for grid connection

a When renewable energy (RE) power producers make requests for grid connection, the power companies will upgrade transmission and distribution systems as quickly as possible and at appropriate prices in order to facilitate interconnection.

b The costs of upgrading lines will be borne 50-50 between the transmission and distribution company and the RE power supply company.

④ Ghana Renewable Energy Fund (GREEN Fund)

This is established in order to promote the use and development of renewable energy.

a The Fund is used for feed-in tariffs, investment assistance, renewable energy research and development, standard formulation for RE use, RE production equipment, remote location mini-grids and off-grid systems, and RE development for other than electric power. The Energy Commission decides how the Fund will be used.

b The Fund is financed by grants from overseas governments, contributions from individuals and international organizations, special funds, feed-in tariffs and the budget decided by the national diet, etc.

⑤ Violations and punitive provisions

Punitive provisions are also stipulated for cases of violations against the law.

⑥ Guidelines

The Energy Commission decides and announces the guidelines for implementing RE projects.

⑦ Rules

The MOE formulates the following kinds of regulations at the recommendation of the Energy Commission:

a Standards for the construction, operation, maintenance and equipment installation of power plants that use bio fuels

b Standards for development and utilization of RE

c Technical standards for utilization of RE

d Control and regulation of bio fuels and firewood fuel, etc.

2) Examination of power quality

Items that need to be examined when introducing a grid connection system to photovoltaic generating equipment are flicker and higher harmonics. Upon conducting a hearing investigation at the MOE and Energy Commission, ECG supply regulations (Electricity Supply and Distribution: Technical and Operational Rule 2005) allow for a voltage fluctuation of ±10%, or ±15% if less than a minute, for frequency fluctuations of up to ±5% and require a power factor of 0.9 or more on distribution lines of 11 kV or less. However, there are no standards prescribed concerning flicker and higher harmonics, etc. in Ghana. Moreover, since there are no large factories or construction sites near the University of Ghana, there is no danger of higher harmonic currents arising from the load side. Concerning the photovoltaic system that will be introduced in the Project, by requiring the current distortion level of power conditioners to less than 5% for overall current and less than 3% for each order in accordance with Japanese codes and standards, power supply quality in terms of higher harmonics will be satisfied as the same level of Japan. As for a standard for flicker, a result of research in Japan recommends that the level of voltage flicker represented by ΔV_{10} should be lower than 0.45V and IEC6100-4-15 also defines an international standard for flicker. These standards shall be adopted in order to secure the required quality of power.

3) Examination of Voltage Rise around Grid Connection Points

When a PV system is connected to the grid and there is reverse flow, voltage rise occurs around the grid connection point, and it is necessary to take steps to ensure that the range of voltage increase doesn’t deviate from the power company’s control standard. The study here targets distribution line between the M substation of ECG, from which the University of Ghana receives power, and the grid connection point of the PV system, and it aims to confirm that the receiving voltage of load located closest to the interconnection point within the university does not deviate from the control standard range. In order to conduct the examination, it is necessary to have data on the power line specifications and load, etc. on the distribution line when the load is light. However, since no data are maintained on power load inside the University of Ghana, it is difficult to conduct examination during low load. Accordingly, it was confirmed that receiving voltage of the nearest load doesn't exceed the control level when all load being cut off, i.e. when reverse flow occurs from the grid-connected PV system to the distribution line in the unloaded state (a harsher state than the low-load condition). The examination was conducted assuming the secondary side bus line of M substation to be an infinite bus line and the transmission voltage on the distribution line to be 11 kV.

NMIMR is just one of the power loads within the University of Ghana; it receives power supply along 11 kV distribution line via the university's receiving equipment, and the distance between M substation and NMIMR is approximately 3.0 km. This 11 kV distribution line has a cross-sectional area of 95 mm^2 and comprises a 3-core CV cable. Concerning the line constant of this cable, figures indicated in specifications obtained in neighboring countries that use similar British standard cable have been applied. Moreover, according to the electricity supply and operational rule of ECG (the Electricity Supply and Distribution: Technical and Operational Rules 2005), it is stipulated that voltage on distribution lines of 11 kV or less should be controlled at ±10%. According to the results of examination shown in Table 2-2-2.5, even if reverse flow occurs from the grid-connected PV system to an unloaded distribution line, received power voltage of the nearest load only increases by around 0.59 V and stays within the upper control limit of 264 V. Therefore, there is deemed to be no problem.

Table 2-2-2.5 Results of Examination on Distribution Line Voltage at the Grid Connection Point and the Nearest Low-Voltage Consumer

Distance between M substation and NMIMR	Sending voltage	Cable type	R [Ω/km]	Reverse flow current from PV	Voltage rise at high voltage line	Received voltage at the closest low voltage consumer
3.0km	11kV	CV, 3 Core, 95mm sq	0.248	21.0A	27.0V	240.59V

Source: JICA Survey Team

4) Potential installation capacity of grid-connected photovoltaic power generation

ECG supplies power to NMIMR, while it receives power from the generating company VRA (Volta River Authority). According to the power transmission regulations of Ghana (Grid Code, Art 12.22), power transmission and distribution line operators aim to preserve line frequency in the range of 49.8 Hz to 50.2 Hz (50±0.2Hz); accordingly, the introduction of renewable energy must not hinder the operation of such line frequency.

In Ghana, combined cycle power plants have been introduced and acceptable frequency drop for such thermal power plants is around -1.5Hz. If the frequency drops further, rotating speed will reach close to resonance frequency of turbine blades and the plant can not continue operation. Even though ECG's operational rules allow frequency fluctuation of 50Hz±5% (50Hz±2.5Hz), it is not realistic considering above mentioned limitation in frequency drop of thermal power plants. Moreover, measured frequency fluctuation of ECG's distribution system is from 49.8Hz to 50.5Hz (-0.4%~+1%). Therefore, the number in National Grid Code (±0.2Hz) is applied as an acceptable range for frequency fluctuation to determine allowable capacity of grid connected PV system.

In cases where generating equipment drops off the network due to accidents and so on, the frequency declines because the balance between power demand and supply is upset. The following formula is used to express this relationship.

$$\Delta F = -\frac{1}{K} \times \frac{\Delta P}{P} \times 100$$

Where,

ΔF : Grid frequency fluctuation (Hz)
ΔP : Output or load of the generator concerned (MW)
P : Total load of grid (MW)
K : Grid constant (KG + KL) (%MW/0.1Hz)
KG : Frequency characteristics of the generator (%MW/0.1Hz)
KL : Frequency characteristics of the network (%MW/0.1Hz)

The generating output of photovoltaic systems is subject to sudden drops due to changes in the weather. In such cases, it is necessary to limit the drop in generating output so that the grid frequency stays within the range of 50±0.2 Hz, i.e. to limit the capacity of the photovoltaic system connected to the grid. The grid constant (K) in Ghana is unknown, however, grid constant (K) generally varies in the range of 0.85~1.4% MW/0.1 Hz and 1%MW/0.1 Hz is statistically the most frequent level[2)]. Therefore, assuming the grid constant in Ghana to be 1%MW/0.1 Hz, the potential installation capacity of photovoltaic power generation shall be examined. The potential installation capacity of grid-connected photovoltaic power generation (ΔP) assuming fluctuation in grid frequency to be ΔF is expressed by the following formula.

2) In Japanese power companies, 7 out of 9 companies adopt a grid constant of 1% MW/0.1Hz for load frequency control (LFC) (Institute of Electrical Engineers (March 2002) Load Frequency Control at Normal Times and Emergencies in Power Grids, Institute of Electrical Engineers Technical Report No. 869)

$$\Delta P = -\frac{\Delta F \times K \times P}{100}$$

Where,

ΔF=-0.2 Hz

P=1,500 MW (peak power demand in Ghana in 2010)

K=1.0% MW/0.1Hz

In this case, ΔP=30 MW; therefore, the potential installation capacity of grid-connected photovoltaic power generation in the current situation is around 30 MW. Currently only 54.5 kWp of grid-connected photovoltaic system capacity is connected to the grid in Ghana, so even if another 315 kWp of capacity is installed in the Project, the above potential installation capacity will still be greatly undercut and the Ghanaian power grid will not be badly affected.

5) Examination of technical requirements concerning grid connection

Since Ghana has no technical standards or regulations concerning grid connection of generating systems, the technical requirements for connecting the photovoltaic system to the grid will be examined according to Japanese grid-connection regulations. In the Project, voltage on the distribution grid that will be connected to the photovoltaic system is 415 V (low voltage), however, since the University of Ghana receives power from ECG at 11 kV, Japanese high voltage grid connection regulations (6.6 kV) shall be applied.

In connections with high voltage distribution lines, it is required to install protective devices for ensuring disconnection of the generating system from the grid when problems occur in the generating equipment or grid. Moreover, when the circuit breakers in distribution substations detect an earth fault in the distribution grid and respond by breaking for a set time and then closing again, if generators connected to the grid have continued operation, there is risk that the circuit breakers will come on at asynchronous times. Accordingly, it is also compulsory to install line non-voltage confirmation devices.

Table 2-2-2.6 shows the protective relay that is required for the high voltage interconnection of generating equipment. In the Project, reverse flows to the grid will not occur, however, according to the grid connection regulations, even in cases of no reverse flow, installation of protective devices assuming reverse flow conditions is recognized; therefore, the examination here will assume the ‘with reverse flow’ case. As is shown in Table 2-2-2.6, protective relays other than overvoltage ground relays can be substituted by power conditioner’s protective devices for converting direct current into alternating current. Because the 11 kV distribution grid in Ghana has an effective earthing system, overvoltage ground relays will be adopted to detect grounding on the grid side and disconnect generating system.

Concerning the line non-voltage confirmation device, this can be omitted in cases where the system has two or more islanding operation detection functions and connection is broken by separate circuit breakers. Since the power conditioner planned for installation in the Project fulfills this condition, it will be possible to omit the line non-voltage confirmation device.

Table 2-2-2.6 Devices for Ensuring Disconnection of Generating Equipment, etc. at Times of Trouble (assuming connection with high voltage distribution lines)

With or without electronic power inverter	With or without reverse flows	Protective relay required by interconnection regulations	Handling in the Project
With	With (*1)	Over-voltage relay(*3)	Detection/protection by the power conditioner's protective device
		Under-voltage relay (*3) (*4)	Ditto
		Over-voltage Ground Relay (*5)	Detection/protection by over-voltage grounding relay
		Over frequency relay (*6)	Detection/protection by the power conditioner's protective device
		Under frequency relay	Ditto
		Transfer circuit breaker or islanding operation detection device (*7)	Detection/protection by the power conditioner's islanding operation detection function
	Without (*2)	Over-voltage relay(*3)	
		Under-voltage relay (*3) (*4)	
		Over-voltage Ground Relay (*5)	
		Reverse power relay (*8)	
		Under frequency relay	

*1: Even when there are reverse flows, in the distribution transformer of the distribution substation that connects the generating system to the grid, always ensure that no reverse currents occur.

*2: Even when there are no reverse flows, a device can be installed for enabling the parallel-off of generating equipment at times of trouble assuming the condition with reverse flows.

*3: This can be omitted in cases where the protective device of the generating equipment can conduct detection and protection.

*4: It is possible to share with the under-voltage relay for detecting troubles in the generating system, etc. (abnormal generating voltage, etc).

*5: This can be omitted in cases where the grid is connected to the low voltage system in a facility, the output capacity of generating equipment is much smaller than the receiving power capacity, and an islanding operation detection device detects islanding operation at high speed and stops or causes parallel-off the generating equipment, etc.

*6: This can be omitted when connecting with a dedicated line.

*7: The islanding operation detection device should include at least one active detection method and satisfy all the following conditions:

a) It can definitely detect within the required time upon taking the state of grid impedance and load, etc. into account.

b) It has enough detection sensitivity not to cause frequent unnecessary parallel-offs.

c) Active signals do not having a problematic impact on the grid.

*8: This can be omitted in cases where the grid is connected to the low voltage system in a facility, the output capacity of generating equipment is much smaller than the receiving power capacity (around 5% or less), and an islanding operation detection device that includes at least one passive method and active method each detects islanding operation at high speed and stops or causes parallel-off the generating equipment, etc.

[Source] Grid Interconnection Regulations JEAC 9701-2006

(3) Preconditions for selection of specifications in primary equipment

The preconditions for selecting the specifications of primary equipment are determined in consideration of the compatibility of instruments, natural conditions in Ghana, the electricity situation and installation space, etc.

1) Photovoltaic module

① NMIMR photovoltaic module

As is shown in Table 2-2-2.7, PV modules are divided into silicon types, compound semiconductors and organic photovoltaic cells.

Table 2-2-2.7 Types of Photovoltaic Cells

	Silicon				Compound Types		Organic Types	
	Crystal silicon		Thin Film Silicon		CIS	III-V Crystal	Pigment Sensitization	Organic Thin Film
	Monocrystal	Polycrystal	Amorphous	Multi-joined				
Features	200 μm~ Use a thin (300 μm) silicon monocrystal base plate. This is the PV cell with the longest history. The base plate is expensive, however, it has excellent performance and reliability.	PV cell built on a base plate of polycrystals comprising relatively small-size crystal. Since it is cheaper and easier to make than monocrystals, it is now the mainstream. Conversion efficiency is slightly inferior to that of monocrystals.	PV cell formed as a thin film of 1 μm of amorphous (non-crystal) silicon on a base plate of glass, etc. A feature is that large areas can be mass produced, and compared to crystal silicon, it has performance issues.	PV cells made from laminatd amorphous silicon and fine crystal silicon. The amount of silicon used is small (approx. 1/100 of the amount of crystal silicon) and large areas can be mass produced. Since the absorbed wavelength is wide, efficiency is higher than amorphous silicon PV cells.	A type of compound semiconductor, this thin film PV cell is made from copper, indium and selen, etc. Since the manufacturing process is simple and high performance, technical development is well advanced.	Ultra-high performance (conversion efficiency: 30~40%) PV cells using semiconductor base plates made from special compound such as gallium arsenide, etc. Costs are high and these types were originally developed for special uses such as space. Currently, cost reduction is being advanced through combination with light collection systems.	In these PV cells, energy is generated when pigment on titanium oxide (seminconductors) absorbs light and emit electrons. Since they are easy to make, there is anticipation over cost reduction, however, issues are achieving higher efficiency and durability.	PV cells made through PN joining of organic semiconductors. There is anticipation over cost reduction, however, issues are achieving higher efficiency and durability.
Module conversion efficiency (Research levels shown in brackets)	~15%	~14%	~6%	~10%	~11%	~30% ~37% (when collecting light)	(11%)	(5%)
Situation regarding practical application	Dissemination stage	Dissemination stage	Dissemination stage	Dissemination stage	Dissemination stage	Research stage	Research stage	Research stage
Manufacturer	Sharp SANYO Electric Co. (HIT type)	Sharp Kyocera Mitsubishi Electric	Mitsubishi heavy Industries KANEKA	Mitsubishi heavy Industries KANEKA Fuji Electric Holdings Sharp	Showa Shell Honda	Sharp	Sharp Fujikura Sony AISIN Seiki	Panasonic Electric Works ENEOS Mitsubishi Chemical Corporation Sumitomo Chemical Co., Ltd.

[Source] Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, Japan

Silicon modules are divided into crystal silicon and thin film silicon types. Crystal silicon includes mono-crystalline silicon and poly-crystalline silicon types and is currently used in numerous modules. Crystal silicon modules have conversion efficiency of 14~15 percent and good weather resistance, and they also have the longest history of use. Thin film silicon PV cells comprise amorphous and multi-joint PV cells. As is shown in the table, thin film silicon PV cells can be mass produced from a small amount of materials, however, they are inferior in terms of conversion efficiency. In the area of compound PV modules, there are numerous compound semiconductors, however, now mostly CIS PV cells and GaAs PV cells are used. CIS and CIGS are almost the same: CIS is a compound made from copper, indium and selen, while CIGS semiconductors are made by adding gallium to CIS. CIS PV cells went into mass production in Japan in fiscal 2009 and they have started to be used in ordinary households. GaAs PV cells are used in artificial satellites and generate power through absorbing solar waves over a wide scope. They have good conversion efficiency, however, they are not commonly used due to the prohibitively high price. Organic PV cells are currently attracting a lot of attention, however, research is still being conducted into improving generating efficiency and durability, etc. These PV cells have great potential for cheap manufacture in the future.

② PV modules for selection in the Project

Accra is situated at north latitude 5 degrees and the climate is divided into the rainy season and the 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 and humidity are 31.3°C and 90 percent respectively and the natural environment is extremely harsh. Preconditions for selecting the module specifications in the Project are the existence of past performance, reliability, durability, good conversion efficiency and ability to withstand harsh natural conditions. Furthermore, it is desirable to keep the panel installation area to a minimum to ensure that future land use around the University of Ghana is not restricted. Bearing in mind these conditions, the specifications indicated in Table 2-2-2.8 have been selected for the Project.

Table 2-2-2.8 Module Specifications

Specifications	Conditions
Country of manufacture	Japan (all parts shall be made in Japan)
Module type	Mono-crystalline or poly-crystalline silicone or tandem of crystalline silicone and amorphous
Reference technical standards	IEC or equivalent
Module output	180W or higher, 210W or less Measurement conditions (AM: 1.5, temperature 25°C, solar irradiation 1000W/m^2)
Total output	No less than 315kW
Module conversion efficiency	No less than 12%
Module weight	Weight per module: 15kg ~20kg
Size	According to maker specifications

2) Junction box and collecting box

Ghana 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 of the Sahara Desert. In particular, 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 IP44 or higher in order to protect the junction boxes and collection boxes from the harsh environment, high temperatures, high humidity, sand and squalls, etc. For detailed equipment specifications, see 2-2-2-3 Equipment Plan.

3) Power conditioner

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 2-2-2-3 Equipment Plan.

4) Transformer

The transformer is used to step-up or step-down the AC power converted in the power conditioner according to the voltage of the distribution grid. The transformer is installed in the power conditioner room. Output terminals are divided over five voltage stages in order to conform to voltage fluctuations on the grid side.

5) Display system

The display system, which displays the operating status of the PV power generating system on a liquid crystal panel, will be installed with the goal of enabling the numerous visitors to NMIMR to realize the value of photovoltaic power generation. It is desirable to adopt a Japanese display liquid crystal panel in order to raise awareness of Japanese products among Ghanaian people. For detailed equipment specifications, see 2-2-2-3 Equipment Plan.

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) Climate and site conditions

Table 2-2-2.9 Climate and Site Conditions

(a) Altitude	67.4 m
(b) Ambient temperature(maximum) *1	33.0 ˚C
(c) Ambient temperature (minimum) *1	23.2 ˚C
(d) Relative humidity, Maximum *1	83 %
(e) Peak monthly rainfall *1	395.3 mm
(h) Maximum wind velocity	48 knots
(i) Particulate	Take into consideration

[Source] *1 Ghana Meteorological Agency

(2) Electric system conditions

① Distribution voltage : 3 phase 4 line, 415V
② Frequency : 50 Hz
③ Grounding system : Direct grounding
④ Grounding resistance : 10 Ω or less
⑤ Coloring : IEC standards (red, white, blue, black)

(3) Facilities planning conditions

The Project target site is land adjacent to the Noguchi Memorial Institute for Medical Research (NMIMR) on the grounds of the University of Ghana and it is being used with consent from the university. Because the site is sloped and undulating and also includes rainwater drainage channels, the area over which PV panels can be installed is limited to an extent. Accordingly, the panels shall be arranged upon carrying out the refitting, etc. of rainwater drainage channels. Concerning the layout of panels, intervals shall be secured between the panels in order to minimize shade; moreover, the minimum necessary mounting structures equipped with angle adjustment function (to enable the panels to be adjusted so as to secure the maximum electrical output) shall be planned. When arranging the panels, safety measures shall be adopted regarding the upward force of winds when designing the mounting structure and foundations.

Since the Project site doesn't contain an existing building for storing necessary electrical instruments such as the transformer and power conditioner, construction of a power conditioner room (single story, measuring around 5.0 m x 11.0 m) shall be newly planned on the site.

Regarding the new power conditioner room, in order to ensure a structure that blocks out the heat created by the year-round high temperatures, chipboard shall be used for roofing materials, and ceilings shall be fitted indoors in order to minimize the impact of heat from the roof.

The transformer for converting power to the voltage used in NMIMR shall be installed inside the new power conditioner room; 415 V cable shall be directly laid to the 415 V circuit breaker panel installed in the electricity room of the existing emergency generator house, and this shall be connected to the bus line of the existing circuit breaker in order to supply power. Moreover, the Japanese side shall bear all the equipment, materials and works required to achieve connection.

2-2-2-3 Equipment Plan

(1) Facilities plan conditions

The PV cells (315 kW) will be installed on approximately 6,100 m^2 of land outside the fence on the southeast side of the NMIMR main building. Since the land here is rough and slopes towards the southeast, it will be necessary to conduct thorough foundation works. The panels will be split up in consideration of the works space. The power conditioner will be installed on the southeast corner of the intersection between the north-south and east-west site roads. The distribution line on the output side (3 phase 4 line, 415V) will be laid under the road and will lead to the existing electricity room at the rear (west side) of the main building of NMIMR some 300 m away. At nighttime, since the area becomes deserted, street lights will be installed around the site perimeter (see 2-2-3 Outline Design Drawings).

(2) Outline specifications of equipment

The PV power generating equipment to be procured and installed by the Japanese side in the Project shall be based on IEC standards and specifications. Also, when selecting the facilities and equipment for the PV grid-connected system, unified items and standard design models shall be adopted in order to shorten the installation period. The following table shows the outline of the basic plan and the outline specifications of the equipment. Since the system differs between makers, the numbers of junction boxes, collecting boxes and power conditioners will not necessarily be as indicated in Table 2-2-2.10.

In the Project, when power interruptions occur in the distribution grid, the PV system shall be stopped and there will be no parallel operation with the private generator. This is because it is difficult for the generator governor to keep up with the photovoltaic power output, which is influenced by the amount of solar irradiation, and there is a risk of the generator side being damaged. In this Project, automatic re-starting of a power conditioner shall be prevented by the transfer of signal on the position of change over switch which has a function to switch power source from distribution grid side to private generator side.

Table 2-2-2.10 Outline of the Basic Plan

	Procurement and installation of the following PV power generating equipment	Quantity
Equipment procurement and installation works	PV modules	315kW
	PV modules mounting structure	1 set
	Junction box (quantities differ according to the maker)	1 set
	Collecting box (quantities differ according to the maker)	4 or more
	Power conditioner	4 sets
	Step-up transformer	1 set
	Display system	1 set
	Instrumentation	1 set
	Wiring materials	1 set
	Grounding work materials	1 set
Equipment procurement plan	PV power generating equipment replacement parts, maintenance tools and test devices	1 set

Table 2-2-2.11 PV Module Specifications

Equipment	Specifications	Required Specifications
1. PV modules	(1) Applicable standard	IEC and equivalent standards
	(2) Environment of use	Tropical environment
	(3) Ambient temperature	+31.3°C
	(4) Installation method	Above ground installation
	(5) Type	Mono-crystalline or poly-crystalline silicone or tandem of crystalline silicone and amorphous
	(6) Module efficiency	12% or higher
	(7) Module capacity	180~210W per panel

Table 2-2-2.12 PV Module Mounting Structure Specifications

Equipment	Specifications	Required Specifications
2. PV module mounting structure	(1) Support method	Steel frame
	(2) Environment of use	Sandy area
	(3) Material	SS400 or SHPC with hot dip zinc finish or equivalent quality

Table 2-2-2.13 Junction Box Specifications

Equipment	Specifications	Required Specifications
3. Junction box	(1) Structure	Outdoor, vertical standing type
	(2) Environment of use	Tropical, sandy area
	(3) Ambient temperature and humidity	+40°C or less, 85% or less
	(4) Maximum input voltage	String unit nominal open voltage (Voc) or more
	(5) Input circuits	Number of sub-array unit parallel lines or more
	(6) Input current	Module nominal shorting current (ISC) per circuit or higher
	(7) Output circuits	1 circuit
	(8) Output current	Module nominal shorting current (ISC) or higher
	(9) Internal devices	- Wiring circuit breaker: Number of circuits - Reverse flow prevention diode: Each string - Induced lightning protector: All input and output circuits, between wires, between earth

Table 2-2-2.14 Collection Box Specifications

Equipment	Specifications	Required Specifications
4. Collection box	(1) Structure	Outdoor, vertical standing type
	(2) Environment of use	Tropical, sandy area
	(3) Ambient temperature and humidity	+40°C or less, 85% or less
	(4) Maximum input voltage	String unit nominal open voltage (Voc) or more
	(5) Input circuits	Condensed number of junction boxes or more
	(6) Input current	Junction box output current or more
	(7) Output circuits	1 circuit
	(8) Output current	Sub-array nominal short circuit current x multiply Number of input circuits or more
	(9) Internal devices	- Wiring circuit breaker: Number of circuits - Induced lightning protector: All input and output circuits, between wires, between earth

Table 2-2-2.15 Power Conditioner Specifications

Equipment	Specifications	Required Specifications
5. Power conditioner	(1) Structure	Indoor, vertical standing type
	(2) Ambient temperature and humidity	+40°C or less, 85% or less
	(3) Main circuit system	Self exciting voltage
	(4) Switching system	High frequency PWM
	(5) Insulation system	Commercial frequency insulation transformation
	(6) Cooling system	Forced air cooling
	(7) Rated input voltage	To be specified in accordance with PV module's specifications (String maximum output voltage (Vpmax) or thereabouts)
	(8) Input operation voltage range	To be specified in accordance with PV module's specifications (The string maximum output voltage (Vpmax) and nominal open voltage (Voc) shall be within range)
	(9) Input circuits	The number of current collection boxes or more
	(10) Output electricity system	3φ3W or 3φ4W
	(11) Rated output voltage	AC202V or AC420V
	(12) Rated frequency	50Hz
	(13) AC output current distortion factor	General current 5% or less, each sub-wave 3% or less
	(14) Power control system	Maximum output follow-up control
	(15) Rated power conversion efficiency	90% or more
	(16) Control functions	- Automatic start/stop, soft start - Automatic voltage adjustment - Input/output over-current adjustment - Output adjustment
	(17) Grid-connected protective functions	- Over voltage (OVR): Configurable over the range of 0~+15% - Under voltage (UVR): Configurable over the range of 0~-15% - Over frequency (OFR): Configurable over the range of 50~52.0 Hz - Under frequency (UFR): Configurable over the range of 48.0~50 Hz All permanent values, with timed variation
	(18) Islanding operation detection function	- Active type (at least 1 mode out of the following): ① Frequency shift system ② Active power fluctuation system ③ Reactive power fluctuation system ④ Load fluctuation system - Passive type (at least 1 mode out of the following): ① Detection method for power phase jump ② Detection method for sudden increase in third harmonic voltage

Equipment	Specifications	Required Specifications
		③ Detection method for frequency change rate

Table 2-2-2.16 Transformer Panel Specifications

Equipment	Specifications	Required Specifications
6. Grid-connected transformer Panel	(1) Structure	Indoor, vertical self standing, dry type transformer
	(2) Ambient temperature and humidity	+40°C or less, 85% or less
	(3) Primary voltage	To accord with the output voltage of the power conditioner (3φ4W AC420V or φ3W AC200V)
	(4) Secondary voltage	3φ4W AC415V (grid voltage)
	(5) Capacity	500kVA
	(6) Frequency	50 Hz
	(7) Insulation grade	B

Table 2-2-2.17 Instrumentation Specifications

Equipment	Specifications	Required Specifications
7. Instrumentation	(1) Actinometer 1) Applicable standard 2) Sensitivity	 ISO9060 Second class or equivalent Ex. (6~8μV/(kW・m-2))
	(2) Thermometer 1) Type 2) Shape 3) Temperature range of use	 Measurement resistor Pt100Ω 4wire With basic shelter -40°C~＋60°C
	(3) Climate change box 1) Structure 2) Material 3) Input signals 4) Output signals 5) Power source 6) Housed equipment	 Outdoor wall hanging type SS400 hot dip zinc finish or equivalent quality Actinometer (0-10mV), thermometer (Pt100Ω) 4-20mA×2 AC240V Actinometer signal converter, thermometer signal converter, wiring circuit breaker, induced lightning protector
	(4) Instrumentation monitoring device (site side) 1) Data measuring method - Measurement cycle - Data collection items 2) Used devices	Install in the power conditioner room 6 seconds Inclined plane solar intensity, temperature, generated electric energy Instrumentation monitoring device Serial signal converter (RS485→RS232C conversion) Uninterrupted power supply (to counter instantaneous stoppage) Instrumentation monitoring device box

Equipment	Specifications	Required Specifications
	3) Soft specifications (server side)	Instantaneous value display, graph and form display
	(5) Remote monitoring system	Install in the electricity room in the main building of NMIMR
	1) Specifications	Power conditioner operating status and interference information display
	- Data download	Power conditioner protective device setting information storage
		Transmission of site side data to the data logger and data storage
		Download of forms data, display and printing of forms and graphs

Table 2-2-2.18 Electric Wire Specifications

Equipment	Specifications	Required Specifications
8. Wiring materials		
(1) Module ~ Junction box	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	① HEM-CE cable single end (+) with connector ② HEM-CE cable single end (-) with connector ③ HEM-CE cable single end (+)(-) with connector
	(3) Size	① 3.5sq-1C ② 3.5sq-1C ③ 3.5sq-1C
(2) Junction box ~ Current collection box	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	600V CVD
	(3) Size	22mm^2
(3) Current collection box ~ Power conditioner	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	600V CV-1c
	(3) Size	150mm^2
(4) Power conditioner ~ Transformer	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	600V CV-3c
	(3) Size	325mm^2
(5) Transformer ~ Existing distribution panel	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	600V CV-3c
	(3) Size	325mm^2
	(4) Other	Terminal lug, bolts, nuts, end terminal materials
(6) Electric room ~ Climate change box (Communication cable)	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	4C
	(3) Size	1.25mm
(7) Ground works materials	(1) Applicable standard	IEC, JIS or an equivalent standard
	(2) Model	600V IV
	(3) Size	8mm^2
	(4) Other	Ground rod 10mm x 1m

Table 2-2-2.19 400V MCCB Panel Specifications

Equipment	Specifications	Required Specifications
9. 400V MCCB Panel	(1) Structure	Indoor, self-standing, MCCB type
	(2) Rated Voltage	600V or more
	(3) Rated Current	400AF/ 400AT or more
	(4) LIWV	75kV or more

2-2-3 Outline Design Drawings

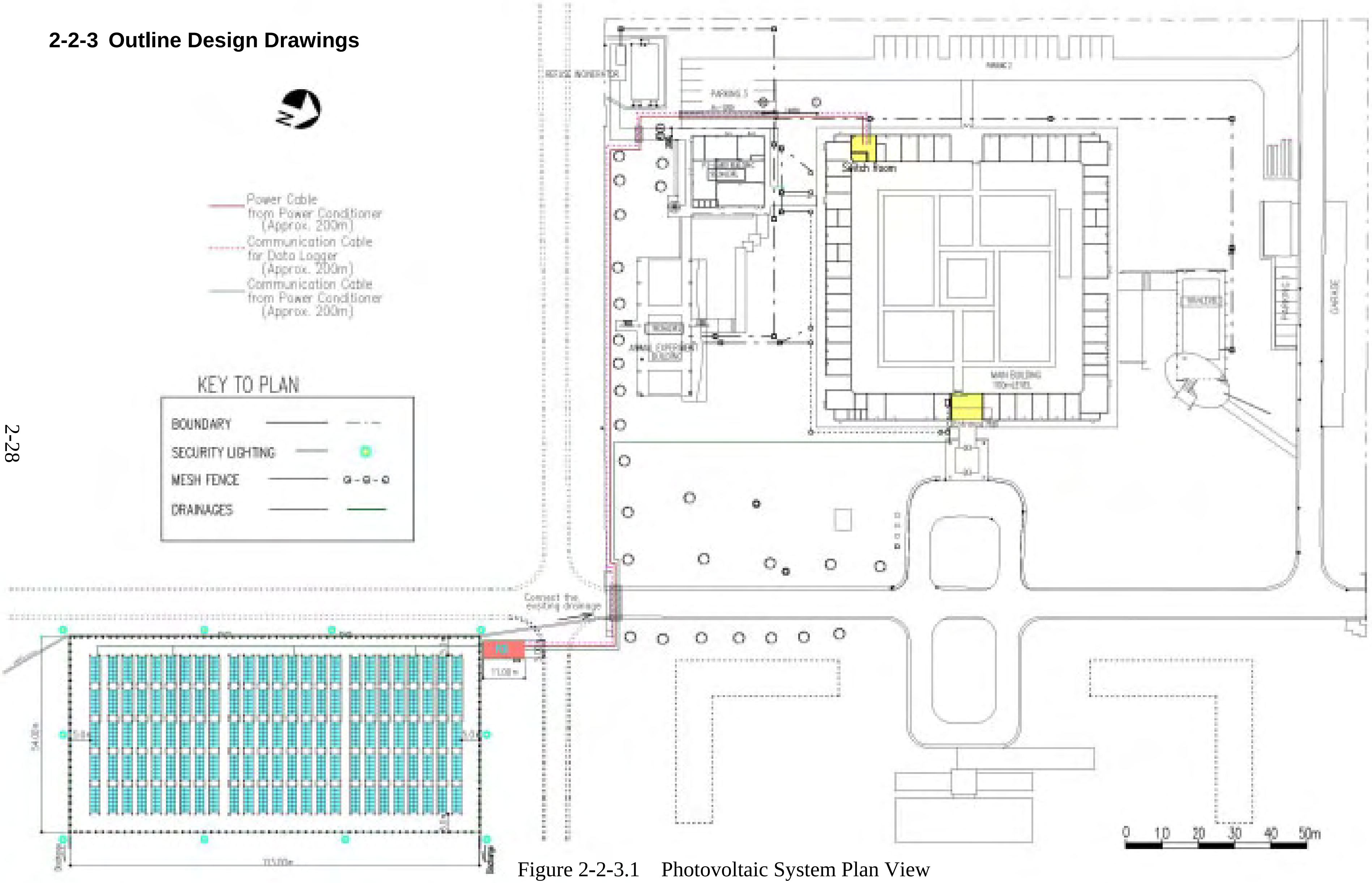

Figure 2-2-3.1 Photovoltaic System Plan View

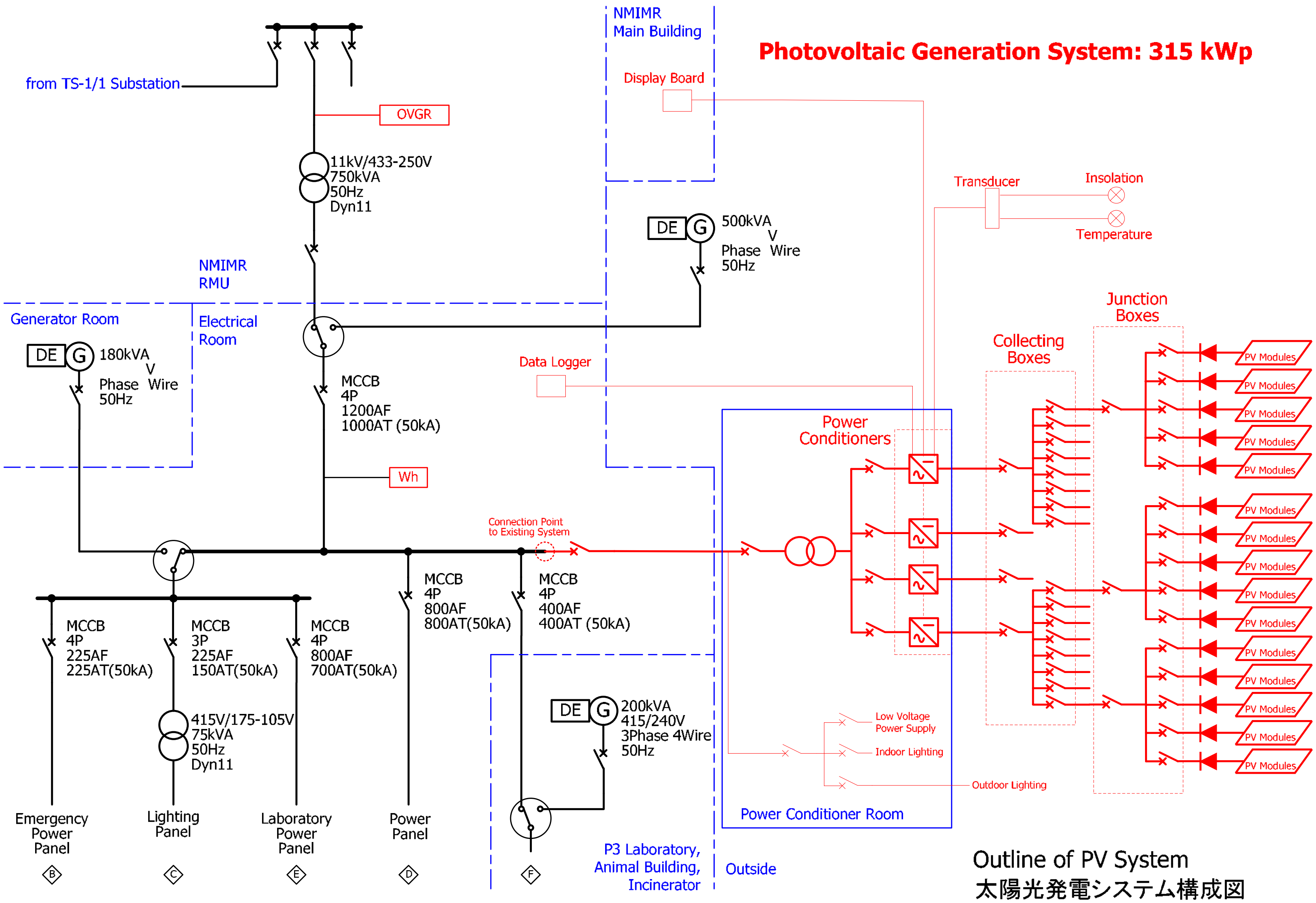

Figure 2-2-3.2 Photovoltaic System Outline Drawing

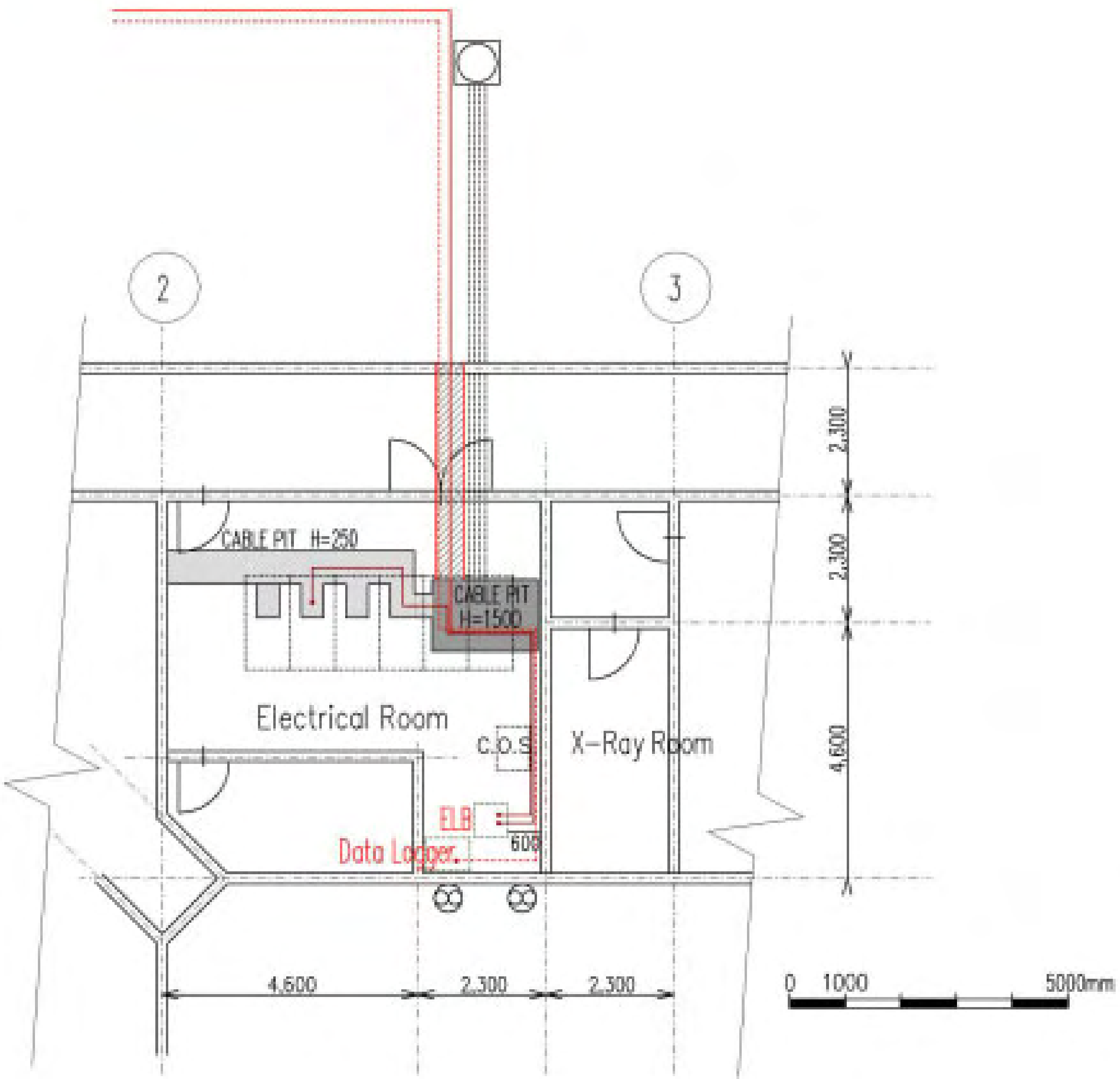

Figure 2-2-3.3 Plan of Cable Route in the Electrical Room

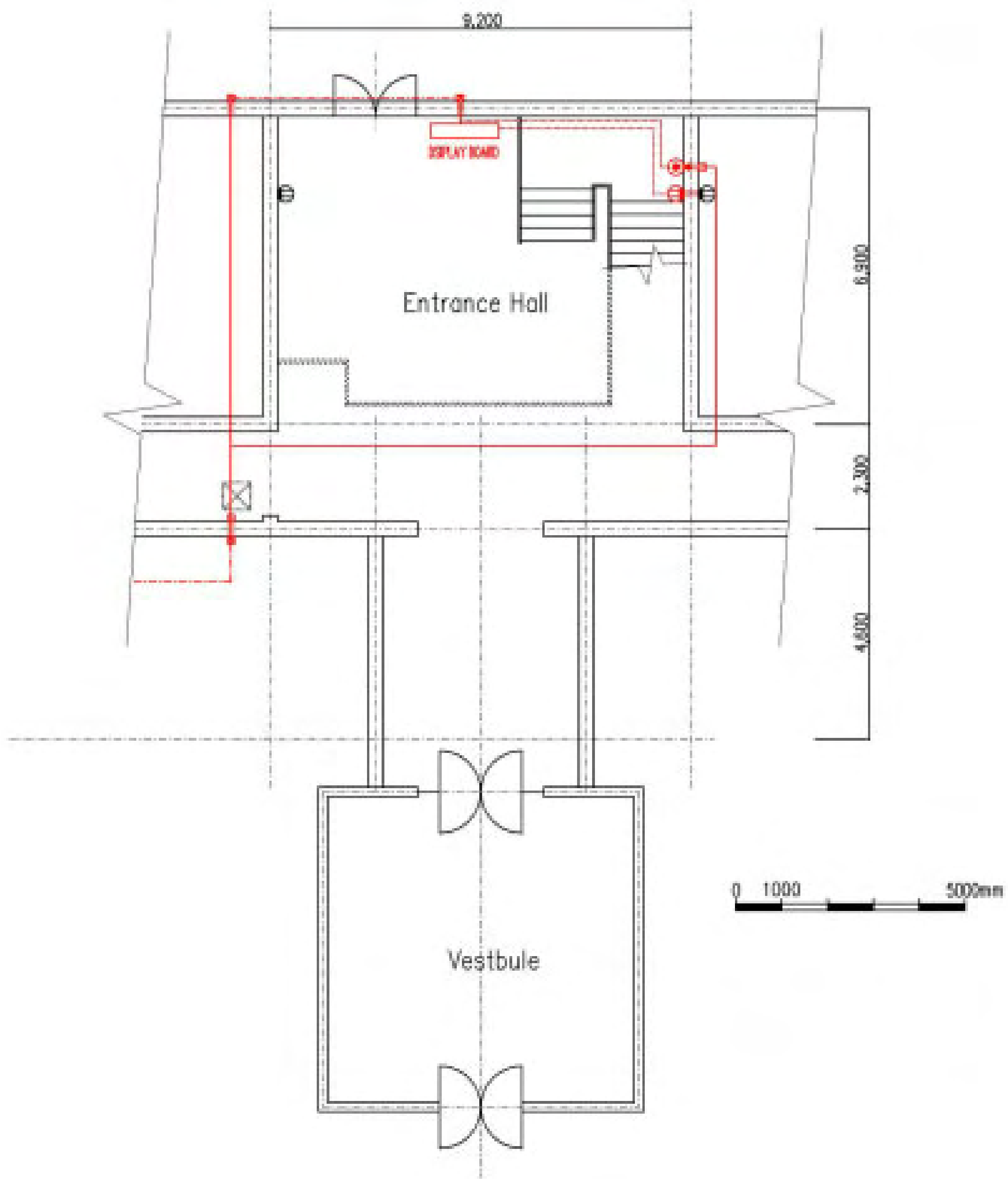

Figure 2-2-3.4 Layout of Display Board

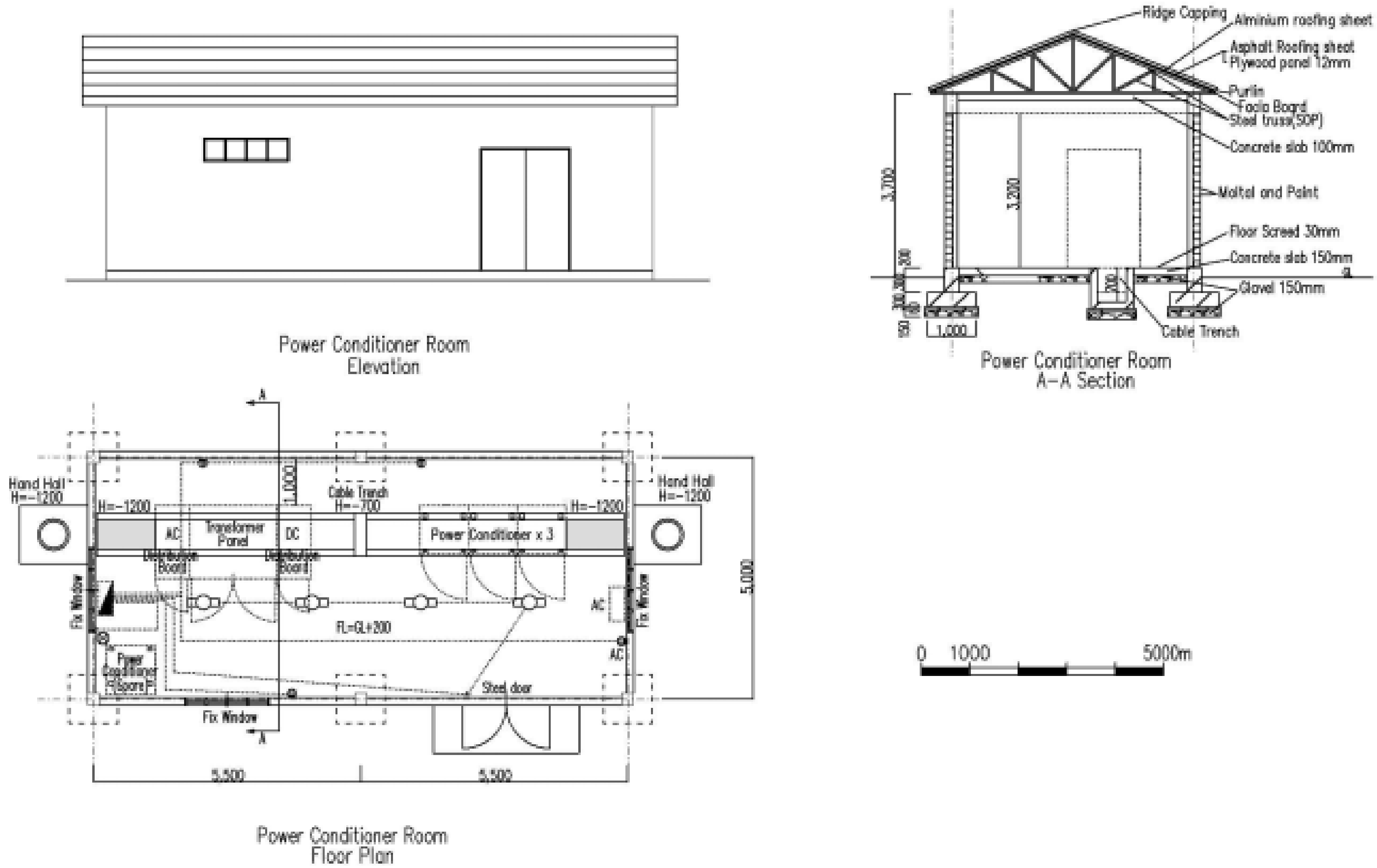

Figure 2-2-3.5 Building Plan of Power Conditioner Room

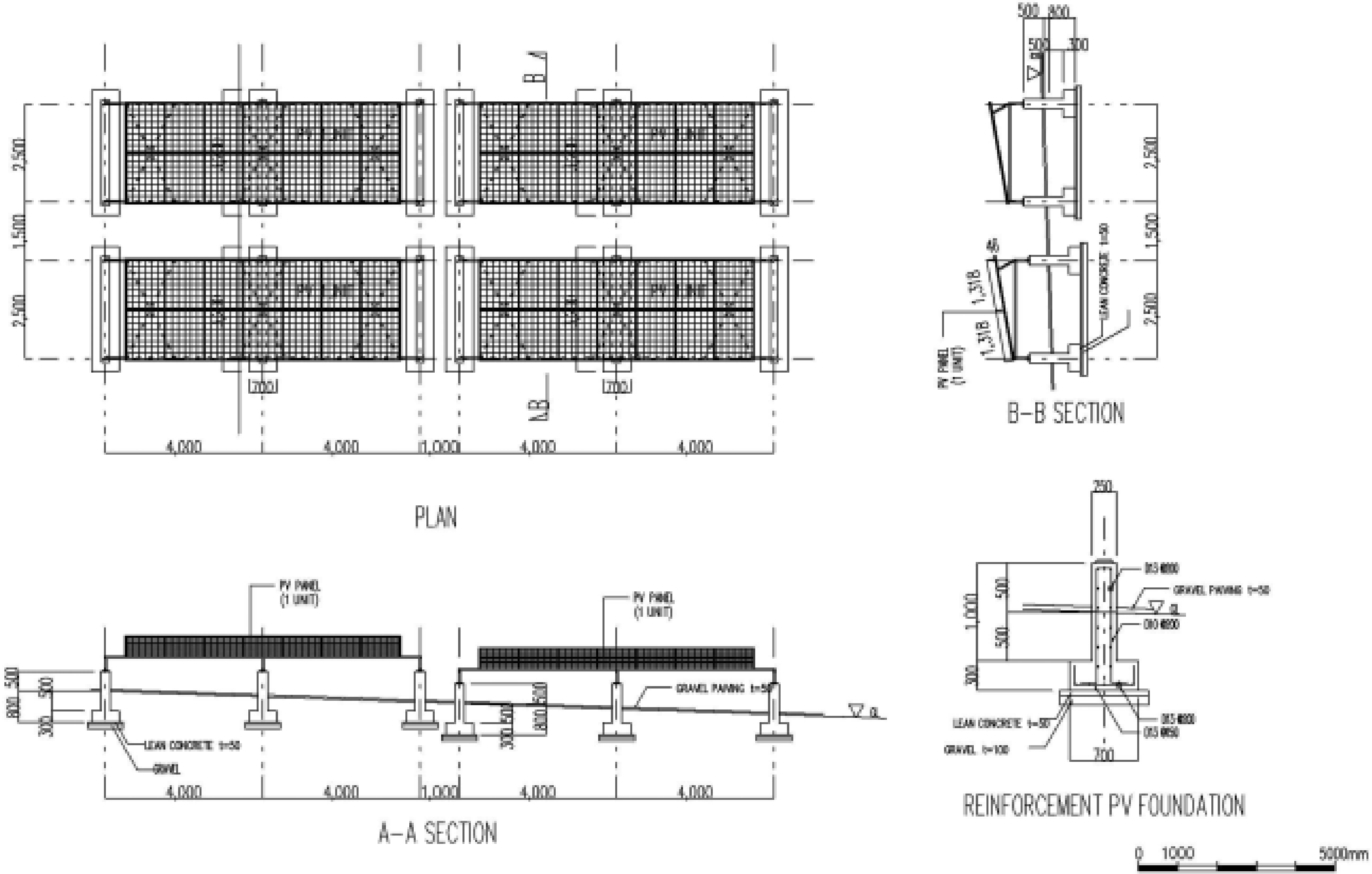

Figure 2-2-3.6 Plan of Mounting Structure and Foundation for PV Panels

2-2-4 Implementation Plan/Procurement Plan

2-2-4-1 Implementation Policy/Procurement Policy

The Project will be implemented based on the Government of Japan's Environment and Climate Change Program Grant Aid scheme. According to this, the Project will receive approval by the Government of Japan, the two countries' governments will sign the Exchange of Notes (E/N) and the Grant Agreement (G/A) before the Project progresses to the implementation stage. The Procurement Agent will be recommended to the Ghanaian side by the Government of Japan, while the University of Ghana will be the responsible government agency and the Noguchi Memorial Institute for Medical Research acting as the mandatory will be the implementing agency to ensure that the contract (tender and equipment procurement) is appropriately and smoothly executed.

(1) Implementation Setup

Following the conclusion of the Exchange of Notes (E/N) and Grant Agreement (G/A) concerning the Project, the Government of Ghana 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 Government Agency

The responsible government agency will be the University of Ghana.

(3) Implementing Agency

The implementing agency for the Project is the Noguchi Memorial Institute for Medical Research. The Project will be implemented as an Environment and Climate Change Program Grant Aid undertaking based on the procurement agency contract that is concluded between the University of Ghana – the responsible government agency on the Ghanaian side – and the Japanese Procurement Agent.

Other related agencies on the Ghanaian side are as indicated below, and it will be necessary to fully share information and coordinate with each agency in the implementation stage. When coordinating with each agency, it has been confirmed that the Maintenance Department of NMIMR will act as the primary contact.

- Ministry of Energy (MOE)
- Energy Commission
- University of Ghana

Also, the main agencies on the Ghanaian side and the Government of Japan will establish an intergovernmental conference composed of representatives from each to discuss the items that require confirmation at government level. Furthermore, a working group will be established by the NMIMR and the Procurement Agent, and this will confirm progress and discuss technical confirmation points and so on.

The Project implementation setup is indicated below.

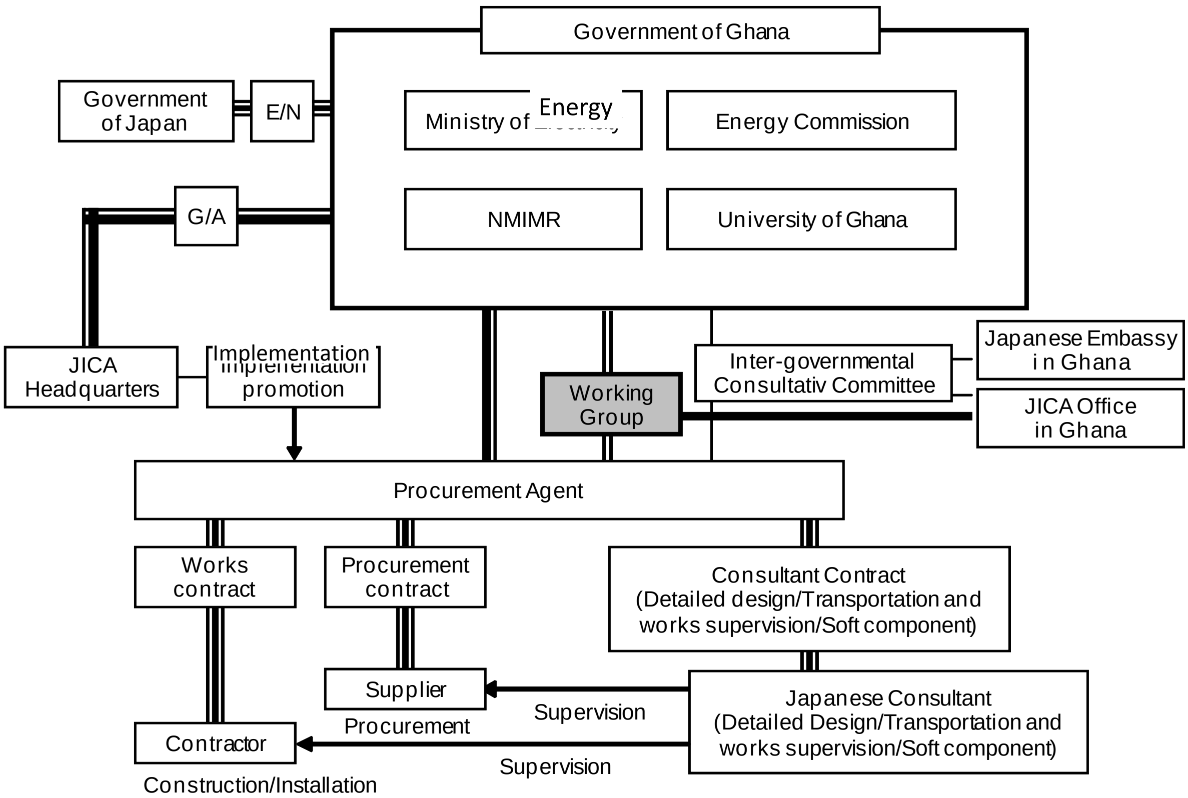

Figure 2-2-4.1 Implementation Setup

(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 Ghanaian side by the Government of Japan, will implement and execute general supervision to ensure that the Project components are appropriately and smoothly implemented in its capacity as the mandatory of the implementing agency.

Concerning tender work supervision, the Procurement Agent will prepare documents concerning the Agent Agreement, banking 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 Ghanaian 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 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.

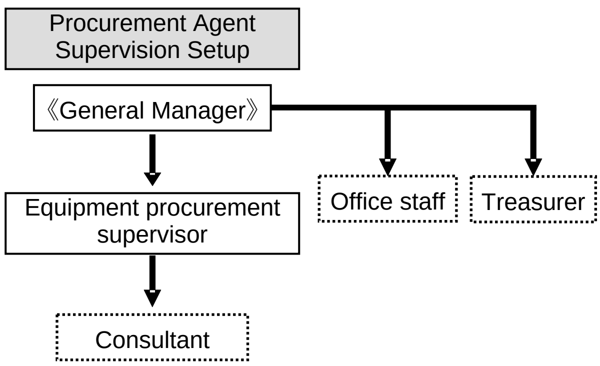

Figure 2-2-4.2 Procurement Agent Supervision Setup

(5) Construction Supervision and Procurement Supervision Consultant

The technical consultant that is appointed by the Procurement Agent will supervise the procurement and construction works in its capacity as the construction supervision and procurement supervision consultant. The consultant will supervise the quality of work, schedule and safety, etc. of facilities construction, confirm quality, functions, performance and quantities in the equipment procurement, and check for exterior damage, etc. during the transportation of equipment. 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 works contractors.

(6) Facilities Contractors and Equipment Suppliers

The contractors and suppliers that are selected by the Procurement Agent by tender must fully understand and promptly and certainly execute the contents of the contracts they bind with the Agent.

2-2-4-2 Implementation Conditions

(1) Construction Situation in Ghana

It is possible to secure operators (workers) for construction works in Ghana, 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 and/or third country as the need arises.

Meanwhile, since Ghana has no prior experience of PV 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 and/or third country. Moreover, the engineers from Japan and/or third country will conduct technology transfer in the shape of OJT for Ghanaian engineers during the installation period.

(2) Implementation Planning Conditions

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

2) 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.

3) When excavating for buried cables, it will be necessary to display ample care concerning existing sewers and telephone lines and to compile the schedule so that work doesn't coincide with telephone line expansion works, etc.

(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 PV modules can be procured in Ghana, although it will be necessary to implement management and supervision of quality and deadlines. Accordingly, when compiling the implementation plan, locally procurable equipment shall be utilized as far as possible.

(4) Safety Measures

Since the Project target site is located inside the Noguchi Memorial Institute for Medical Research on the campus of the University of Ghana, it has relatively few problems in terms of law and order, however, it will be necessary to display ample care for preventing theft of equipment and securing the safety of works personnel. Accordingly, not only is it essential that the Ghanaian side take safety measures, but also the Japanese side will need to take steps such as assigning guards and so on.

(5) Tax Exemptions

In order to receive exemptions of customs charges and tariffs on the Project equipment, the contractor will need to give advance notification to the Ministry of Finance and Economic Planning via the responsible department of NMIMR. It is possible to receive exemptions on tariffs 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 Ghana avoids any tax burden.

(6) Transportation

Equipment carried to Ghana by sea is usually landed and undergoes customs clearance at the international port of Tema. There are a number of 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 shouldn't 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

According to the Environment and Climate Change Program Grant Aid scheme, Table 2-2-4.1 shows the detailed scope of works on the Japanese and Ghanaian sides.

Table 2-2-4.1 Scope of Works on the Japanese and Ghanaian sides

No.	Item	Japan	Ghana	Remarks
1	Securing of the equipment installation site		○	
2	Ground leveling and removal of obstructions on the equipment installation site	○*1	○*2	*1: Ground leveling *2: Removal of obstructions
3	Installation of fences and gates	○		
4	Facilities construction works and equipment installation	○		Including temporary installation works accompanying the facilities construction
5	Electrical works			
(1)	Electrical works			
	a) Indoor wiring works (lighting, sockets, etc.)	○		
	b) Site lighting works	○		
	c) Installation of power receiving panel	○		
(2)	Site drainage works (rainwater)	○		
6	Commission for opening of bank account based on the B/A		○	
7	Handling of transport and customs clearance procedures and taxes			
(1)	Responsibility for ocean transport (air transport) of products related to procured equipment to the recipient country (Ghana)	○		
(2)	Tax burden and customs clearance procedures at the port of unloading in Ghana		○	
(3)	Transportation of procured equipment, etc. from the port of unloading to the inland site in Ghana	○		
(4)	Exemption or bearing of domestic value added tax on procured construction materials and equipment in Ghana		○	
8	OJT concerning operation and maintenance of facilities and procured equipment	○		The Ghanaian side will select the personnel who will receive OJT
9	Operation and maintenance of facilities and procured equipment		○	
10	Other costs not covered by the grant aid		○	

Note: ○: Indicates the scope of responsibility regarding each item

2-2-4-4 Consultant Supervision

Based on the scheme of the Government of Japan's Environment and Climate Change Program, the consultant will organize a consistent project team to smoothly conduct the implementation 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 plant 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 Ghana.

(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 that the site works are executed safely.

The important points to consider in consultant supervision are described below.

(2) Schedule Control

The contractor will compare progress with the implementation schedule decided 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 contractor will warn the subcontractors, present and instruct 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 civil engineering works on site)

② Confirmation of equipment and materials delivery (switching equipment, distribution equipment and materials, 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, etc.

(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. In cases where doubts arise over quality and performance, the consultant 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 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

(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) Works Supervisor

The contractor will implement the PV module and mounting structure construction works, the procurement and installation of PV equipment and materials and the installation of distribution and communications cables. In order to implement these works, the contractor will employ a subcontractor(s) in Ghana. Therefore, since the contractor will need to ensure that the subcontractor(s) complies with the works schedule, quality, 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 completion drawings

2-2-4-6 Procurement Plan

The PV modules and power conditioner to be procured and installed in the Project are not manufactured in Ghana. However, although PV system retail agents do exist in Ghana, it is difficult to acquire the necessary quality and quantities. Accordingly, when selecting the supplier of PV equipment in the Project, 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.

Concerning the major items of equipment, the Ghanaian side recognizes that Japanese PV equipment makers are superior to makers in other countries in terms of product quality and reliability, and it hopes that Japanese PV equipment will be employed in this Japanese Environment and Climate Change Program Grant Aid Project. As for directly buried materials such as armored cable, etc., since these aren't manufactured in Japan, third country products from DAC affiliated nations shall be planned.

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

(1) Locally procured equipment and materials

Works equipment and materials including 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

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

(3) Equipment and materials procured from third countries

Wiring materials, etc.

2-2-4-7 Operational Guidance Plan

Guidance on initial equipment controls and operation will basically be conducted as OJT (on the job training). In order to install and operate the grid-connected photovoltaic generating system (grid-connected PV system), the site electrical engineers must have ample knowledge on photovoltaic power generation. Figure 2-2-4.3 shows the proposed schedule for the grid-connected PV system installation woks, initial equipment controls and operation guidance and soft component.

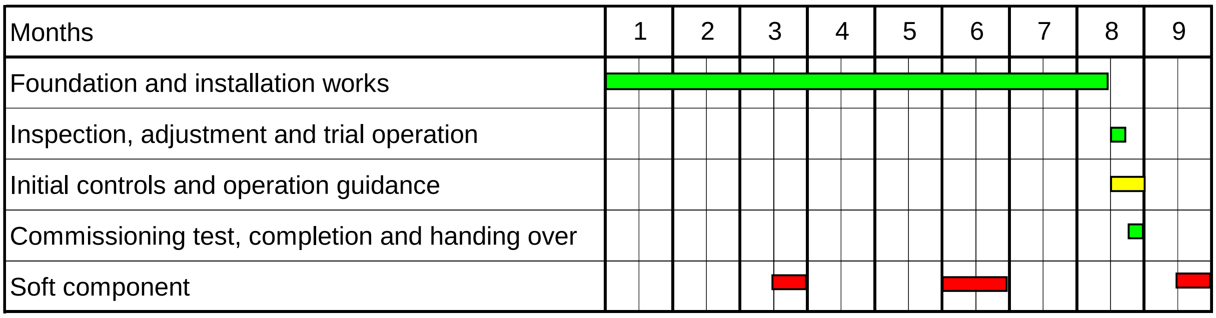

Figure 2-2-4.3 Initial Control Guidance Schedule (Draft)

Installation works for the grid-connected PV system are scheduled to finish 8 months after the commencement of the work.

The operation managers 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 7.5 months after the commencement of the installation work.

1. Initial operation guidance plan

The grid-connected PV system operation managers have already learned the basics of photovoltaic cells and grid-connected PV systems.

The operation managers will implement the following items together with the installation engineers:

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

1.1 Inspections, checks and measurement guidance before the start of operation

(1) The inspection, check and measurement items to be implemented before operation are described in detail in 2-4-1 (Routine Inspection and Periodic Inspection Items). The results of inspections, checks and measurements shall always be recorded.

(2) Main inspection and check guidance

The installation engineers will conduct technology transfer of the following items to the operation managers.

① PV 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.

② Checking of wiring and cables

Since the service life of PV systems is long, damage or twisting of power lines and cables during installation can lead to decline of insulation resistance and dielectric breakdown. Keep records of the parts that cannot be checked after the installation works have been finished. In routine inspections and periodic inspections, check for signs of damage by visual inspection.

③ Confirmation of connecting terminals

Screws of power conditioners, etc. sometimes become loose during transportation. Temporary wiring is sometimes left unfinished, while cases that have been loosened for testing, etc. are sometimes forgotten about. 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.

④ Inspection of other peripheral instruments

Also check other peripheral instruments by visual inspection.

1.2 Measurement guidance and safety measures guidance

The operation manager will check that the installed PV 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 PV 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).

1) Clothing

Wear helmets, sneakers and hip bags.

2) Shock prevention

① Detach one end of PV cell strings before the start of work
② Wear low voltage insulated gloves
③ Use insulated tools
④ Do not work when it is raining.

(2) PV array inspection: Confirmation of voltage and polarity and measurement of short circuit currents

① Confirm that the PV modules have been correctly installed and that voltage is being generated as described in the specifications.

Make sure that positive and negative polarities are not confused by checking each string with a voltmeter.

② Measurement of short circuit current

Measure the PV 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 OK to turn on power to the PV system. Insulation resistance will be measured following 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

At the project site, mesh type grounding wires are to be installed around the PV modules and metal supporting frames for PV panels and metal external boxes of electrical equipment in power conditioner room such as power conditioner, transformer, etc. are connected to the mesh grounding wires. The mesh grounding wires shall be designed and installed so that the ground resistance will become less than 10Ω in accordance with Japanese grounding standard (C-type, standard of grounding for metal external boxes used for low voltage equipment with rated voltage of more than 300V:10Ω or less) and the grounding standard in Ghana (10Ω or less).

Grounding resistance shall be measured by using a grounding resistance meter to be procured under the Project and the value should be checked that it satisfies 10Ω or less.

1.3 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 PV 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, implement careful checks to ensure the system is operating correctly. For details refer to 2-4-1 (Routine Inspection and Periodic Inspection Items).

1.4 Confirmation of Trial Operation Methods

The grid-connected PV system will be installed in a pathological research facility, where power cuts cannot be tolerated. Accordingly, it will be necessary to fully discuss trial operation methods following system completion with the NMIMR side in advance.

2. Operation Guidance Plan

Once the grid-connected PV system goes into operation, unlike diesel engine generators, there is no need to conduct system controls. The grid-connected PV system automatically operates every day, however, if for some reason it is stopped, it will need to be switched on after checking. At the start of operation, since problems are apt to occur in the semiconductors and PV modules, it will be necessary to conduct inspections every day. At the start of grid-connected PV system operation, 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 2-4-1 (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 PV 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 Hamatan blows during the dry season.

2-2-4-8 Soft Component Plan

(1) Soft Component Plan

Following completion of the Project, the operation and maintenance of the PV power generating equipment will be handled by the Maintenance Department of the Noguchi Memorial Institute for Medical Research. As is shown in Figure 2-2-4.4, the Maintenance Department is divided into four sections: the Electrical Section has two staff members, the Refrigeration and Air conditioning handling Section has two members (one of which also serves as the Maintenance Department Manager), the Piping Section has two members and one carpenter, and the Gardens and Cleansing Section has 17 members. The Electrical Section will primarily be responsible for the operation and maintenance of the PV power generating equipment.

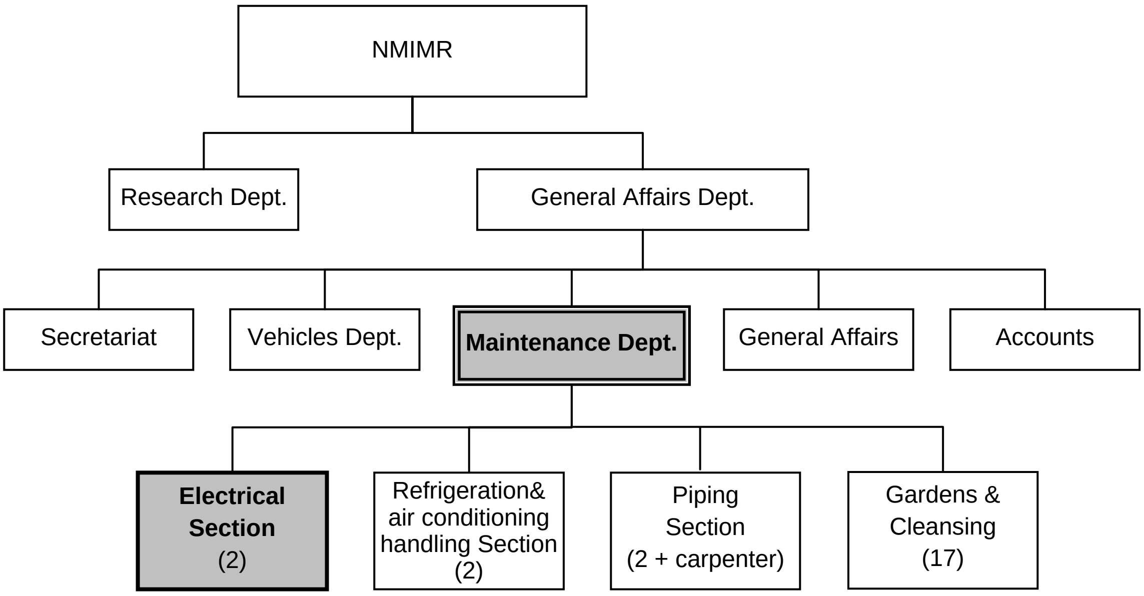

Figure 2-2-4.4 Organization of Noguchi Memorial Institute for Medical Research

Efforts to introduce photovoltaic systems in Ghana have so far comprised installation of SHS (solar home systems), PV3 refrigerator for storing vaccines, solar pumps and PV streetlamps, etc. primarily by aid agencies, while large-scale photovoltaic system development has been limited to installation of a 50 kW grid-connected system on the roof of the Ministry of Energy (MOE) car park under assistance by the Government of Spain. More recently, a 4.5 kW follow-up PV grid-connected system was introduced in the front yard of the Energy Commission (EC) under assistance by the Government of Germany. Thus, photovoltaic power systems are being introduced in Ghana, however, there are still only two grid-related PV systems and the

[3] PV: Abbreviation for photovoltaic, meaning of solar cells.

local sides lacks experience and knowledge for operating and maintaining PV grid-connected systems.

Since NMIMR staff conduct the routine operation and maintenance of electrical equipment and emergency generator at the research institute, they have basic knowledge on electrical equipment operation and maintenance. However, since NMIMR does not possess photovoltaic generating equipment, it will be difficult for the institute's staff to acquire the know-how and technology required for operating and maintaining the PV grid-connected system through their everyday work. Moreover, due to limited experience in installing and operating grid-connected private generator systems, the ECG (Electricity Corporation of Ghana) also lacks knowledge concerning important points and troubleshooting for PV grid-connected systems. Furthermore, Ghana has no regulations or technical criteria, etc. concerning the grid connection of generating facilities that do not entail power sale or purchase.

This soft component aims to support the smooth launch of activities at the start of the Project and to facilitate the sustainable operation and maintenance of the PV grid-connected system through implementing technology transfer on PV grid-connected system operation and maintenance primarily for NMIMR (implementing agency) Maintenance Department. Moreover, since it is also necessary for operation and maintenance staff of the distribution grid to which the PV system will be connected to grasp the characteristics of the PV grid-connected system, the necessary technology transfer concerning outline of the PV grid-connected system, important points in system operation and technical conditions for interconnection will be carried out with respect to the Facilities Department of the University of Ghana, which is in charge of maintaining distribution facilities on campus, the ECG, which is the grid operator, and the Ministry of Energy and Energy Committee, which are the regulating agencies for the power sector.

(2) Goals of the Soft Component

The goals of the soft component are as indicated below. It is anticipated that through achieving these goals the effects of the Grant Aid project will be realized on a sustained basis.

1) Operation and maintenance of the PV grid-connected system will be commenced by the Ghanaian side following completion of the Project.
2) Operation and maintenance of the PV grid-connected system will be conducted on a sustained basis.
3) The power distribution grid to which the PV system is connected will be operated in a stable manner.

(3) Outputs of the Soft Component

The outputs that should be achieved in the soft component are as indicated below.

Table 2-2-4.2 Outputs of the Soft Component

Target	Soft Component Outputs	targets
1. Operation and maintenance of the PV grid-connected system will be commenced by the Ghanaian side following completion of the Project.	1-1 The operation and maintenance organization for the PV grid-connected system is established. 1-2 Operation and maintenance personnel acquire the operation and maintenance technology for the PV grid-connected system.	NMIMR Maintenance Department
2. Operation and maintenance of the PV grid-connected system will be conducted on a sustained basis.	2-1 The PV grid-connected system operation and maintenance manual including contents on troubleshooting is prepared.	NMIMR Maintenance Department
	2-2 The outline and characteristics of the PV grid-connected system are understood. 2-3 Troubleshooting methods for the PV grid-connected system are established. (The distribution grid within the university is the target).	University of Ghana Facilities Department
3. The power distribution grid to which the PV system is connected will be operated in a stable manner.	3-1 The outline and characteristics (including reverse flows) of the PV grid-connected system are understood.	ECG Ministry of Energy Energy Commission
	3-2 Troubleshooting methods for the PV grid-connected system are established. (The ECG distribution grid is the target).	ECG

(4) Method for Confirming the Degree of Attainment of Outputs

Outputs of the soft component will be grasped by confirming the prepared operation and maintenance manual and reports of the participants. Table 2-2-4.3 shows the methods for confirming outputs according to each component of activity. In the manual, it will be confirmed that all necessary items including operation and maintenance organization, roles, routine maintenance, periodic inspections and troubleshooting, etc. are covered and that technical contents are stated without error, and advice and guidance will be offered where necessary. In the reports, trainees will be asked to describe the contents they have understood under each technology transfer topic in order to evaluate the degree of understanding regarding the lecture contents. Moreover, supplementary lectures will be conducted on items for which understanding is insufficient.

Table 2-2-4.3 Soft Component Outputs and Confirmation Method

Target	Soft Component Outputs	Method for Confirming Degree of Attainment
NMIMR Maintenance Department	• The operation and maintenance organization for the PV grid-connected system is established. • Operation and maintenance personnel acquire the operation and maintenance technology for the PV grid-connected system. • The PV grid-connected system operation and maintenance manual including contents on troubleshooting is prepared.	• Manual • Reports • Manual
University of Ghana Facilities Department	• The outline and characteristics of the PV grid-connected system are understood. • Troubleshooting methods for the PV grid-connected system are established. (The distribution grid within the university is the target).	• Reports • Manual
ECG	• The outline and characteristics (including reverse flows) of the PV grid-connected system are understood. • Troubleshooting methods for the PV grid-connected system are established. (The ECG distribution grid is the target).	• Reports • Manual
Ministry of Energy	• The outline and characteristics (including reverse flows) of the PV grid-connected system are understood.	• Reports
Energy Commission	• The outline and characteristics (including reverse flows) of the PV grid-connected system are understood.	• Reports

(5) Soft Component Activities (Input Plan)

1) Soft Component Contents and Activities

As is indicated in Table 2-2-4.4, the contents of soft component activities extend from the basics of solar cells to operation and maintenance and monitoring. Technology transfer will be conducted by means of classroom lessons, drills (manual preparation by the trainees) and practical exercises using actual equipment and materials. The equipment and materials used in the practical exercises will be the PV modules, measuring instruments and tools that are scheduled for introduction to NMIMR. Moreover, although the Project PV grid-connected system will not generate reverse flows to the distribution grid, assuming that PV grid-connected systems which entail reverse flows will be introduced to Ghana in future, contents pertaining to reverse flow will be included in the technology transfer items.

Table 2-2-4.4 Contents of Soft Component Activities and Method of Technology Transfer

Target		Soft Component Outputs	Contents of Activities	Technology Transfer Method	Target
1. Operation and maintenance of the PV grid-connected system will be commenced by the Ghanaian side following completion of the Project.	1-1	The operation and maintenance organization for the PV grid-connected system is established.	• Clarification of the responsibilities of operation and maintenance personnel • Evaluation of the operation and maintenance setup	• Classroom lessons • Classroom lessons, group drills	NMIMR Maintenance Department
	1-2	Operation and maintenance personnel acquire the operation and maintenance technology for the PV grid-connected system.	• Transfer of PV system principles and basic knowledge • Lectures on PV grid-connected system features and protective functions (including reverse flows) • Transfer of operation technology • Transfer of maintenance technology • Technology transfer of periodic inspection techniques • Monitoring	• Classroom lessons • Classroom lessons • Practical exercises (operations using actual equipment) • Practical exercises (preparation of inspection list, inspections, repairs) • Practical exercises (including measurement of insulation resistance and open-circuit voltage) • Practical exercises (recording and evaluation of operating data, monitoring of equipment status)	NMIMR Maintenance Department
2. Operation and maintenance of the PV grid-connected system will be conducted on a sustained basis.	2-1	The PV grid-connected system operation and maintenance manual, including contents on troubleshooting, is prepared.	• Preparation of an operation and maintenance manual based on mutual cooperation with the Ghanaian side • Optimization of troubleshooting and operation and maintenance manual	• Classroom lessons, drills (manual preparation) • Practical exercises (operations based on manual, breakdown simulation training)	NMIMR Maintenance Department
	2-2	The outline and characteristics of the	• Lectures on PV grid-connected system	• Classroom lessons	University of Ghana Facilities

		PV grid-connected system are understood.	features and protective functions (including reverse flows)		Department
	2-3	Troubleshooting methods for the PV grid-connected system are established. (The distribution grid within the university is the target).	• Optimization of troubleshooting (including reverse flows) and operation and maintenance manual	• Practical exercises (operations based on manual, breakdown simulation training)	
3. The power distribution grid to which the PV system is connected will be operated in a stable manner.	3-1	The outline and characteristics (including reverse flows) of the PV grid-connected system are understood.	• Lectures on PV grid-connected system features and protective functions (including reverse flows) • Issues for examination (including reverse flows) when introducing the PV grid-connected system	• Classroom lessons • Classroom lessons	ECG Ministry of Energy Energy Commission
	3-2	Troubleshooting methods for the PV grid-connected system are established. (The ECG distribution grid is the target).	• Optimization of troubleshooting (including reverse flows) and operation and maintenance manual	• Practical exercises (operations based on manual, breakdown simulation training)	ECG

2) Input Plan

① Input Plan on the Japanese Side

In this soft component, through implementing the activities indicated in Table 2-2-4.4, the necessary technology transfer will be conducted to enable the implementing agency (NMIMR) to specifically understand and practice operation and maintenance methods for the PV grid-connected system. Moreover, with respect to the University of Ghana Facilities Department, which operates power distribution facilities on the campus, the ECG, which operates the power distribution grid, and the Ministry of Energy and Energy Committee, which supervise and regulate power systems, technology transfer will be conducted concerning the outline of the PV grid-connected system and important points in operation. The Consultant will dispatch Guidance engineer 1 (PV system) and Guidance engineer 2 (grid interconnection) to Ghana in order to conduct technology transfer for the period shown in Table 2-2-4.5.

Table 2-2-4.5 Input Plan concerning the Soft Component

Name		Rank	Period of Dispatch	Number of Trips	Work Contents
1.	Construction of the operation and maintenance setup				
	Guidance engineer 1 (PV system)	3	0.50 months	1	Construction of the operation and maintenance setup in the implementing agency
	Guidance engineer 2 (grid interconnection)	3	0.50 months	1	Construction of the mutual communication setup with the power utility operator
2.	Technical training				
	Guidance engineer 1 (PV system)	3	1.00 months	1	Transfer of operation and maintenance technology for the PV system
	Guidance engineer 2 (grid interconnection)	3	1.00 months	1	Transfer of technology concerning interconnection with the commercial grid
3.	Monitoring				
	Guidance engineer 1 (PV system)	3	0.50 months	1	Evaluation of technology learning concerning the PV system
	Guidance engineer 2 (grid interconnection)	3	0.50 months	1	Evaluation of technology learning concerning grid interconnection

② **Input Plan on the Ghanaian Side**

As the inputs on the Ghanaian side, it will be necessary to appoint the trainees who will receive the soft component, guarantee their participation in lectures, establish an operation and maintenance organization and establish a steering organization to smoothly implement the soft component. Specific inputs will be as follows.

a. PV System Operating Committee (provisional title)

Following the start of the soft component, the NMIMR Maintenance Department will promptly establish the PV System Operating Committee (provisional title) to ensure the smooth implementation of the soft component and sustainable operation following completion of the soft component. Since the Committee will be the recipient of the soft component while also serving as a forum for grasping the achievements, exchanging opinions and discussing issues in the soft component, it will hold regular meetings during the term of the soft component. Following completion of the soft component plan, the PV System Operating Committee will offer guidance to the PV Working group to ensure that operation and maintenance of the Project equipment is smoothly and continuously conducted after the soft component is finished. The PV Working Group will report to the Committee on the operation and maintenance conditions of the PV system and will receive guidance and advice when required.

The PV System Operating Committee, which will establish a secretariat in NMIMR (Noguchi Memorial Institute of Medical Research), will comprise representatives from five agencies, namely MOE, EC, ECG, University of Ghana and NMIMR. Specifically, one or two members each from the responsible departments in each agency will join the Committee. Figure 2-2-4.5 shows the organization of the PV System Operating Committee.

The PV System Operating Committee will be operated according to the implementation setup shown in Table 2-2-4.6 and it will discuss the following items geared to disseminating the PV grid-connected system throughout Ghana.

Issues concerning the operation and maintenance of the PV grid-connected system.

Impacts of the PV grid-connected system on operation of the power company’s grid and quality of power supply

Impediments to disseminating the PV grid-connected system in Ghana

Legal regulations for disseminating the PV grid-connected system in Ghana

Technical criteria (including reverse flow current) for disseminating the PV grid-connected system in Ghana

b. PV Working Group (PVWG) Draft

The PV Working Group (PVWG) will be established as a subordinate organization of the PV System Operating Committee and will conduct operation and maintenance of the PV grid-connected system under the guidance and supervision of the Committee.

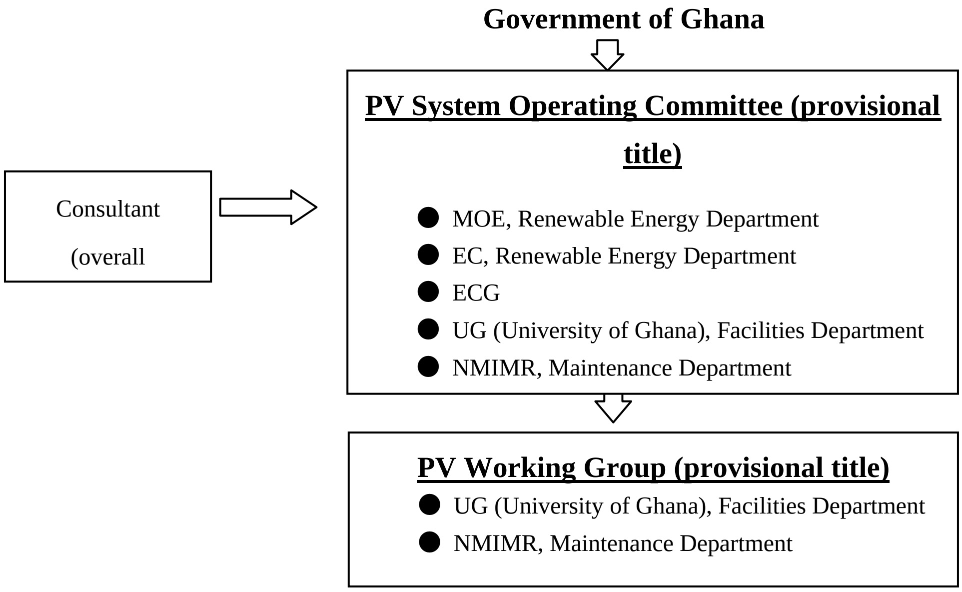

Figure 2-2-4.5 PV System Operating Committee Implementation Setup (Proposed)

Table 2-2-4.6 shows the implementation setup (proposal) for the PV System Operating Committee and PV Working Group.

Table 2-2-4.6 PV System Operating Committee Implementation Setup (Proposed)

	Japanese Consultant	PV System Operating Committee	PV Working Group
Number of members	2	5-10	3-5
Role	Overall progress management	Overall work management	System maintenance
Role in soft component	Explanation	Staging	Staging, participation
Maintenance manual	Advice	Draft proposal checking	Draft proposal preparation
Operation, analysis	Advice	Data analysis, consideration	Operation, data analysis
Maintenance follow-up	Management guidance	Maintenance reporting	Maintenance reporting
Report destinations	Japanese Embassy JICA Ghana Office	JICA Ghana Office	PV System Operating Committee

6) Method for Procuring Resources for Soft Component Implementation

Since the major instruments of the PV grid-connected system to be procured and installed in the Project are made in Japan, the engineers dispatched in the soft component will need to be well versed in Japanese PV products and systems. Although there are engineers who can conduct PV system installation in Ghana, they have only ever handled European or Chinese products and also lack experience in grid interconnection. Accordingly, as the implementation resources for the soft component, a system whereby a consultant with a thorough understanding of Japanese PV systems and grid interconnection gives direct support will be adopted.

(7) Soft Component Implementation Schedule (Proposed)

Table 2-2-4.7 shows the soft component implementation schedule.

The engineers dispatched from Japan will implement the soft component according to the categories shown in the table. The timing of each category will be as indicated below.

Construction of the operation and maintenance setup: The objective will be to support construction of the operation and maintenance setup. Since clarifying the maintenance setup before installation will stimulate awareness among staff, this will be implemented before the equipment is installed.

Technical training: Actual equipment will be used for conducting training on installation, inspection and operation, etc. In order to prepare the maintenance manual, etc. required before the equipment goes into operation, training will be implemented from around halfway through installation and before equipment goes into operation.

Monitoring: Since monitoring will be geared to confirming that the Ghanaian side can autonomously conduct maintenance, it will be implemented for approximately one month after completion of installation.

Table 2-2-4.7 Soft Component Implementation Schedule

Month		1	2	3	4	5	6	7	8	9	10
Foundation and installation works		■	■	■	■	■	■	■	■		
Inspection, adjustment, trial operation									■		
Initial operation guidance									■	■	
Acceptance inspection, completion and handover									■		
Soft component	Construction of the operation and maintenance setup			■							
	Technical training						■				
	Monitoring									■	
Outputs	Operation and maintenance manual						▼				
	Progress report			▼			▼			▼	
	Final report										▼

(8) Outputs

As is shown in Table 2-2-4.7, outputs of the soft component will be the Operation and Maintenance Manual (including troubleshooting), Progress Reports (English Progress Reports for the client), the Final Report (English Final Report for the client) and the teaching materials used in technology transfer.

(9) Responsibilities of Agencies on the Ghanaian Side

(1) Noguchi Memorial Institute for Medical Research (NMIMR) will establish the PV System Operating Committee for cooperating with the soft component.

(2) NMIMR will provide the conference rooms, etc. needed for implementing the soft component.

(3) NMIMR will provide the human resources necessary for implementing the soft component.

(4) The PV System Operating Committee will prepare the maintenance manual while consulting with the consultant. Also, it will revise and update the manual according to actual conditions following the start of system operation.

(5) NMIMR will appropriately maintain the grid-connected PV system based on the maintenance manual. In cases where PV system maintenance personnel and so on are transferred, the outputs of the soft component will be utilized in transferring technology to successors.

(6) The PV System Operating Committee will conduct inspections and present performance reports to the JICA Ghana Office based on the maintenance manual.

2-2-4-9 Implementation Schedule

The Project implementation schedule was compiled as follows based on the scheme of the Government of Japan's Environment and Climate Change Program Grant Aid.

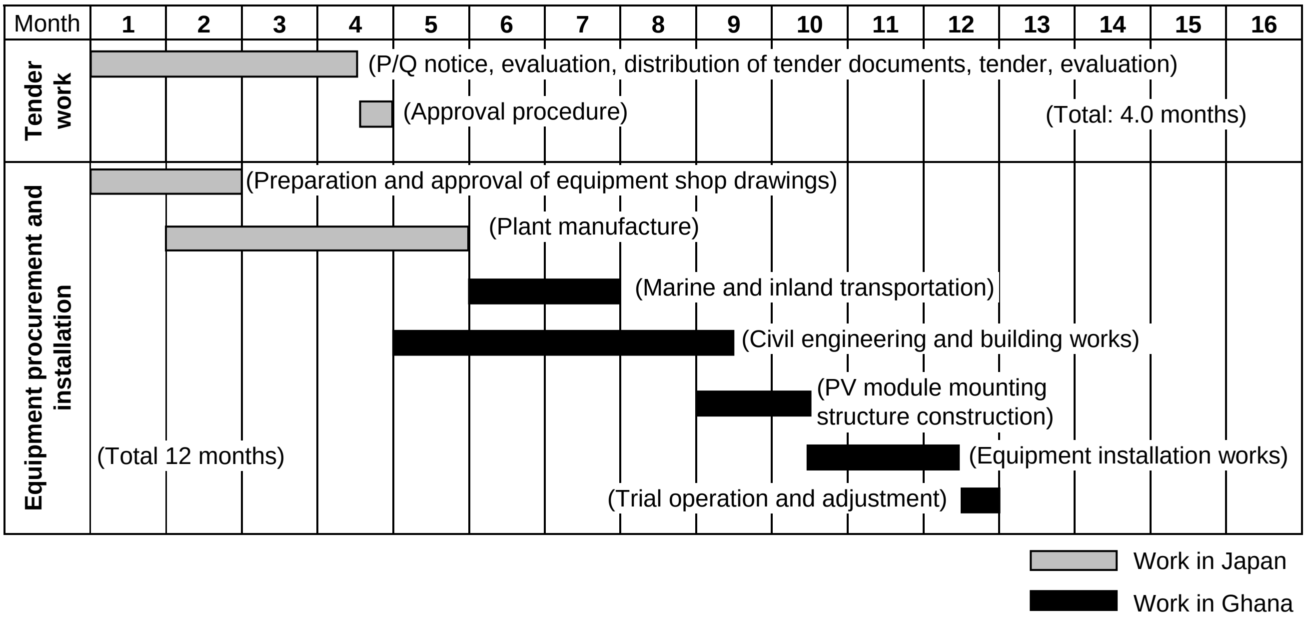

Figure 2-2-4.6 Project Implementation Schedule Sheet

2-3 Obligations of Recipient Country

When it comes to implementing the Project, in addition to the scope of works on the Ghanaian side indicated in 2-2-4-3 Scope of Works, items to be implemented or borne by the Ghanaian 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 Ghana

(3) To grant permission for Japanese nationals to enter and stay in Ghana in relation to the products and services provided based on the authorized contract

(4) To exempt Japanese nationals from taxes and tariffs, etc. that are ordinarily levied in Ghana on products and services supplied based on authorized contracts.

(5) To pay commission fees to the Japanese bank in relation to opening of the bank account for the Project

(6) To bear all items not covered under Japan's Program Grant Aid for Environment and Climate Change when implementing the Project

(7) 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

(8) To properly and effectively use and maintain the equipment and materials procured under Japan's grant aid

(9) To secure a disposal site for excavated earth, sewage, waste oil and recovered equipment and materials during the works period (if necessary)

(10) To secure the safety and provide guidance and education to local residents and related officials of the University of Ghana and Noguchi Memorial Institute for Medical Research during the works period

(11) To take the minimum required power interruption countermeasures when connecting the Project equipment and existing equipment

(12) To build a temporary road and equipment and materials storage area, etc. during the works

2-4 Project Operation Plan

2-4-1 Routine Inspection and Periodic Inspection Items

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

- Inspections and checking on completion of the grid-connected PV system and before the start of operation
- Routine inspections following the start of operation
- Periodic inspections after operation or after passage of a set period

Since NMIMR is the owner of the PV system, NMIMR is responsible for daily maintenance and operation, periodical checkup and the procurement of spare parts.

(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 2-4-1.1 shows the inspection items and measurement items. For details on the system completion inspection and checking, see 2-2-4-7 (Technical Assistance Plan).

(2) Routine inspections

Unlike diesel engine generators and other rotating devices, the grid-connected PV system requires no special controls following the start of operation.

The grid-connected PV system automatically starts operating every day once the sun rises to a certain point. If a power interruption occurs on the connected distribution grid, the grid-connected PV system automatically stops, and it automatically restarts once the grid is restored. However, if the grid-connected PV 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 PV modules, it is necessary to implement inspections every day. In the initial stage, the operation managers shall patrol the PV installation site with the Japanese engineers (installation engineers) to learn the inspection areas and techniques.

The PV power generating equipment can be automatically operated without any operating personnel. Routine maintenance and inspections are basically not needed, however, it will be necessary to clean the PV panel surfaces during the dusty dry season. 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 they 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 2-4-1.1 shows the inspection items.

Table 2-4-1.1 Routine Inspection Items

Inspection target	Visual inspection, etc.
Solar cell 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 generated electrical energy records - Checking of instrumentation and displays

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 as indicated in Table 2-4-1.1 (Routine Inspection Items). After checking the items indicated in the table, the operation manager will record the results and archive 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 PV 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 Hamatan season in the dry season.

(3) Periodic inspections

Table 2-4-1.2 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 in 2017.

Table 2-4-1.2 Periodic Inspection Items

Inspection Target	Inspection Item	Measurement/Test
Solar cell 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 conducting the inspections and checks shown in Table 2-4-1.2.

(b) Major inspection and check items

① PV module and array inspection

Thoroughly check for no broken or damaged panels. Check for cracking, fractures and discoloration of the surface glass.

② Checking of wiring and cables

Since the service life of PV systems is long, damage or twisting of power lines and cables during installation can lead to decline of insulation resistance and dielectric breakdown. Keep records of the parts that cannot be checked after the installation works have been finished. In routine inspections and periodic inspections, check for signs of damage by visual inspection.

③ Confirmation of connecting terminals

Screws of power conditioners, etc. sometimes become loose during transportation. Temporary wiring is sometimes left unfinished, while cases that have been loosened for testing, etc. are sometimes forgotten about. 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.

④ Inspection of other peripheral instruments

Also check for abnormalities in other peripheral instruments by visual inspection.

2) Measurement and safety measures

The operation manager will check that the installed PV 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 PV arrays from the installation engineers before the start of actual work, and safety measures will be implemented for the work assistants.

(a) Safety measures

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

a) Clothing

Wear helmets, sneakers and hip bags.

b) Shock prevention

① Detach one end of PV cell strings before the start of work
② Wear low voltage insulated gloves
③ Use insulated tools
④ Do not work when it is raining.

(b) PV array inspection: Confirmation of voltage and polarity and measurement of short circuit currents

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

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

(c) Insulation resistance measurement

Insulation resistance testing will be implemented in order to confirm that it is OK to turn on power to the PV system. Insulation resistance will be measured following 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.

(d) Ground resistance measurement

At the project site, mesh type grounding wires are to be installed around the PV modules and metal supporting frames for PV panels and metal external boxes of electrical equipment in power conditioner room such as power conditioner, transformer, etc. are connected to the mesh grounding wires. The mesh grounding wires shall be designed and installed so that the ground resistance will become 10Ω or less in accordance with Japanese grounding standard (C-type, standard of grounding for metal external boxes used for low voltage equipment with rated voltage of more than 300V) and the grounding standard in Ghana (10Ω or less).

Grounding resistance shall be measured by using a grounding resistance meter to be procured under the Project and the value should be checked that it satisfies 10Ω or less.

3) Grid-connected system inspection sheet

Table 2-4-1.3 shows the periodic inspection items and judgment criteria for the grid-connected PV system. Inspection records shall be archived.

Table 2-4-1.3 Inspection Items and Judgment Criteria for the Grid-Connected PV System

Instrument, etc.	Inspection Item		Judgment Criteria	Remarks	Inspector
PV 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 PV 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.		
	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 DC1000V		Insulation resistance between the PV cells + (plus) and ground should be at least 1MΩ.	MΩ	
			Insulation resistance between the PV cells – (minus) and ground should be at least 1MΩ.	MΩ	
	PV cell open voltage measurement	Open voltage in case of ( ) series	This should be no more than DC (-) V. Decide according to the system.	PV1 PV2 PV3	
		Voltage fluctuation	Voltage fluctuation between each series should be no more than ( ) V. (Decide according to the system).	V	
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	

(4) 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 PV 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 ③, 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 stops safely.

Note: Since there are differences between makers, refer to the maker specifications.

2-4-2 Spare Parts Purchasing Plan

Since the PV power generating system contains no internal operating parts, it is basically a maintenance-free system. 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 can’t be caused by natural disasters and fires, or that there will be no degradation or wear caused by long-term use. It is necessary to keep spare items on hand for the power conditioners, which are the heart of the system, and a number of other instruments.

(1) Equipment replacement intervals and inspection contents

Equipment becomes worn down and eventually loses its functions over time. The state of degradation in PV modules can be judged to an extent 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 2-4-2.1 shows the recommended replacement intervals and inspection contents of major instruments for reference.

Table 2-4-2.1 Replacement Intervals and Inspection Contents of Major Equipment

Part Type	Recommended Replacement Interval	Inspection Contents
PV module	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
Transformer	20 years or more	Temperature increase
Cooling fan	10 years or more	Change in air flow or turning sound
Fuse	7 years or 50,000 hours	Meltdown
Cooler	10~15 years	Malfunction, reduced performance

(2) Spare parts procurement plan

Breakages and failures of main items of equipment in PV power generating 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 keep stores 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 2-4-2.2 shows the types and quantities of spare parts that are recommended for storage at all times.

Table 2-4-2.2 Recommended Types and Quantities of Spare Parts

Equipment	Recommended storage quantity	Replacement parts to be procured in the Project
PV module	3% of the total number of modules	3% of the total number of modules
Junction box	2	2
Collecting box	1	1
Power conditioner	1	-
Fuse	10% of the total	-
Wiring	1 roll	-

In the Project, since spare units will be procured for all the main instruments that comprise the PV power generating system, the implementing agency will not incur a major maintenance cost. However, in order to cope with unexpected repairs or equipment replacements, it is recommended that the NMIMR maintain a fund for equipment repairs by using the money it saves on power tariffs as a result of the PV system. Table 2-5-2.1 indicates necessary operation and maintenance cost to be borne by NMIMR annually; it is estimated to be around 8,200 GHc.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) Costs to be borne by the Ghanaian side: 10,000 US$ (approximately 0.91 million yen)

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

① Clearing trees and grass from the PV panels installation site:
3,300 US$ (Approx. 0.3 million yen)

② Payment of commission to Japanese bank for money transfer:
6,700 US$ (Approx. 0.61 million yen)

(2) Estimation criteria

① Estimation point: : April 2010

② Exchange rate : 1 US$=91.20 yen (TTS mean value from October 2009 to March 2010)

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 Grant Aid Scheme of the Government of Japan.

2-5-2 Operation and Maintenance Cost

The operation and maintenance costs of the grid-connected PV system to be procured and installed in the Project are as indicated in Table 2-5-2.1, and the annual cost to be borne by NMIMR is approximately 8,200 GHc (US$5,691).

Table 2-5-2.1 Operation and Maintenance Cost

	Annual Cost (Cedi /year)	Remarks
Personnel expenses	3,950	Personnel expenses for the dispatch of engineers from manufacturers on the occasion of periodical maintenance (every five years)
Equipment replenishment	4,250	Replacement of parts for power conditioners, etc. converted into an annual amount
Total	8,200	

(1) Equipment replenishment cost

Table 2-5-2.2 shows the necessary equipment and estimated service lives for operating the grid-connected PV system over the long term. Assuming that the life of the Project is 20years based on the service life of PV modules which have the longest life among the project components, necessary equipment replenishment cost is calculated as follows. Since replenishment for PV modules, junction boxes and collecting boxes are to be procured under the Project, it is not necessary to consider the replenishment cost for such equipment. In order to cope with possible breakdown of power conditioners during the project life, cost for parts estimated to be 10% of initial investment for four units is considered. Unlike other equipment, since the cooler includes rotating parts such as a compressor and air blower, wear will certainly arise as a result of long-term continuous use and it will be necessary to replace parts.

As shown in Table 2-5-2.2, cost for equipment replenishment is estimated to be 5.38 million Yen (84,992 GHc) or 0.269 million Yen (4,250GHc) per year converted into an annual amount.

Table 2-5-2.2 Equipment Service Lives and Replacement Costs

Part	Recommended Replacement Interval	Inspection Contents and Troubleshooting		Cost
PV module	20 ~30 years	External appearance and voltage measurement	Replace with spare parts	-
Junction box	20 years	Malfunction	Replace with spare parts	-
Collecting box	10~15 years	Malfunction	Replace with spare parts	-
Power conditioner	10~15 years	Malfunction	Purchase and replace	5.20 million yen
Transformer	20 years or more	Abnormal heating	Examine new investment*	(9 million yen)
Cooler	10 years	Malfunction, reduced performance	Purchase and replace	0.18 million yen

Note: *: Judge the wisdom of conducting re-investment depending on the condition of the PV module (major equipment). The service life of a transformer is more than 20 years, the same as PV modules.

(2) Electricity cost

1) Electricity consumption of NMIMR

Based on electricity consumption data for NMIMR from July to November 2009, annual electricity consumption was calculated as shown below. Since no major fluctuations can be seen in the monthly power consumption, the annual total was obtained by multiplying the mean amount for the said five months by 12.

Table 2-5-2.3 Electricity Consumption in 2009

Month	Electricity Consumption (kWh)
July	105,500
August	101,200
September	110,900
October	114,700
November	115,300
Total	547,600

The mean amount is 109,520kWh/month, and annual consumption is 1,314,240kWh.

2) Electricity tariff

NMIMR pays its electricity tariff to the University of Ghana, although this does not entail the actual transfer of cash. Table 2-5-2.4 shows the electricity tariff for NMIMR for the four years from 2006 to 2009.

Table 2-5-2.4 NMIMR Electricity Tariff

Year	Electricity Tariff (GHc)
2006	18,000
2007	20,000
2008	24,000
2009	28,000

3) Electricity tariff in 2009

Based on 1) and 2) above, the mean electricity tariff per 1 kWh works out as 2.1GHp/kWh.

4) Electricity tariff for the power conditioner room

The electricity tariff for the power conditioner room will be as follows.

① Electricity consumption of 3 kW/h is assumed for the cooler in the power conditioner room (assuming a room temperature of 30~35°C).

② Annual power consumption: 365 days x 8h x 0.5 x 3kWh=4,380kWh / year
(Assuming usage of 8 hours per day with a 50% power rate).

③ Annual electricity tariff: 4,380kWh x 2.1p=9,198GHp=91.98GHc

CHAPTGER 3 PROJECT EVALUATION

Chapter 3 Project Evaluation

3-1 Project Preconditions

3-1-1 Preconditions for Project Implementation

Project implementation requires the acquisition of permission from the University of Ghana to use the site and the granting of environmental permission, however, since these have already been secured during the preparatory survey, there is no problem.

3-1-2 Preconditions and External Conditions for Achievement of the Overall Project Plan

The issues that need to be tackled by the Government of Ghana in order to realize and sustain the Project effects are as follows.

(1) It will be necessary to appropriately conduct routine maintenance to ensure that the PV system equipment procured and installed by the Japanese side is utilized to the full.

(2) It will be necessary for related agencies to participate in equipment installation and technical guidance in the Project, in order to acquire PV system technology and utilize it in future enlightenment and dissemination.

(3) It will be necessary to build a framework for saving the tariff reductions enabled by PV generation and to utilize this saved money for renewing and maintaining equipment.

(4) It will be necessary to secure, educate and training personnel for maintaining the PV system equipment.

(5) It will be necessary to share data on solar irradiation and generated electric energy, etc. with related agencies and utilize it in future plans.

3-2 Project Evaluation

3-2-1 Relevance

As is indicated below, since the Project will contribute to the realization of Ghana’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) Benefitting population

Project implementation will enable employees (approximately 220) of Noguchi Memorial Institute for Medical Research to receive power supply from PV generation. Moreover, the reduction in emissions of greenhouse gases enabled by PV generation will benefit all the people of Ghana.

(2) Contribution to stable operation of public welfare facilities

In addition to contributing to power supply for Noguchi Memorial Institute for Medical Research (a public welfare facility), the Project will aid in the dissemination and public education of renewable energy.

(3) Operation and maintenance capacity

Since the equipment and materials to be procured in the Project can be comfortably operated and maintained under the present technical capacity in Ghana, they will present no particular problems regarding implementation of the Project.

(4) Contribution to development plans in Ghana

The project will contribute to the national energy policy and strategic national energy plans being implemented by the Government of Ghana.

(5) Government of Japan's Grant Aid Scheme

The Government of Japan's Grant Aid Scheme will not hinder implementation of the Project. Moreover, since the Project contents and schedule are feasible for implementation under the Grant Aid Scheme, the Project can be implemented without any major difficulty.

(6) Necessity and superiority of Japanese technology

In the Project it will be possible to utilize Japanese advanced technology in the field of clean energy including renewable energy. In particular, it will be possible to utilize extremely superior Japanese technology in the field of photovoltaic power generation.

3-2-2 Efficiency

The anticipated effects of Project implementation are as indicated below.

① **Quantitative effects**

Indicator	Reference value (2010)	Target value (2015)
Net electric energy (MWh/year)	0	382
CO_2 reduction (t/year)*	0	220

*: Arising out of the Project

② **Qualitative effects**

Current conditions and problems	Project countermeasures (grant aid project)	Degree of Project effects and improvement
1. Although the Government of Ghana regards promotion of the introduction of renewable energy as a policy goal, a lack of enlightenment and dissemination activities is hindering progress.	Introduce a 315 kWp grid-connected PV system at the Noguchi Memorial Institute for Medical Research of the University of Ghana.	Through installing a PV system at the Noguchi Memorial Institute for Medical Research of the University of Ghana, which has approximately 39,000 students, an enlightenment effect can be expected with respect to the teachers and students of the university and visitors.
2. Although the Government of Ghana is aiming to introduce grid-connected renewable energy based on the Renewable Energy Law, the country has hardly any experience of similar systems.	Ditto	Because personnel on the Ghanaian side will be involved in the planning, installation and maintenance of grid-connected PV system equipment, they will acquire knowledge and experience on PV equipment, and this will contribute to future dissemination.

3-2-3 Conclusion

As was indicated above, since the Project can be expected to impart major effects and to contribute to realizing the energy policy of Ghana, it will be highly relevant and effective to implement the Government of Japan’s Grant Aid Scheme for part of the Project activity. Moreover, the Ghanaian side is deemed to possess adequate personnel and budget capability to host the Project and handle the operation and maintenance of equipment after its completion.