Ministry of Industry, Mines and Energy
The Kingdom of Cambodia

FINAL REPORT
OF THE PREPARATORY SURVEY
ON THE PROJECT
FOR
INTRODUCTION OF CLEAN ENERGY
BY SOLAR ELECTRICITY GENERATION SYSTEM
IN
THE KINGDOM OF CAMBODIA

February 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NEWJEC Inc.

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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 Kingdom of Cambodia.

JICA sent to Cambodia survey team headed by Mr. Yasuharu MATSUDA of NEWJEC Inc. from December 6th to December 17th, 2009 and from March 1st to March 30th, 2010.

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia from October 17 to 22, 2010 in order to discuss a draft outline design, and as this result, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

February 2011

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

SUMMARY

SUMMARY

I. Outline of the Recipient Country

The kingdom of Cambodia (hereinafter referred to as "Cambodia") is located in Southern-west part of the Indo-China Peninsula bordered by Thailand, Laos and Vietnam. The country stretches 560 km from East to West and 440 km from South to North. The total population as of 2008 is 13.4 million and the total land area is 181,035 km^2 and equivalent to half area of Japan and one-third area of Thailand. Natural condition of the Cambodia is characterized by the Mekong River and the Tonle Sap Lake. The Mekong River having total length of 4,200 km is the largest international river in South-east Asia and runs through Cambodia which extends 486 kms from north to south.

Cambodian belongs to a tropical monsoon region and has rainy season from the latter half of May to October, and dry season from November to the former half of May. Precipitation concentrates in the latter half of the rainy season, especially in September and October. Cambodia has a climate of high-temperature and humidity for whole year round and the average temperature reaches to 27.6°C.

Cambodia is a typical agricultural country and had abundant rice fields. However, a lot of social infrastructures were destroyed during the Pol Pot Administration era and the Cambodian economy had been suffered from catastrophic damage. In 1980's, USSR and Eastern European Countries were the main donors and provided economic and physical support. In 1990's and thereafter, the United Nations started to support Cambodia and also the West and Japan started to support the reconstruction of Cambodian economy and social infrastructures. Cambodian economy has now remarkably developed under self-supporting efforts and donors' support.

The average growth rate of GDP for the period from 2000 to 2007 attained 9.4% and 6.7% for 2008. One of the backgrounds for the remarkable development of Cambodian economy seems to be caused by direct investment from abroad. Cumulative amounts of registered capital from 1994 to 2007 by the direct investment from abroad reached to 14,830 Million US$[1]. Among 14,830 Million US$, China occupies 1,760 Million US$ and followed by Korea amounted 1,500 Million US$. China and Korea mainly invest in apparel manufacturer related and real estate. On the other hand, Malaysia and Singapore invest in rubber and tourism related.

Main industries in Cambodia are tourism and service field, which accounts for 37.5%[2] of GDP, agriculture 31.7% of GDP and mining and manufacturing 23.8% of GDP. These three industries account for about 70% of the total GDP. Concerning trade partners[3], main exporting courtiers

[1] Bangkokshuho No.1314 (March 17, 2008)
[2] Cambodian Government data, 2008
[3] Cambodian Government data, 2008

are USA (45.2%), Hong Kong (19.3%) and Canada (6.7%), and main importing countries are China (21.1%), Thailand (15.8%) and Hong Kong (13.3%).
Cambodian currency is Riel and exchange rate against US$ is 4,240 Riel as of February 2010.

II. Background of the Project and its Outline

Cambodia ratified UNFCC in December 1995 and Kyoto Protocol (COP3) in August 2002 and belongs to Non-Annex I Parties. Cambodia prepared the green gas inventory in accordance with the IPCC guidelines (1996) and submitted to COP No.8 Conference.

Concerning the Power Sector, about 90%[4] out of the total power supply by EDC is generated by thermal (diesel) power plants which burn heavy fuel oil and diesel oil. In August 2010, the transmission line project from Phnom Penh to Vietnam border via Takeo was completed by assistance of ADB and 100 MW power is currently imported from Vietnam through this transmission line. The power import from Vietnam will be increased to 200 MW by the end of 2011. However, since the peak load of the Phnom Penh system is estimated at 290 MW at present, the diesel power plants are still required to be operated as before to meet increasing power demand.

With regard to rural electrification of households, 20% of households can access to electricity in 2009. The Cambodian Government sets a target that 70% of households can access to electricity by the year 2030 by grid-connection and utilization of renewable energy technology such as solar power, biomass and mini-hydro. Number of ODA assistances to Energy, Power and Electricity Sector from abroad after 2000 reaches to 34[5] projects as of 2010, of which number rank third following 79 projects for Transportation and 36 projects for Water and Sanitation. It can be overviewd that Cambodia expects ODA in Energy, Power and Electricity Sector.

Under the above circumstances, Cambodia decided to join “Cool Earth Partnership” and gives a priority to policies for reduction of GHGs emission and promotion of economic development, by the approach of adaption and mitigation to climate change. In accordance with the initiative, Cambodian Government requested to the Government of Japan for Grant Aid in October 2009.

Under this request, JICA conducted the first phase site survey between December 6th and 17th in 2009, and decided the Phum Prek Water Treatment Plant managed by PPWSA as candidate site, and made into agreement with the Recipient.

III. Outline of Study Result and the Content of the Project

Subsequently, JICA sent the Survey Team for the second phase site survey between March 1st, 2010 and March 30th to Cambodia, to investigate the Site, collect related information and have

[4] Source: EDC Annual Report 2007
[5] Source: CDC Website (http://cdc.khmer.biz/Reports/reports_by_sector.asp)

discussion with the Recipient concerning the contents of the Project.

After coming back to Japan, the Survey Team examined the necessity, effectiveness and appropriateness of the Project based on the result of the site survey, and prepared a Draft Outline Design Report. JICA's Study Team visited Cambodia again between October 17th, 2010 and October 22th to submit the report. After explaination and discussion the report, JICA and the Government of Cambodia signed the minutes of discussion.

The responsible organization is the Ministry of Industry, Mines and Energy and the implementation organization is the Phnom Penh Water Supply Authority.

The summary of outline design of the PV system is shown below.

Category	Content
Site and PV Capacity	Phum Prek Water Treatment Plant: 488 kW PV system - The roof of No.2 Distribution Reservoir(264.6 kW), the roof of No.3Ditribution Reservoir (173.8 kW) and the roof of Chemical Feeding & Storage Building (50.4 kW) - PV system shall be grid-connected and without batteries. - In the case of blackout, PV system shall be designed to shut down automatically.
Procurement of PV System and Installation Work	488kW PV modules Ancillary equipment for PV system - Junction box - Collecting terminal box - Power conditioner - Power conditioner cubicle - Meteorological observation device - Monitoring device and remote monitoring system - External and internal lightning protection device - Mounting frame for PV modules - Foundation for mounting frame and power conditioner cubicle - Power panel for grid-connection - Display device - Laying cables Waterproof work for the roofs of No.2 & No.3 distribution reservoirs
Spare Parts & Tool Kits and Training Program	Spare parts and tool kits for maintenance of the PV system Manuals for O&M and implementation of Operation Guidance

IV. Project Implementation Cost and Period

The cost of this project implemented under Japan's Grant Aid scheme includes no expenses on Cambodian side.

The project period is planned to be 5.5 months for tendering stage, and about 9.5 months for the procurement of PV system and its installation.

V. Evaluation of the Project

PPWSA will be responsible for daily operation and maintenance of the PV system as the implementation organization nominated by the Project. MIME as the responsible organization and EDC as the relevant organization will give advice for operation and maintenance.

At the implementation stage of the Project, a series of the training program will be provided for operation and maintenance relating to techniques and knowledge of PV system and its use. The training program intends to make the Project of effective and sustainable operation and maintenance by the organization mentioned the above, and to contribute to the promotion of grid-connected PV system in Cambodia.

The direct effect of the Project will be providing additional power and energy by clean energy and reducing consumption of fossil fuel and CO_2 emission in Cambodia which remarkably depends on fossil fuels. The effect of reduction of CO_2 emission on the basis of EDC's 2007 generation energy by thermal power plants is expected to be 400 t-CO_2 per year.

With regard to PPWSA, despite increasing production cost for drinking water in the recent years, PPWSA has not increased the water tariff since 2001 and electricity payment to EDC reached to about 80% of the total production cost in 2008. The Project will yield the saving of the electricity payment and it is expected to contribute to reinforcement of management foundation of PPWSA, water supply to Phnom Penh citizens at affordable price and to improve the sanitation in Phnom Penh City consequently.

Meanwhile, PV modules and power conditioners made by Japanese manufacturers have technical advantages over other countries for their efficiency, longevity, reliability, etc. in the market. As the Project qualifies the main equipment to be procured in Japan, the Project will be able to offer advanced technology of Japanese products.

Adding up the discussions above, it is concluded that the Project planned herein is very effective and appropriate as a project to be implemented as Programme Grant Aid for Environment and Climate Change.

Table of Contents

The Kingdom of Cambodia

Phnom Penh City

List of Figures

List of Tables

Abbreviations

AC	Alternating Current
B/A	Bank Arrangement
CDC	Council for the Development of Cambodia
CT	Current Transformer
DC	Direct Current
DEG	Diesel Engine Generator
EAC	Electricity Authority of Cambodia
EDC	Electricite du Cambodge
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
GDP	Gross Domestic Product
GNI	Gross National Income
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JCS	Japanese Electric Wire & Cable Makers' Association Standard
JEAC	Japan Electric Association Code
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer's Association
JICA	Japan International Cooperation Agency
JICS	Japan International Cooperation System
JIS	Japanese Industrial Standards
MCCB	Molded Case Circuit Breaker
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
NEDO	New Energy and Industrial Technology Development Organization
O&M	Operation and Maintenance
OJT	On the Job Training
PCS	Power Conditioners
PPWSA	Phnom Penh Water Supply Authority
PV	Photovoltaic
PVC	Polyvinyl Chloride
SI	The International System of Units
SPD	Surge Protective Device
SHS	Solar Home System
UNFCC	United Nations Framework Convention on Climate Change
VCT	Voltage Current Transformer
VT	Voltage Transformer

CHAPTER 1

BACKGROUND OF PROJECT

Chapter 1 Background of Project

1-1 Background of Project

Power sector in Cambodia remarkably depends on imported fossil fuels such as heavy fuel oil and diesel oil. About ninety per cent out of the total generation energy are produced by thermal power plants burning fossil fuels as of 2009. With regard to the rural electrification, only twenty per cent of the total households can access to electricity in 2009. On the other hand, poverty headcounts as of 2007 are estimated at 30.1% for the whole country and 34.7% for the rural area. The Government of Cambodia sets forth a target for reduction of the poverty rate in the National Strategic Development Plan. The Ministry of Industry, Mines and Energy also tackles the target for reduction of the poverty rate through the improvement of the rural electrification rate and development of rural economy by utilizing clean energy technology such as photovoltaic generation, biomass and small hydropower.

Japanese government announced its policy initiative in Davos in January 2008 to assist developing countries which intend to contribution to mitigate of climate change by means of reduction of greenhouse gas emission without compromising their economic development. The initiative is called “Cool Earth Partnership” and aims to support developing countries in their efforts to reduce energy consumption and emissions, and also adapt to the change in climate. As one of measures, Japanese government set up “Program Grant Aid for Environment and Climate Change”, a financial mechanism to support member countries which have difficulties in executing capabilities and funding.

Cambodia decided to join “Cool Earth Partnership” and takes up as its policy priority reduction of GHGs emission and promotion of economic development, by the approach of adoption and mitigation to climate change. It responded with its candidate projects to needs surveys by the Ministry of Foreign Affairs of Japan.

Solar energy is generally regarded as mitigation strategy of climate change because it does not consume fossil fuel, and especially in Cambodia which is highly dependent on imported fossil fuel, it is also expected to contribute to the diversification of primary energy set forth in the National Strategic Development Plan.

Description of the request for the Grant Aid project submitted by the Government of Cambodia in October 2009 is as follows.

Requested amount: 5,000,000 US$

Description of Requested Components:

Photovoltaic Power Generation System (200 kW)
PV module, supporting structure, extension cable, junction box, connection box, power conditioner, display unit, data management and monitoring system, transformer, control panel etc.
Project site: Phum Prek Water Treatment Plant, Cambodia

Having received the request, technical issue such as potential of installation of photovoltaic modules, etc. for the above site has been studied in the first phase site survey implemented in December 2009. Then after discussion with Cambodia, Phum Prek Water Treatment Plant has been selected as a project site candidate, and agreed between Phnom Penh Water Supply Authority, Ministry of Industry, Mines and Energy in Cambodia and JICA Study Team on December 15, 2009.

Phum Prek Water Treatment Plant managed by PPWSA was constructed by French assistance in the old days and was extended its facilities by Japan Grant Aid in 1996 and 2003. PPWSA was one of the departments of Phnom Penh City Government and changed to an independent authority in 1993. PPWSA has now three water treatment plants in Phnom Penh City and supply approximately 1.4 million citizens in Phnom Penh with drinking water in 2008.

In this Grant Aid project, photovoltaic power generation system (PV system) will be provided as part of assistance for countermeasure of climate change in Cambodia, and a part of power system in this country will be replaced by renewable energy, in order to support for coping with both greenhouse gas emission and economic growth, by decreasing dependency rate on fossil fuel in this country.

1-2 Project Site and Surroundings

1-2-1 Related Infrastructure

(1) Unloading Port and Transportation Route

The products procured in Japan will be unloaded at Sihanoukville Port, only one international port in Cambodia, and transported to Phnom Penh City via National Route No.4, about 200 km from the port. The port is equipped with large cranes sufficient enough for unloading of containers for the products. The National Route No.4 is well paved and expected to serve as a transportation route of the products. Fig.1-2.1 shows the transportation route from the Sihanoukville Port to Phnom Penh City.

Fig.1-2.1 Transportation Route

(2) Transportation in Phnom Penh City

The Phum Prek Water Treatment Plant is located in the center of Phnom Penh City and looks to a trunk road. Therefore, the products will be smoothly delivered to the Phum Prek Water Treatment Plant via Route No.4.

(3) Electricity, City Water, and Communication Facility

Electricity, city water and communication facility are necessary for the installation work. All these social infrastructures are available at the site.

(4) Land Acquisition

Since the PV modules will be installed on the roofs of the existing facilities (No.2 Distribution Reservoir, No.3 Distribution Reservoirs and Chemical Feeding & Storage Building) in the premises of Phum Prek Water Treatment Plant, land acquisition and leveling are not required.

(5) Phum Prek Water Treatment Plant

Phum Prek Water Treatment Plan has its facilities consisting of sedimentation basins, a chemical feeding & storage building, a central control room, a pumping station, an electrical room, distribution reservoirs. There are also the PPWSA head office and an administration building and so on. Fig. 1-2.2 shows the overall layout of the Phum Prek Water Treatment Plant.

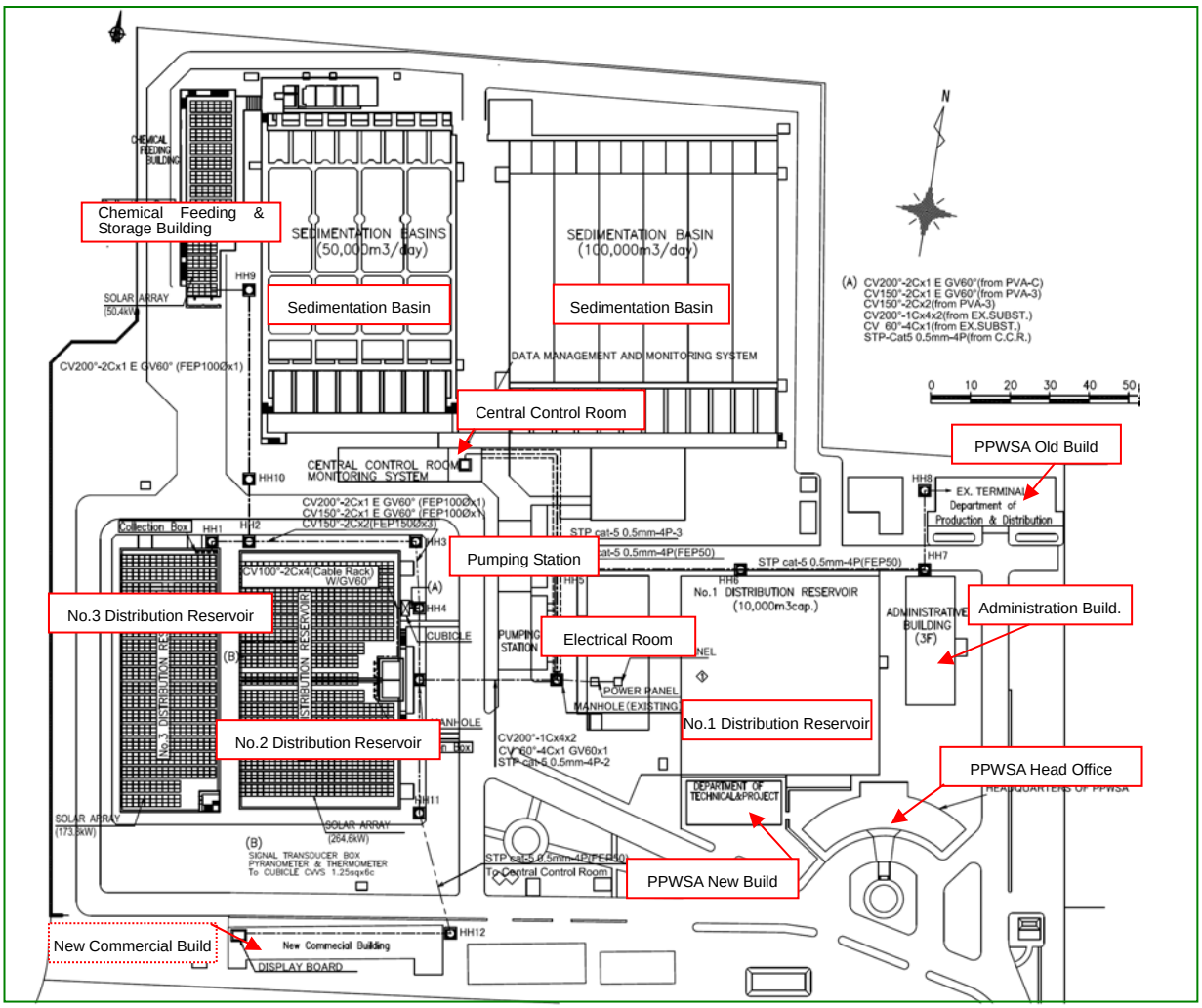


Fig. 1-2.2 Overall Layout of the Phum Prek Water Treatment Plant

1-2-2 Natural Condition

(1) Rainfall and Temperature

Due to the monsoon in South-east Asia, the climate of Cambodia is clearly separated by rainy season and dry season, and high-temperature and humidity for all year round. The rainy season is May to October and the dry season is November to April and it has much rain especially in September and October.

The average temperature is 27.6°C and the annual rainfall in Phnom Penh City is about 1,300 mm ~ 2,000 mm. About 85% out of the annual rainfall concentrate on the rainy season and monthly rainfall of 200 mm and above are observed sometimes in the rainy season. And in the rainy season, structural damages caused by a lot of thunders are reported. Table 1-2.1 shows the rainfall in the Phnom Penh City for the last three years.

Table 1-2.1 Monthly Rainfall in Phnom Penh City (2007, 2008 and 2009)

(unit: mm)

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total	0.0	0.0	33.2	39.8	201.4	252.0	141.0	263.6	159.2	212.1	71.3	0.0
Max.	0.0	0.0	12.0	33.0	37.4	77.8	50.0	115.0	29.8	57.4	23.8	0.0
No. of Rainning day	0	0	6	5	18	13	16	22	18	20	11	0

Total in the Year : (2007) 1,373.6

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total	74.1	0.6	111.3	83.4	177.7	224.9	170.8	295.5	289.8	262.4	191.1	52.0
Max.	63.6	0.4	87.8	36.8	77.8	53.0	65.8	43.0	52.0	44.6	40.0	26.8
No. of Rainning day	2	2	3	10	16	21	15	24	24	23	14	4

Total in the Year : (2008) 1,933.6

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total	26.8	4.3	1.7	270.5	241.7	148.1	151.8	262.2	304.1	111.2	74.2	0.0
Max.	26.8	2.0	1.7	54.3	50.4	32.2	54.0	73.6	57.2	22.8	47.2	0.0
No. of Rainning day	1	3	1	18	22	15	19	20	25	19	5	0

Total in the Year : (2009) 1,596.6

Source: Ministry of Water Resources and Meteorology

(2) Earthquake

Concerning the earthquakes, Cambodia is one of the countries where occurrence of earthquakes is very few. According to United States Geological Survey (USGS), earthquakes with magnitude of 2.5 and above have not been observed since 1973 in Cambodia. Fig. 1-2.3 show the earthquake map within 500 km radius from Phnom Penh City.

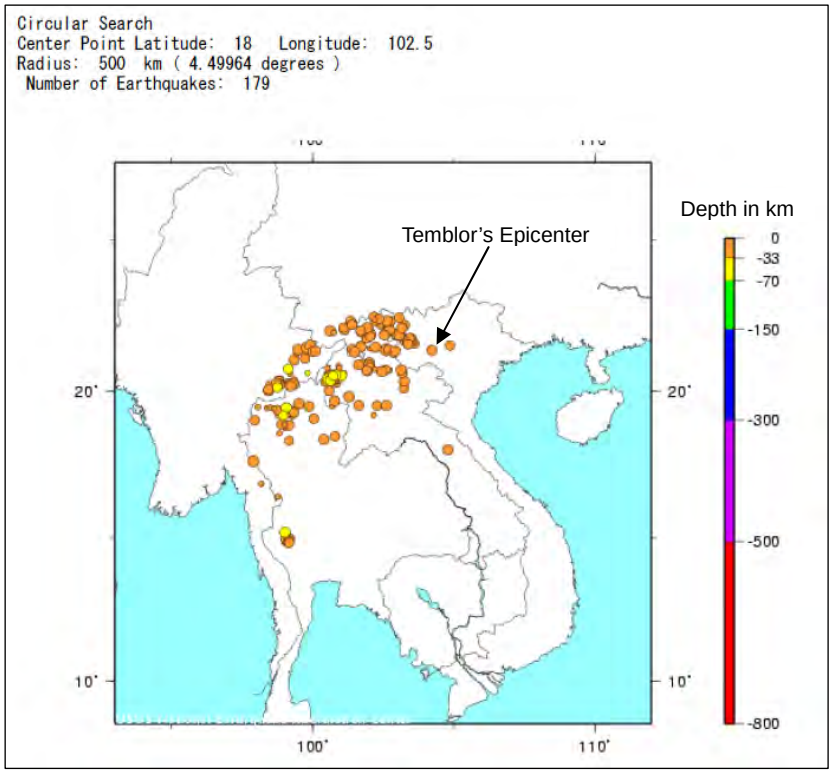


Fig. 1-2.3 Earthquake Map within 500 km radius from Phnom Penh City

(3) Typhoon

Concerning the typhoons, typhoons have seldom attacked Cambodia. In recent years, only No.16 typhoon (Asian Name is Ketsana) which originated in the sea close to Philippine and passed through Cambodia from September 26 to September 30 in 2009, and caused 35 people dead, of which maximum wind velocity was estimated 35 m/sec.

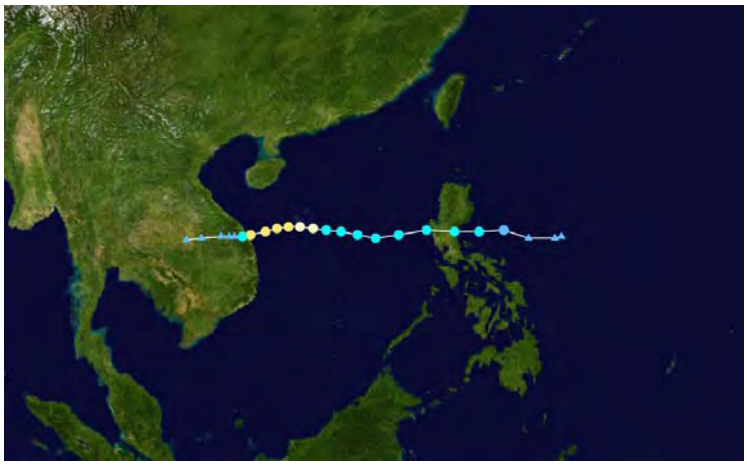


Fig. 1-2.4 Path of Ketsana Typhoon

(4) Ground Condition at the Site

Since the PV modules are to be placed on the roofs, the ground condition at the site is only applicable to the foundation design for power conditioner cubicles which are to be placed on the ground. Seven (7) borings were carried out at the foundation ground of the No.3 Distribution Reservoirs Building prior to the construction and N values by Standard Penetration Test were obtained. According to the test results, up to the depth of 2.5 m from the ground surface, foundation soil consist of silty clay and N values indicated 2 ~ 3, which are equivalent to allowable bearing power of 30 kN/m^2 [6].

1-2-3 Environmental and Social Considerations

With regard to laws and regulations relating to the environmental and social considerations, Ministry of Environment published "Declaration on the Evaluation of EIA on Project" in 2000. The declaration covers overall industry and stipulates project scales which are required for IEIA and/or EIA. Concerning the power sector, the project which is required for IEIA and/or IEA is a thermal power plant project of which installed capacity is 5 MW and above, and a hydropower project of which installed capacity is 1 MW and above.

Since the installed capacity of the PV system at Phum Prek Water Treatment Plant is 488 kW at the moment, the project is not subject to the above declaration. Furthermore, PPWSA confirmed with IEA department in MOE that PPWSA has no obligation to submit the environment-related documents for the implementation of the project.

Meanwhile, according to "JICA Guideline for Environmental and Social Considerations", April 2010, a photovoltaic power generation system is not included in "Category A" which is likely to have a significant adverse impact on the environment and society. Therefore, a photovoltaic power generation system belongs to "Category B" or "Category C".

Table 1-2.2 shows the result of screening based on the JICA guideline and was submitted to PPWSA. As shown in Table 1-2.2, "Waste" and "Accident" during the construction period are ranked as "B" and other remaining items are ranked as "C". "Waste" and "Accident" ranked as "B" have an adverse impact on environment and society for just limited period. For the above reasons, the project is categorized as "Category C" which is likely to have minor or little adverse impact on the environment and society.

"Waste" treatment (Waste Disposal) is stipulated in Clause 3.1.3 in the General Specification and "Accident" (Safety Control) is also stipulated in Clause 6 in the Technical Specification as the Contractor's obligation.

[6] Based on the Table in "Guidance for Small Architectural Foundation Design", Architectural Institute of Japan

Table 1-2.2 Screening Results in Terms of Environmental and Social Considerations

Items	Rank	Reasons
Resettlement	C	Since the construction sites are within PPWSA's properties, resettlements and land compensation will not be necessary.
Impact on the residents nearby	C	Since the construction site is located in PPWSA's large premise isolated from the residential area, the impact on the residents nearby will not occur.
Land Use	C	The PV system will be installed on the roof of the distribution reservoir at the PPWSA, therefore, the impact on the land use will not occur.
Impact on social practice	C	The installation of PV system at the roof of the distribution reservoir will not impact on social practice.
Impact on infrastructure	C	Since the PV system is installed in the PPWSA's premise, impact on infrastructure will not occur.
Impact on poverty group, vulnerable group and minority group	C	Since the PV system is installed in the PPWSA's premise in Phnom Penh impact on those groups will not occur.
Uneven distribution of benefit	C	Benefit to be yielded by PV system will belong to the PPWSA, a state enterprise.
Cultural monument	C	Since the PV system is installed in the PPWSA's premise, impact on cultural monument will not occur.
Conflict with residents near by	C	Since the PV system is installed in the PPWSA's premise, conflict with residents will not occur.
Water use and right of water	C	PV system does not require any water use and the right of water. Therefore, no impact will occur.
Sanitation	C	During construction period, workers will be increased to a certain extent at the sites. However, it seems to be very few possibility of the worsening of sanitation because the construction period will be only about five to six months.
Risk on infectious disease	C	During construction period, workers will be increased to a certain extent at the sites. However, it seems to be few possibilities because the construction period will be only about five or six months.
Impact on nature of soil and geographic feature	C	Any reclamation, embankment and reforming the geography feature are not required because PV system will be installed on the roof. Therefore no impact will occur.
Soil erosion	C	PV system will never cause soil erosion like a hydropower plant.
Underground water	C	PV system will never use underground water.
Impact on surrounding water	C	PV system will never use cooling water like a thermal power plant.
Impact on sea frontier	C	Since PV system will not be installed at sea frontier, impact on sea frontier will not occur.
Fauna and flora, and diversification	C	Since the PV system is installed in the PPWSA's premise in Phnom Penh, impact will not occur.
Atmospheric phenomena	C	PV system will never release particles causing the change of atmospheric phenomena.
Landscape	C	Installed PV panel will present the good landscape generally.
Global warning	C	PV system will produce electric energy without the emission of CO_2.
Air pollution	C	PV system will not release particles after operation.
Water pollution	C	PV system will not release the water contamination materials after operation.
Soil pollution	C	PV system will not release the soil contamination materials after operation.
Waste	B	During construction period, waste will be increased to a certain extent but for the limited period.
Noise and vibration	C	Since the PV system is installed in the PPWSA's premise, the noise and vibration will not impact on the residents nearby.
Ground settlement	C	The weight of PV system including the mounting frame is not so heavy to cause ground settlement.
Offensive odor	C	PV system will never release any odors.
Impact on bottom sediment	C	Since PV system will never require oil tanks like an oil-fired thermal power plant, there will be no possibility of leaking materials impacting on bottom sediment.
Accident	B	During the transportation and construction, it cannot be denied that accidents will never happen. However, the possibility of accident occurrence can be reduced by safety management by the Contractor, such as allocation of security guard.

Note; A: Serious impact, B: Minor Impact, C: Minimum or negligible impact

CHAPTER 2

CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

The project is to provide Phum Prek Water Treatment Plant managed by PPWSA with a photovoltaic system (PV system) of 488 kW and to burden a part of power consumption in the Phum Prek Water Treatment Plant premises.

The PV system works with the power from the utility grid (grid-connection) without batteries, and in the case of blackout of grid power, the system also shut down automatically. Since the power consumption at the plant is huge as described later, surplus power by the PV system and reverse power flow to the grid will not occur accordingly.

The project is conducted under the scheme the Programme Grant Aid for Environment and Climate Change and the tendering for the contract for the procurement of equipments and construction shall be held for Japanese companies. Among the various to be procured by the project, PV modules and power conditioners shall be limited to Japanese products. Site works including civil works for foundations, installation of PV modules and electric works, shall be undertaken and managed by the Japanese contractor in cooperation with local contractors in the recipient country.

2-2 Design Policy

2-2-1 Design Policy

Phum Prek Water Treatment Plant is one of the three water treatment plants managed by the PPWSA and supply Phnom Penh Citizens of 1.4 Million[7] with safety-drinking water. Therefore, Phum Prek Water Treatment is an important facility in terms of contribution to sanitation. Table 2-2.1 shows the agreement which was signed by JICA and the Government of Cambodia on December 15, 2009 concerning the project. With respect to the installed capacity of PV modules, the installed capacity was increased to 488 kW instead of 200 kW resulting from the cost estimation.

[7] Population of supplied areas is about 1,425,000 in the end of 2008.

Table 2-2.1 Agreement Concerning the Project

	Description
Location	Phum Prek Water Treatment Plant, PPWSA
Outline	The power produced by PV system is used for Phum Prek Water Treatment Plant
Requested Equipment	(1) Solar module (panel): total capacity might be 200 kW (The Cambodian side remarked to the Survey (2) Team that it should be better installing more than 200 kW of the solar module for the Project.) * The final capacity of the PV system to be installed under the project will be decided by GoJ. (3) Junction box (4) Power conditioner (5) Distribution board (6) Cables for electric distribution (7) Data collecting and display device (8) Mounting frame for solar module
Capacity Building	-

Taken into consideration of the above importance and the concurrence, the following design policy is applied to the project.

- Since the project is the grid-connected PV system, the project will be designed on "Grid-interconnection Code" in Japan and make clear the applicable range between the above Japanese standard and Cambodian standard, if any.
- Since the project is the grid-connected PV system, islanding operation of the PV system is not permitted in case of grid trouble.
- The PV system to be introduced to Cambodia is about 500 kW class and the first case in the country. And the operation performance of the project may affect the promotion of the PV system in the future. Therefore, the proven technology in Japan will be applied to the project.
- Since the grid-connected PV system is the first case in Cambodia, the PV system is equipped with grid protection device to prevent national grid and the existing electrical facilities in Phum Prek Water Treatment Plant from being electrically disturbed by the PV system, when troubles occur in the PV system.
- PV array shall be installed on the roofs of the existing buildings due to the lack of ground space in the Phum Prek Water Treatment Plant. In order to check the structural stability of the building where increase of load by the PV array will occur, the PV array should be installed at the building of which structural drawings are available to review the structural safety of the relevant buildings.
- Crystal and amorphous type module are considerable when selecting a module type generally. However, to secure the prescribed installed capacity in the restricted space on the roof, crystal type module seems to be only applicable to the Plant.

2-2-1-1 Design Policy for Natural Condition

(1) Temperature

Since Cambodia belongs to a tropical monsoon region, Cambodia is high temperature and humidity for all year round and the average temperature reaches to 27.6°C. Power conditioner with a lot of IC parts shall be protected from the high temperature and humidity by a forced cooling system (air conditioner) to be installed in a cubicle. And cubicles are planned to be made of heat shielding treatment (such as heat shielding plate, heat shielding paint, sheet steel with double structure and heat insulation board and so on). Therefore, other countermeasures against high temperature at the site seem to be unnecessary. And a junction box is also planned to be coated and finalized for use in tropical region.

(2) Lightning

Structures damages caused by a lot of thunders in the rainy season are reported in Cambodia. And Phum Prek Water Treatment Plant has also lightning rods as a measure against thunders. Considering the importance of the facilities and that the PV modules are to be installed on the roof, lightning protection will be adapted into the project. An external lightning protection device will be installed at PV array and internal lightning protection devices are installed in junction boxes, power conditioners and a distribution board for grid connection concretely.

(3) Rainfall

More than 85% of annual rainfall concentrates on the rainy season from May to November and the monthly rainfall sometimes exceeds 200 mm. Considering the above condition, the available working days in the rainy season is set as the day of which daily rainfall is 20 mm and below provisionally by collecting the daily rainfall data in Phnom Penh for the last three years.

(4) Design Wind Velocity

Considering that:

1) The maximum wind velocity of the typhoon (Asian name is Ketsana) attacking Cambodia in September 2009 was estimated at 35 m per second by Meteorological Bureau in Japan.

2) “Electric Technical Standard of the Kingdome of Cambodia, August 2007” prescribes the design wind velocity in Part 3 Conductor “2.1.3 Reference Wind Velocity” and stipulates as shown below. According to the above clause, the design wind velocity can be changeable depending on the importance of the facility.

Based on the above consideration, the design wind velocity applicable to the PV array is set 40 m per second including about 10 % margin.

2.1.3 Reference Wind Velocity

Reference wind velocity to design overhead lines shall be as given in Table 13.

Table 13: Reference Wind Velocity

Yearly maximum of 10-minute average wind velocity (50 year return period)[8]	32 m/sec

In the following circumstances, the above reference wind velocity can be changed.
a. When sufficient observed data have been accumulated.
b. When greater reliability is especially needed.
c. When the design is needed to cooperate with the designs of neighboring countries.

(5) Earthquake Load

There are few earthquakes in Cambodia as mentioned previously and the earthquake load was not considered in the design stage for the Phum Prek Water Treatment Plant. Therefore, earthquake load is not considered in the project.

(6) Allowable Bearing Power of the Ground

The allowable bearing power of the ground is only applied to the design of concrete foundation supporting the power conditioner cubicles to be installed on the ground because PV modules are to be installed on the roofs of the existing facilities. Standard penetration test was conducted and N values were measured via seven borings at the construction stage of No.3 Distribution Reservoir. According to the test result, the foundation soil up to the depth of 2.5 m from the ground surface consists of silty clay and the N values are between 2 and 3. Therefore, the allowable bearing power of the ground corresponding to N value of 2 ~ 3[9] is set 30 kN/m^2.

(7) Angle of Inclination for PV Array

Since the Phnom Penh City is located at latitude 11.5 degree centigrade N, the PV array is designed to be southward with angle of inclination of 10 degree.

(8) Measures against Small Animals

Since cable damages being bitted by small animals such as rats and weasels were reported during the site survey, cables exposed in the air are protected by flexible metal conduits and cables under the ground are protected by synthetic resin conduits to prevent small animals from going into.

[8] Note: 50-year return period is also adapted in “Guidebook for Introduction of PV Generation System, NEDO” in Japan.
[9] Based on the Table in “Guidance for Small Architectural Foundation Design”, Architectural Institute of Japan

2-2-1-2 Policy for Social and Economic Environment

The recipient country might have to burden some financial expenses in response to the install conditions of the PV system even though the project will be implemented by the Grant Aid. In consideration of the national budget of Cambodia, the project pays attention to selection of the location and layout of PV system not to cause Cambodia financial burden as much as possible.

Since Phum Prek Water Treatment Plan supplies the tap water to customers in Phnom Penh City for twenty-four hours, designing of configuration will be paid attention so as to minimize the blackout required for grid connection work.

A lot of citizens come to the Phum Prek Water Treatment Plant during daytime to pay water tariff. Therefore, it is important to give enough information on construction schedule and safety control to PPWSA in advance in order to avoid accidents accompanied by the construction work. And it is also important to incorporate the safety control, such as traffic accidents prevention etc., into the Tender Documents.

2-2-1-3 Policy for Construction /Procurement Environment

Based on the agreement as shown in Table 2-2.1, the main components will be procured in Japan. Other components and materials & equipment required for the installation will be procured in Cambodia.
Labor Law (No. 06NA, published in 1997) stipulating labor environment shall be respected.

2-2-1-3 Policy for Utilization of Local Contractor

Since the local contractors have no experience of such a large scale installation of the PV system in Cambodia, the Japanese prime contractor will employ the local contractors and the local contractors will install the PV system under the supervision of the prime contractor.

2-2-1-4 Policy for Operation and Maintenance

In order to secure the sustainable operation of the PV system, daily and periodical maintenance seem to be essential. The Soft Component will be conducted focusing on that the implementation organization can acquire the capacity of finding malfunctions of the PV system and responding to malfunctions appropriately.

In the course of the Soft Component, if the maintenance organization established by the implementation organization is found to be insufficient in terms of operation and maintenance,

the maintenance organization will be reviewed with the implementation organization. The review includes the possibility of introduction of the external technical support, such as EDC and so on.

The life time of a PV system is said to be more than twenty years generally. The project provides the recipient country the minimum spare part such as a power conditioner for emergency use and consumable goods. Beside the spare part and consumable goods, it is also important to reserve the money from the commissioning year in preparation for replacement/repair of the equipment in the future. After estimation of expected economic benefit for the implementation organization, required reserve will be consulted with the implementation organization. If the implementation organization cannot burden the required reserve, measures will be consulted with implementation organization and the responsible organization.

2-2-1-5 Policy for Facility and Procurement

The technical specification and grade to the PV system will be determined in consideration of the current maintenance environment. However, the first priority will be assigned to the procurement of PV system with high reliability and quality because Phum Prek Water Treatment Plant has a lot of local and foreign visitors[10].

The PV system with the installed capacity of 488 kW is the first experience in Cambodia. And grid protection devices are installed in power conditioners due to the grid-connected PV system. In order not to disturb the grid and operation of the plant when malfunctions and/or troubles happen to the PV system, the technology to be introduced to Cambodia shall be proven technology in Japan.

2-2-1-6 Policy for Construction Method and Period

The PV array (PV modules + supporting frame) is installed on the roofs of the existing facilities. Therefore, it is important to decide the layout of PV array on the roof and its dimensions to keep the same structural safety as they are. And it is also important to check the impact on the existing waterproof layer by the increased load of the PV array.
The construction schedule will be prepared to minimize the construction period in consideration of available working days and number of teams for installation work resulting from reviewing the raining days and rainfall.

[10] There were 122 visitors including from Vietnam and Laos in 2007 and 65 visitors in 2008.

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

Table 2-2.2 shows the requirement raised by the Government of Cambodia and the basic plan responding to the requirement.

Table 2-2.2 Request by the Government of Cambodia and Basic Plan

Items	Request by the Government of Cambodia	Basic Plan responding to the Request
Location	Phum Prek Water Treatment Plant, PPWSA	Same as on the left
Outline	The power produced by PV system is used for Phum Prek Water Treatment Plant	Same as on the left
Requested Equipment	(1) Solar module (panel): total capacity might be 200 kW (The Cambodian side remarked to the SureyTeam that it should be better installing more than 200 kW of the solar module for the Project.) * The final capacity of the PV system to be installed under the project will be decided by GoJ. (2) Junction box (3) Power conditioner (4) Distribution board (5) Cables for electric distribution (6) Data collecting and display device (7) Mounting frame for solar module	(1) Revision of the installed capacity No.2 Reservoir;264.6 kW No.3 Reservoir;173.8 kW Chemical Feeding B.; 50.4kW Total ; 488 kW (2) Lightning protection will be added. (3) Wiring cables will be protected by FEP pipe against small animals.
Capacity Building	- * In the first field survey, MIME requested the Survey Team to conduct the technical transfer, and PPWSA expressed his comments that PPWSA would intend to install a PV system at another water treatment plant if the performance of the PV system is good.	(1) Soft Component (Technical Transfer) will be conducted.
Procurement	Main components will be procured in Japan	(1) Main components will be procured in Japan and ancillary equipment and materials will be procured in Cambodia.
Grid-interconnection	-	(1) Protection device for the national grid will be added. (2) Islanding operation of the PV system is not allowed.
Design	-	(1) In order to check the structural stability of the No.2 and No.3 Reservoirs after installation of PV array, the structural calculation for No.3 Reservoir will be collected. (2) The angle of inclination of the PV array will be 10° in consideration of the latitude of Phnom Penh. (3) The type of PV module will be crystal module type due to the restriction of available installation space. (4) Supporting frame for PV modules will be designed based on JIS C 8955-2004and the supporting members will be coated by hot dip galvanized. (5) Design wind velocity will be 40 m/s. and earthquake load will not be considered in the design. (6) The allowable bearing power of the ground applied to the concrete foundation supporting power conditioner cubicles shall be 30 kN/m^2. (7) The safety factor for sliding of the foundation concrete block for supporting frame will be at least 2 and above. (8) The maintenance path will be secured on the roof. (9) Collecting boxes will be placed on the roof preventing from monkey trick. (10) Power conditioner cubicles will be protected by fences. (11) New water supply equipment for the installation work will not be placed because water supply system is available at the moment. (12) Daily visual check the PV system shall doubles with patrol to protect the PV system against theft and vandalism.
Construction Method	-	(1) Reviewing the impact on the existing waterproof layer and necessary measures are taken

(1) Overall Plan

1) Site Selection

The application submitted by the Government of Cambodia requested the PV system installation be in Phum Prek Water Treatment Plant, PPWSA and the PV array installation be on the roof of No.2 Reservoir Building. Since the Cambodian side remarked to the Survey Team that it should be better installing more than 200 kW of the solar module for the Project in the agreement dated December 2009, the roof of the No.3 Reservoir Building next to the No.2 Reservoir Building was also selected as the site for the PV array. The No.2 Reservoir was completed in 1996 by Japan Grant Aid and has water distribution capacity of 50,000 ton per day in combination with No.1 Reservoir. The roof of No.2 Reservoir is around 2700 m^2 and enough space to install the PV array. The No.3 Reservoir Building was completed in 2003 by Japan Grant Aid and its roof area is around 1700 m^2. And the Chemical Feeding & Storage Building assigned to the new installation site after 2nd survey was completed in 2003 by Japan Grant Aid and its roof area is around 550 m^2.

There are not any high buildings and tall trees nearby, which might cause shadows on the PV modules of the above three buildings. And thanks to the Japan Grant Aid, the structural drawings are available for the three buildings. Based on the above considerations, the roofs of the existing three buildings are judged as appropriate sites for the PV array installation.

2) Overall Layout

Phum Prek Water Treatment Plant is located in the center of Phnom Penh City. A head office of PPWSA, water treatment facilities and water tariff payment building are built in the premises of Phum Prek Water Treatment Plant. Water treatment facility consists of a pumping station, an electrical room, a central control room, sedimentation basins and distribution reservoirs and so on. The PV modules will be installed on the roofs of No.2 Reservoir, No.3 Reservoir and Chemical Feeding Building. Electricity generated by the PV modules will be transferred to power conditioners via junction boxes and collecting terminal boxes. And electricity converted to AC in the power conditioner will be transferred to the existing distribution board in the electrical room via hand holes and a new distribution board (power panel). Meteorological measurement instruments, such as an actinometer and a temperature gauge will be placed near the power conditioner cubicles. On the other hand, a communication cable from the power conditioner will connected to a monitoring device to be installed in the central control room, to monitor and store the relevant information and data, through the existing cable rack adjacent to the electrical room. Instantaneous power output and cumulative generation energy from the commissioning will be displayed on the panel in the water tariff payment room to be moved to a new commercial building. Furthermore, a new site for remote monitoring will be established in the PPWSA website so that key personnel can monitor and download the

operation performance of the PV system from outside of the central control room via Internet. The accessible key personnel are controlled by their ID and password.

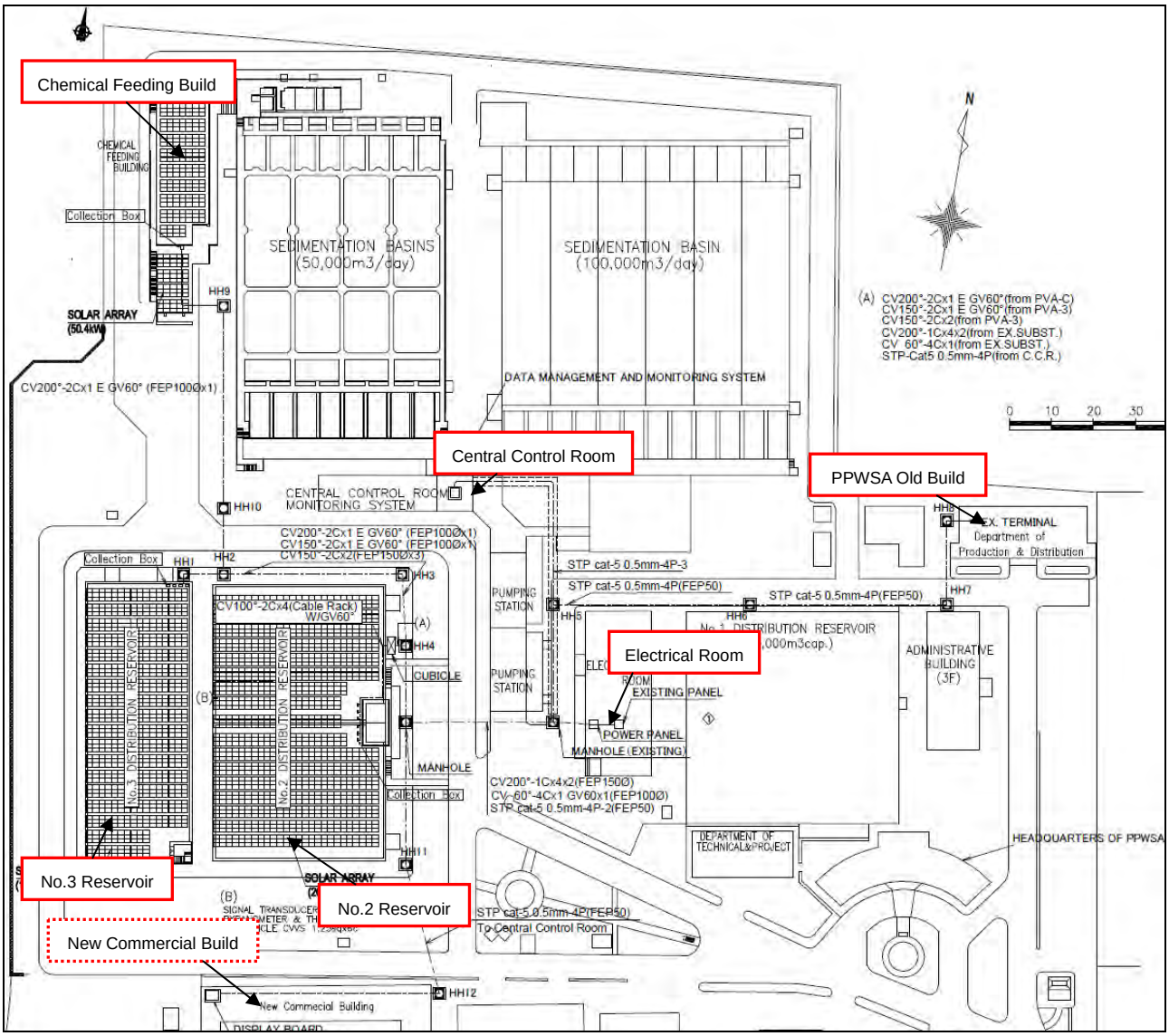


Fig. 2-2.1 Relevant Buildings for PV System

(2) Civil and Architectural Work (Supporting Frame and Foundation)

1) Study on Foundation Concrete Block and its Arrangement

The existing No.2 and No.3 Reservoirs are designed as a multi-span box rigid structure and the span length is 4.0 m for No.2 Reservoir and 4.2 m for No.3 Reservoir. The foundation block were arranged to be placed on the columns as a single block so as not to cause additional bending moment and shearing force on slabs which might impact the structural stability of the existing reservoir buildings (Fig. 2-2.2).

The continuous block is preferable in terms of sliding stability than a single block because

the continuous block has more area of base than a single block, which contributes to resistance against the sliding. However, the continuous block will cause bending moment and shearing force and might interfere with the smooth rain flow toward drainage boxes placed on the roof of No.3 Reservoir as shown in Photo 2-2.1. This is the reason why a single block is selected as foundation block for the PV array. The size of the single block is determined as W 80 cm × B 80 cm × H 55 cm based on the stability analysis of the block as described later.

On the other hand, Chemical Feeding Building is designed as a different structure from No.2 and No.3 Reservoirs and there is no intermediate column, where the single block is to be put on. Therefore, the block has no choice except to be placed on a beam as the continuous block to transmit the additional load of PV array to the beam thinly and broadly. The width of the continuous block is determined as 30 cm in consideration of chemical anchors drilling on the surface of the block (Fig. 2-2.3).

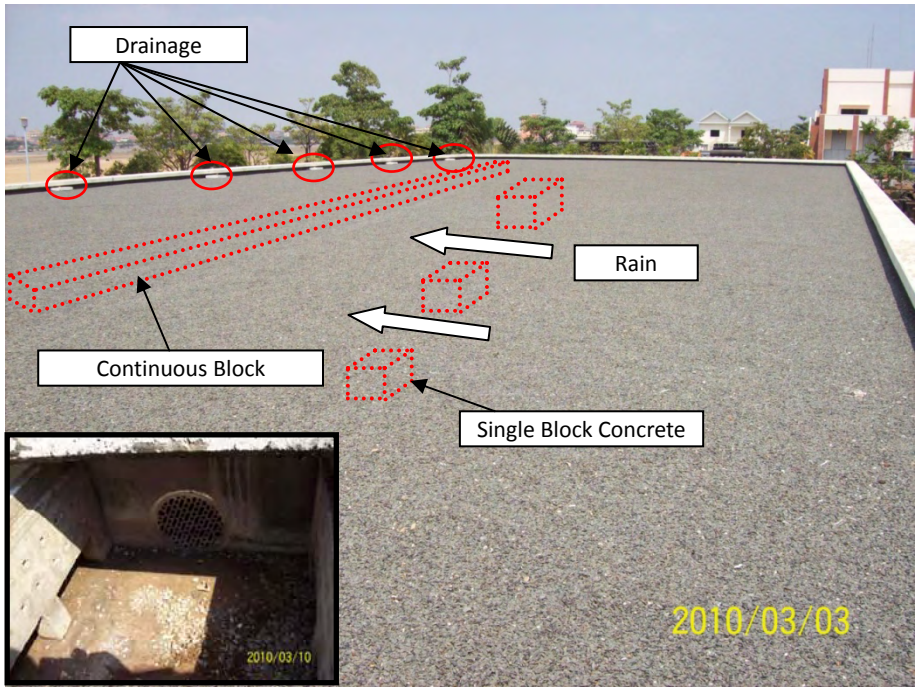


Photo 2-2.1 Relationship between Drainage Boxes and Blocks (No.3 Reservoir)

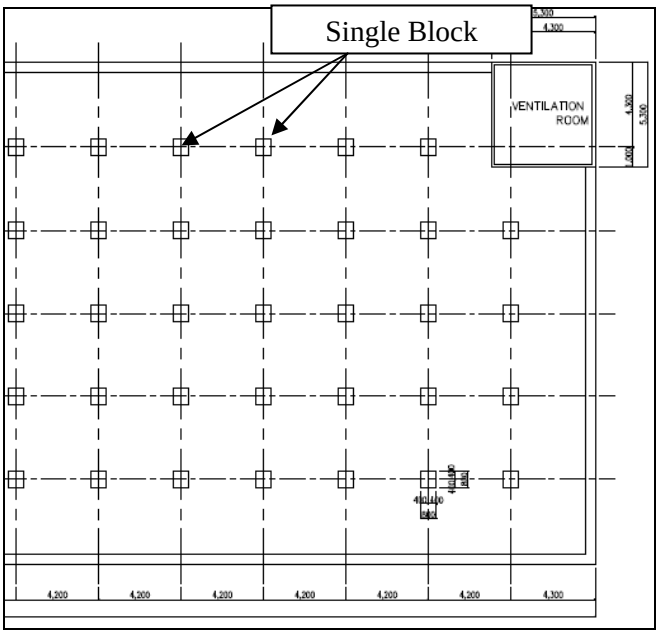


Fig. 2-2.2 No.3 Reservoir Single Block Layout

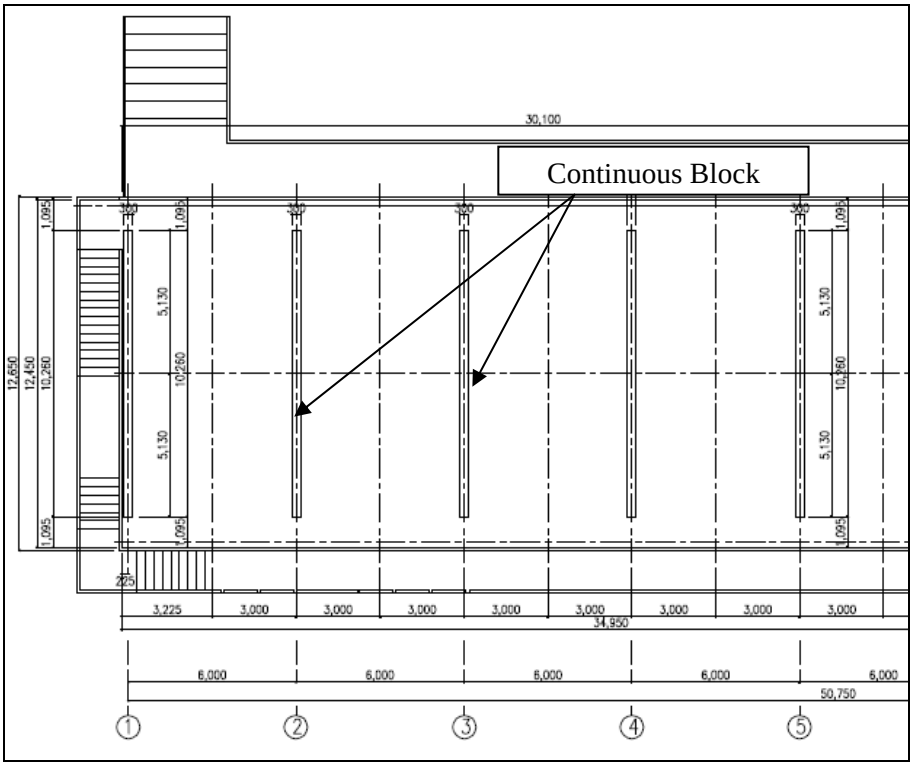


Fig. 2-2.3 Chemical Feeding Building Continuous Block Layout

2) Waterproof Work

Waterproof treatment by an asphalt layer with 20 mm thickness was done at the roof of No.3 Reservoirs as shown in Fig. 2-2.4 and coating film for No.2 Reservoir. Since the waterproof treatment is said to be effective for 10 ~ 15 years generally, the repair and/or refurnishing of the waterproof treatment will be necessary within a few years for No.2

Reservoir which was constructed in 1996, and the coming around five years for No.3 Reservoir which was constructed in 2003. But after installation of PV array on the roof, repair and/or refurnishing of the water treatment seem to be impossible in actuality because all PV modules and supporting frame have to be temporarily removed and demolished prior to the commencement of the treatment work. And local impact on the waterproof layers by the additional load of PV array is also unclear.

Comparative study for the assumption that the function of waterproof layer becomes impaired is conducted concerning Distribution Reservoirs and Chemical Feeding & Storage Building and the result is shown in Table 2-2.3. Based on the comparative study, it is concluded that waterproof treatment works for No.2 and No.3 Distribution Reservoirs should be done by the project. Fig. 2-2.5 shows the concept of the waterproof treatment to be done by the project.

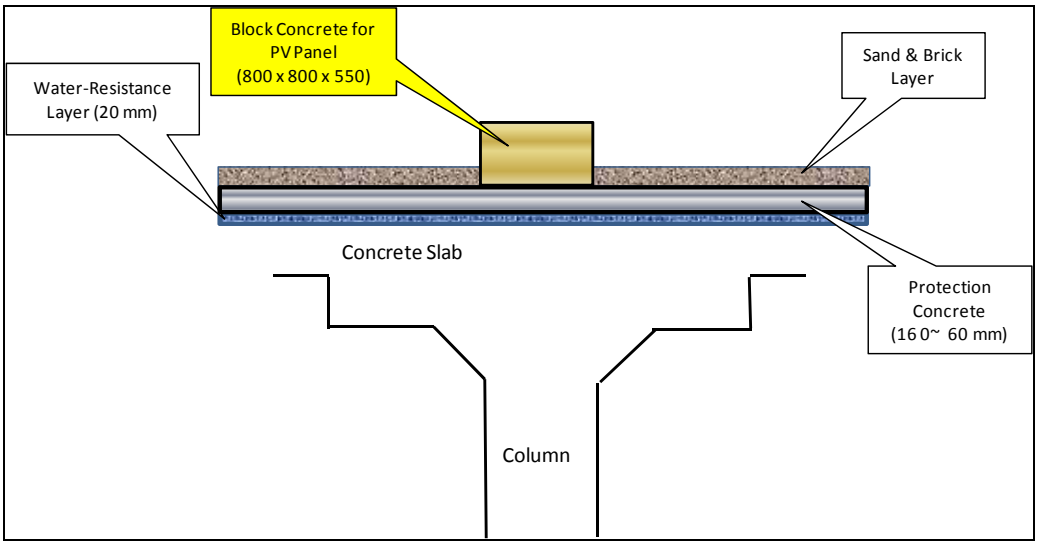


Fig. 2-2.4 Existing Waterproof Layer on the Roof of Reservoir

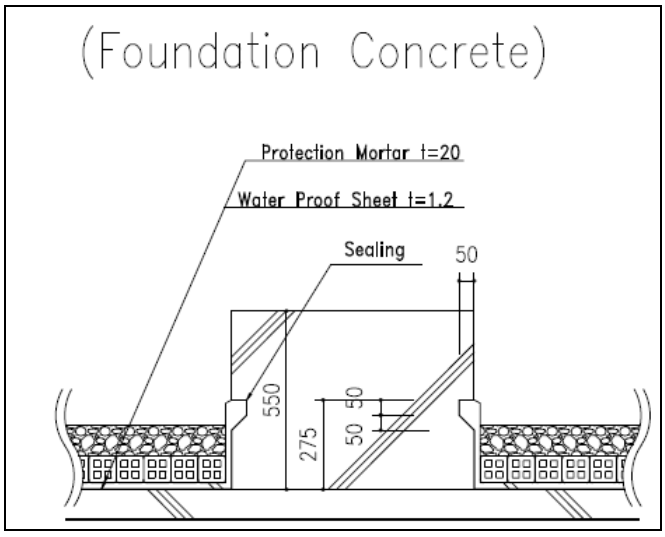


Fig. 2-2.5 Concept of Waterproof Treatment Work

Table 2-2.3 Comparative Study for Distribution Reservoirs and Chemical Feeding Building

Facility				No.2 Distribution Reservoir	No.3 Distribution Reservoir	Chemical Feeding & Storage Building
Function and structure of the Building	Function of facility			Storage of tap water for customers		Chemical treatment for raw water
	Quality of water			Final treated water (tap water)		Raw water
	Storage in the building			Final treated water (tap water)		Raw water and chemicals
	Facilities in the building			Distribution reservoir		2F：Laboratory, Electrical Room, Chemical Feeding Room
						1F：Chemical storage
	Structure of Roof	Base structure		Concrete slab		Concrete slab
		Waterproof layer		Coating film	Asphalt (t=20 mm)	Asphalt (t=9 mm)
		Protection concrete		Protection concrete (t=60-160mm)		Protection concrete (t=50-150mm)
		Protection layer		Bricks, clayware and gravel		Facing tile bonded by mortar
	In the building	Lighting equipment		Without lighting		With lighting
		Ceiling (surface)		Concrete slab		Concrete slab
						With ceiling panel for laboratory and electrical room
		Accessibility		Only accessible when the reservoir is empty		Easy access to the leaking point
Concerns relating to Waterproof and Leakage	Impact on the existing waterproof layer by the project			There would be possibility that the Project affects the existing waterproof layer		Same as on the left
				Guarantee period of waterproof effect is expired during the service life time of the PV modules		Same as on the left
	Waterproof	Need (Facility)		Very high need in terms of water supply with good and safe quality		High need for laboratory and electrical room even though water is raw water
		Importance	Water supply	Very important because water leakage might cause tap water contamination		Normal
			Protection of facility	–		Important for laboratory and electrical room
		Repair & Renovation		Very difficult after installation of PV array		Same as on the left
	Water Leakage	Impact on water supply by water leakage		Possibility of stopping water supply due to water contamination seems high		Possibility of stopping water supply seems low
		Identification of water leakage point		Difficult to identify the leaking points		Easy to identify the leaking points in the building
				Very difficult to identify cracks on the roof due to the protection layer		Easy to identify cracks on the surface of tiles
		Measures	In the building	Very difficult due to not accessible in the normal condition		Measures, such as caulking, seem possible
			On the roof	Measures seem difficult due to not identifying the point		Measures, such as caulking, can be done once the leaking point is identified.
				Protection layer has to be removed		Tiles have to be removed
			Duration	Treatment duration seems long as well as the stoppage of water supply		Shorter than that for No.2 and No.3 Reservoirs
Evaluation	Importance (Facility)			Very important due to the final treated water		Important for electrical room and so on
	Impact on (water supply, facility)			Very high		Normal
	Identification of leaking point			Impossible		Possible
	Easiness of measures			Very difficult		Easy
Conclusion				Taking into consideration importance of facility, accessibility to water leakage points, and easiness of measures, the waterproof treatment work should be done under the Project.		There would be possibility that the Project affects the existing waterproof layer. However, impact by the water leakage seems not serious, and identification of and measures against water leakage seem easy. Therefore, waterproof treatment work is not done and the existing cracks observed on the surface of tiles will be caulked under the Project.
Notes	Condition of water leakage			Once water leakage occurs, leaked water forms a drop after exuding from the cracks and drips.		
Others	Repair			–		Cracks observed at the parapet wall foot portion, which might be caused by the existing asphalt sheet, will not be repaired under the Project because the repair can be done after the Project.

3) Stability Analysis of Foundation Block

The preliminary stability analysis of the foundation block against the wind load was conducted. The resistance force against the sliding of the foundation block is determined by the shearing strength and internal friction angle of the bottom face of a foundation block as shown in the following formula.

$$Fs = \frac{Rf}{Sf} = \frac{C \times A + W \times \tan\phi}{Pw}$$

Where; Fs : Safety factor for sliding
Rf : Resistance force against sliding
= shearing strength of bottom face (C) × Area of contact (A)
+ Vertical load (W) × internal friction angle (φ)
Sf : Sliding force = Horizontal load by wind (Pw)

The result of stability analysis for No.3 Reservoir, of which blocks receive heavier load per block than No.2 Reservoir, is shown in Table 2-2.4. The safety criterion is determined by referring to the relevant criteria[11] in Japan.

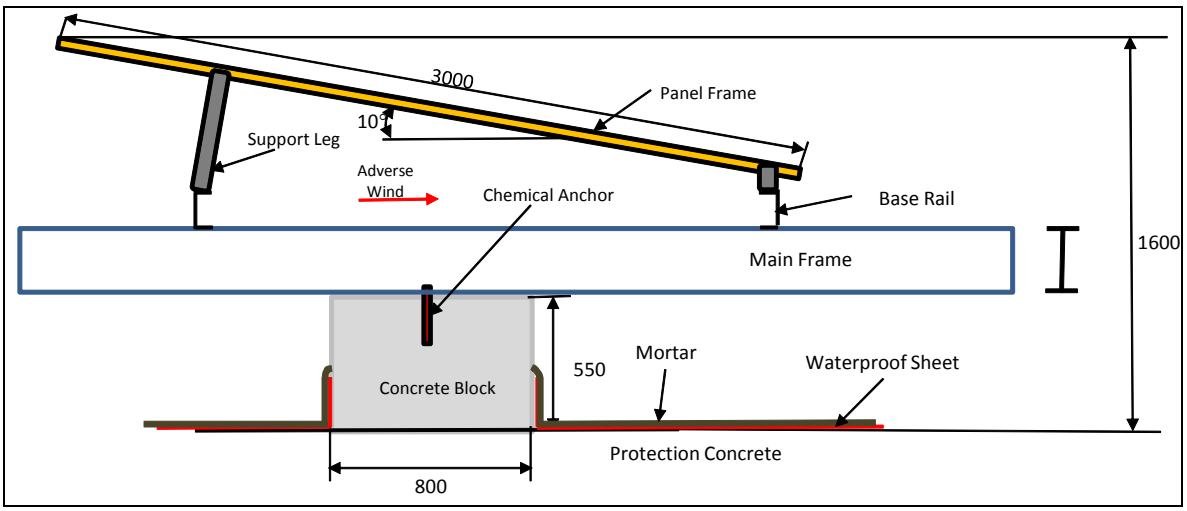


Fig. 2-2.6 Construction for Stability Analysis

Table 2-2.4 Result of Stability Analysis for Single Block

Stability against Sliding		Fs	Safety Criterion	Judgment
0	Without vertical load	∞	1.5	OK
1	Normal load	∞	1.5	OK
4	Acting of following wind	5.53	1.2	OK
5	Acting of adverse wind	3.84	1.2	OK

[11] Guideline for base structures of road bridges, Technical standard and guideline for port facilities, and Construction of multipurpose dams in Japan

Concerning the sliding stability about Chemical Feeding Building, the safety factor is envisaged to be higher than that of a single block because bottom area per ton, which contributes to the resistance force, is bigger than that of a single block.

Based on the above considerations, the salient features relating to the supporting frame and foundation blocks are shown in Table 2-2.5

Table 2-2.5 Salient Features relating to Supporting Frame and Foundation Block

Items	Phum Prek Water Treatment Plant, PPWSA		
Location	No.2 Reservoir	No.3 Reservoir	Chemical Feeding Bld.
PV array installation area	2,700 m^2	1,700 m^2	550 m^2
Rated Installed Capacity	264.6 KW	173.8 kW	50.4 kW
Inclination of PV array	10°		
Size of Foundation Block	W 800 × L 800 × H (average) 550 mm		W 300 × L 5430 ~ 10260 × H 500 mm
Numbers of blocks and bottom face area of total foundation block	124 pc. (single) (79.4 m^2)	74 pc.(single) (47.4 m^2)	11 rows (continuous) (28.8 m^2)
Total weight of PV modules	23.9 ton	15.7 ton	4.6 ton
Total weight of fixing clasp	14.7 ton	9.7 ton	2.8 ton
Total weight of supporting frame	30.3 ton	19.3 ton	6.2 ton
Total weight of foundation block	100.39 ton	59.91 ton	33.1 ton
Total weight	169.3 ton	104.6 ton	46.7 ton
Contact area per ton	0.47 m^2/ton	0.45 m^2/ton	0.62 m^2/ton
Design standard for supporting frame	JIS C 8955-2004		
Design Conditions	1) Design wind velocity; 40 m/s. 2) Horizontal load of earthquake; none 3) Shearing strength of concrete block; 2 ton/m^2 4) Internal friction angle of concrete block; 20°		
Safety against sliding for single block	Safety factor against sliding under adverse wind load; 3.84 * Concerning the stability analysis for the foundation block, the obligation of the submission of calculation sheet for the stability analysis will be incorporated in the Tender Document for Consultant's review.		
Stability study for reservoir structure	Since the foundation blocks will be placed on the columns of the grid-frame structure, additional bending moment and shearing stress acting on slabs will not occur. Therefore, the PV array and foundation block will not affect on the existing structural stability except the buckling of the column. It is confirmed that the enough safety factor for buckling of the column is well kept.		
Other ancillary works	The waterproof treatment work will be executed on the roofs of No.2 and No.3 Reservoirs	None	

(3) Equipment and Device

Outline of the equipment and device are as follows.

Items	Phum Prek Water Treatment Plant, PPWSA		
Location	No.2 Reservoir	No.3 Reservoir	Chemical Feeding Bld.
Grid-connected to	National grid of EDC		
Batteries	None		
Module type	Crystal type[12] module due to the restricted space for PV array installation		
Number of PV modules	1260 pcs. (210 W/pc)	828 pcs. (210 W/pc)	240 pcs. (210 W/pc)
Rated installed capacity	264.60 kW	173.88 kW	50.40 kW
Angle of inclination of PV array	10° facing the south		
Sub-array	Sub-array will be placed for every 5 ~ 15 kW PV modules.		
Junction Box	− Junction boxes with sub-array unit will be installed. − Junction box is equipped with isolating connector, blocking device and internal lightning protection device. − Circuit breaker for wiring will be placed at output side of the junction box.		
Collection Box	− For every junction box relay, once circuit breaker for wiring with switching function and one circuit breaker for wiring at output side will be installed. − Design voltage of DC 600 V will be applied to every DC relay.		
Power Conditioner (Board)	Power Conditioner (Board) will build in the following functions and devices. − Grid protection device − Islanding operation detector − External communication function − Internal lightning protection device − Transformer − Data transmittal device		
Cubicle	− Outside dimension; W1280 × H2300 × D 2400 − Number of cubicles; 6 pieces − Cubicle will be treated as suitable for tropical region and equipped with heat shielding plate Power conditioner (board), transformer and other devices will be built in.		
Meteorological Observation Device	− An actinometer with the same direction and inclination with the PV array, and a temperature gauge will be placed near the cubicles. The above instruments are useful for analyzing the performance of the PV system.		
Distribution Board for Grid-connection	− A distribution board equipped with MCCB and a watthour meter will be installed near the connection point with the grid, in order to protect the grid and PV system line from the power conditioner to the connection point. A distribution board is useful for pre-connecting work in order to minimize the blackout required for the grid connecting work.		
Data Transmittal Device	The following information and data from power conditioner (board) will be transmitted to the monitoring device. − PV voltage and current (DC) − PV generated energy and delivery current (AC) − Delivery current to the grid (AC) − System voltage(AC) − Frequency		

[12] Amorphous module type requires about 1.4 times larger space in comparison with the crystal module type for the same installed capacity.

Items	Phum Prek Water Treatment Plant, PPWSA
	− Performance of relays and information of major and minor malfunctions − Performance of active and passive methods
Monitoring Device	− Based on the data transmitted by power conditioner (board), processing and storing data function will be equipped. And the function of sending out signals of emergency alarm will be also equipped. − Addition to the data and information from power conditioner (board), the function of storing cumulative generation energy, malfunction records, alarm records, solar insolation records, and air temperature records will be also equipped. − The monitoring device will be installed in the existing control room.
Remote Monitoring Device	− To monitor the generation status and other relevant information outside of the central control room, remote monitoring system in manner of internet will be developed. − The personnel who can access the website (General Director and Directors of PPWSA, the personnel in charge of technical responsibility of the Contractors) will be registered their ID and password in advance. Earlier detection of troubles and necessary actions are expected by allowing the access to the website for the personnel in charge of technical responsibility of the Contractor.
Display Device	Display panel showing instantaneous value of power output and cumulative generation energy since the start of the operation will be placed in the water tariff payment room.
Wiring Materials	− Wiring materials will follow JIS standard. − Allowable voltage drop from junction boxes to power conditioner board will be set at 2% and below. The Contractor has to use the appropriate wiring cables to meet the allowable voltage drop. − The connection point in the outside and under the ground will be protected by waterproof covers and/or waterproof treatment.
External Lightning Protection Device	− In order to protect PV module against direct thunder stroke, lightning protection device will be placed. − Protection area will be set by rotating sphere method and protection level will be set at level II. − Electrical potential will be kept the same value with the supporting frame. − The design of lightning protection device will follow JIS A 4201.
Internal Lightning Protection Device	− Internal lightning protection device will be installed in junction boxes, collection boxes and power conditioner (board). − Lightning protection element will conform with the following specification; SPD class II, rated voltage of 500 V and above, nominal effluent current of 20 kVA and above, voltage drop protection level of 2.5 kV and below, displaying function of deterioration
Spare Parts	− Three (3) % of installed PV modules will be provided as spare parts. − Power conditioner (100 kW × 1) will be also provided as spare parts.

Note: Technical specification of main components is shown in Table 2-2.9.

1) Possibility of Reverse Power Flow

The installed capacity at Phum Prek Water Treatment Plant is determined by the available roof area of the existing facilities and installed capacity is set at 488 kW at the moment consisting of No.2 Reservoir with 264 kW, No.3 Reservoir with 173 kW and Chemical Feeding Building with 50 kW. The installed capacity of 488 kW is the largest PV generation system in Cambodia.

According to the power consumption recorded at the plant as shown in Table 2-2.6, power consumption at daytime exceeds 1,500 kW without depending on the day of the week and is much bigger than the installed capacity of 488 kW due to the use of motors and pumps requiring bulk power consumption. Therefore, there would be no surplus power by the PV system and no reverse power flow to the national grid.

Table 2-2.6 Power Consumption at Phum Prek Water Treatment Plant (kW)

Time	Nov.09 Sat.	Nov.10 Sun	Nov.11 Mon.	Nov.12 Tue.	Nov.13 Wed.	Nov.14 Thu.	Nov.15 Fri.
0							
1							
2							
3							
4							
5							
6	1,020	1,024	1,002	850	1,159	950	655
7	1,610	1,554	1,567	1,573	1,561	1,540	1,521
8	1,614	1,637	1,824	1,575	1,727	1,510	1,627
9	1,512	1,698	1,818	1,755	1,853	1,531	1,580
10	1,555	1,788	1,820	1,725	1,864	1,582	1,745
11	1,817	1,973	1,763	1,723	1,866	1,792	1,731
12	1,628	1,833	1,823	1,923	1,904	1,695	1,799
13	1,623	1,816	1,816	1,868	1,948	1,798	1,575
14	1,667	1,880	1,830	1,845	1,924	1,698	1,653
15	1,615	1,865	1,808	1,960	1,839	1,760	1,855
16	1,665	1,670	1,803	1,655	1,705	1,552	1,540
17	1,484	1,644	1,590	1,672	1,596	1,520	1,780
18	1,481	1,561	1,515	1,607	1,622	1,520	1,656
19	1,500	1,534	1,590	1,407	1,624	1,590	1,499
20	1,568	1,520	1,523	1,534	1,608	1,593	1,557
21	1,527	1,473	1,386	1,407	1,389	1,482	1,430
22	1,031	1,527	1,252	1,404	1,099	1,206	1,280
23	744	1,320	1,098	1,057	690	850	1,085
24	640	1,192	624	1,014	612	816	

Source: PPWSA, Daily Monitoring Record Sheet for Electric Room (1/3), 2009

2) Expected Power Generation

Table 2-2.7 shows the expected power generation yielded by the PV system of 488 kW. According to the estimation, generation energy of 652,800 kWh will be expected annually.

Table 2-2.7 Expected Power Generation

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
Irradiaion(kw/m^2/day)	5.3	5.8	5.95	5.9	5.4	4.8	4.8	4.5	4.6	4.6	4.9	5.0	5.1
PV temprature (C°)	63.0	64.7	66.5	67.1	66.9	66.0	64.9	64.6	63.7	63.0	63.0	61.6	64.6
Generation (kWh/day)	1,864	2,024	2,059	2,035	1,864	1,665	1,673	1,571	1,613	1,618	1,724	1,770	1,790
Generation (kWH/mon)	57,793	56,659	63,825	61,048	57,793	49,941	51,865	48,699	48,387	50,171	51,713	54,881	54,398

Source: Irradiation is the reading values on Fig. 15 in "The Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia, Final Report 2006"

3) Grid Protection Device

Grid protection devices will be installed in the power conditioner board although the reverse power flow to the national grid would not happen as fore-mentioned. Required protection devices are considered following the Grid-Interconnection Code in Japan basically. Since the receiving voltage from EDC is 20 kV, the grid-connection is categorized as "High voltage grid-interconnection" according to the Grid Interconnection Code in Japan and OVGR (Over voltage ground relay) is required. However, since OVGR is already installed in the existing receiving board, additional OVGR will not be installed in the project.

The following grid protection devices will be installed in the power conditioner board to meet the requirement in the "Guidebook for Power Engineers[13]", 2004.

- Over voltage relay (OVR)
- Under voltage relay (UVR)
- Over frequency relay (OFR)
- Under frequency relay (UFR)
- Islanding Operation Detector

The Tender Document will stipulate that the setting value and time should be determined between the Contractor and EDC based on the nominal voltage, allowable voltage fluctuation, nominal frequency and allowable frequency fluctuation described in Electric Power Technical Standards of Kingdom of Cambodia, August 2007, page 15 "Quality of Electric Power".

Table 2-2.8 Proposed Setting Values and Electric Power Technical Standards

Nominal Voltage	Allowable Voltage Fluctuation	OVR	UVR
230 V	207 V ~ 253 V	225/230/235/240	160/165/170/175/180
400 V	360 V ~ 440 V	410/420/430	350/360/370

Nominal Frequency	Allowable Frequency Fluctuation	OFR	UFR
50 Hz	49.5 ~ 50.5 Hz	50.5/51/51.5/52	48.5/49/49.5

Note: Nominal voltage, allowable voltage fluctuation, nominal frequency and allowable frequency fluctuation are quoted from "Electric Power Technical Standards of Kingdom of Cambodia", EDC

4) List of Main Equipment

Table 2-2.9 shows the list of main equipment required for the PV system at Phum Prek Water Treatment Plant. The quantity and detailed specification in the table might be changed depending on the conclusion of the Bid Tender provided that the installed capacity of 488 kW shall be met. Quantity and detailed specification to be procured will be

[13]Chapter 2: Technical Standard for Electric Power Facilities , Title: Condition of Connection with Power System for Distributed Generator , Main Protection Relay, Page C-06 in the "Guidebook for Power Engineers", 2004

determined in the negotiation between the Procurement Contractor, the Procurement Agent and the Consultant, and incorporated into the Contract Document.

Table 2-2.9 List of Main Equipment (1/2)

Name of Device	Main Specification and/or Components	Qty	Purpose
Photovoltaic Module	(1) Applicable Standard: IEC or equivalent standard (2) General specification: 1) Type: Crystal type 2) Rated installed capacity: 488 kWp (264.6kW array + 173.8kW array +50.4kW array)	2328 pc	Fundamental device in the PV system to convert solar energy to electric energy of DC
Adjunct Cable for PV Module	(1) Applicable Standard: JCS 4418B (2) Type: (a) HEM - CE Cable with (+) connector at one edge (b) HEM - CE Cable with (-) connector at one edge (c) HEM - CE Cable with (+) (-) connector at both edges (3) Size: 3.5sq - 1C	194 pc	Cables connecting each module in series and necessary cable for the system
Junction Box	(1) Construction: Outdoor hanging type (2) Material: SPHC Steel plate (3) Input voltage cell: DC 500 V/circuit (4) Number of input circuits: 3 ~ 5 circuits (5) Input current of PV cell: 8.9 A/circuit (6) Number of output circuits: 1 circuit (breaker workable in tropical region) (7) Devices to be stored: Circuit breaker for wiring (DC500V 50A), islanding connector, blocking device, lightning protection device by induction type, and heat-sensitive terminal caps	50 pc	Boxes to integrate the wiring cables connecting each module in series, and necessary device for the system
Collection Box	(1) Construction: Outdoor hanging type (2) Material: SPHC Steel plate (3) Input voltage cell: DC500V (4) Input current of PV cell: 50A/circuit (5) Number of input circuits: 5 circuits with breaker for tropical region use (6) Number of output circuits: 1 circuit with breaker for tropical region use (7) Breaker (Switch): Circuit breaker for input wiring (DC500V 50A) Circuit breaker for output wiring (DC500V 225A) (8) Others: Heat-sensitive terminal caps	11 pc	The wiring cables from each junction box will connect to the collection boxes in parallel and DC electricity will be transmitted to power conditioner from the collecting boxes. The collecting boxes are necessary for a large scale PV system.
Power Conditioner	(1) General specification for installed capacity: 488 kW 1) Construction: Indoor free-standing type 2) Main circuit model: Self-excitation voltage type 3) Switching method: HF PWM 4) Cooling method: Forced cooling system (2) Electrical specification 1) Rated capacity: 100 kW×3 pc (No.2 Reservoir), 100kWx2 pc (No.3 Reservoir and Chemical Feeding Bld.) 2) Rated input voltage: DC300V and less 3) Maximum allowable input voltage: DC0~500V and less 4) Voltage range for input operation: DC240V~470V and less 5) Follow-up control range for maximum output: DC240V ~ 420V and less 6) Output electrical mode: 3-phase and 3-wire system 7) Rated output voltage: AC202V 8) AC output current distortion rate: Total 5 % and less, each harmonic 3% and less 9) Power control system: Maximum output follow-up control 10) Efficiency: 90 % and more 11) Function: Automatic start, shut down, soft start, automatic voltage regulator (3) Grid Protection Device: OVR(225/230/235/240V), (410/420/430V), interval (0.5/1.0/2.0S), UVR(160/165/170/175/180V), (350/360/370V), interval (0.5/1.0/2.0S), OVF(50.5/51/51.5/52Hz), interval (0.5/1.0/2.0S), UVF(48.5/49/49.5Hz), interval (0.5/1.0/2.0S), Blocking time after restoration: (5/150/200/300S) (4) Islanding Operation Detector: Active method range of fluctuation: Wattles power shall be 5 % of rated output, Detective factor: cycle fluctuation of frequency, Detective level: 0.25 Hz, Parallel off time:0.5~1S, Passive method: ±3/5/8/10°, Detective time: 0.5S and less (5) External Communication; Transmitted information: malfunction & measuring information by RS485	1 Ls	Power conditioner has the following functions; (a) Converting DC to AC generated by PV module, (b) Keeping power quality at appropriate level by monitoring and watching AC power Therefore, a power conditioner is the essential device for PV system.

Table 2-2.9 List of Main Equipment (2/2)

Name of Device	Main Specification and/or Components	Qty	Purpose
Power Conditioner	(6) Internal Lightning Protection Device; DC SPD Class II and above, AC SPD gap type class II and above		
Transformer	(1) Rated output: 600kVA (2) Primary voltage (output): AC380-230V, 3-phases and 4-wires (3) Secondary voltage (input): AC200V, 3-phases and 3-wires (4) Frequency: 50Hz (5) Insulating class: H-type and dry class (6) Other specification: Rating plate, primary terminal - 5 taps and more	1 Ls	One of the main components of the power conditioner and converting AC voltage into required voltage level.
External Lightning Protection	(1) Applicable Standard: JIS A 4201-2003 (2) Protection level: Class II (3) Receiving part: lightning rod, horizontal conductor, and mesh conductor by rotating sphere method (4) Grounding: Keeping the same electrical potential with that of supporting structure of PV panel	1 LS	Protecting outdoor facilities from lightning strike, necessary device for PV system to be installed in countries, where there are many lightning in rainy season.
Cubicle	(1) Material: SPHC Steel plate (2) Devices to be stored: 100kW x 5 power conditioner, 600 kVA equivalent transformer, data transmittal device, I/O switch, and circuit breaker (3) Internal Lightning Protection : AC SPD Class II and above at output side (4) Ventilation: Forced cooling system (22kW air conditioner)	1 LS	Box containing electrical devices, such as power conditioner and transformer, and protecting those devices from direct light and rain. The box is necessary when those electrical devices are installed outside.
Data Monitoring System	(1) Data monitoring device Measuring method: Measuring interval: 6 second Collecting data: DC - voltage /current, AC - voltage/current/power/ frequency Monitoring device: Personal computer (WindowsXP or equivalent), serial signal converter (from RS485 to RS232C), uninterruptible power supply system (UPS), rack for personal computer (2) Required Function: Displaying instantaneous value, graph, operation performance of power conditioner, malfunction information and storing setting values for grid protection device in power conditioner (3) Remote Monitoring System Data control at site: Delivering data from the site to the server and storing transmitted data into the server Access to data: Displaying on Web site through internet Data download: Displaying and printing graphs Access control: User ID and password	1 Ls	Monitoring device for operation performance of the PV system. The data monitoring system is necessary in terms of operation and maintenance of the system.
Display Device	(1) Construction: Indoor hanging type, LED plane luminescence panel (brightness 85% and more, average luminance of panel 200 lux/ 600 cd and more) (2) Display items: Instantaneous value of power output and cumulative generation energy (3) Display panel: 5~15 cm/ number (4) Size: 1000 mm x 1600 mm ±15%	1 Ls	Necessary device for enlightenment of the PV system.
Distribution Board for Grid Connection	(1) Construction: Indoor free-standing type (2) Material: SPHC Steel plate (3) Size: 1950W x 800H x 350D (4) Devices to be store: Voltmeter, ammeter, watt-hour meter, and SPD (5) Breaker (Switch): MCCB4P1000AF/1000AT with alarm function	1 Ls	Distribution board (Power panel) to be used for pre-connection work to minimize the blackout required for grid connection work.
Fixing Clasp for PV Module	(1) Type: Fixing clasp for PV module (2) Material: SS400 hot dip galvanized finishing (HDZ45 equivalent) (3) Angle of inclination: 10° (4) Installed capacity: 264.6kW +173.8kW+50.4kW, to be considered of roof structure (5) Grounding: grounding rod or plane grounding pole, reduction conductor 22 mm^2 and above (6) Design wind velocity: 40m/sec.	776 pc	Clasp for fixing PV module onto supporting structure.
Supporting Structure for PV Module	(1) Material: JIS G3101, SS400 (2) Coating: Hot dip galvanized HDZ45 equivalent	1 Ls	Supporting and fixing PV modules

2-2-3 Outline Design Drawing

Outline design drawings are listed below and the drawings are attached at the end of the report.

No.	Drawing No.	Title
1.	PPWSA-01-01N	Overall Layout at Phum Prek Water Treatment Plant
2.	PPWSA-01-02N	Single Line Diagram for Photovoltaic Power Panel
3	PPWSA-01-03	Detail of Electrical Room for Cable Connection
4	PPWSA-01-04	Single Line Diagram of Distribution Board and Photovoltaic Power Panel
5	PPWSA-02-01	Layout Plan of Installation Frame and Solar Array, No.2 Distribution Reservoir
6	PPWSA-02-02	Layout Plan of Installation Frame for Solar Module, No.2 Distribution Reservoir
7	PPWSA-02-03	Layout Plan of Foundation for Installation Frame, No.2 Distribution Reservoir
8	PPWSA-02-04	Detail of Installation Frame Section A-A, No.2 Distribution Reservoir
9	PPWSA-02-05	Detail of Installation Frame Section B-B, No.2 Distribution Reservoir
10	PPWSA-03-01	Layout Plan of Installation Frame and Solar Array, No.3 Distribution Reservoir
11	PPWSA-03-02	Layout Plan of Installation Frame for Solar Module, No.3 Distribution Reservoir
12	PPWSA-03-03	Layout Plan of Foundation for Installation Frame, No.3 Distribution Reservoir
13	PPWSA-03-04	Detail of Installation Frame Section A-A, No.3 Distribution Reservoir
14	PPWSA-03-05	Detail of Installation Frame Section B-B, No.3 Distribution Reservoir
15	PPWSA-04-01	Layout Plan of Installation Frame and Solar Array, Chemical Feeding Building and Storage
16	PPWSA-04-02	Layout Plan of Installation for Solar Module, Chemical Feeding Building and Storage
17	PPWSA-04-03	Layout Plan of Foundation for Installation Frame, Chemical Feeding Building and Storage
18	PPWSA-04-04	West Side Elevation And Detail of Solar Array, Chemical Feeding Building and Storage
19	PPWSA-04-05	South Side Elevation And Detail of Solar Array, Chemical Feeding Building and Storage
20	PPWSA-05-01	Detail of Power Conditioner
21	PPWSA-05-02	Detail of Waterproofing Works No.2 Distribution Reservoir

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The project will be implemented under the scheme of “the Programme Grant Aid for Environmental and Climate Change”. The programme aims to newly tackle issues relating to the climate change and consists of multiple components, such as provision of equipment and capacity building and so on. The recipient country has to assign a responsible organization and an implementation organization. The responsible organization has an obligation to coordinate with the relevant agencies in Cambodia and Japan side toward the smooth implementation of the project. The implementation organization has an obligation to operate and maintain the project after implementation of the project.

The project implementation system is shown in Fig. 2-2.7and the role of each relevant organization concerning the implementation of the project is shown in Fig. 2-2.8.

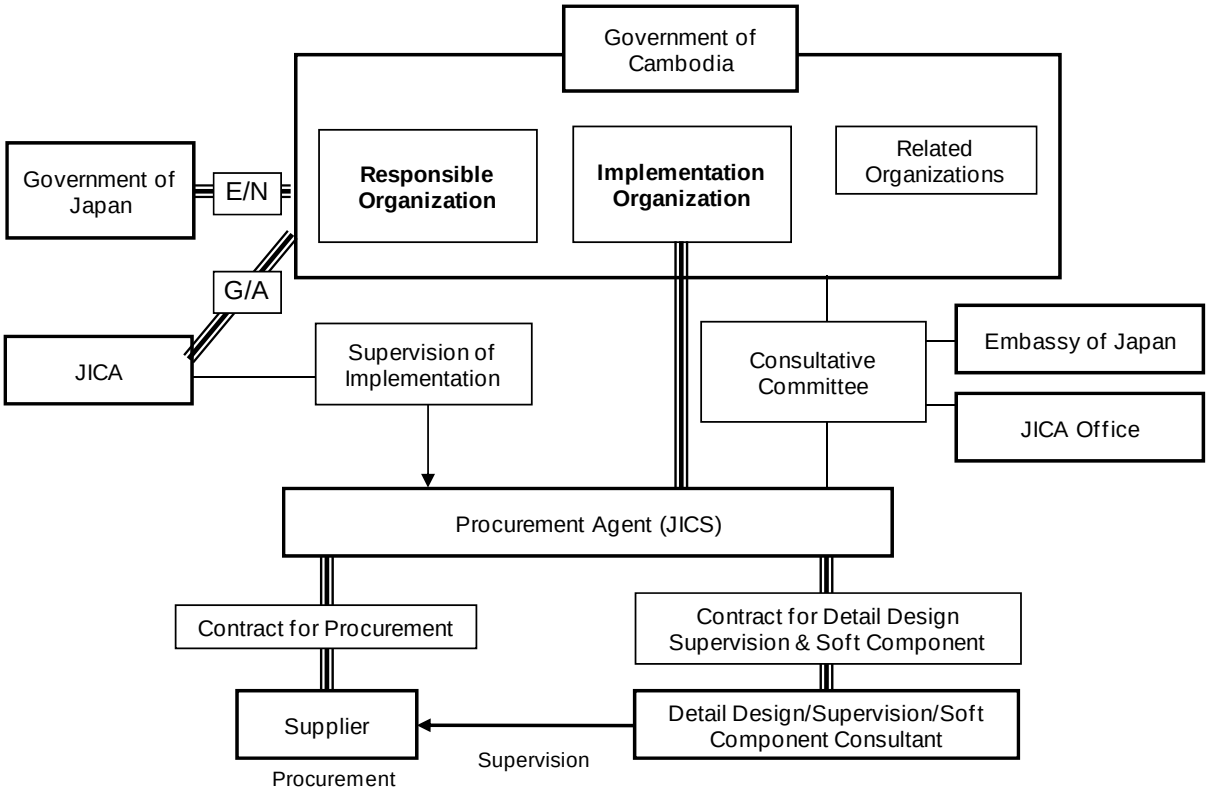


Fig. 2-2.7 Project Implementation System

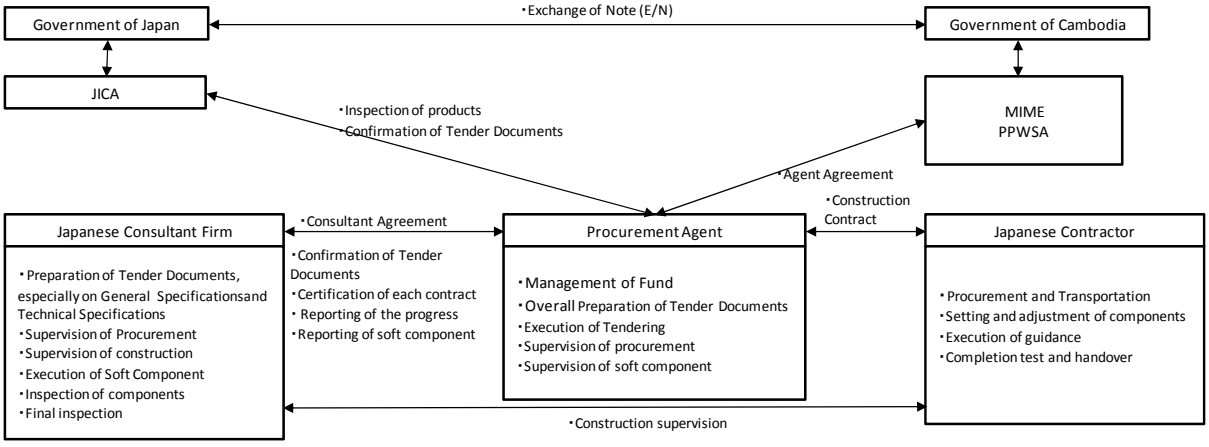


Fig. 2-2.8 Role of Organization Concerning the Implementation

(1) Responsible Organization and Implementation Organization

The implementation organization of the project is PPWSA. PPWSA takes responsibility for operation, maintenance, preparation of budget and manpower required for the operation and maintenance of the PV system as the owner of the system.

The responsible organization of the project is MIME. MIME takes responsibility for coordination with the relevant organization in Cambodia and Japan side until the completion of the project, and establishment of the Consultative Committee. Addition to the above role, MIME will advise operation and maintenance of the PV system to be done by the implementation organization.

Table 2-2.10 Organization of Recipient Country

Organization in Cambodia	Name of Organization	Name of Department	Department for Maintenance
Responsible Organization	Ministry of Industry, Mines and Energy	Department of Energy Technique	-
Implementation Organization	Phnom Penh Water Supply Authority	Planning and Technical Department	Electric Section in Production and Distribution Department

(2) Procurement Agent

The procurement Agent will contract the Agent Agreement with the recipient country and the Agent will handle and supervise the tender process, contract negotiation and contract, and also manage the payments to the Contractor and the Consultant, and the bank account on behalf of the recipient country.

(3) Consultant

The Consultant will contract the Consultant Agreement with the Procurement Agent and undertake the preparation of technical tender documents, supervision of the procurements & construction, and execution of the Soft Component.

(4) Japanese Contractors

The Japanese Contractors will offer their tender based on the Tender Documents and the successful tenderer will contract the Construction Contract with the Procurement Agent under the approval of the recipient country. Since contractors in Cambodia have few experiences of such a large scale PV system installation, the site work will be carried out by the local contractors under the supervision of the relevant experts dispatched by the Prime Contractor as shown in Table 2-2.11.

Table 2-2.11 Role of Local Contractors and Required Experts dispatched by the Prime Contractor

Content of Work	Local Contractors	Required Experts
Preparatory work	O	Civil Engineer
Water proof treatment work	O	
Foundation for supporting structure	O	
Construction of supporting structure	O	
Installation of PV modules	O	Electrical Engineer
Foundation work for power conditioner cubicle	O	
Installation of power conditioner	O	
Wiring work	O	Civil Engineer
Electrical work	O	Electrical Engineer
Grounding work	O	
Cleanup work	O	

(5) Policy for Construction Method

Based on the above considerations, the following policy for construction method will be applied.

- The local contractors will undertake the implementation of the site work under the supervision of the experts dispatched by the Prime Contractor.
- The prevailed construction method in Japan will be applied to the project in order to build up the capability of the local contractors in respect to the construction of the PV system.

(6) Policy for Procurement

Based on the relationship as shown in Fig. 2-2.8, the following policy will be applied to the project.

- The Prime Contractor for the procurement will be the Japanese contractor(business firms, manufacturers and so on)
- Publication announcement of the project will be done in Japan.
- Tender documents will be prepared by English.
- Tender evaluation will be done in Japan.
- The tender evaluation of the prime contractors will be done in terms of their oversea experiences of construction of the similar scale of PV system, their financial status, their technical level and their bid prices.
- The result of the evaluation will be submitted to Cambodian side, and the Prime Contractor (a successful tenderer) will be determined after approval of Cambodian side.

2-2-4-2 Implementation Conditions

(1) Waterproof Treatment Work (Roofs of No.2 and No.3 Reservoirs)

The waterproof treatment work had better be done in the dry season (November to April) and the work will proceed as follows;

- Removal of the existing protection layer (gravel, clayware and block) and temporary store of the layer materials at surrounding area of the reservoirs
- Cleaning the surface of protection concrete
- Placing foundation concrete blocks and curing
- Laying waterproof sheets onto the surface of protection concrete and foundation concrete blocks by using adhesion bond
- Placing protection mortal on waterproof sheet
- Restoring the protection layer to original form

(2) Blackout required for Grid Connection

PPWSA carries out 2-days periodical inspection for the plant facilities every year. During the periodical inspection, PPWSA stops water supply 3 hours for two (2) days due to the overhaul of the equipment, and the water supply are suspended in the midnight of which water demand is less. The Survey Team confirmed with PPWSA that 3-hours blackout required for the grid connection work will not cause any troubles with customers provided that the advance notice to customers will be done.
For the above reasons, the grid connection work will be done in the midnight and the target duration of blackout is set the maximum 3 hours.

(3) Safety Control for Customers

A lot of customers in the neighborhood area come to Phum Prek Water Treatment Plant during the daytime to pay water tariff. Safety control for customers seems to be very important because trailer trucks with full load come in and out the premises during the daytime. The establishment of safety control measures for customers will be incorporated into the Tender Documents as the obligation of the Contractor such as traffic accidents prevention and keep out to the work area.

(4) Waste Treatment

During the construction period, there would be construction waste at the site. In order to prevent illegal waste disposal, the tender documents will stipulate that the Contractor shall follows the relevant regulations and submit the designated waste disposal area prior to the commencement of the work for Consultant’s approval.

2-2-4-3 Scope of Works

Table 2-2.12 shows the undertakings to be taken by each government relating to the programme.

Table 2-2.12 Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side		
			MIME	PPWSA	Other organization
1	To secure land			○	
2	To clear, level and reclaim the site when needed urgently			○	
3	To construct gates and fences in and around the site			○	
4	To construct a parking lot if necessary			○	
5	To construct roads				
	1) Within the site	○			
	2) Outside the site and Access road			○	
6	To construct the facility and install equipment	●			
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities if necessary:				
	1) Electricity			○	
	a. The power distribution line to the site	○			
	b. The drop wiring and internal wiring within the site	○			
	c. The main circuit breaker and transformer for the site				
	2) Water Supply				
	a. The city water distribution main to the site			○	
	b. The supply system within the site (receiving and elevated tanks)	○			
	3) Drainage				
	a. The city drainage main (for conveying storm water, sewage, etc. from the site)			○	
	b. The drainage system within the site (for sewage, ordinary waste, storm water, etc.)	○			
8	To bear the following commissions applied by the bank in Japan for banking services based upon the Bank Arrangement (B/A):				
	1) Payment of bank commission				●
9	To ensure all the expense and prompt execution of customs clearance at the port of disembarkation in the recipient country				
	1) Marine or air transportation of the products from Japan or third countries to the recipient	●			
	2) To ensure all the expense and prompt execution of unloading, tax exemption and customs clearance of the products at the port of disembarkation			●	
	3) Internal transportation from the port of disembarkation to the project site	●			
10	To accord Japanese nationals and / or nationals of third countries, including persons employed by the agent whose services may be required in connection with the Components such facilities as may be necessary for their entry into recipient country and stay therein for the performance of their work.			●	
11	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the Components and to the employment of the Agent will be exempted by the Government of recipient country			●	
12	To maintain and use properly and effectively the facilities that are constructed and the equipment that is provided under the Grant.			●	
13	To bear all the expenses, other than those covered by the Grant and its accrued interest, necessary for the purchase of the Components as well as for the agent's fees.			●	
14	To ensure environmental and social consideration for the Programme.			●	

Note: ● means coming undertaking and ○ means already done or out of subject

2-2-4-4 Consultant Supervision

(1) Civil and Architectural Work

- Civil and architectural work includes preparatory work, waterproof treatment work on the roof, foundation work for supporting frame, and placing hand holes for wiring. Since civil and architectural work will be carried out in advance of or in parallel with the installation work of the equipment, the management of the construction schedule relating to the civil and architectural work will be paid attention to firstly in terms of keeping the overall construction period on schedule.
- Especially, for the foundation work, the accuracy of arrangement of reinforcing bars, securing the strength of the concrete blocks, the accuracy of level of surface of the block concrete and accuracy of the spin finishing of the center will be required because the supporting structure (frame) will place on the block concrete. And waterproof treatment work also requires degree of precision so as not to drop rain into the distribution reservoir.
- Civil and architectural work will continue about three (3) months and a civil engineer will be required to be permanently stationed at the site during the work period to attain the required accuracy and quality.

(2) Equipment

- The installation work of the equipment consists of a lot of works, such as (a) building up the supporting structure (frame), (b) wiring between PV modules, from PV modules to junction boxes, from junction boxes to collecting terminal boxes, from collecting terminal boxes to power conditioners, and power conditioners to the existing distribution board, (c) installation of power conditioners in cubicles and internal wiring in the cubicles, (d) communication wiring from power conditioners to the monitoring device, from the monitoring device to the display panel, (e) installation of lightning protection device and grounding, (f) Commissioning test.
- The all above works are required to operate the PV system in proper working order. The installation of equipment will continue about 4.5 months. During the installation period, electrical engineers dispatched by Consultant will be permanently stationed at the site to supervise the works in order to secure the required quality.

2-2-4-5 Quality Control Plan

(1) Civil and Architectural Work

- The quality especially required for civil and architectural work is the strength of the foundation block concrete. The foundation block concrete is planned to be placed by

ready-mixed concrete. The standard of mix proportion for the ready-mixed concrete and the minimum compressive strength with 28-ages are shown in Table 2-2.13.

- The compressive strength test for the concrete will be executed for every 20 m^3 of the concrete placing[14] basically. Six (6) test pieces are sampled and 7-ages and 28-ages compressive strength test will be carried out following JIS Standard.

Table 2-2.13 Mix Proportion and Compressive Strength with 28-ages

Items	Value
Maximum size of aggregate	40 mm (concrete)
	20 mm (mortal)
Slump	8 ~ 12 cm
Air content	4 ~ 7 %
Min. compressive strength with 28-ages	21 N/mm^2

(2) Equipment

The quality control for the main equipment will be carried out in three (3) stages.

- Quantity, specification, factory inspection reports and shipping list of main equipment will be checked at the timing of the delivery (1st stage).
- After installation of the PV modules, open circuit-voltage for all modules by sub-array unit will be measured to check the breaking of wire and the measured open circuit-voltage will be recorded (2nd stage).
- Before starting the operation of the PV system, the following individual and integrated test will be conducted as shown in Table 2-2.14 (3rd stage).

Table 2-2.14 Individual and Integrated Tests before Operation (Draft)

Test Items	Test of Content
Confirmation of voltage and poles for all circuits in junction boxes	Operation stop test
Confirmation of voltage at main relays in the board	Safety stop and resetting test by using simulated malfunction signal
Confirmation of phase (AC) by a phase rotation instrument	Auto start test for the condition being restored of the grid from the blackout (blackout is artificially simulated)
Confirmation of all indicators of meters installed in the board	System performance test for the condition when one PV inverter becomes malfunction
Confirmation of recording data (confirmation period is 48 hours with grid-connected condition)	Automatic operation test for a few days (confirmation of long run operation around one week with grid-connected condition)
Start up and shut down test	-

[14] Since block concrete volume is estimated at 85 m^3, the test will be carried out for four (4) times during the work.

2-2-4-6 Procurement Plan

The main construction materials to be used in the site work are cement, aggregates and reinforcing bars. These materials can be procured in Cambodia because of their reliable quality based on the market survey. Therefore, the construction materials except main equipment of the PV system are to be procured in Cambodia. The main equipment of the PV system, such as PV modules, power conditioners and so on are to be procured in Japan.

Table 2-2.15 shows the spare parts to be provided in the scope of the project, which seem difficult to be procured in Cambodia and, of which malfunction give severe impact on the PV system operation.

Table 2-2.15 Spare Parts Provided by the Project

Items	Quantity	Reason of Provision
PV Modules	3% of installed PV modules	Spare parts for damaged modules which might be caused during transportation, installation and operation
Power Conditioner	100 kW × 1 pc	The service life time of modules is said more than twenty (20) years. On the other hand, the service life time of other electrical equipment is said more than ten (10) years as well as electrical appliances. Therefore, power conditioner will be provided as a spare part for emergency.

2-2-4-7 Operational Guidance Plan

(1) Objective

Operation Guidance shall be given to those engineers and technicians who will be in charge of operation and maintenance of the PV system so that the system, which is the first case of this size, will be operated and maintained properly, even under emergency situations.

Other local conditions such as high temperature and humidity are also negative factors in long-term maintenance of PV equipment which uses sensitive components such as semiconductors. Considering these, it is proposed that the Prime Contractor should conduct inspection of the PV equipment 4.5 months after the commissioning. Furthermore, the above inspection will be incorporated into the program of the Soft Component described in the next section.

(2) Planning of Operational Guidance

There has been no experience and knowledge of grid-connection of renewable resources such as PV system in Cambodia. Therefore, the obligation of conducting operational guidance to the engineers in Cambodia at the timing of inspection of PV system, which will be carried out in the course of the installation work, will be stipulated in the Contract Document.

1) Plan for guidance on operation and maintenance during installation work

The program is outlined below.

a) Time and location of guidance

Lecture and exercises: Approximately two weeks (at the site)

b) Instructors

The engineer(s) in charge of supervising installation works, pre-commissioning and adjustment, dispatched by the manufacturer of the PV system are assumed to be the instructor(s) of the guidance.

c) Trainees

The trainees who receive the guidance are mainly electrical technicians in the Production and Distribution Department in PPWSA who will be in charge of operation and maintenance of the PV system after the commissioning. The implementation organization is recommended to appoint trainees specifically before the installation works start.

Table 2-2.16 Organization Control of Operation and Maintenance

Person in Charge		Number	Main Role
Senior Electrical Engineer		1	Well understanding the PV system and instruct the operation and maintenance staff to take appropriate actions when a malfunction occurs
Operation Staff	Electrical Engineer	1	Monitoring the PV system operation performance and stop the operation when the grid system has some troubles
Maintenance Staff	Electrical Engineer	1	Conducting periodical inspection and required measuring, and reporting to the senior electrical engineer when some troubles are detected
	Electrical Technician	1 ~ 2	Daily inspection
	Workers	1 ~ 2	Cleaning of PV modules

d) Contents of guidance

i) Operational guidance during the commissioning test

Operational guidance during the commissioning test is as follows.

- Technical guidance at the joint survey on final inspection of the PV system before the commissioning test
- Technical guidance at joint survey on the commissioning test and adjustment
- Lecture and exercise on start, stop and re-start operation based on the “Operation Manual”

ii) Technical guidance on periodical inspection and data management after the commissioning

Guidance in early stage after the commissioning is as follows.

- Guidance on daily maintenance, periodical maintenance including intervals and inspection items, and data log management based on the “Maintenance Manual”
- Explanation of the PV system components and guidance on and practice of replacement of consumable goods
- Introduction of FAQ relating to operation and maintenance
- Introduction of examples of malfunctions and measures (including exercise)
- Execution of joint inspection with trainees at 4.5th months after the commissioning
- Evaluation on maintenance performance for the 4.5 months and trouble shooting, if any

Operation Manual and Maintenance Manual should be prepared by English at least one month before the commissioning and distributed to trainees translating to local language. The above preparation and translation will be stipulated in the Contract Document.

2-2-4-8 Soft Component (Technical Assistance) Plan

(1) Background

The Project for Introduction of Clean Energy by Solar Electricity Generation System will procure a Photovoltaic Generation system with 488 kW capacity, furnish it to Phum Prek Water Treatment Plant in Phnom Penh City, The Kingdom of Cambodia and supply the generated energy to the Plant for its power demand. The grid-connected PV system is the first case for Cambodia, although they have experience of independent off-grid PV systems. And staffs to be involved in operation and maintenance of the PV system at PPWSA have no experience and knowledge about PV system. Therefore, it is important to train those engineers/technicians who will be actually operating and maintain the PV system. At the same time, it is also important to offer the training program for officers in the MIME and EDC being involved in the project, in terms of support the national target to attain the village electrification of 100% by 2020 by utilizing clean energy, such as PV system, biomass and mini-hydro and so on.

The contractor will be conducting an Operation Guidance for the purpose of furnishing the operators with practical method of operation and maintenance of the PV system. However, the basic knowledge underlying these methods is crucial in nurturing capabilities of judgment and decision making in various occasions of operating and maintaining the PV system, which is also useful in development and application thereto of future similar projects.

(2) Objectives in Training Program

Based on the above background, the following targets are set in terms of production of effect and sustainability of the project.

- The installed PV system can work as planned.
- The installed PV system can be maintained in a sustainable manner.

(3) Outcomes of Training Program

Outcomes of the training program are as follows;

[For Operation and Maintenance Staff at the site]

- Staff can operate and maintain the PV system in the normal condition.
- Staff can take appropriate actions when troubles and malfunctions occur.
- Staff can replace minor consumable goods, and procure necessary spare parts and consumable goods by themselves.

[For Officers in MIME and Engineers in EDC]

- They can acquire the knowledge relating to the fundamental technology of a PV system.
- They can understand the necessary technical issues relating to the agreement accompanied by a grid-connected PV system.
- They can acquire the knowledge to train the manpower relating to the introduction of a PV system.

(4) Outcome Confirmation and Evaluation

Outcome confirmation and evaluation will be conducted in the second training program because the training program will be conducted twice, at the commissioning and 4.5 months after commissioning.

[For Operation and Maintenance Staff at the site]

1) Operation of the PV System

Operation performance record for the previous 4.5 months will be reviewed from the following viewpoint.

- Whether the PV system can work daily and generate electricity.
- Whether the electricity generation fluctuates within the range of ±20% in comparison with the expected monthly generation set at the planning stage as shown in Table 2-2.17.

If the actual electricity generation remains within the range of ±20%, it can be evaluated that the PV system works normally. If the actual electricity generation lowers than minus

20% or continuously declines, the PV system is supposed to be in some troubles. In this case, the operation and maintenance staff are requested to propose the estimated causes and their reasons in practical exercises. And their learning level will be confirmed in this practical exercise.

Table 2-2.17 Control Value for Monthly Generation Energy

(kWh/Month)	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
Expected Generation	57,793	56,659	63,825	61,048	57,793	49,941	51,865	48,699	48,387	50,171	51,713	54,881
Upper Limit	69,000	68,000	77,000	73,000	69,000	60,000	62,000	58,000	58,000	60,000	62,000	66,000
Lower Limit	46,000	45,000	51,000	49,000	46,000	40,000	41,000	39,000	39,000	40,000	41,000	44,000

2) Maintenance of the PV System

Daily and periodical maintenance check sheets and malfunction & trouble recording sheets for the previous 4.5 months will be reviewed from the following viewpoints.

- Whether any troubles and/or any malfunctions occur, and whether appropriate actions were taken based on the Maintenance Manual when some troubles and/or malfunctions had occurred.
- Whether consumable goods were replaced with properly when they replaced consumable goods (including the confirmation at the site).
- Whether daily and periodical inspections have been carried out properly based on the daily and periodical check sheets.

Any malfunctions would not happen generally because of just 4.5 months after the commissioning. If some malfunctions had happened, the malfunction part ought to have been replaced by the Contractor without charge because 4.5 months is within one (1) year's guarantee period. If the replacement and/or necessary measures were done by the Contractor based on the claim by the owner, it can be evaluated that the installed PV system is appropriately maintained in sustainable manner due to their well acquirement of knowledge about the PV system.

If some consumable goods such as SPD and lighting in cubicles were replaced with by the maintenance staff, the proper replacement (to be confirmed at the site) is worth evaluation. If all inspection items had been checked based on the daily and periodical maintenance manual, the maintenance inspection is worth evaluation. If some inspection items had been skipped and/or daily and periodical inspections had not been conducted as planned, the maintenance staff is requested to state the reasons and propose more practical maintenance plan in practical exercise. And their learning level will be confirmed in this practical exercise.

Inquiry survey of the learning level relating to operation and maintenance will be conducted on the last day of the Training Program to evaluate the outcome of Training Program.

[For Officers in MIME and Engineers in EDC]

The training program conducted at the commissioning will provide;

(a) Fundamental technical knowledge about a PV system,
(b) Introduction of FAQ,
(c) Introduction of examples of typical malfunctions and their measures, and
(d) How to utilize operation log sheets.

Their learning level will be evaluated in practical exercise to be conducted in the above training courses.
In the training program conducted in 4.5 months after commissioning, their learning level will be evaluated in the same manner as for operation and maintenance staff as mentioned above.

(5) Planning of Training Program

1) Content

Training program is planned to consist of a series of lectures, practical exercises, and OJT led by Japanese consultants. The program is to be carried out in two separate periods; one during the commissioning of the PV system, and the other 4.5 months after the commissioning.

There will also be O&M training provided by the Contractor of the project. Therefore, the consultant will coordinate with the Contractor and plan the detail of his training program so that the necessary techniques and knowledge are effectively transferred to the participants of the program. Those training items with a symbol (*) below are the ones presumably provided by the Contractor. The consultants will provide additional information for such items, if necessary, to make them more relevant, not just “how to operate”, in the context of understanding of PV system.

[Before Commissioning (Approximately two weeks before Commissioning)]

Lecture on basic knowledge

- Concept of Grid-connection and its planning
- Concept of reverse power flow
- Characteristics of PV power generation (difference between rated output and actual output)
- Required equipment and its electrical specification
- Dominant factors such as power consumption and load etc. in premises affecting the installed capacity of PV system

- Response of PV system to the grid troubles
- Shut down and start up of PV system

OJT Program

- Joint survey on wiring work
- Joint survey on final inspection before commissioning test
- Joint survey on commissioning test and adjustment (*)
- Start up, shut down and re-start up (*)
- Joint survey on completion inspection

[After Commissioning]

Training provided by the Contractor

- Daily inspection and maintenance (*)
- Periodical inspection and maintenance (*)
- Consumables and replacing work (*) (inc. exercises)
- Introduction of FAQ relating to operation and maintenance (*)
- Introduction of typical malfunctions and their measures (*) (inc. exercises)

Work plan for O&M on the basis of Operation Manuals (inc. exercises)

- Preparation of operation log sheet form (inc. exercises)
- Preparation of daily and periodical check sheet (inc. exercises)
- Preparation of failures/accident record form (inc. exercises)
- Analysis of operation log sheet and manner of utilization (inc. exercises)

It is very often experienced, in Japan and in other countries as well, that initial setting of the equipment and/or the lack of familiarity of operation lead to malfunction or unsatisfying performance of the PV system. Therefore, it is necessary to carry out a follow-up training program a certain period after the commissioning. This follow-up training program is proposed to consider 4.5-month experience of actual operation and maintenance of PV system, operation issues unique in the implementation and in Cambodia circumstances, to discuss problems and questions arose, and to revise the operation and maintenance management plan. This process aims for the establishment of more pragmatic and steady method of operation.

[About 4.5-month after commissioning]

- Joint inspection on the equipment (*)
- Evaluation of maintenance performance and trouble shooting (*)
- Evaluation of operational performance based on the analysis of log sheets, and finding critical issues and their measures, if any (inc. exercises)
- Review of data log sheet form and check sheet form

The obligation of the following-up training by the Contractor shall be incorporated into the Tender Documents as well as the training by the Contractor at the commissioning.

2) Participants

Eleven (11) staff in Electric Section and an assistant under the Production and Distribution Department being in charge of maintenance of the electric equipment of three water treatment plants managed by PPWSA are to operate and maintain the PV system.
Table 2-2.18 shows the required role and experiences for operation and maintenance staff of the PV system.

PPWSA has intention to introduce a PV system to the other water treatment plants after evaluation of the PV system's effects. Therefore, the staff of Plan and Technical Department of PPWSA will be also objective personnel of the training program in terms of assistance to introduction of a PV system.

Addition to the PPWSA staffs, officers in Department of Energy Technique being in charge of PV system related in MIME and engineers in Distribution Department being in charge of grid-connection generation plants in EDC will be also objective personnel of the training program in terms of assistance to introduction of a grid-connected PV system in Cambodia.

Table 2-2.18 Candidate Participants to the Training Program

Organization	Department	Training Purpose (a) and Required Qualification (b)
PPWSA	Electric Section in Production & Distribution Dept.	(a) Daily operation and maintenance of the PV system (b) Those in charge of maintenance of electric facilities at least 5 years
PPWSA	Plan and Technical Dept.	(a) Introduction of PV system to other water treatment plants in PPWSA (b) Bachelor of electrical engineering and his business experience at least 10 years
EDC	Distribution Dept.	(a) Finding critical issues and establishing measures (b) Bachelor of electrical engineering and his business experience at least 10 years
MIME	Dept. of Energy Technique	(a) Introduction of grid-connected PV system to Cambodia in future (b) Bachelor of electrical engineering and his business experience at least 10 yeas

The tentative program applicable to candidate participants is shown in Table 2-2.19. And number of participants are set 3 ~ 5 personnel basically considering the possibility that participants may move to another section or department in future.

Table 2-2.19 Tentative Program Applicable to Participants

Contents of Program	PPWSA		EDC	MIME
	Electric Section	Plan and Technical Dept.	Distribution Dept.	Dept. of Energy Technique
	3~5 personnel	2 ~ 3 personnel	3 ~ 5 personnel	3 ~ 5 personnel
Before Commissioning				
Lecture on basic technology		○	○	○
OJT (Joint survey on wiring work)	○		○	
OJT (Joint survey on final inspection before commissioning)	○		○	
OJT (Start up, shut down and re-start up)	○		○	
OJT (Completion Inspection)	○	○	○	
After Commissioning				
Follow-up of operation guidance	○		○	
Work plan for operation and maintenance	○		○	
4.5 months after commissioning				
Joint inspection on the equipment	○	○	○	
Evaluation on maintenance performance and trouble shooting	○		○	
Evaluation of operational performance and improvement	○	○	○	○
Review of data log sheet and check sheet form	○			

3) Schedule

The planned schedule for the above mentioned program is shown in Table 2-2.20 and Table 2-2.21.

Table 2-2.20 Training Schedule Before/After Commissioning

	Activities	-2nd week	-1st week	1week	2nd week
Contents of Activities	Preparatory Work				
	Lecture on basic knowledge				
	Joint survey on work & test (OJT)				
	Joint survey on completion inspection (OJT)				
	Operational Guidance (*)				
	Work plan for operation & Maintenance				
Participants	Electric Section in PPWSA				
	Plan and Technical Department				
	EDC Distribution Department				
	MIME Department of Energy Technique				
Lecturer	PV system Expert				
	Equipment & Electrical Expert				
	Interpreter				

Note: Bar chart expressed in dot line shows hourly base activities.

Table 2-2.21 Training Schedule 4.5 months after Commissioning

	Activities	1st week	2nd week
Contents of Activities	4.5 month inspection (*)		
	Evaluation of maintenance performance and trouble shooting (*)		
	Evaluation of operational performance and improvement measures		
	Review of data log sheet form and check sheet form		
Participants	Electric Section in PPWSA		
	Plan and Technical Department		
	EDC Distribution Department		
	MIME Department of Energy Technique		
Lecturer	PV system Expert		
	Equipment & Electrical Expert		
	Interpreter		

4) Resource for the Training Program

As already mentioned, the PV system with grid interconnection is the first-ever experience in Cambodia. Therefore, Japanese consultants are assumed to undertake the implementation of the training program. Consultants to be assigned should have adequate experiences in planning of PV system with grid connection. There will be two Japanese consultants, one leader and one assistant, to be lecturers to the programs of both periods. National consultants are not considered as the recipient country does not have an experience in similar projects.

On the other hand, some of participants are supposed to be not good at English. Therefore, the program had better be done in local language as much as possible by employing an interpreter. An interpreter will be dispatched from Japan unless an interpreter can be available in Cambodia. Addition to the employment of an interpreter, texts, manuals and technical references to be distributed in the program are translated into English. And some of them which seem to be very important had better be translated to the local language as much as possible to achieve further effectiveness of the program

5) Schedule of Training Program

The work schedule for the training program is shown below, assuming that the agreement between the procurement agent and the Contractor will be concluded in August 2011.

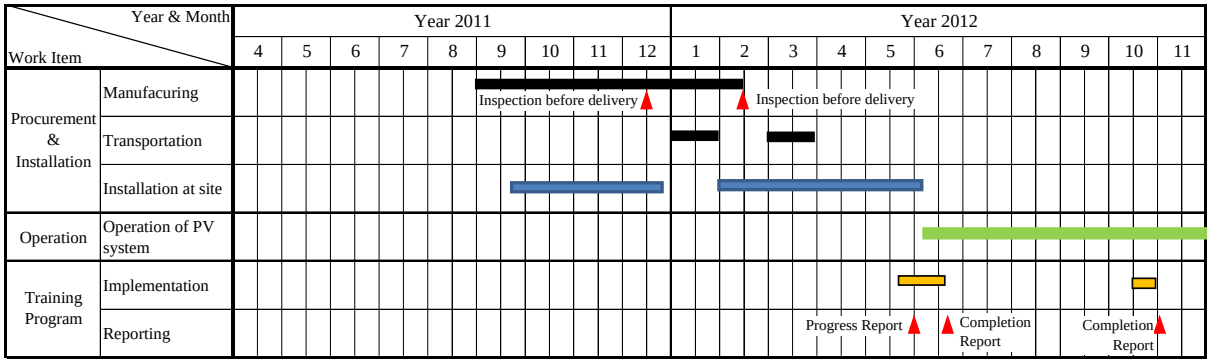


Fig. 2-2.9 Training Program Implementation Schedule

6) Products of Training Program

Products of training program are outlined below.

- A training program textbook prepared by the Consultant
- Progress reports
- Completion reports (inc. evaluation of operation record and trouble shootings)
- Single line diagram prepared in the exercise and so on
- Visual record (DVD) of periodical inspection (4.5-month inspection)
- Work plan for operation and maintenance (with revision)
- Results of questionnaires

7) The Responsibility of Recipient Country

It is important that participants take part in the training in full for the achievement of the program objectives, which, however, requires the participants of being away from their work place for weeks. Therefore, there must be an official designation as a participant given by the section/department management who appreciates the usefulness of the program. It is also important that the government agencies appoint persons who will be in charge of PV and renewable energy in the future.

2-2-4-9 Implementation Schedule

In making implementation schedule, it is necessary to take the grant aid cooperation into full consideration and set up a proper implementation system with the work schedule. The implementation schedule is as follows:

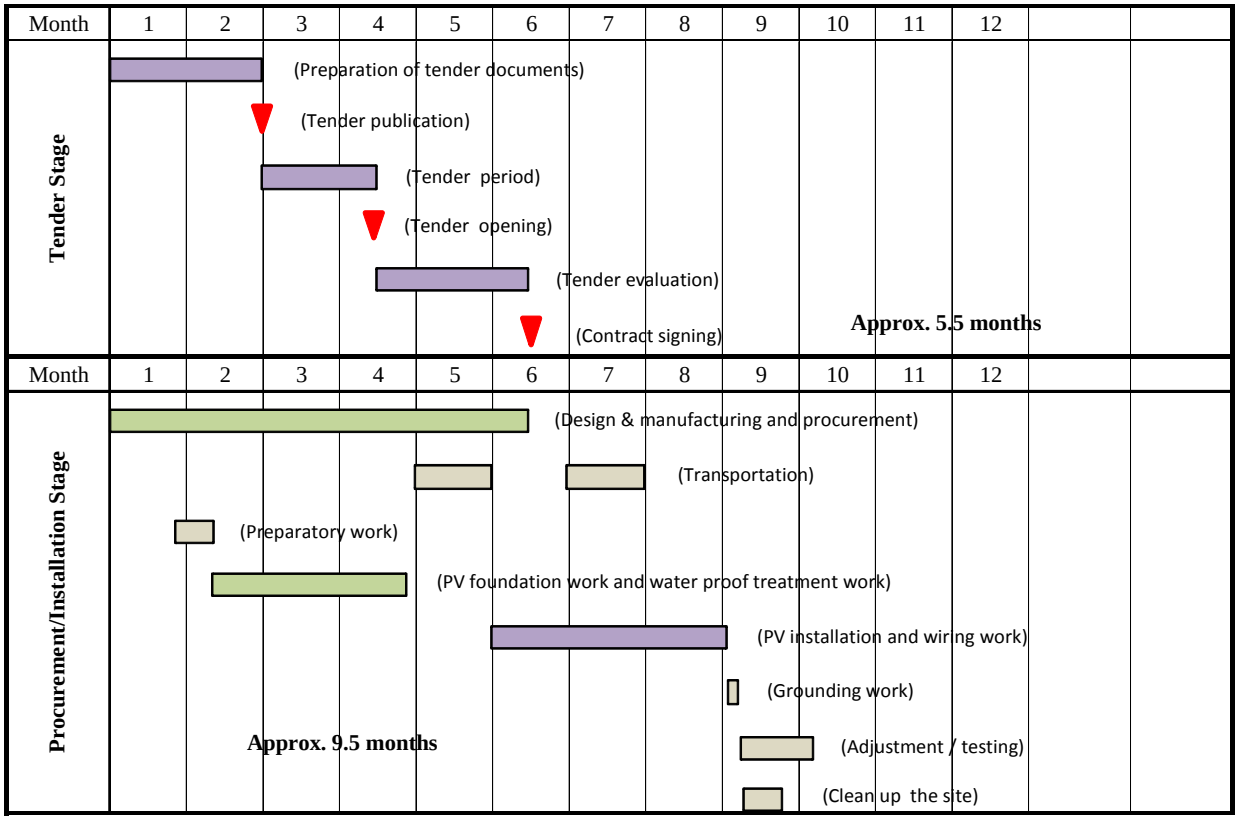
(a) Exchange of Notes (E/N)..... (March 18, 2002)
(b) Consultant Agreement .....(February 2011)
(c) Tender document preparation ..... (March to April 2011)
(d) Tendering and signing of contract with selected contractor ..... (May to August 2011)

(e) Manufacturing and procurement of materials and equipment
.....(September 2011 to February 2012)
(f) Installation of PV equipment ..... (January to June 2012)
(g) Implementation of soft component
(h) Completion and taking-over

The project will be implemented in about 27 months upon conclusion of E/N. The work will be completed in about 9.5 months including manufacturing and installation. The whole period of implementation of the project consists of design and manufacturing, transportation, foundation work, installation work, pre-commissioning and adjustment. The foundation work can be implemented while the electric items are manufactured in Japan.

Table 2-2.22 shows preliminary implementation schedule based on the grant aid scheme.

Table 2-2.22 Preliminary Implementation Schedule



2-3 Obligation of Recipient Country

Undertakings required of the Recipient Country had been confirmed by the minutes of discussion concluded in First Phase Study of the Project. The specific items required for implementation are as tabulated in Table 2-3.1.

Table 2-3.1 Undertakings required of the Recipient Country

No.	Undertakings by Cambodia	Implementation System in Cambodia
1	To secure the land	Installation site is the roof of the existing facilities and already secured.
2	To clear and level the area for PV module installation	Already cleared and leveled
3	To conclude a bank arrangement with Japanese bank and pay commission	PPWSA is responsible.
4	To ensure all the expenses and prompt execution of customs clearance	PPWSA is responsible.
5	To go through required procedure for the installation of PV system	PPWSA is responsible.
6	To accord Japanese nationals and/or nationals of third countries	PPWSA is responsible.
7	To ensure the exemption of custom duties, internal taxes and other fiscal levies imposed in Cambodia	PPWSA is responsible.
8	To maintain and use properly and effectively the PV system	PPWSA is responsible.
9	To bear all expenses, other than those covered by the Grant	PPWSA is responsible.
10	To ensure environmental and social considerations for the programme	PPWSA is responsible.

2-4 Project Operation Plan

The generating equipment to be procured in the project is designed to be operated and maintained by PPWSA on daily basis. In the long-run, the responsible organization of MIME and EDC may have to cooperate in the maintenance works.

The recipient is expected to implement the preventive measures and proper maintenance of the generating equipments to keep the performance, function, and continuous supply of power, on the basis of improvement of reliability, safety, and efficiency. The basic concept of maintenance is shown in Fig. 2-4.1.

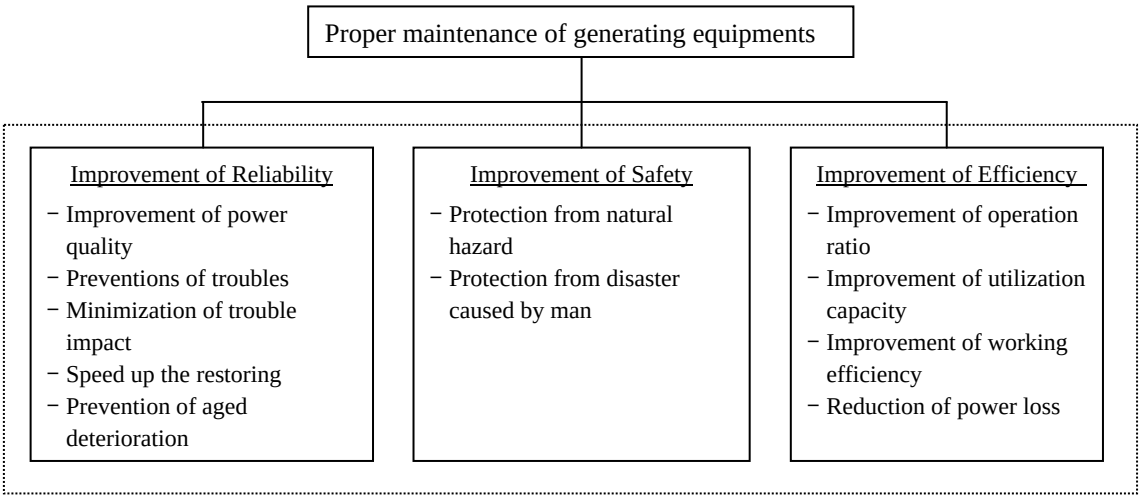


Fig. 2-4.1 Basic Concept for Maintenance of Generating Equipment

Keeping the basic concept in mind, the recipient country should operate and maintain the PV system, utilizing O&M techniques transferred during the Contract through OJT by Contractor's experts and through training program by the Consultant, and according to Operation and Maintenance Manuals.

2-4-1 Operation and Maintenance Organization and Staff

Fig. 2-4.2 shows the organization chart of PWSA once more focusing on maintenance staff. Eleven (11) staff in Electric Section and an assistant under the Production and Distribution Department being in charge of maintenance of the electric equipment of the water treatment plants managed by PPWSA are to operate and maintain the PV system. All staffs of the electric section and an assistant are bachelors (electrical engineering related) and their technical skills seem to be excellent.

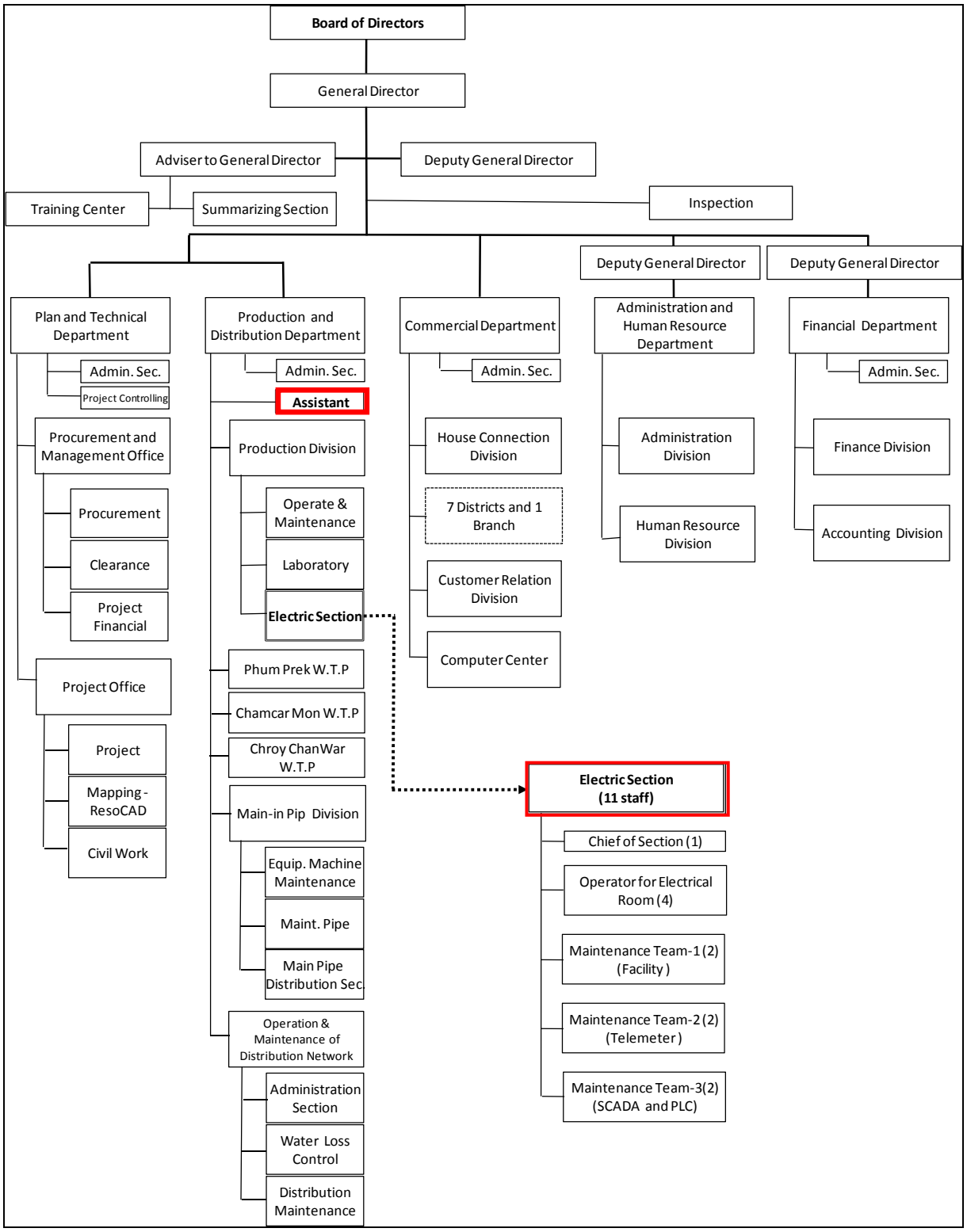


Fig. 2-4.2 Organization Chart of PPWSA Focusing on Maintenance

2-4-2 Inspections

PPWSA is requested to establish work plan for operation and maintenance of the PV system based on the standard daily and periodical inspections prevailed in Japan as mentioned below, and Operation and Maintenance Manuals provided by the Contractor.

(1) Daily Inspections

Daily inspections are mainly visual inspections conducted by daily. Recommended inspection items are shown in Table 2-4.1. In the case of detection of abnormal conditions, consultation with a responsible engineer of the PV system is required.

Table 2-4.1 Standard Daily Inspection Items and Findings

Category	Items		Findings
PV array	Visual	a) Surface of arrays	Stain and damage
		b) Support stands	Corrosion and rust
		c) Connecting cable	Damage
Junction box	Visual	a) Boxes	Corrosion and rust
		b) Connecting cables	Damage
Power Conditioner Cubicle	Visual	a) Outside boxes	Corrosion and rust, energized part being covered
		b) Connection cables	Damage
		c) Vent hole (air shaft, filters etc)	Aeration, Filter clogging
		d) Condition	Abnormal sound, vibration, odor, and overheating
		e) Control panel	Signal of errors
		f) Power generating	Errors of power generating condition on control panel

(2) Periodical Inspections (Bi-monthly Inspections)

Bi-monthly inspections are advisable to be conducted once every two months. Recommended inspection items are shown in Table 2-4.2.

Table 2-4.2 Standard Bi-monthly Inspection Items and Findings

Category	Items		Findings
PV Sub-array[15]	Visual and touch	Grounding wires and grounding terminals	Junction with Grounding wires, Loose screws
Junction box	Visual and touch	a) Boxes	Corrosion and damage
		b) Connecting cables and terminals	Anomaly in wiring, Loose screws
		c) Grounding wires and connecting terminals	Anomaly in wiring, Loose screws
	Measurement and test	a) Insulating resistance	<PV – Grounding wires> 0.2MΩ[16] or over, measured voltage DC500V (Measure all circuits) <Output Terminals – Grounding wires> 1MΩ or over, Measured voltage DC500V
		b) Open circuit voltage	Specified voltage, Polarity (Measure all circuits)
Power conditioner Cubicle	Visual and touch	a) Outside boxes	Corrosion and damage
		b) Connecting cables and terminals	Anomaly in wiring, Loose screws
		c) Earthling wires and connecting terminals	Anomaly in wiring, Loose screws
		d) Vent hole (air shaft, filters etc.)	Aeration, Filter clogging
		e) Condition	Abnormal sound, vibration, odor, and overheating
		f) Control panel	Signal of errors
	Measurement and test	a) Insulating resistance (Power conditioner - Grounding)	1 MΩ or over Measured voltage DC500V
		b) Control panel	Operation checks (Display and power generating)
		c) Re-starting Timer	Confirmation of automatic start-up
Switch for PV	Visual and touch	a) Connecting terminals of switch	Loose screws

2-4-3 Long Term Operation and Maintenance

Although the expected operation of PV modules and power conditioners, the main components of PV system, varies by manufacturers, PV modules would last for 20 years[17] and power conditioners 10 years[18], under the proper O&M and favorable environment. Actual operation life, however, depends on the execution of inspections and daily operation/maintenance conditions. There are some parts inside the equipment that have to be replaced before operation life of the equipment.

Those maintenances including the replacement of major worn-out parts are generally called “full-scale maintenance”, “detailed maintenance” or “overhaul”, in the project defined as

[15] PV modules should be checked for the following points
- Smudges on the surface, cracks and discolorations on the surface, etc,
- Deformation of support structure, rust, loosened bolts, etc.

[16] Allowable Insulating resistance; 0.4MΩ or over for Insulating resistance of 300V or over.
[17] Japan Photovoltaic Energy Association (Website)
[18] Japan Photovoltaic Energy Association (Website)

"long term maintenance". Frequency of long term maintenance is once every five to seven years.

Long term maintenance can be the most expensive maintenance work related to PV system, because major parts may have to be purchased and replaced, and in some unfortunate cases a dispatch of manufacturer's engineers have to be requested. Therefore, unlike regular maintenances and periodical inspections, some special provision for long term maintenance is needed. Regular maintenances and periodic inspections are assumed to be implemented by the technicians and on the current operation budget at the facility. Long term maintenance, therefore, requires, among others, financial support from the implementation/responsible organizations of the government. Also, there are some cases which require the involvement of electricity utility company (EDC) as the PV system is interconnected to the utility grid.

Table 2-4.3 Organization Control for Long Term Maintenance

	Organization	Periodical and Daily Inspection	Long term Maintenance
Implementation Organization	PPWSA	Operation of PV system Planning and implementation of daily and periodical inspection	Planning and implementation
Responsible Organization	MIME	Monitoring of operation and effect on PV system	Technical Support
Related Organization	EDC	Monitoring of grid interconnection and reverse power flow conditions	Technical Support

It is desirable for sustainable supply of electric power by the PV system to have a proper supporting program especially targeting long term maintenance. Within the project, the following measures are proposed.
Provision of spare parts needed up to the first long term maintenance
Provision of a dedicated section in O&M Manuals that explains how to use spare parts

As specification of spare parts and maintenances varies by manufacturers, detailed lists are proposed by bidders and finally will be fixed after tendering.

2-4-4 Spare Parts

Spare parts for the PV system are classified into two categories; standard components for periodic replacements and components for unscheduled replacements. Owner of the PV system has to purchase these parts for periodical inspections and maintenances.

It is important that spare parts necessary up to the first long term maintenance are procured in the project. The recipient country himself has to meet subsequent needs for spare parts. The list of spare parts and tools proposed to be procured in the project are shown in Table 2-4.4.

Table 2-4.4 List of Spare Parts and Tools for PV System

< Consumable Goods >

SPD Class II	10 pieces
Lamps in boards and cubicles	200%
Heat response terminal cap	200%

< Spare Parts >

PV modules (% of installed capacity)	3 %
Power Conditioner	1 set

< Tools and Measuring Equipment >

Measuring Equipment

Clamp meter (AC: 3000 A、DC 600 A)	1 unit
Insulating resistance meter 500V, 1000V	1 unit
Earth resistance meter	1 unit
Phase meter for low voltage (~600 V)	1 unit
(Voltage) Detector (AC, DC)	1 unit
Digital tester	1 unit

Tools

Hole saw	2 pieces
Crimping pliers	2 pieces
Hydraulic crimping machine (separated hydraulic head)	1 unit
Hydraulic crimping machine- manual hydraulic machine	Unit

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) The Cost of Cambodia

The obligations of the recipient side were discussed in Section 2-2-4-3 of this report. Camboia Side shall bear the bank commission applied for bank services based upon the Banking Arrangement (B/A).

(2) Condition of Calculation

1. Time of calculation: March 2010
2. Exchange rates of foreign currencies: 1 US$ = JPY 91.36
   1 Riel = JPY 0.02154

3. Time of Event: As shown in Table 2-2.22
4. Remarks: Calculation is done according to the rules for Japan's Gant Aid Program

2-5-2 Operation and Maintenance Cost

(1) Estimation of Cost of Operation and Maintenance

The following cost factors are considered here.

1. Cost for daily operation
2. Cost for personnel in operation and maintenance
3. Cost for spare parts to be required
4. Cost for renovation

Cost estimation in this section does not consider unlikely, but still possible, breakdown of equipment and resulting repair cost. Also, repair cost after vandalism or sabotage is not considered. Further the cost of requesting Japanese manufacturer's engineers to be present at the site for repair and/or diagnosis work is not considered.

1) Cost for daily operation

As PV system does not consume any fuels, there would be very few expenses under this category. To be very precise, there are expenses for water used in cleaning of PV modules, electricity for system monitoring and air conditioners during not-generating hours of the day, which are small enough to be negligible.

2) Cost for personnel in operation and maintenance

The PV system to be procured in the project can be, and will be operated and maintained by the existing maintenance staff of the facilities. Therefore, operating and maintain the PV system does not require additional persons to be employed by PPWSA. Concerning the cleaning of PV modules, existing workers for cleaning in the premises are expected to be in charge of cleaning of PV modules for monthly basis.

3) Cost for spare parts to be required

A PV system to be procured in the project is in general considered to have an expected operation life of more than twenty years. PV modules require little maintenance cost as they have no moving parts, hence, less possibility of breakdown. In particular, Japanese made PV modules have reputation of lower rate of deterioration of conversion efficiency compared to products of other countries. On top of this, there will be a few percent extra modules to be procured in the contract as spare parts. There will be no spare parts of PV modules to be procured by the recipient in the future, leaving necessity of purchasing only

those parts related to power conditioners.

As discussed in Section 2-4, the procurement contract for the project is planned to include provision of spare parts to be necessary up to the first long-term maintenance work. This will relieve the recipient from the expenses of purchasing spare parts until the first long-term maintenance work. The first long-term maintenance work will take place, with some variation among manufacturers, about seven years after commissioning of the equipment.

There is an exception to the above, the parts related to air conditioners are not considered in the list of spare parts provided by the Contractor.

In summary, the cost of spare parts will be for those for air conditioners until the first long-term maintenance, which will be added with those for power conditioners thereafter. Roughly speaking, and on average, these costs are estimated in Table 2-5.1.

As mentioned in the table below, before and after the first long-term maintenance, the average annual cost are estimated at 150,000 Japanese Yen and 1,940,000 Japanese Yen respectively, which are equivalent to about 7,000,000 Riel and about 90,000,000 Riel (1 Riel = 0.02154 Yen).

Table 2-5.1 Expenses for Spare Parts

(unit: Japanese Yen)

	Aggregate for a period of long-term Maintenance (7 years)	Average Annual Cost
Power Conditioner (100kW) (Applicable only after the 1st Long-term Maintenance)	Approx. 12,500,000	Approx. 1,790,000
Air conditioner related	Approx. 1,000,000	Approx. 150,000
Total (after the 1st Long-term Maintenance)	Approx. 13,500,000	Approx. 1,940,000

Remarks: As mentioned before, these costs do not include that for dispatched engineers from abroad.
These costs are subject to large variation due to the environment and conditions of operation and maintenance.

Table 2-5.2 Long-term Maintenance and Cost Reserve

Item	Years from the Taking-over														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Taking-over	▼														
Guarantee Period	■	No financial burden for PPWSA even if malfunctions and troubles occur within guarantee period. And initial troubles mostly occur within one year from the operation start.													
Long-term Maintenance							**1st Inspection** ▼						**2nd Inspection** ▼		
Assumed replacement of equipment and reserving period															
Air Conditioner	Setting aside money for the next replacement →						▼	→					▼		
Power Conditioner		← Covered by Spare Parts →						Setting aside money for the next replacement →						▼	

4) Cost for Renovation

As mentioned in the previous section, PV modules have long expected life with slow deterioration rate. Therefore, PV modules do not require replacement during the lifetime of the whole PV system.

The power conditioners on the other hand are just like ordinary equipment in the power utility industry and some of their parts have statutory service lives. Those parts that have to been deteriorated should be, on occasions of periodical and/or long-term maintenance, replaced with the spare parts considered in the previous section. Beyond this, overall replacement of the equipment or renovation is considered out of scope of the project.

(2) Financial Resources for Operation and Maintenance

The expected generation energy and cost saving to be yielded by the project, of which installed capacity is 488 kW, are shown in Table 3-1.2 in the report and the expected cost saving is estimated at about 10.9 Million Japanese Yen or 507 Million Riel annually. Comparing the cost saving of 10.9 Million Japanese Yen with the annual cost of 2.0 Million Japanese Yen, PPWSA seems to be able to reserve the required annual cost from the cost saving.

2-6 Other Relevant Issues

Toward the smooth implementation of the programme, the following issues are kept in mind.

(1) New Commercial Building

A display board showing simultaneous power output and cumulative generation energy is to be installed in the water tariff payment room aiming at enlightenment toward Phnom Penh citizens. However, it was found during the third survey that the existing payment room will move to a new commercial building in the same premises. According to PPWSA's information, construction of a new commercial building will start in the first quarter in 2011 and complete in September 2011. The installation work of the display board will not be interrupted, if the new commercial building is completed on schedule in September 2011, otherwise the installation schedule might be delayed. Therefore, it is important to monitor the construction progress of the new commercial building closely and work on PPWSA to keep the construction schedule.

(2) Exemption Procedure

Since the project is implemented by the Japan's Grant Aid, import tax on the equipment procured by the programme will be exempted. CDC is the authorized organization to examine the importing equipment based on the equipment master list submitted by the Contractor and other required documents. If the documents pass the examination, the exemption proceeds. A series of above procedure will be handled by PPWSA and PPWSA is requested to take necessary actions steadily and without delay.

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATION

Chapter 3 Project Evaluation and Recommendation

3-1 Project Effect

(1) Expected Power Generation and Saving of Electricity Payment

Expected generation energy is estimated at 652,800 kWh in the case of the installed capacity of 488 kW based on the "Monthly Variation of Solar Irradiation in Cambodia (Figure 15)" in "The Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia, Vol. 1" by JICA in 2006. The amount of 652,800 kWh accounts for about 5.3 % of total power consumption of 12,265,400 kWh at Phum Prek Water Treatment Plant.

For the above power consumption, PPWSA pays electricity charge amounted to 9,528 Million Riel at the average power tariff of 776.8 Riel/kWh. If the power tariff of 776.8 Riel/kWh is applied to the above expected generation energy of 652,800 kWh, the expected saving amount is estimated at 507 Million Riel per annum.

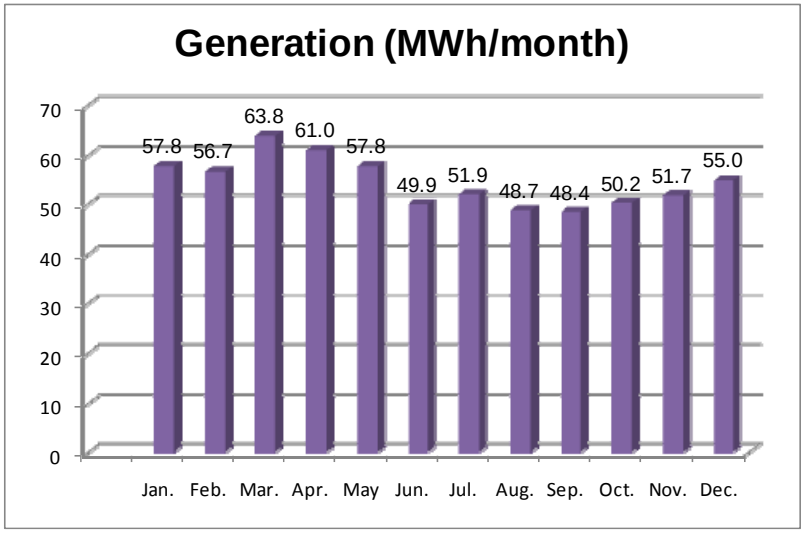


Fig. 3-1.1 Expected Monthly Generation Energy

Table 3-1.1 Power Consumption and Electricity Charge at Phum Prek Water Treatment Plant (Year : 2007&2008)

1 US$ = 3900 Riel

From	To	Previous	Current	Multiplier	Consumption (kWh)	Rate (R/kWh)	Value (Riel)	Annual Payment (Riel)	US$
22/12/06	22/01/07	49995	60967	100	1,097,200	613	672,583,600		
23/01/07	21/02/07	60967	71196	100	1,022,900	624	638,289,600		
22/02/07	21/03/07	71196	81124	100	992,800	611	606,600,800		
22/03/07	20/04/07	81124	91457	100	1,033,300	626	646,845,800		
21/04/07	21/05/07	91457	102933	100	1,147,600	646	741,349,600		
22/05/07	21/06/07	102933	114545	100	1,161,200	673	781,487,600		
22/06/07	20/07/07	114545	124711	100	1,016,600	688	699,420,800		
21/07/07	21/08/07	124711	135931	100	1,122,000	695	779,790,000		
22/08/07	21/09/07	135931	147039	100	1,110,800	691	767,562,800		
22/09/07	22/10/07	147039	157390	100	1,035,100	700	724,570,000		
23/10/07	21/11/07	157390	167538	100	1,014,800	714	724,567,200		
22/11/07	21/12/07	167538	176488	100	895,000	724	647,980,000	8,431,047,800	2,161,807
22/12/07	21/01/08	176488	186889	100	1,040,100	782	813,358,200		
22/01/08	22/02/08	186889	197558	100	1,066,900	800	853,520,000		
23/02/08	21/03/08	197558	207184	100	962,600	820	789,332,000		
22/03/08	21/04/08	207184	216970	100	978,600	818	800,494,800		
22/04/08	21/05/08	216970	227141	100	1,017,100	838	852,329,800		
22/05/08	20/06/08	227141	237729	100	1,058,800	882	933,861,600		
21/06/08	21/07/08	237729	247993	100	1,026,400	947	972,000,800		
22/07/08	21/08/08	247993	257034	100	904,100	1,009	912,236,900		
22/08/08	22/09/08	257034	267317	100	1,028,300	1,061	1,091,026,300		
23/09/08	21/10/08	267317	275934	100	861,700	1,032	889,274,400		
22/10/08	21/11/08	275934	285332	100	939,800	957	899,388,600		
22/11/08	22/12/08	285332	295303	100	997,100	821	818,619,100	10,625,442,500	2,724,472
Average per Year					12,265,400	776.8	9,528,245,150		

Source: PPWSA

Table 3-1.2 Expected Saving of Electricity Charge

Items	Unit	Quantity
Expected Generation Energy (488 kW)	kWh	652,778
Average Power Consumption (2007 & 2008)	kWh	12,265,400
The Average Power Tariff	R/kWh	776.8
Expected Saving of Electricity Charge	R'000	507,078
PPWSA Electricity Charge Payment per annum	R'000	9,528,245
Expected Saving of Electricity Charge	%	5.3%

(2) Improvement of Sanitation

PPWAS reformed its water tariff system in 1994, 1997 and 2001, and has kept the same tariff system since 2001 and been supplying about 200,000 lower income households in Phnom Penh City with drinking water at their affordable water tariff by virtue of PPWSA's continuous dealing with improvement of management efficiency, even though material prices for water production has been increased by almost twice since 2001.

PPWSA is going forward a plan to expand its supply area to the outer edge of Phnom Penh City based on the Government Policy by assistance of JICA. Since a number of poor households live in the outer edge of Phnom Penh City, PPWSA will be requested to tackle further improvement of management efficiency and reinforcement of management foundation in order to supply those people with drinking water at their affordable water tariff.

At the moment, electricity payment to EDC accounts for about 80 % of the total water production cost. The saving of electricity payment to be yielded by the project will be expected to contribute not only to improvement of PPWSA management foundation but also to improvement of sanitation in Phnom Penh area.

(3) Reduction of CO_2 Emission

The reduction of CO_2 emission is estimated based on the unit CO_2 emission rate for burning fuel and for plant operation released by "Central Research Institute of Electric Power Industry". If the above emission rates apply to the generation energy in 2007 by fuel basis, reduction of CO_2 emission is expected to be 400 ton-CO_2 per annum as demonstrated in Table 3-1.3.

Table 3-1.3 Reduction of CO_2 Emission by the Project

Energy Generation in 2007	Generation Type	Enegy Generation	CO_2 emission		
			by fuel burning (E1)	by plant operation (E2)	E1 + E2
		MWh	g/kWh	g/kWh	kg
	HFO	1,105	704	38	819,910
	DO	138	704	38	102,396
	IMPORT	81	0	0	0
	HYDRO	50	0	11	550
	Others	5.1	0	0	0
	Total	1,379			922,856
	Average (kg/MWh)				669
PV System (488 kW)		653	669	-53	402,248

Source: EDC Annual Report 2007, Table 5, page 26

3-2 Recommendations

(1) Privatization of PPWSA

Why the Government of Cambodia proposed PPWSA to the Government of Japan as an objective department/ministry for "Grid-connected Photovoltaic Power Generation System" can be assumed as follows:

1) PPWSA had been a recipient of Japan Grant Aid and well operated and maintained the facilities provided by the Grant Aid. Therefore, PPWSA is expected to operate and

maintain well the Photovoltaic Generation System to be procured by the project.

2) PPWSA contributes to improvement of sanitation for citizens in Phnom Penh Area in manner of supplying safety-drinking water as a state-managed company. On the other hand, PPWSA is faced to address the further improvement of management efficiency which means the saving of electricity charge to keep the affordable water tariff, because electricity charge accounts for 80 % of total production cost in 2008.

If PPWSA is privatized and private businesses become share holders, the business policy might be changed from contribution to sanitation for citizens to profit seeking and the PV system procured by the project might be also used as a profit seeking tool with different purpose. To avoid such situation, the Government of Cambodia is recommended to hold majority of shares even after privatization.

(2) Cooperation with Other Donors

As forementioned, the rural electrification rate seems to be still low and poverty rate in the rural area seems to be high in Cambodia. In order to improve the current situation, international donors assist the rural electrification by Solar Home System.

Operation and maintenance of the grid-connected PV with 488 kW are the first experience for Cambodia. MIME and EDC, key players in Power Sector in the Cambodia will participate in the training program to be conducted under the project. Therefore, MIME and EDC are expected to deepen their knowledge about Grid-connected PV system and share the performance and maintenance data of the PV system with other donors. Sharing technical data with other donors is expected to extend the possibility of new assistances to the Power Sector in Cambodia.

(3) Establishment of Operation and Maintenance Organization

Since the training program is intended to foster the personnel who will play a key role in the operation and maintenance of the PV system, PPWSA is recommended to bring appropriate personnel into the training program to meet the above intension.

And it is important to establish the operation and maintenance organization so that the knowledge and know-how provided in the training program can be handed over to the next generation in PPWSA in terms of sustainability of the project, without participant’s property.