Ministry of Energy and Mines
The Lao People's Democratic Republic

FINAL REPORT
OF THE PREPARATORY SURVEY
ON THE PROJECT
FOR
INTRODUCTION OF CLEAN ENERGY
BY SOLAR ELECTRICITY GENERATION SYSTEM
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

March 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 Lao People's Democratic Republic.

JICA sent to Laos survey team headed by Mr. Yasuharu MATSUDA of NEWJEC Inc. from December 16th to December 25th, 2009 and from January 31th to March 1st, 2010.

The team held discussions with the officials concerned of the Government of Laos, 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 Laos from September 5th to 10th, 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 Lao People's Democratic Republic for their close cooperation extended to the teams.

March 2011

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

SUMMARY

SUMMARY

I. Outline of the Recipient Country

The Lao People's Democratic Republic (hereinafter referred to as "Laos") is located in the center of the Indo-China Peninsula and the landlocked country. Laos is bordered by all Indo-China countries, such as Thailand, Cambodia, Vietnam, China and Myanmar. The total population as of 2009 is about 6 million and the total land area is 236,800 km^2 which is equivalent to 65% of that of Japan. Population density in 2009 is 25.9 persons per km^2. Natural condition of Laos is characterized by Mekong River passing through from North to South and mountainous area accounts for about 80 % of the total land.

Laos belongs to a tropical monsoon region and has rainy season from May to October, and dry season from November to April. The average temperature is around 28°C and the maximum temperature rises to 38°C in April and May although the minimum temperature drops to about 17°C in January at Vientiane.

Main export products in Laos are mineral resources, apparel, power, wood & forest products, and agricultural products. In 2008, export of mineral resources was amounted to 774.2 Million US$, consisting of apparel 259.9 Million US$, power 97.1 Million US$, wood & forest products 59.3 Million US$ and agricultural products 60.3 Million US$, and the total export amount (FOB) in 2008 was 1307.4 Million US$. Main import products in 2008 were machine products, fuel & gas, raw material for apparel, raw material for industry and vehicles & their parts. The total import amount (CIF) in 2008 was 1364.8 Million US$.

The real GDP growth rate after 2005 was 6.0% in 2005, 7.3% in 2006, 7.4% in 2007, 7.5% in 2008 and 7.5% in 2009. The economy in Laos has been well developed since 2005.

Concerning the direct investment from overseas from November 1988 to 2006, the cumulative direct investment is amounted to 14,288 Million US$. The direct investment to Energy Sector is amounted to 11,371 Million US$, which accounts for about 80% of the total investment amount dominantly, although the number of investments for the industry & handicraft is at the top.

Currency unit in Laos is Kip and exchange rate against US$ is 8,451 Kip as of March 2010.

II. Background of the Project and its Outline

Laos ratified UNFCC in December 1995 and Kyoto Protocol (COP3) in August 2002 and belongs to Non-Annex I Parties. Laos challenges the reduction of greenhouse gas emission and prepared "Climate Change Strategy" in December 2009. In the strategy in 2009, the government of Laos (hereinafter referred to as "GoL") sets forth that electrification attains 90% by the year

2020 by means of grid connection and renewable energy, such as solar power generation, wind power generation, and micro hydropower.

On the other hand, "National Growth and Poverty Eradication Strategy (NGPES)" prepared in 2004 sets forth the eradication of poverty by the year 2020. In virtue of NGPES, the number of poverties is remarkably reduced from 33.2% in 2003 to 27.1% in 2008. However, GNI per capita still remains 740 US$ in 2008.

Power export in 2008 occupies the third place among the total export amount and the GoL expects the development of power sector due to its geographical advantages, such as abundant hydropower potential and bordering all Indo-China countries.

Under the above circumstances, the GoL decided to join "Cool Earth Partnership" and takes up as its policy priority reduction of greenhouse gas emission and promotion of economic development, by the approach of adaption and mitigation to climate change. In accordance with the initiative, the GoL requested to the government of Japan for Grant Aid in June[1] 2009 and September[2] 2009.

Receiving the requests, technical survey such as the possibility of the installation of photovoltaic modules, etc. for the proposed sites was conducted by the JICA Study Team in the first phase site survey between December 16th and 25th in 2009. Then after discussion with the Laos side, PMO and Wattay International Airport have been selected as a candidate for the Project respectively, and M/D was concluded between Ministry of Energy and Mines, Prime Minister's Office, Ministry of Public Works and Transport and JICA Study Team on January 12, 2010.

Then through the second phase site survey implemented in February 2010 and the subsequent home works, the JICA Study Team prepared the Draft Outline Design Report and visited Laos to explain and discuss with the Laos side relating to the Report in September 2010 as the third phase site survey. In the course of meeting with PMO, PMO proposed the following additional conditions to the JICA Study Team.

PV modules should be placed on the roof of a new parking building with 2 or 3 floors to be built in the next 2 ~ 3 years.

In this connection, another 3 ~ 4 years's extention of the effective period of JICA Grant Aid is desired.

The JICA Study Team examined the above proposal and answered to PMO in the meeting that the JICA Study Team cannot accept the PMO's proposal considering the characteristic of the Project.

[1] Five ministries such PMO, MEM, MPI and so on
[2] Wattay International Airport

After the frequent negotiations between Japan and Laos, PMO has resulted in withdrawing the request for Japan Grant Aid finally. Therefore, Wattay International Airport has been the only one candidate for the Project.

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

Due to the PMO's withdrawal from the Project and cost estimation, the installed capacity at the existing parking lots in Wattay international Airport has been increased from 90 kW in the M/D concluded in January 2010 to 236 kW finally. The Project also includes provision of the training program aiming at the technical transfer relating to fundamental knowledge and operation & maintenance of the PV system.

The responsible organization is the Ministry of Energy and Mines, and the implementation organization is the Ministry of Public Works and Transport.

The salient features of the Project in the M/D concluded on March 16, 2011 are shown in bellow.

Category	Content
Site and PV Capacity	Wattay International Airport: 236 kW PV system - 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	236 kW PV modules Ancillary equipment for PV system - Junction box - Collection box - Power conditioner - Power conditioner cubicle - Meteorological observation device - Monitoring device - External and internal lightning protection device - Supporting frame for PV modules - Foundation for supporting frame and power conditioner cubicle - Display device - Laying cables
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 the Project implemented under Japan's Grant Aid scheme includes no expenses on the Laos side except for the Bank Commission Fee for the bank service based upon the Banking Arrangement (B/A).

The Project period is planned to be 6 months for tendering stage, and 11 months for the procurement of the PV system and its installation.

V. Evaluation of the Project

LAA will be responsible for daily operation and maintenance of the PV system on behalf of MPWT as the implementation organization nominated by the Project. MEM as the responsible organization and EDL as the relevant organization will support the Project toward smooth implementation and also support for operation and maintenance.

At the implementation stage of the Project, a series of the training program will be provided for operation and maintenance including technical knowledge of a PV system and its use. The training program intends to make the Project effective and sustainable operation and maintenance, and to support the promotion of grid-connected PV system in Laos.

The direct effect of the Project will support the diversification of energy resources in Laos by introducing the PV system, one of the clean energies. And considering the power import of the neighbouring coutries from Laos, introducing the PV system is to contribute to the expansion of the power export of Laos indirectly, and to the reduction of fossil fuel comsumption and CO_2 emission in the neighbouring countries consequently. The effect of reduction of CO_2 emission in Laos is expected to be 198 t-CO_2 per year.

Contributing to the power export will assist the GoL's challenge to eradicate the poverty by the year 2020 by means of increase of government annual revenue 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.

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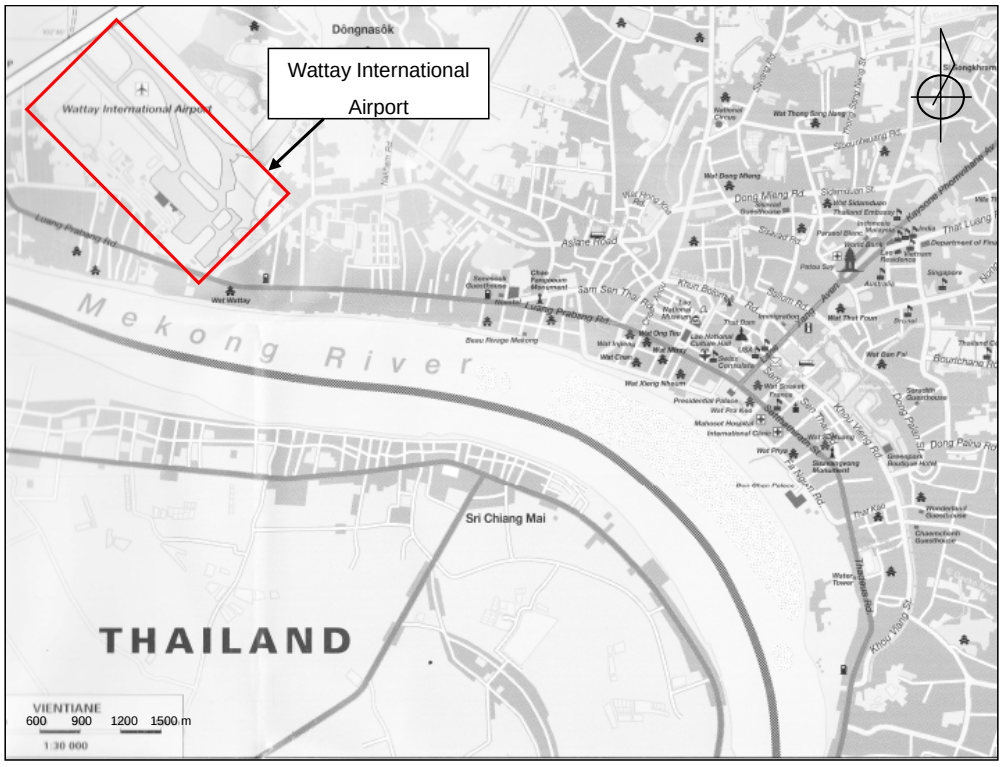

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Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
B/A	Bank Arrangement
CDM	Clean Development Mechanism
CT	Current Transformer
DC	Direct Current
DCA	Department of Civil Aviation
DOE	Department of Electricity
EDL	Electricite du LAOS
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
GDP	Gross Domestic Product
GNI	Gross National Income
IEE	Initial Environmental Examination
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
LAA	Lao Airports Authority
L-JATS	Lao-Japan Airport Terminal Services
MCCB	Molded Case Circuit Breaker
MEM	Ministry of Energy and Mines
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
NGPES	National Growth and Poverty Eradication Strategy
O&M	Operation and Maintenance
OJT	On the Job Training
PCS	Power Conditioners
PMO	Prime Minister's Office
PV	Photovoltaic
PVC	Polyvinyl Chloride
SI	The International System of Units
SPD	Surge Protective Device
UNFCCC	United Nations Framework Convention on Climate Change
VCT	Voltage Current Transformer
VT	Voltage Transformer
WB	World Bank
WREA	Water Resource and Environment Administration

CHAPTER 1

BACKGROUND OF PROJECT

Chapter 1 Background of Project

1-1 Background of Project

Lao PDR ratified UNFCCC in December 1995 and Kyoto Protocol (COP3) in August 2002. Lao PDR belongs to Non-Annex I Parties and works on reduction of the greenhouse gas emission as national commitment. In this connection, Lao PDR prepared Climate Change Strategy in Lao PDR in December 2009 and underlined that Lao PDR would utilize the renewable energy, such as photovoltaic power generation, wind generation and small hydropower, to attain 90 %[3] of the rural electrification by 2020.

On the other hand, "National Growth and Poverty Eradication Strategy (NGPES)" prepared in 2004 sets forth the eradication of poverty by the year 2020. In virtue of NGPES, the number of poverties is remarkably reduced from 33.2% in 2003 to 27.1% in 2008. However, GNI per capita still remains 740 US$ in 2008.

Power export in 2008 occupies the third place among the total export amount and the GoL expects the development of power sector due to its geographical advantages, such as abundant hydropower potential and bordering all Indo-China countries.

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 the "Program Grant Aid for Environment and Climate Change", a financial mechanism to support member countries which have difficulties in executing capabilities and funding.

Under the above circumstances, the GoL decided to join "Cool Earth Partnership" and takes up as its policy priority reduction of greenhouse gas emission and promotion of economic development, by the approach of adaption and mitigation to climate change. In accordance with the initiative, the GoL requested to the government of Japan for Grant Aid in June[4] 2009 and September[5] 2009.

The request for the Grant Aid project submitted by the GoL in June 2009 is as follows;

[3] "National Growth and Poverty Reduction Strategy (NGPES)"
[4] Five ministries such PMO, MEM, MPI and so on
[5] Wattay International Airport

Requested amount: 5,000,000 US$
Description of Requested Components:

Solar PV (50 Wp × 5,000), inverter, dual way meter (In-Out)
Soft Component: Training for DOE's staff before installation, On-the-job training during for operation, monitoring know-how
Project site: Ministry of Energy and Mines, Ministry of Planning and Investment, Prime Minister' Office and so on

Addition to the above request, the following supplemental request dated September 2009 was submitted by the GoL.

Requested amoun: 7,500,000 US$
Description of Requested Components:

Photovoltaic Power Generation System (300 kWp)
Photovoltaic modules, junction box, connection box, power conditioner, display unit, data management and monitoring system, transformer, cable and others, mounting structure for photovoltaic module
Soft Component: -
Project site: Wattay International Airport

Receiving the requests, the technical survey such as possibility of the installation of photovoltaic modules, etc. for the above proposed sites was conducted in the first phase site survey implemented in December 2009. Then after discussion with the Laos side, PMO and Wattay International Airport have been selected as a candidate for the Project respectively, and M/D was concluded between Ministry of Energy and Mines, Prime Minister's Office, Ministry of Public Works and Transport and JICA Study Team on January 12, 2010.

Then through the second phase site survey implemented in February 2010 and the subsequent home works, the JICA Study Team prepared the Draft Outline Design Report and visited Laos to explain and discuss with the Laos side relating to the Report in September 2010 as the third phase site survey. In the course of discussion with PMO, PMO proposed the following additional conditions to the JICA Study Team.

1) PV modules should be placed on the roof of a new parking building with 2 or 3 floors to be built in the next 2 ~ 3 years.
2) In this connection, another 3 ~ 4 years's extention of the effective period of JICA Grant Aid is desired.

The JICA Study Team examined the above proposal and answered to PMO in the meeting that the JICA Study Team cannot accept the PMO's proposal considering the characteristic of the

Project. After the frequent negotiations between Japan and Laos, PMO has resulted in withdrawing the request for Japan Grant Aid finally. Therefore, Wattay International Airport has been the only one candidate for the Project.

In this Grant Aid project, photovoltaic power generation system (PV system) will be provided as part of assistance of countermeasure of climate change in Laos, and support power export to neighboring countries by means of connecting the PV system to the grid to reduce dependency rate on fossil fuel in the neighboring countries and support the economic growth in Laos.

1-2 Project Site and Surroundings

1-2-1 Related Infrastructure

(1) Unloading Port and Transportation Route

Since Laos is located in the center of Indo-China Peninsula, there is no outer port in Laos. Therefore, the products procured in Japan will be unloaded at Bangkok port in Thailand and transported to Vientiane City via National Route No.2 and Thai-Lao Friendship Bridge, about 600 km far from the port. The port is supposed to be equipped with large cranes sufficient enough for unloading of containers for the products. For the domestic road in Laos from Thai-Lao Friendship Bridge to the airport is well paved and expected to serve as a transportation route of the products. Fig.1-2.1 shows the transportation route from the Bangkok port to Vientiane City.

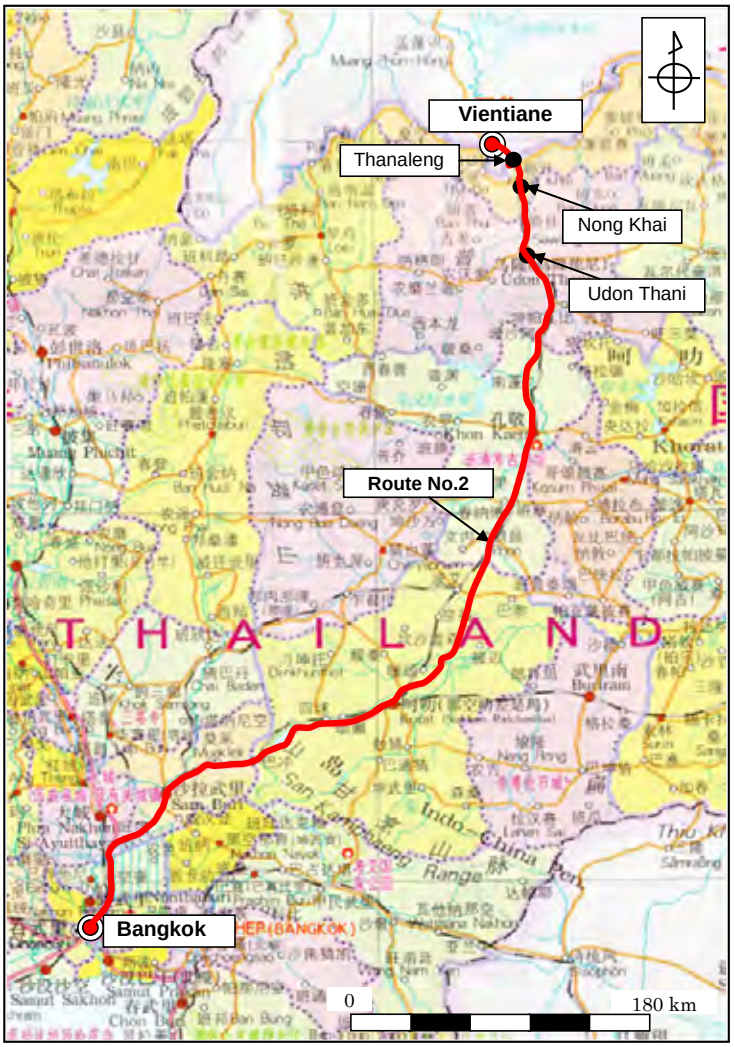


Fig.1-2.1 Transportation Route

(2) Transportation in Vientiane City

Wattay International Airport is located about 3 km far from the center of Vientiane City and looks to a trunk road. Therefore, the products will be smoothly delivered to Wattay International Airport.

(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 at the existing parking lots in the airport, land acquisition and leveling are not required.

(5) Wataty Internatinoal Airport

Wattay International Airport is located about 3 km far from the center of Vientiane City and there are a domestic terminal building and an international terminal building. Numbers of passengers are reported to be about 400,000 people per annum and fourteen international air flights enter service. The airport facilities except the international terminal building are managed and maintained Lao Airport Authority (LAA). Management and maintenance of the international terminal building is entrusted to Loa-Japan Airport Terminal Service (L-JATS) which was established between LAA (60% share) and Japanese firm (40% share). Fig. 1-2.2 shows the overall photo of Wattay International Airport.

Fig. 1-2.2 Overall Photo of Wattay International Airport

1-2-2 Natural Condition

(1) Rainfall and Temperature

Due to the monsoon in South-east Asia, the climate of Laos is clearly separated by rainy season and dry season. The rainy season is May to October and the dry season is November to April. The average temperature is around 28°C and the maximum temperature rises to 38°C in April and May although the minimum temperature drops to about 17°C in January at Vientiane.

Annual rainfall at Vientiane is around 1,500 ~ 2,200 mm (the average rainfall is around 1700 mm). 85% out of annual rainfall concentrate on the rainy season from May to October and

monthly rainfall in the rainy season reaches to 200 mm and above in some cases. Observed maximum daily rainfall from 2007 to 2009 at Vientiane was 127 mm. In the rainy season, a lot of thunders occur and structural damages by thunders are reported.

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

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total (mm)	0.0	1.0	70.4	223.0	200.0	158.9	330.2	159.3	251.3	110.8	7.0	0.0
Max. (mm)	0.0	0.6	29.8	127.4	25.2	25.4	67.4	43.3	41.0	85.4	4.6	0.0
No. of Raining day	0	2	6	8	21	21	25	15	17	7	2	0

Total in the Year : (2009)	1,511.9

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total (mm)	15.6	29.0	138.1	142.0	289.2	384.1	444.8	202.4	264.6	257.6	105.9	0.0
Max. (mm)	10.6	12.9	74.8	47.4	48.8	69.4	52.0	34.6	41.9	56.2	65.8	0.0
No. of Raining day	5	4	8	10	20	24	23	17	16	13	5	2

Total in the Year : (2008)	2,273.3

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total (mm)	0.0	7.6	2.9	86.3	191.7	270.6	200.4	327.5	269.9	205.3	3.2	0.0
Max. (mm)	0.0	6.6	1.7	63.0	50.0	92.7	97.3	58.5	62.4	40.1	3.2	0.0
No. of Raining day	0	2	2	11	16	17	13	24	16	12	1	0

Total in the Year : (2007)	1,565.4

(2) Earthquake

Laos is one of the countries where occurrence of earthquakes is very few. According to United States Geological Survey (USGS), almost earthquakes in Laos are observed in the northern area. Number of earthquakes observed within 500 km radius from Vientiane after 1973 are 179 times and observed earthquakes within 200 km radius are remarkably reduced to only 5 times after 1973 with the maximum magnitude of 4.8. Fig. 1-2.3 shows the earthquake map within 500 km radius from Vientiane City.

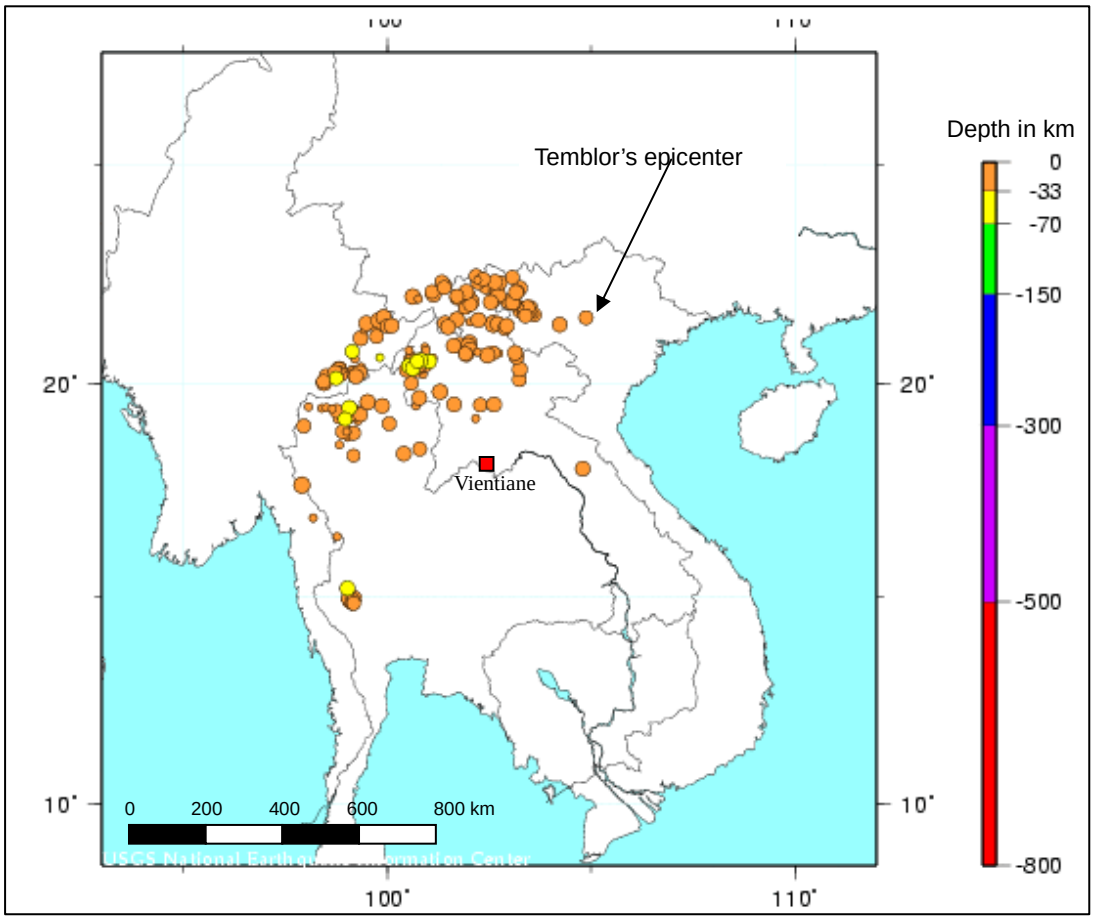


Fig. 1-2.3 Earthquake Map within 500 km Radius from Vientiane City

(3) Typhoon

Concerning the typhoons, numbers of typhoons attacked Laos are few due to its location in Indo-China Peninsula. No.16 typhoon (Asian Name is Ketsana) oriented in the sea close to Philippine attacking Cambodia from September 26 to September 30 in 2009 has been reported since 2005. The typhoon No.16 becomes tropical cyclone after attacking Cambodia

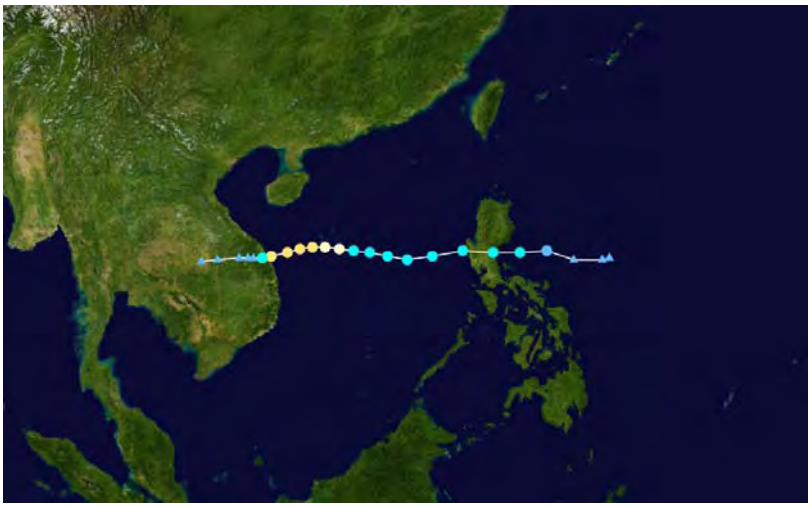


Fig. 1-2.4 Path of Ketsana Typhoon

(4) Ground Condition at the Site

According to the result of exploration boring conducted in October 10, 1994 prior to the construction of the International Terminal Building, underground water level was observed at 50 cm depth from the ground surface and the underground water level seems high because the airport is located near Mekong River. According to the standard penetration test which was conducted at the same time, the foundation soil up to 1.5 m depth from the ground surface is soft soil (weathering soil) with N = 5, and the soil between 1.5 m and 4m is hard soil (clay soil) with N=20 and above. N value of 5 is equivalent to allowable bearing power of 50 kN/m^2 [6].

1-2-3 Environmental and Social Consideration

With regard to the environmental and social considerations in Laos, Ministry of Water Resources & Environmental Administration is the authorized organization and "Law on Environmental Protection" published in 1999 is the regulating law. Addition to the above law, DOE prepared "Environmental Management Standard for Electricity" in June 2003. According to Article 4.4.2 in the Standard, no environmental document, such as IEE and EIA is required for the power generation plant of which installed capacity is less than 100 kW. Since the installed capacity at Wattay International Airport is planned to be 236 kW, IEE and/or IEA are requested for the Project generally based on the above standard. However, the GoL reconfirmed that EIA and IEE are not required for the project implementation of solar generation in the M/D concluded on March 16, 2011.

And since the Project is the installation of PV system, the Project does not generate air pollution, water pollution and soli pollution. Furthermore resettlement and land compensation are not required and there would be no impact on ecosystem of nature because the PV modules are installed in the existing parking lots in the airport.

Furthermoe, according to "JICA Guideline for Environmental and Social Considerations", April 2010, 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 Social and Environmental Management Division, DOE in the second phase site survey. 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. "Waste" treatment (Waste Disposal) will be stipulated in Clause 3.1.4 and "Accident" (Safety Control) will be also stipulated in Clause 5 in the Technical Specification as the Contractor's obligation.

[6] Based on the Table in "Guideline 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 PMO's and MPWP's properties, resettlements and land compensation are not necessary.
Impact on the residents nearby	C	Since the construction site is located at Wattay International and PMO compound, the impact on the residents nearby will not occur.
Land Use	C	The PV system will be installed utilizing the existing parking lot at the airport and the PMO, therefore, the impact on the land use will not occur.
Impact on social practice	C	The installation of PV system at the parking lot will not impact on social practice.
Impact on infrastructure	C	Since the PV system is installed in the PMO's and MPWT'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 PMO's and MPWT's premise, impact on those groups will not occur.
Uneven distribution of benefit	C	Benefit to be yielded by PV system will belong to the Lao Government.
Cultural monument	C	Since the PV system is installed in the PMO's and MPWT's premise, impact on cultural monument will not occur.
Conflict with residents near by	C	Since the PV system is installed in the PMO's and MPWT'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 four 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 four or three months.
Impact on nature of soil and geographic feature	C	Any reclamation, embankment and reforming the geography feature are not required. 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 PMO's and MPWT's premise, 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 PMO's and MPWT'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 Wattay International Airport, being about 3 km from Vientiane City, managed by LAA with a PV system of 236 kW and to burden a part of power consumption by facilities in the airport. Introdusing the PV system to Laos aims to contribute to the diversification of energy resources in Laos and the reduction of electricity charge of the facilities in Wattay International Airport. And introduction of the PV system is expected to contribute to expand power export indirectly and reduce the fossil fuels consumption in the neighouring power import countries (Thailand, Cambodia, Vietnam and Myanmar), which corresponds to the reduction of greenhouse gas emission, as well as economic growth in Laos.

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 airport 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 Outline Design of the Japanese Assistance

2-2-1 Design Policy

Table 2-2.1 shows the agreement which was concluded by JICA and the GoL on March 16, 2011 concerning the Project. With respect to the installed capacity of PV modules at Wattay International Airport, where about 400,000 passangers have use of annually, the installed capacity has been increased from 90 kWp to 236 kWp resulting from the withdrawal of PMO and cost estimation.

Table 2-2.1 Agreement Concerning the Project

	Description
Location	Wattay International Airport
Outline	The power produced is used for each building and excess power will be transmitted to the national grid.
Requested Equipment	(1) PV module: Approximately 236 kWp (2) Junction boxes (3) Power conditioners (4) Distribution boards (5) Cables for electric distribution (6) Data collecting and display device
Capacity Building	(1) On the Job training (2) Operation and maintenance training (3) Data collection and analysis training
Procurement	Products of Japan for major equipments

Taken into account of the above agreement and the characteristic of Wattay International Airport, the following design policies are applied to the Project.

- Since the Project is the grid-connected PV system, the Project will be designed based on "Grid-interconnection Code" in Japan and make clear the applicable range between the above Japanese standard and Lao 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 grid-connected PV system to be introduced to Laos is the first case in the country including its large scale of 200 kW class. The operation performance 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 PV system is connected to the national grid, the PV system is equipped with grid protection devices to prevent national grid and the existing electrical facilities in the airport from being electrically disturbed by the PV system, when trouble occurs in the PV system.
- A crystal type module and an amorphous type module are considerable when selecting a module type generally. However, to secure the prescribed installed capacity in the restricted space of parking lots, a crystal type module seems to be only applicable to the Project.

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

(1) Temperature

Since Laos belongs to a tropical monsoon region, Laos is high temperature and humidity for all year round and the average temperature reaches to 28°C. Power conditioner with a lot of IC parts shall be protected from the high temperature and humidity by a forced cooling system (air fans) 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 Laos. Considering the importance of the international airport, lightning protection is considered in the Project. An external lightning protection device will be installed at PV array and internal lightning protection devices are installed in junction boxes and power conditioners concretely.

(3) Rainfall

More than 85% of annual rainfall concentrates on the rainy season from May to October and the monthly rainfall sometimes exceeds 400 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 Vientiane City for the last three years.

(4) Design Wind Velocity

As mentioned before, consideration of wind velocities of typhoons are not necessary because Laos is located in the center of Indo-China Peninsula.

Design wind velocity applied to power facilities is stipulated in “Lao Electric Power Technical Standards 2004”. According to Clause 104 “Loads on Supporting Structure and Safety” in Section 3-5-4 Supporting Structure, the wind velocity of 35 m/s is set as one criterion to calculate wind pressure load. Based on the above standard, the design wind velocity applied to PV module and supporting structure member is set at 40 m/s considering about 10% margin.

(5) Earthquake Load

There are few earthquakes within 200 km radius from Vientiane City as mentioned previously. Therefore, earthquake load is not considered in the Project.

(6) Allowable Bearing Power of the Ground

Based on the standard penetration test result as mentioned before, N value of 5, which indicates the supporting strength of the foundation soil from the ground surface to 1.5 m depth, is adopted for the designing of the foundation stability. The allowable bearing power of the ground corresponding to N value of 5 is set 50 kN/m^2.

(7) Angle of Inclination for PV Array

Since Vientiane City is located at latitude 17.99 degree centigrade N, the PV array is designed to face south-westward with angle of inclination of 15 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.

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

The recipient country might have to burden some financial expenses subject 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 Laos, the Project pays attention to selection of the location and layout of PV system not to cause Laos financial burden as much as possible.

A lot of citizens have use of Wattay International Airport during daytime and nighttime. Therefore, it is important to give enough information on construction schedule and safety control to LAA 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 document.

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

Based on the agreement as shown 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 Laos.
Labor Law (No. 06NA, published in 2007) stipulating labor environment shall be respected.

2-2-1-4 Policy for Utilization of Local Contractor

Since the local contractors have no experience of such a large scale installation of the PV system in Laos, 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.

2-2-1-5 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 so 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 EDL 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.

2-2-1-6 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 a lot of local and foreign VIPs have use of Wattay International Airport.

The PV system with the installed capacity of 236 kW is the first experience in Laos. 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 existing facilities in the airport when malfunctions and/or troubles happen to the PV system, the technology to be introduced to Laos shall be proven technology in Japan.

2-2-1-7 Policy for Construction Method and Period

PV arrays (PV modules + supporting frame) are installed in the parking lots which are widely distributed in the airport. And about 400,000 peoples have use of the airport and parking lots. Considering the above conditions, safety ensuring for common people during the work should be the first priority. And minimizing the inconvenience for the people who will use parking lots during the work should be also considered. In terms of safety ensuring and minimizing the inconvenience, the smaller working space is desirable. Therefore, the whole working space will be divided into some blocks (three or more blocks) and installation work will be done block by block.

The construction schedule will be prepared to minimize the construction period taken into account available working days and number of teams for installation work resulting from reviewing the rainy days and rainfall.

2-2-1-8 Others

Taken into account the characteristics of the airport, whether reflected light of the PV panel will interfere with the flight routes will be checked in advance.

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

Table 2-2.2 shows the requirement raised by the GoL and the basic plan responding to the requirement.

Table 2-2.2 Request by the GoL and Basic Plan

Items	Request from Lao Government	Basic Plan responding to the Request
Location	PMO Complex and Wattay International Airport	Wattay International Airport only due to the withdrawal of PMO
Outline	The power produced is used for each building and excess power will be transmitted to the national grid.	Same as on the left
Requested Equipment	(1) Solar module PMO: approximately 50kW Wattay International Airport: approximately 90 kW Total capacity will be 140 kW (2) Junction boxes (3) Power Conditioners (4) Distribution boards (5) Cables for electric distribution (6) Data collecting and display device	(1) Revision of the installed capacity Wattay International Airport: approximately 236 kW (2) Lightning protection device will be added. (3) Meteorological measuring equipment will be added. (4) Wining cable will be protected by FEP pipe against small animals.
Capacity Building	(1) On the Job training (2) Operation and maintenance training (3) Data collection and analysis training	(4) Technical transfer of basic technology of PV system will be added in the Soft Component.
Procurement	Main components will be procured in Japan	Main components will be procured in Japan and ancillary equipment and materials will be procured in Laos
Grid-interconnection	-	- Protection device for the national grid will be added. - Islanding operation of the PV system is not allowed.
Design	(1) The minimum clearance of the supporting structure shall be kept at least 3m from the ground in consideration of high roof vehicles. (2) The number of parking spaces shall be kept the same number as it is.	(1) The minimum clearance of 3 m will be kept. (2) The current number of parking spaces and parking direction will be kept. (3) The angle of inclination of the PV array will be 15° in consideration of the latitude of Vientiane. (4) The type of PV module will be crystal type due to the restriction of available installation space. (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 shall be 50 kN/m^2. (7) The cat walk for maintenance will be placed on the supporting frame. (8) Night lighting equipment will be place on the supporting rame. (9) Members of supporting frame shall be strong enough so as not to affect PV modules even when the supporting frame is attacked by parking cars. The supporting members will be coated by hot dip galvanizing. Supporting frame for PV module will be designed based on JIS C8955-2004. (10) Collecting boxes will be placed on the supporting structure preventing from monkey trick. (11) Power conditioner cubicles will be protected by fences. (12) New water supply equipment for the installation work will not be placed because water supply system is available. (13) JIS C 8955-2004 will be respected as an applicable standard for designing of supporting frame.
Construction Method	(1) Interference with the parking users during construction period shall be minimized. (2) Temporary stock yard shall be restored to the original form.	(1) The whole working space will be divided into some blocks and the installation work shall be carried out block by block. (2) The obligation of restoring to the original form will be stipulated in the Tender Documents.

(1) Overall Plan

1) Site Selection

GoL proposed plural candidate sites for the PV system installation other than PMO and Wattay International Airport and finally PMO and Wattay International Airport were selected in the first phase site survey based on the reasons shown in Table 2-2.3. After that, due to the withdrawal of the PMO from the Project, the PV system is to be installed at Wattay International Airport only.

Table 2-2.3 Candidates other than PMO and Airport

Candidate Site		Reasons of Not Recommendable
MEM	Roof of the main building	A slate roof is additionally placed on the existing roof of the main building to prevent leaking of rain and the slate has been remarkably deteriorated and become eroded. And it seems to be difficult to secure the structural stability if PV array is installed on the slate roof.
MPI	Parking lot	The parking lot in the yard of MPI is not recommendable because more than half space of the parking lot goes into shade in the afternoon affected by the main building of MPI.
	Roof of the main building	The roof of the main building is the steep roof with about 40 degree and structural conditions are unknown. Therefore, the roof of the main building is not recommendable in terms of structural stability.
	Parking lot at training center	The training center is located far from the center of Vientiane and it seems to be difficult to expect the show effect.

2) Overall Layout

Wattay International is located about 3 km from the center of Vientiane City and there are an international terminal building and a domestic terminal building in the premises. The PV modules and their supporting frame will be installed at the parking lots in the airport. Since the parking lot is located in a direction toward North-west to South-east, the PV array faces in direction of South-west. Therefore, when installing the PV modules at the third parking line in front of the international terminal building, street lightings and trees surrounding the third parking line is required to move another places due to the shade of trees and street lightings covering the PV modules. Based on the above reason, the PV modules will not be installed at the third parking line.

The generated electricity by PV modules runs through junction boxes and collection boxes, and is converted from DC to AC in the power conditioner, and is connected to the distribution board at the LAA office finally. Meteorological measurement instruments, such as an actinometer and a temperature gage will be placed near the entrance gate for the parking lots in front of the international terminal building. Data and information from the power conditioner and meteorological data will be transmitted to the monitoring device to be placed in the power

house, around 400 m far from the international terminal building, by communication cables. And instantaneous power output and cumulative power generation will be displayed on the third floor in the international terminal building. Fig. 2-2.1 shows layout of the PV modules at Wattay International Airport.

Location (G) in Fig. 2-2.1 shows the potential site for PV modules installation, if the Project requires additional purchase of PV modules after the result of tendering.

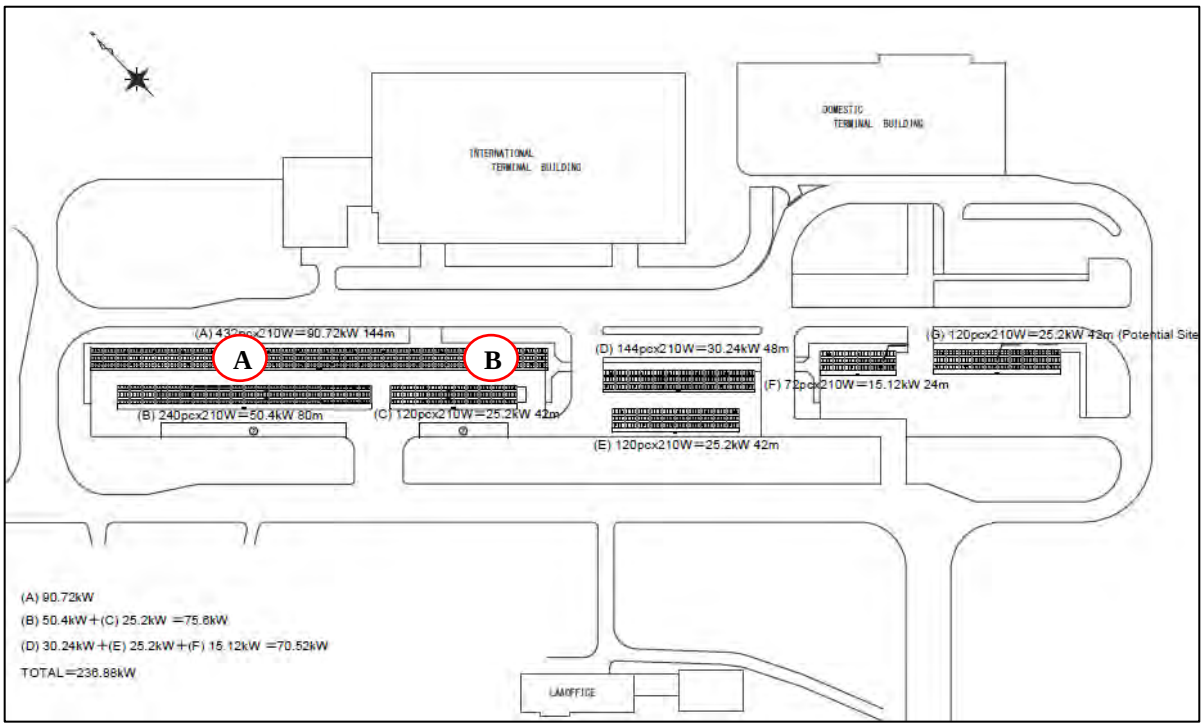


Fig. 2-2.1 Layout of PV Modules at Wattay International Airport

In order to confirm whether the reflected light will interfere with the flight route, the reflected light area was measured at the points with circled-A and B in Fig. 2-2.1. Fig. 2-2.2 shows the result of measurements, and it was confirmed that the reflected light of the PV modules would not interfere with the flight route.

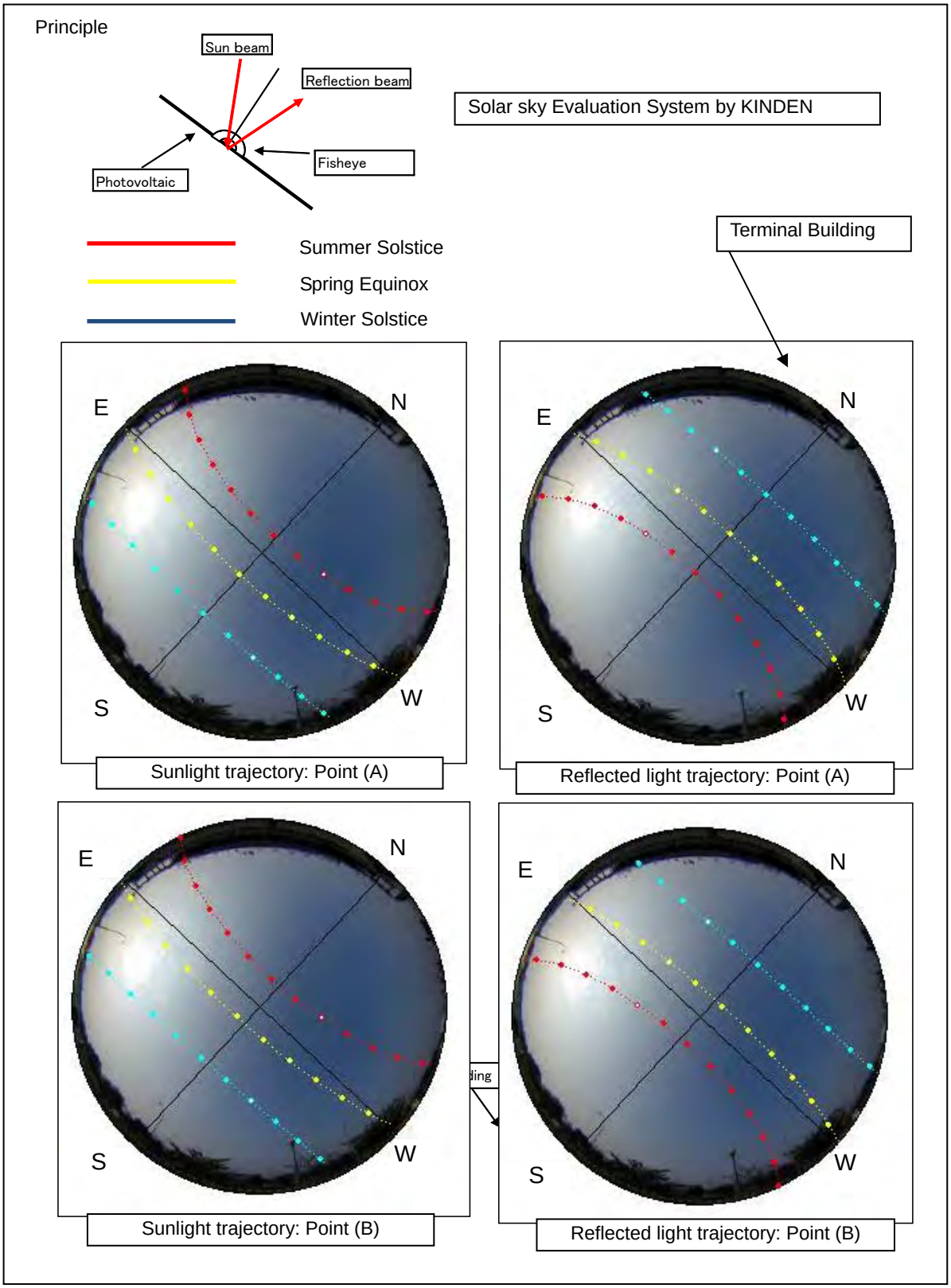


Fig. 2-2.2 Sunlight Reflected Trajectory

(2) Supporting Frame and Its Foundation

Table 2-2.4 shows the relevant features relating to supporting frame and its foundation. Based on the conditions shown in Table 2-2.4, the result of preliminary stability analysis conducted by the JICA Study Team is shown in Fig. 2-2.3 and Table 2-2.5. The result of stability analysis shown below serves as reference because arrangement of PV modules and supporting frame will depend on the Contractor.

Table 2-2.4 Relevant Features for Supporting Frame and Its Foundation

Items	Wattay International Airport					
Location site	Parking Lots in front of the International Terminal Building					Domestic
Location number	(A)	(B)	(C)	(D)	(E)	(F)
Installed capacity (Total 236 kW)	90.72 kW	50.40 kW	25.20 kW	30.24 kW	25.20 kW	15.12 kW
No of PV panels (Total 1128 pc) 0.21 kW/pc	432	240	120	144	120	72
Area (W × L m)	6 × 144	6 × 80	6 × 40	6 × 48	6 × 40	6 × 24
Angle of inclination	15°towards NW					
Numbers of parking (Total 118 cars)	46	25	12	15	12	8
Parking width per one car	2.70 m					
Direction of parking	Angle parking					Perpendicular parking
Supporting frame foundation block Dimension	W 120 cm × L 120 cm × H 45 cm					
No. of foundation blocks (Total 97 pc)	35	20	10	12	10	10
Mini. clearance of supporting frame	3.0 m					
Structure of supporting frame	Truss					
Member of supporting frame	SHS 200 × 200 × 12 , hot dip galvanizing. The above member will be used so as not to damage PV modules by car's attack.					
Weight of PV panel ton (19 kg/pc)	8.2	4.6	2.3	2.7	2.3	1.4
Weight of supporting frame ton	49.4	27.6	14.0	16.7	14.0	9.6
Unit load (ton/one foundation block)	1.65	1.61	1.63	1.62	1.63	1.1
Design standard for supporting frame	JIS C 8955-2004					
Design conditions	Design wind velocity: 40m/s, No earthquake load Allowable bearing power of the ground: 50 kN/m^2					
Stability analysis of foundation block	Preliminary stability analysis for sliding and bearing power is conduced. And it is confirmed that the current design ensure the safety. The execution of detailed stability analysis by the Contractor for the Consultant's approval will be stipulated in the Tender Documents.					
Ancillaries on the supporting frame	Joint box, collection box, cat walk (W 60 cm), lighting					

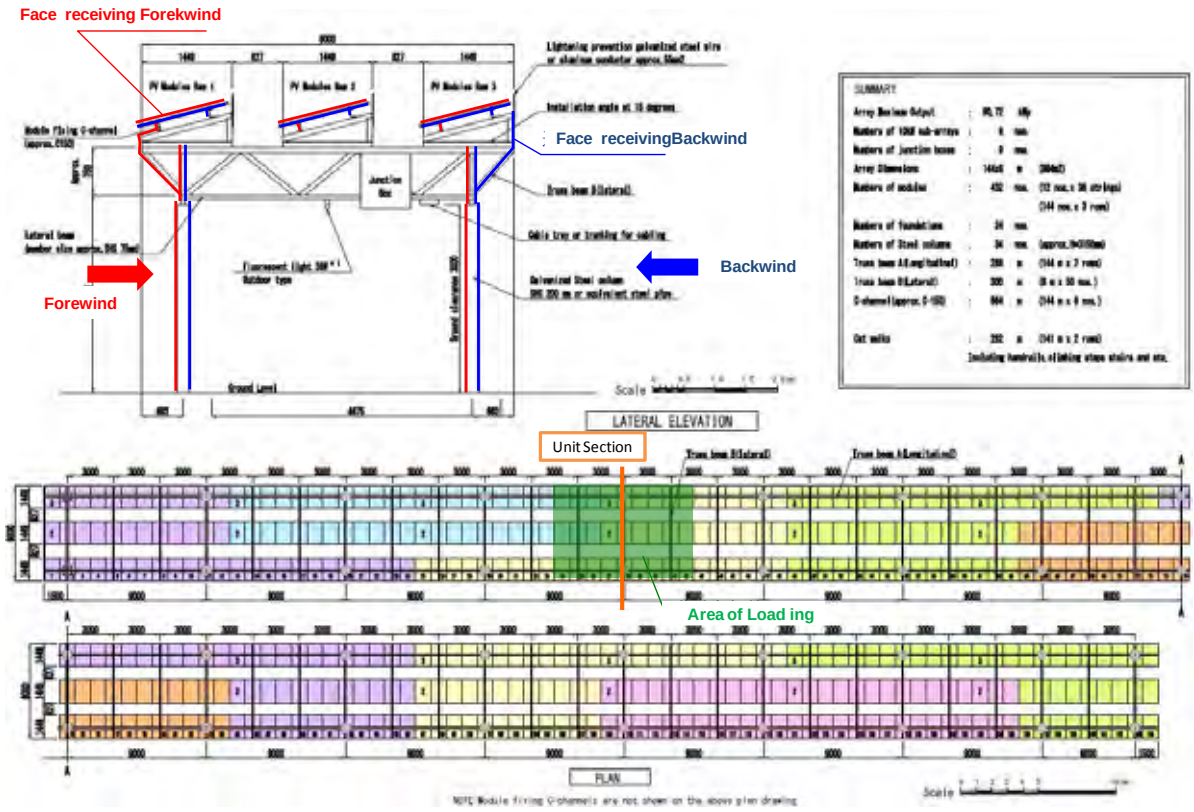


Fig. 2-2.3 Reference Drawing for Foundation Block Stability Analysis

Table 2-2.5 Result of Foundation Block Stability Analysis (Reference)

Summary of Acting Load

Load Condition		Total Load ΣV [kN]※1	Total Load ΣH [kN]※2	Overturn Moment※5 ΣM [kNm]	= ΣVX	+ ΣHY
Normal : N	+	60.527	-	177.992	177.992	-
Wind Acting : N+W	+	61.186	17.469	262.423	179.928	82.495
	-	59.729	-16.625	97.137	175.648	-78.511

※1 : + ; Downward ※2 : +; Forewind ※3 : +; Downward
※4 : Origin; Left bottom edge of Block ※5 : +; Clockwise

Stability against Sliding of the Concrete Block

F = μ·ΣV/ΣH		Coefficient of Friction Angle μ	Resistance by Friction μΣV [kN]	Safety Ratio F		Judgment F > 1.5(N) or 1.2(TW, HW)	
Normanl (N)	+	0.364	22.030	∞	>	F = 1.5	OK
Wind Acting (S)	+	0.364	22.270	1.275	>	F = 1.2	OK
Wind Acting (S)	-	0.364	21.740	1.308	>	F = 1.2	OK

Ground Condition

Friction Angle φ[°]	30	※
Coefficient of Angle μ = tan(2/3φ)	0.364	
Max. Ground Resistance [kN/m²]	50	
Allowable Bearing Capacity q_a [kN/m²]	25	
Allowable Bearing Capacity q_a [kN/m²]	67	

※Assuming sandy ground

Stability Condition

Eccentric Distance (L)	b/6
Eccentric Distance (S)	b/3
Safety Ratio for Sliding (L) F	1.5
Safety Ratiofor Sliding (S) F	1.2
Saety Ratio for Bearing Capacity (L)F	2
Safety Ratio for Bearing Capacity (S) F	1.5

Note : (L) means Long-term and (S) menas Short-term

Stability against Bearing Capacity of the Ground

$\sigma_s = (\sum V/A)\cdot(1 \pm 6\cdot e/b)$		Area of Base A [m²]	Vertical Stress ΣV/A [kN/m²]	Bearing Stress σ_s [kN/m²]		Judgment $\sigma_s \leqq q_a$ [kN/m²]	
Normal (L)	+	2.880	21.016	21.085	≦	q_a = 25	OK
Wind Acting (S)	+	2.880	21.245	50.568	≦	q_a = 67	OK
Wind Acting (S)	-	2.880	20.739	48.511	≦	q_a = 67	OK

(3) Equipment and Device

Outline of equipment and device are as follows.

Item	Wattay International Airport
Grid-connected to	National grid of EDL
Battery	None
Module type	In order to secure the installed capacity within the restricted space for PV module installation, only crystal type seems available.
Number of PV modules	1128 pc (210 W/pc)
Rated installed capacity	236 kWp
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 will be installed.
Collection Box	− For every junction box relay, one 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	− Cubicle will be treated as suitable for tropical region and equipped with heat shielded plate − Power conditioner (board), transformer and other devices will be built in.
Watt-hour meter	Watt-hour meter calibrated by EDL will be placed on the line to selling and from buying
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 (AC) - Performance of relays and information of major and minor malfunctions - Performance of active and passive methods And meteorological data (amount of solar radiation and temperature) are also transmitted.
Monitoring Device	− Based on the data transmitted by power conditioners (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 and alarm records will be also equipped. − Monitoring device will be installed in the powerhouse at the airport.
Display Device	A display panel showing instantaneous value of power output and cumulative generation energy since the start of the operation will be placed at the third floor in the international terminal building.
Meteorological Measurement	Amount of solar radiation and air temperature will be measured to serve performance analysis of the PV system.
Wiring materials	− Wiring cables 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 cavers and/or waterproof treatment.
External Lightning Protection Device	− In order to protect PV modules 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 3. − Electrical potential will be kept the same value with the supporting frame. − The designing 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 DC 500 V and above, nominal effluent current of 20kVA and above, voltage drop protection level of 2.5 kV and less, 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 provided as spare parts for emergency use.

Note: Technical specification of main components is shown in Table 2-2.10.

1) Possibility of Reverse Power Flow

Installed capacity at the airport will be 236 kW as mentioned above. Table 2-2.6 shows power demand of transformer bank to be connected to the PV system. Since the power demand in day time always exceeds 300 kW and more, reverse power flow from transformer bank to EDL grid will not occur even after connecting the PV system.

Table 2-2.6 Records of Transformer Bank

		Interface Voltage	Voltage to ground	Power		
		RT	RN	power(kW)	cos	Tr.temp.
20/6/2008	9:30	380	220	400	95	30
Friday	13:30	380	220	400	96	35
	17:30	380	220	300	98	40
	22:30	380	220	250	98	35
21/6/2008	9:30	380	220	400	95	42
Saturday	13:30	380	220	328	94	45
	17:30	380	220	250	95	42
	22:30	380	220	50	99	42
22/6/2008	9:30	380	220	250	24	50
Sunday	13:30	380	220	320	98	48
	17:30	380	220	340	98	50
	22:30	380	220	30	99	43
23/6/2008	9:30	380	220	475	98	45
Monday	13:30	380	220	420	98	45
	17:30	380	220	350	98	42
	22:30	380	220	400	96	45
24/6/2008	9:30	380	20	500	98	40
Tuseday	13:30	380	220	400	96	35
	17:30	380	220	350	98	48
	22:30	380	220	200	95	48
25/6/2008	9:30	380	220	450	94	45
Wednseday	13:30	380	220	300	97	50
	17:30	380	220	300	99	48
	22:30	380	220	450	98	55
26/6/2008	9:30	380	220	250	94	50
Thirthday	13:30	380	220	450	96	52
	17:30	380	220	300	99	52
	22:30	380	220	200	95	45

Source: L-JATS

2) Expected Power Generation

Table 2-2.7 shows the expected power generation yielded by the PV system of 236 kW. According to the estimation, generation energy of 288,200 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 ($kw/m^2/day$)	4.2	4.6	5.0	5.4	5.2	5.0	4.5	4.4	4.4	4.8	4.4	4.2	4.7
PV temperature (°C)	62.1	65.9	67.2	68.4	65.1	66.7	64.8	64.8	64.5	64.0	60.2	62.0	64.6
Generation (kWh/day)	717	773	828	897	872	843	767	734	750	813	762	722	790
Generation (kWh/month)	22,227	21,644	25,668	26,910	27,032	25,290	23,777	22,754	22,500	25,203	22,860	22,382	24,021

Note: Intensity of solar radiation is quoted from "Assessment of Solar Energy Potentials for LAO PDR"

3) Grid Protection Device

Table 2-2.8 shows voltage and frequency stipulated in Section 2.2 "Power Quality Standard" in Lao Grid Code.

Table 2-2.8 Frequency and Voltage in Laos

Item	Value	Remark
Nominal Fundamental Frequency	50 Hz	
Frequency Variation	49.5 Hz ~ 50.5 Hz	During normal condition, 99.5 % time of the year shall be kept
	47 Hz ~ 52 Hz	During emergency condition, 100 % time of the year shall be kept
Nominal line to line voltages	500 kV, 230 kV, 115 kV, 35 kV, 22 kV	
Voltage Variation	95 ~ 105 % of nominal voltage	Normal condition
	90 ~ 110 % of nominal voltage	Emergency condition

Concerning the grid protection, Section 3.3 "Grid Protection Requirements" stipulates that the Grid owner and the user shall be responsible for the protection system of the electrical equipment and facilities at their respective sides of the connection point. And Table 2-2.9 shows the minimum generating unit protection stipulated in Clause 3.3.6.

Table 2-2.9 Minimum Generating Unit Protection

Item	Remark
Differential Protection	
Overcurrent Protection	
Over/Under Frequency Protection	The frequency setting range shall be between 47 to 52 Hz with increments of 0.05 Hz. The adjustable time delay shall be between 0 to 60 s with increments of 0.1 s. (Clause 3.6.2)
Stator Earth-Fault Protection	-
Rotor Earth-Fault Protection	-
Loss-of-Excitation Protection	-

Based on the above “Grid Code of Lao PDR” and “Grid-interconnection Code” in Japan, the following protection devices will be placed in the power conditioner. Tender Documents for the Project will stipulate that setting value and time for each relay will be determined between the Contractor and EDL.

- Over voltage relay (OVR)
- Under voltage relay (UVR)
- Over frequency relay (OFR)
- Under frequency relay (UFR)
- Islanding operation detector

Considering the installed capacity of 236 kW, grid-connected line by the Project is categorized as “High voltage grid-interconnection” according to “Grid-interconnected Code” in Japan and the installation of OVGR (Overvoltage Ground Relay) is required. However, OVGR is already installed in the receiving facilities at Wattay International Airport. Therefore, additional OVGR will not be placed by the Project.

4) List of Main Equipment

Table 2-2.10 shows the list of main equipments required for the PV system at Wattay International Airport. 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 236 kW shall be met. Quantity and detailed specification to be procured will be determined in the negotiation between the Procurement Contractor, the Procurement Agent and the Consultant, and incorporated into the Contract Documents.

Table 2-2.10 (1/3) List of Main Equipment

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: 236 kWp (90.72 kWp + 50.4 kWp + 25.2 kWp + 30.24 kWp + 25.2 kWp + 15.12 kWp)	1128 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	1 Ls	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	25 pc	Boxes to integrate the wiring cables connecting each module in series, and necessary device for the system

Table 2.2-10 (2/3) List of Main Equipment

Name of Device	Main Specification and/or Components	Qty	Purpose
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: 10 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 400A) (8) Others: Heat-sensitive terminal caps	3 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: 236 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 (fans) (2) Electrical specification 1) Rated capacity: 236 kW 2) Rated input voltage: DC400V and less 3) Maximum allowable input voltage: DC0~600V and less 4) Voltage range for input operation: DC240V~500V 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 and passive method prevailed in Japan (5) External Communication; Transmitted information: malfunction & measuring information by RS485 (6) Internal Lightning Protection Device; DC SPD Class II and above, AC SPD gap type class II and above	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.
Transformer	(1) Rated output: 300 kVA (2) Primary voltage (output): AC380-220V, 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: Level III (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 frame 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 3 power conditioner, 300 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 (cooling fans)	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.

Table 2.2-10 (3/3) List of Main Equipment

Name of Device	Main Specification and/or Components	Qty	Purpose
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 (Windows XP 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	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: H 1000 mm x W 1500 mm approximately	1 Ls	Necessary device for enlightenment of the PV system.
Meteorological Observation Device	(1) One thermometer (2) One pyranometer	1 Ls	Necessary to analyze the generation performance of the PV system
Supporting Frame 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	PWT-01	Overall Layout at Wattay International Airport (NEW)
2	PWT-02	Single Line Diagram for Photovoltaic Power Panel (Airport)
3	PWT-03	Airport 236 kWp PV Array and Steel Structure Arrangement Elevation and Foundation Drawing
4	PWT-04	Airport 236 kWp PV Array and Steel Structure Arrangement Plan and Elevation Drawing Steel Member Arrangement Plan (1/3)
5	PWT-05	Airport 236 kWp PV Array and Steel Structure Arrangement Plan and Elevation Drawing Steel Member Arrangement Plan (2/3)
6	PWT-06	Airport 236 kWp PV Array and Steel Structure Arrangement Plan and Elevation Drawing Steel Member Arrangement Plan (3/3)
7	PWT-07	Airport 236 kWp PV Array Earthing System (1/3)
8	PWT-08	Airport 236 kWp PV Array Earthing System (2/3)
9	PWT-09	Airport 236 kWp PV Array Earthing System (3/3)

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 Laos 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. 2-2.4 and the role of each relevant organization concerning the implementation of the Project is shown in Fig. 2-2.5.

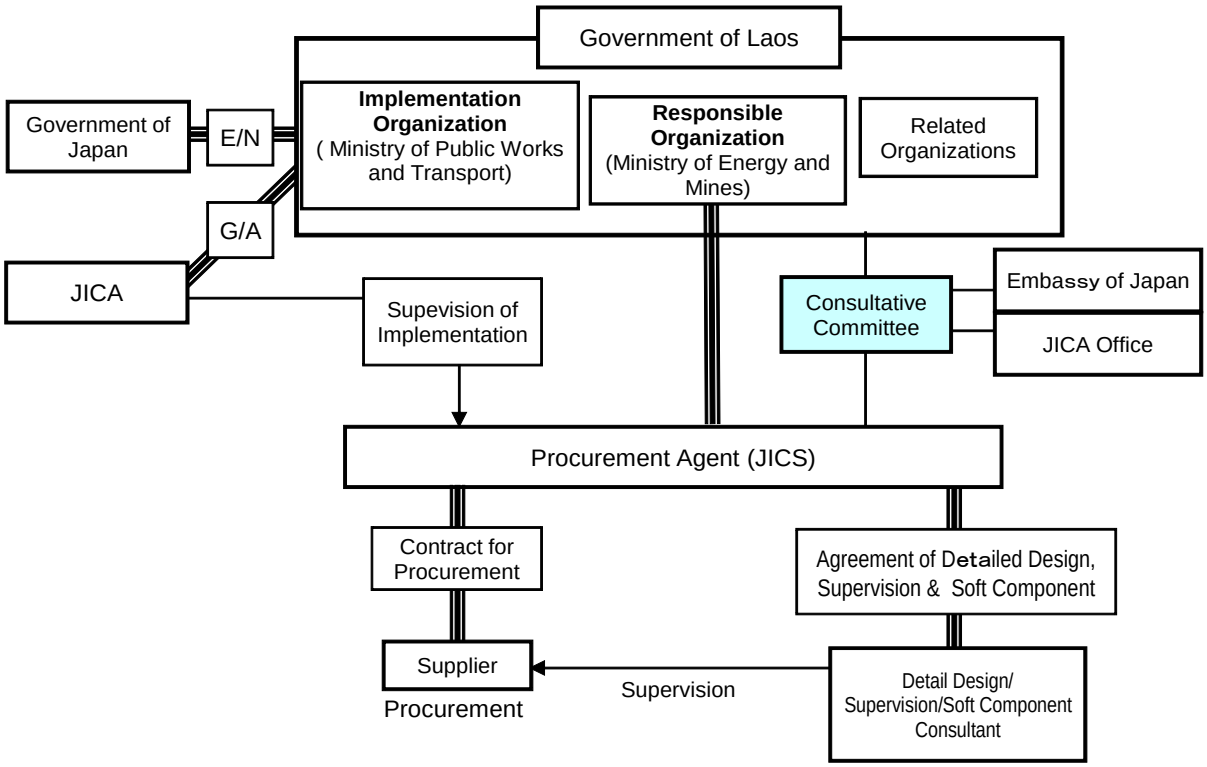


Fig. 2-2.4 Project Implementation System

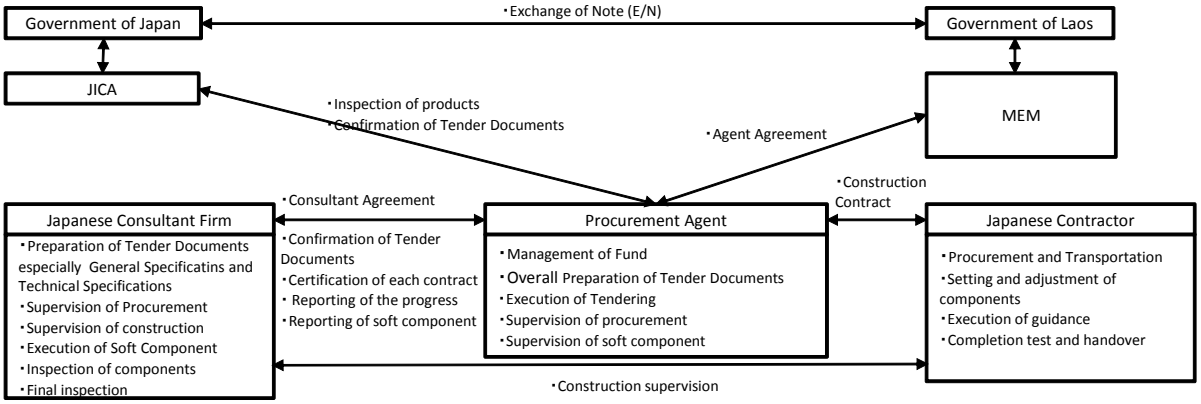


Fig. 2-2.5 Role of Organization Concerning the Implementation

(1) Responsible Organization and Implementation Organization

The responsible organization of the Project is MEM and implementation organization is MPWT as shown in Table 2-2.11. The responsible organization of MEM takes responsibility for coordinate with the relevant organizations in Laos and Japan side until the completion of the project and establishment of the Consultative Committee[7]. Addition to the above roles, the responsible organization will supervise operation and maintenance of the Project to be done by the implementation organization.

The implementation organization of MPWT takes responsibility for operation and maintenance of the Project as the owner of the project, and has an obligation to allocate the budget and manpower required for the operation and maintenance of the Project. The Airport Management Center of LAA will undertake the operation and maintenance of the project substantially after completion of the Project.

Table 2-2.11 Organization of Recipient Country

Organization in Laos	Name of Organization	Name of Department	Department for Maintenance
Responsible Organization	Ministry of Energy and Mines (MEM)	Rural Electrification Division, DOE	—
Implementation Organization	Ministry of Public Works and Transport (MPWT)	Department of Civil Aviation	Airport Management Center, LAA

(2) Procurement Agent

The Procurement 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

[7] The Consultative Committee consists of JICA Laos Office, the Procurement Agency, and the relevant organizations in Laos, and discusses on issues relating to the project implementation, such as progress of the project, design changes and so on.

account on behalf of the recipient country. The procurement agreement was concluded on April 29, 2010

(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 Contractor

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 Laos 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 2-2.12.

Table 2-2.12 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. 2-2.5, 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 the Laos side, and the Prime Contractor (a successful tenderer) will be determined after approval of the Laos side.

2-2-4-2 Implementation Conditions

(1) Safety Control for Common People and passengers

As mentioned before, about 400,000 peoples have use of the airport and parking lots, and a lot of common people come in and out. The parking lots to be installed the PV system are widely distributed in the airport as shown in Fig. 2-2.1. Therefore, safety ensuring of the passengers and common people during the installation work is the most important. In terms of safety ensuring, the smaller working space is desirable. Therefore, the whole working space will be divided into some blocks (three or more blocks) and installation work will be done block by block. During the installation work, the working block will be isolated by vinyl sheet to protect the passengers and common people. And since construction vehicles, such as rigs with full load of procured products, comes in and out especially at the early stage of the work, the arrangement of security guard seems to be also necessary to prevent peoples from traffic accidents. The safety control and divided-construction method will be incorporated into the Tender Documents.

(2) 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 follow the relevant regulations and submit the designated waste disposal area prior to the commencement of the work for the Consultant’s and the Recipient’s approval.

2-2-4-3 Scope of Works

Table 2-2.13 shows the undertakings to be taken by each government relating to the programme.

Table 2-2.13 Undertakings to be taken by Each Government

No.	Items	To be covered by Grant Aid	To be covered by Recipient Side	
			MEM	MPWT
1	To secure land			○
2	To clear, level and reclaim the site when needed urgently			○
3	To construct gates and fences in and around site			○
4	To construct a parking lot if necessary			○
5	To construct roads			
	1) Within 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) Marin or air transportation of the products from Japan or third countries to the recipient	●		
	2) To ensure all the expense and prompt execution of 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 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, such as preparation work, foundation work for PV modules supporting frame, and installation of hand holes for wiring cables will be carried out in advance of and/or in parallel with the installation work of the equipment. Therefore, 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 of which dimension is shown Fig. 2-2.6, the accuracy of arrangement of reinforcing bars, securing the strength of the concrete blocks, the accuracy of level of the surface of the block and the accuracy of the spin finishing of the center will be required because the supporting frame will place on the concrete blocks.

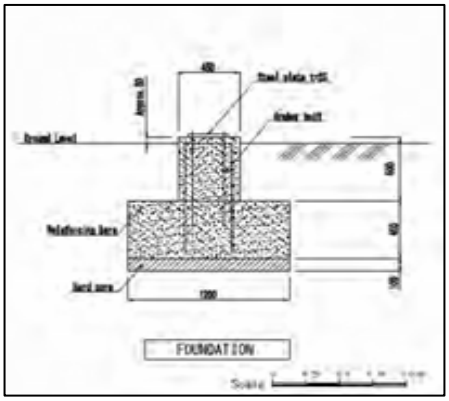


Fig. 2-2.6 Foundation Block

Civil and architectural work will continue 3.5 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 frame, (b) wiring between PV modules, from PV modules to junction boxes, from junction boxes to collection boxes, from collection 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 3 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 2-2.14

The compressive strength test for the concrete will be executed for every 20 m^3 of the concrete placing[8] basically. Six (6) test pieces are sampled and 7-ages and 28-ages compressive strength test will be carried out based on the JIS Standard.

Table 2-2.14 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 2-2.15 (3rd stage).

Table 2-2.15 Individual and Integrated Tests before Operation (Draft)

Test Items	Content of Test
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	-

[8] Since block concrete volume is estimated at 63 m^3, the test will be carried out for three (3) times during the work.

2-2-4-6 Procurement Plant

The main construction materials to be used in the site work are cement, aggregates and reinforcing bars. These materials can be procured in Laos 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 Laos. The main equipment of the PV system, such as PV modules, power conditioners and so on are to be procured in Japan. Concerning the supporting frame member with coating of hot dip galvanized HDZ45 or equivalent, it seems difficult to be procured in Laos based on the market survey[9]. Therefore, the supporting frame member might be procured in Japan.

Since Lao has no outer harbor, the main equipment procured in Japan will be unshipped at the Bangkok harbor and transported to Vientiane via Nong Khai by Route No.2 in Thailand.

Table 2-2.16 shows the spare parts to be provided in the scope of the project, which seem difficult to be procured in Laos and, of which malfunction give severe impact on the PV system operation.

Table 2-2.16 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 2.5 months after the commissioning. Furthermore, the above

[9] Rolled steel plates are imported from Thailand, and cutting and processing of the steel plates are done in Laos generally. And they cannot submit the mill sheet (Inspection Certificate) of which submission will be stipulated in Tender Documents.

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 with a large scale of 200 kW class in Laos. Therefore, the obligation of conducting operational guidance to the engineers in Laos at the timing of inspection of the PV system, which will be carried out in the course of the installation work, will be stipulated in the tender 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 LAA who will be in charge of operation and maintenance of the PV system after the commissioning. The implementation organization is recommended to appoint trainees as shown in Table 2-2.17 specifically before the installation works start.

Table 2-2.17 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 2.5th months after the commissioning
- Evaluation on maintenance performance for the 2.5 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 to the maximum extent. 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 will procure a PV system with the capacity of 236 kW, furnish it to Wattay International Airport in Vientiane City, Laos and supply the generated energy to facilities in the airport for their power demand. The grid-connected PV system with a large scale of 200 kW class is the first case for Laos, although they have experience of independent off-grid PV systems. And staffs to be involved in operation and maintenance of the PV system at LAA have no experience and knowledge about PV system. Therefore, it is desirable to train those engineers/technicians who will be actually operating and maintain the PV system. At the same time, it is also desirable to offer the training program for officers in the MEM and EDL being involved in the Project, in terms of supporting the national target to attain the village electrification of 90% by 2020 by means of grid connection and clean energy, such as PV

system, wind power and mini-hydro.

The contractor will be conducting Operation and Maintenance 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 important for 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 LAA 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 MEM and Engineers in EDL]

- 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 2.5 months after commissioning.

[For LAA Operation and Maintenance Staff at the site]

1) Operation of the PV System

Operation performance record for the previous 2.5 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 2-2.18.

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 2-2.18 Control Value for Monthly Generation Energy

(kWh/Month)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Expected Generation	22,227	21,644	25,668	26,910	27,032	25,290	23,777	22,754	22,500	25,203	22,860	22,382
Upper Limit	27,000	26,000	31,000	32,000	32,000	30,000	29,000	27,000	27,000	30,000	27,000	27,000
Lower Limit	18,000	17,000	21,000	22,000	22,000	20,000	19,000	18,000	18,000	20,000	18,000	18,000

2) Maintenance of the PV System

Daily and periodical maintenance check sheets and malfunction & trouble recording sheets for the previous 2.5 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 2.5 months after the commissioning. If some malfunctions had happened, the malfunction part ought to have been replaced by the Contractor without charge because 2.5 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 MEM and Engineers in EDL]

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 2.5 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 2.5 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 2.5-month experience of actual operation and maintenance of PV system, operation issues unique in the implementation and in Laos 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 2.5-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

Four (4) staffs in Airport Management Center being in charge of maintenance of the power house in the airport are to operate and maintain the PV system. The power house receives the electricity from EDL and provides facilities in the airport with electricity. Table 2-2.19 shows the required role and experiences for operation and maintenance staff of the PV system. Addition to the LAA staffs, officers in Rural Electrification Division being in charge of rural electrification in MEM and engineers in Technical Department being in charge of grid-connection generation plants in EDL will be also objective personnel of the training program in terms of assistance to introduction of a grid-connected PV system in Laos.

Table 2-2.19 Candidate Participants to the Training Program

Organization	Department	Training Purpose (a) and Required Qualification (b)
LAA	Airport Management Center	(a) Daily operation and maintenance of the PV system (b) Those in charge of maintenance of electrical facilities at least 5 years
MEM	Rural Electrification Division	(a) Introduction of grid-connected PV system to Lao PDR in future (b) Bachelor of electrical engineer and his business experience at least 10 years
EDL	Technical Department	(a) Finding critical issues and establishing measures (b) Bachelor of electrical engineer and his business experience at least 10 years

The tentative program applicable to candidate participants is shown Table 2-2.20. 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 2-2.20 Tentative Program Applicable to Participants

Contents of Program	LAA	EDL	MEM
	Airport Management Center	Technical Department	RED in DOE
	3 ~ 5 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 test)	○	○	
OJT (Joint survey on commissioning test & adjustment)	○	○	
OJT (Start up, shut down and re-start up)	○	○	
OJT (Completion inspection)	○	○	
After Commissioning			
Follow-up of operational guidance	○	○	
Work plan for operation & Maintenance	○	○	
2.5 months after commissioning			
Joint inspection on the equipment	○	○	
Evaluation of maintenance performance and trouble shooting	○	○	
Evaluation of operational performance and improvement measures	○	○	○
Review of data log sheet and check sheet form	○		

3) Schedule

The planned schedule for the above mentioned program is shown in Table 2-2.21 and Table 2-2.22.

Table 2-2.21 Training Schedule Before/After Commissioning

	Activities	-2nd week	-1st week	1st week	2nd week
Contents of Activities	Preparation 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	LAA Airport Management Center				
	EDL Technical Department				
	MEM RED in DOE				
Lecturer	PV system Expert				
	Equipment & Electrical Expert				
	Interpreter				

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

Table 2-2.22 Training Schedule 2.5 months after Commissioning

	Activities	1st week	2nd week
Contents of Activities	2.5 months 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	PMO Management Department		
	LAA Airport Management Center		
	EDL Technical Department		
	MEM RED in DOE		
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 Laos. 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. Local 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 Laos. 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 in Fig. 2-2.7, assuming that the agreement between the Procurement Agent and the Contractor will be concluded in November 2011.

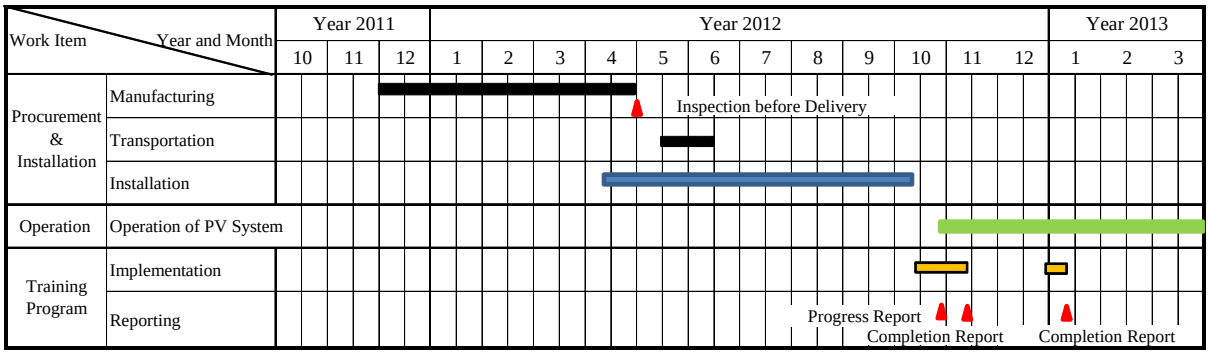


Fig. 2-2.7 Training Program Implementation Schedule

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 (2.5-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 accordance with the training schedule 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

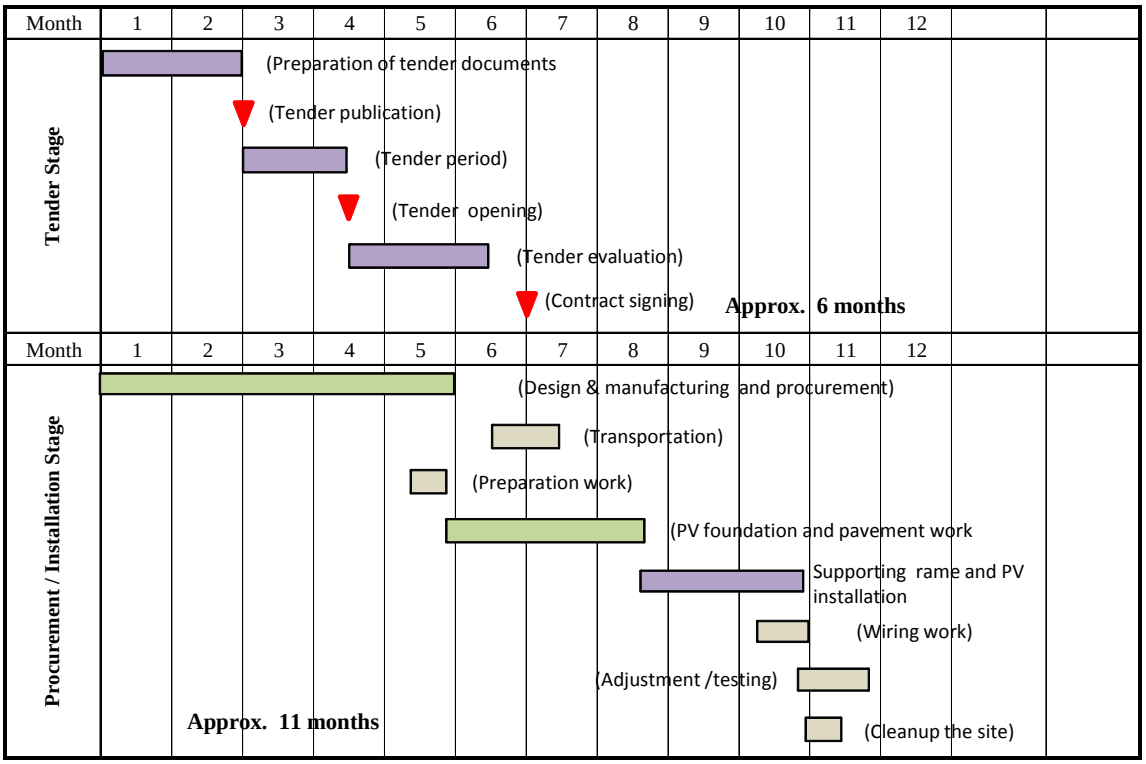
In preparation of implementation schedule, it is necessary to take the grant aid cooperation into full consideration and set up a proper implementation system with the work schedule. The draft of implementation schedule is as follows:

(a) Exchange of Notes (E/N) ..... (March 18, 2002)
(b) Procurement Agent Agreement ..... (April 29, 2010)
(c) Consultant Agreement .....(May 2011)
(d) Tender document preparation .....(May to July2011)
(e) Tendering and signing of contract with selected contractor ..... (November 2011)
(f) Manufacturing and procurement of materials and equipment
..... (December 2011 to April 2012)
(g) Installation of PV equipment ..... (April to October 2012)
(h) Implementation of soft component
(i) Completion and taking-over

The project will be implemented in about 31 months upon conclusion of E/N due to the change of the Project scheme. The work will be completed in about 11 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 started before shipment.

Table 2-2.23 shows preliminary implementation schedule based on the grant aid scheme.

Table 2-2.23 Implementation Schedule



2-3 Obligation of Recipient Country

Undertakings required of the Recipient had been confirmed by the M/D concluded in first phase site survey for 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 existing parking lots in the airport 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	MEM is responsible.
4	To ensure all the expenses and prompt execution of customs clearance	MEM is responsible.
5	To go through required procedure for the installation of PV system	MEM is responsible.
6	To accord Japanese nationals and/or nationals of third countries	MEM is responsible.
7	To ensure the exemption of custom duties, internal taxes and other fiscal levies imposed in Laos	MEM is responsible.
8	To maintain and use properly and effectively the PV system	LAA is responsible under the supervision of MPWT an d MEM
9	To bear all expenses, other than those covered by the Grant	MEM is responsible.
10	To ensure environmental and social considerations for the Grant Aid	MEM is responsible.

2-4 Project Operation Plan

The generating equipment to be procured in the Project is designed to be operated and maintained by LAA on daily basis. In the long-run, the responsible organization of MEM and EDL may have to cooperate in the maintenance works.

The recipient country 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.

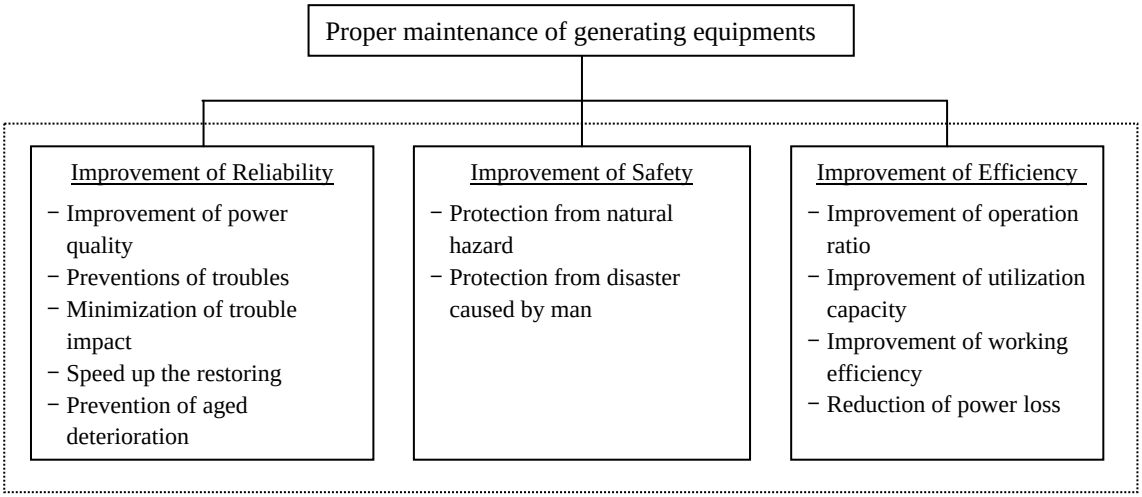


Fig. 2-4.1 Basic Concept for Maintenance of Generating Equipment

Keeping the basic concept in mind, the recipient country should operate and maintain the PV system, utilizing O&M techniques transferred in the course of operational guidance provided by the Contractor and the training program provided 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 LAA focusing on maintenance staff. Four (4) staffs in Airport Management Center being in charge of maintenance of the power house in the airport are to operate and maintain the PV system. Electrical staffs in LAA have been engaged in maintenance of electrical facilities in the airport without technical support by EDL[10]. Therefore, their technical skills seem to be good.

[10] Confirmed by EDL during the second phase survey

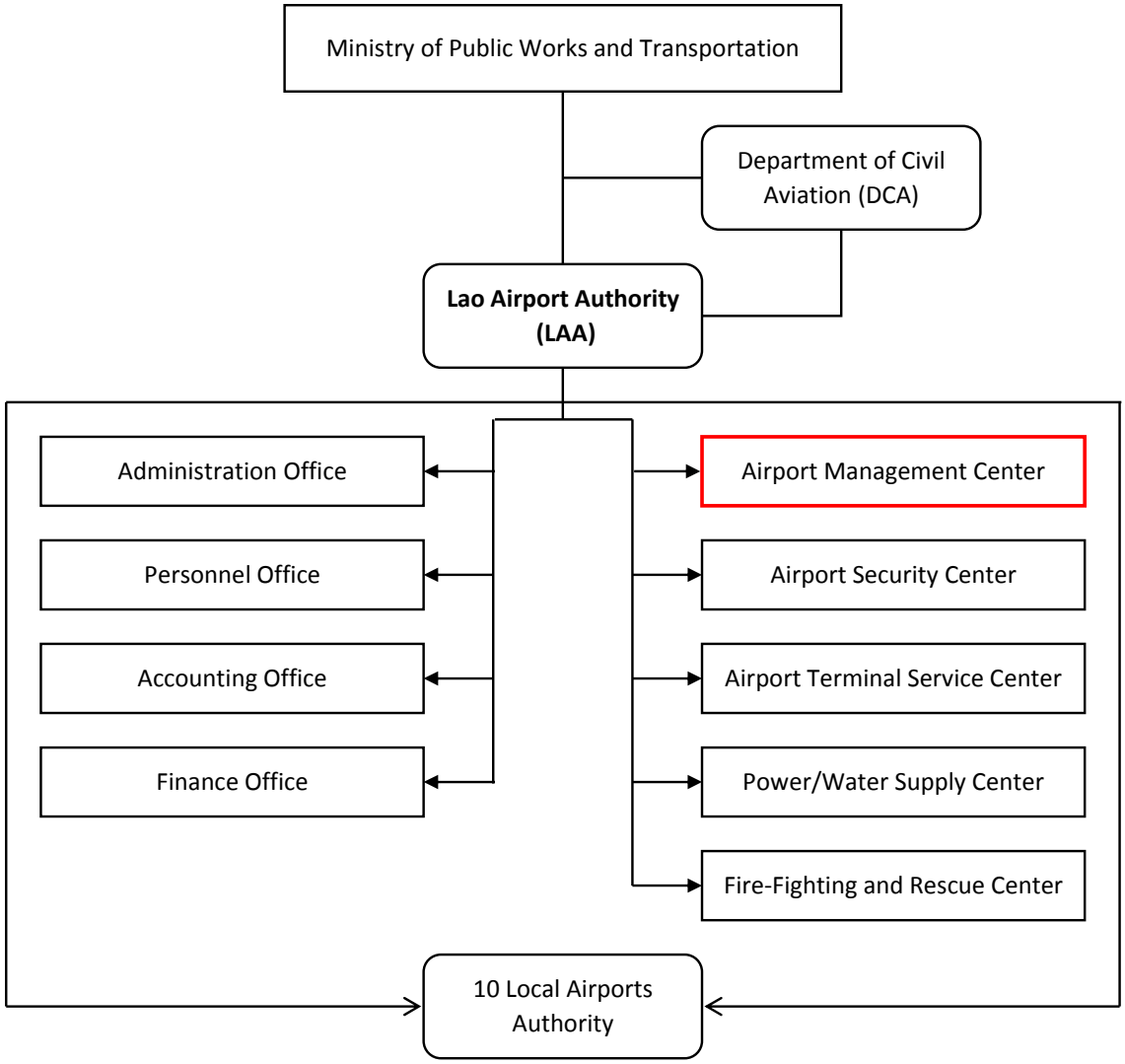


Fig. 2-4.2 Organization Chart of LAA Focusing on Maintenance

2-4-2 Inspections

LAA 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 [11]	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[12] 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

[11] 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.

[12] Allowable Insulating resistance; 0.4MΩ or over for Insulating resistance of 300V or over.

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[13] and power conditioners 10 years[14], 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 "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 (EDL) 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	LAA	Operation of PV system Planning and implementation of daily and periodical inspection	Planning and implementation
Responsible Organization	MEM	Monitoring of operation and effect on PV system	Coordination for implementation
Related Organization	EDL	Monitoring of grid interconnection and reverse power flow conditions	Technical Support

It is desirable to have a proper supporting program especially targeting long term maintenance in terms of sustainable supply of electric power by the PV system. Within the Project, the following measures are proposed.

(a) Provision of spare parts needed up to the first long term maintenance
(b) Provision of a dedicated section in O&M Manuals that explains how to use spare parts

[13] Japan Photovoltaic Energy Association (Website)
[14] Japan Photovoltaic Energy Association (Website)

As specification of spare parts and maintenances varies by manufacturers, detailed lists are proposed by tenderers and finally will be fixed in the contract document.

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 at the timing of daily and periodical inspections and maintenances.

Since the necessary spare parts up to the first long term maintenance are provided in the Project, the Recipient has to prepare the cost to purchase spare parts for emergency after the first long term maintenance. The list of spare parts and tools 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	1 unit

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

(1) The Cost of Laos

The obligations of the recipient side were discussed in Section 2-2-4-3 of this report. Laos 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 Kip = JPY 0.01081
3. Time of Event: As shown in Table 2-2.23
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 a 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 fans during 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 the facility.

Meanwhile, there would be necessary for employment of temporary workers for cleaning PV modules monthly basis because there seems to be no workers for the above cleaning at LAA. The annual cost for employment of temporary workers is estimated about 720 US$, assuming that the cleaning of PV modules is done two days once a month by two (2) workers with their daily wage of 15 US$.

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 break down. 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 purchased 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 the commissioning of the equipment.

There is an exception to the above, the parts related to air fans 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 fans 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 Table 2-5.1 and Table 2-5.2, before and after the first long-term maintenance, the average annual cost to be served are estimated at 50,000 Japanese Yen and 1,770,000 Japanese Yen respectively, which are equivalent to about 4,6000,000 Kip and 163,700,000 Kip (1 Kip = 0.01081 Yen).

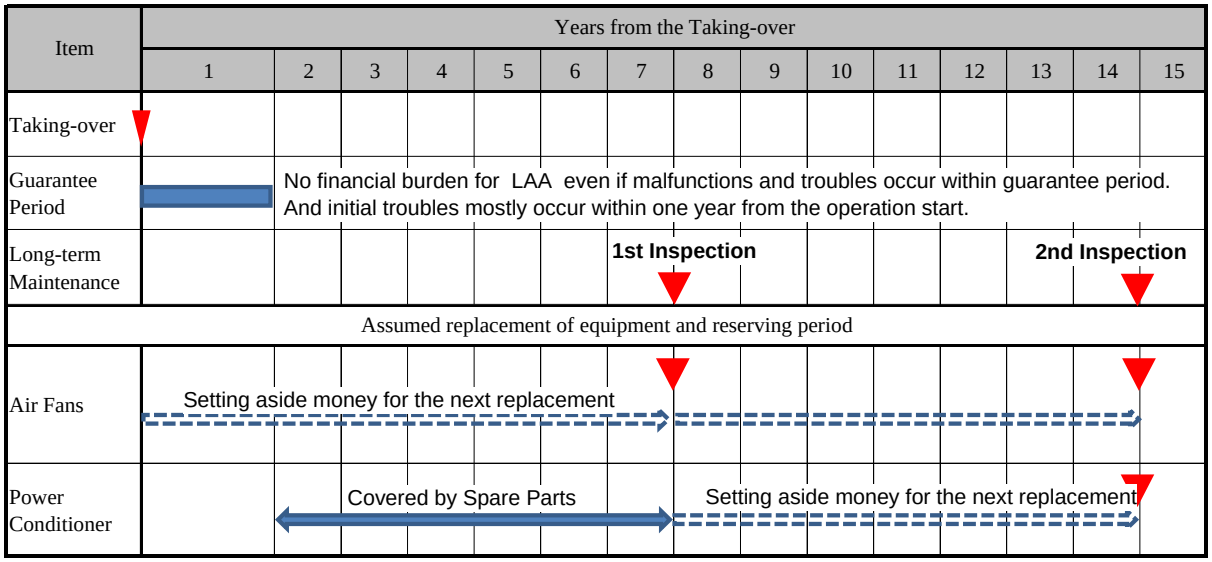
Table 2-5.1 Expenses for Spare Parts

(unit: Japanese Yen)

	Aggregate for a period of long-term Maintenance (7 years)	Average Annual Cost
Power Conditioners (100 kW) (Applicable only after the 1st Long-term Maintenance)	Approx. 12,000,000	Approx. 1,720,000
Air fan related	Approx. 300,000	Approx. 50,000
Total (after the 1st Long-term Maintenance)	Approx. 12,300,000	Approx. 1,770,000

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



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 236 kW, are shown in Table 3-2.1 in the report and the expected cost saving is estimated at about 2.6 Million Japanese Yen or 240 Million Kip annually. Comparing the cost saving of 2.6 Million Japanese Yen with the annual cost of 1.8 Million Japanese Yen, LAA 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) Unloading and Transportation in Thailand

As mentioned before, since Laos is the landlocked country, Laos has no outer port. Therefore, products procured in Japan will be unloaded at the Bangkok port, then, transported to Vientiane City via National Route No.2 and Thai-Lao Friendship Bridge. Unloading and transportation procedures in Thailand will be done by the Contractor by his full responsibility. The delay of unloading and transportation will affect the whole implementation schedule and the Contractor should take care so that the unloading and transportation procedures go smoothly.

(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. A series of above procedure will be handled by MEM and MEM is requested to take necessary actions steadily and without delay.

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATION

Chapter 3 Project Evaluation

3-1 Recommendations

(1) Reserved Fund Preparation

Since LAA is one of the government agencies under MPWT, depreciation of assets and allowance of nature of liability which can be treated in private forms' accounting system seems to be not allowed for LAA. In terms of sustainability of the Project, it is very import for LAA to reserve fund in preparation of purchasing spare parts in the future as proposed in Section 2-5-2. The GoL is recommended to study the appropriate accounting system in compliance with regulations and laws in Laos which allows LAA to reserve fund.

(2) Cooperation with Other Donors

The rural electrification of villages and households in 2007 is 51.3% and 59.0% respectively and the GoL sets forth the target that the electrification will attain 90% by the year 2020. ADB and WB support the rural electrification in accordance with the above target. The rural electrification in Laos will be promoted by means of grid connection and renewable energy. The Project satisfies the both above requirements for the promotion of rural electrification because the Project is the grid-connected PV system.

MEM and EDL, key players in Power Sector in Laos will participate in the training program to be conducted under the Project. Therefore, MEM and EDL are expected to deepen their knowledge about the 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 Laos.

(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, LAA 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 LAA in terms of sustainability of the Project, without participant's personal property.

3-2 Project Evaluation

The direct effect of the Project will support the diversification of energy resources in Laos by introducing the PV system, one of the clean energies. And considering the power import of the neighbouring coutries from Laos, introducing the PV system is to contribute to the expansion of the power export of Laos indirectly, and the reduction of fossil fuel comsumption and CO_2 emission in the neighbouring countries consequently.

Contributing to the power export will assist the GoL's challenge to eradicate the poverty by the year 2020 by means of increase of government annual revenue consequently.

(1) Expected Power Generation and Saving of Electricity Payment

Expected generation energy is estimated at 288,200 kWh in the case of the installed capacity of 236 kW based on the "Assessment of Solar Energy Potential for Lao PDR". The amount of 288,200 kWh as shown in Fig.3-1.1 accounts for about 11 % of total power consumption of 2,603,000 kWh[15] at Wattay International Airport.

For the above power consumption, LAA pays electricity charge amounted to 2,175 Million Kip at the average power tariff of 835 Kip/kWh as shown in Table 3-2.1. If the power tariff of 835 Kip/kWh is applied to the above expected generation energy of 288,200 kWh, the expected saving amount is estimated at 240 Million Kip per annum.

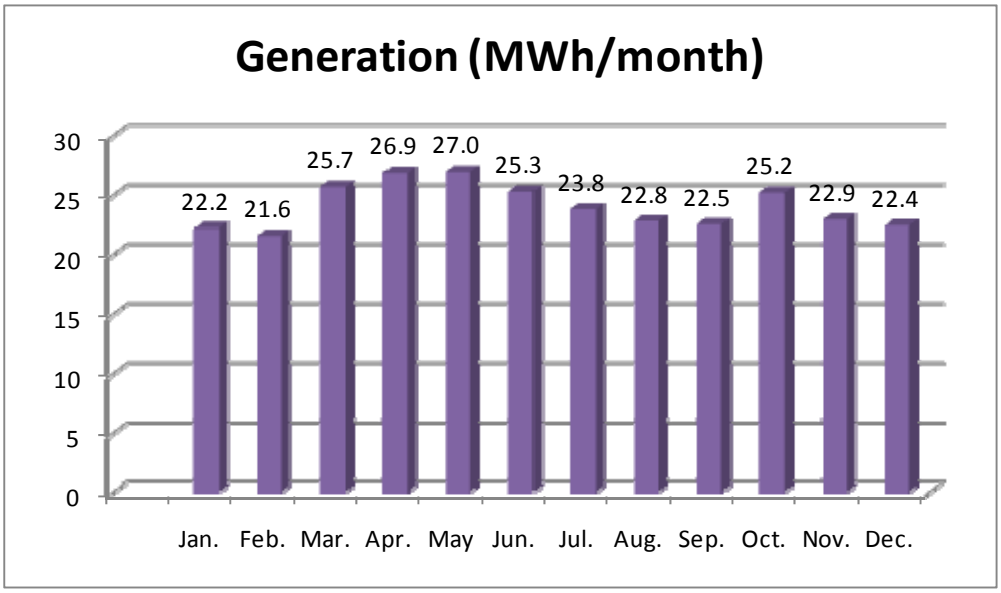


Fig. 3-2.1 Expected Monthly Generation Energy

[15] Power consumption to be burden by LAA.

Table 3-2.1 Power Consumption and Electricity Charge at Wattay International Airport (LAA Portion)

LAA Office and Buildi Installed Capacity 236 kW

Items	Unit	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Expected Annual PV Energy Generation for 236 kW (1)	kWh	**288,273**	22,236	21,641	25,682	26,921	27,034	25,290	23,775	22,750	22,491	25,193	22,871	22,389
Annual Power Consumption for LAA Portion in 2009 (2)	000kWh	**2,603**	157	172	199	229	237	237	229	243	220	248	218	214
Electricity Payment to EDL in 2009 by LAA (3)	K'000	**2,175,102**	131,461	143,981	166,339	191,379	197,639	197,639	191,384	203,010	183,482	207,482	182,442	178,864
Average Power Tariff (4)	Kip/kWh	**835**	835	835	835	835	835	835	835	835	835	835	835	835
Annual Saving of Electricity Payment to EDL (5) = (1) x (4)	K'000	**240,708**	January 2009 = 219,102,452 Kip x 3 / 5 = 131, 461,471 Kip for LAA Portion											
Saving of Electricity Payment (6) = (5) / (3) x 100	%	**11.1%**	(Power tariff is paid to EDL in proportion to share (LAA=60 %, Japanese Firm = 40 %)											

(2) Reduction of CO_2 Emission

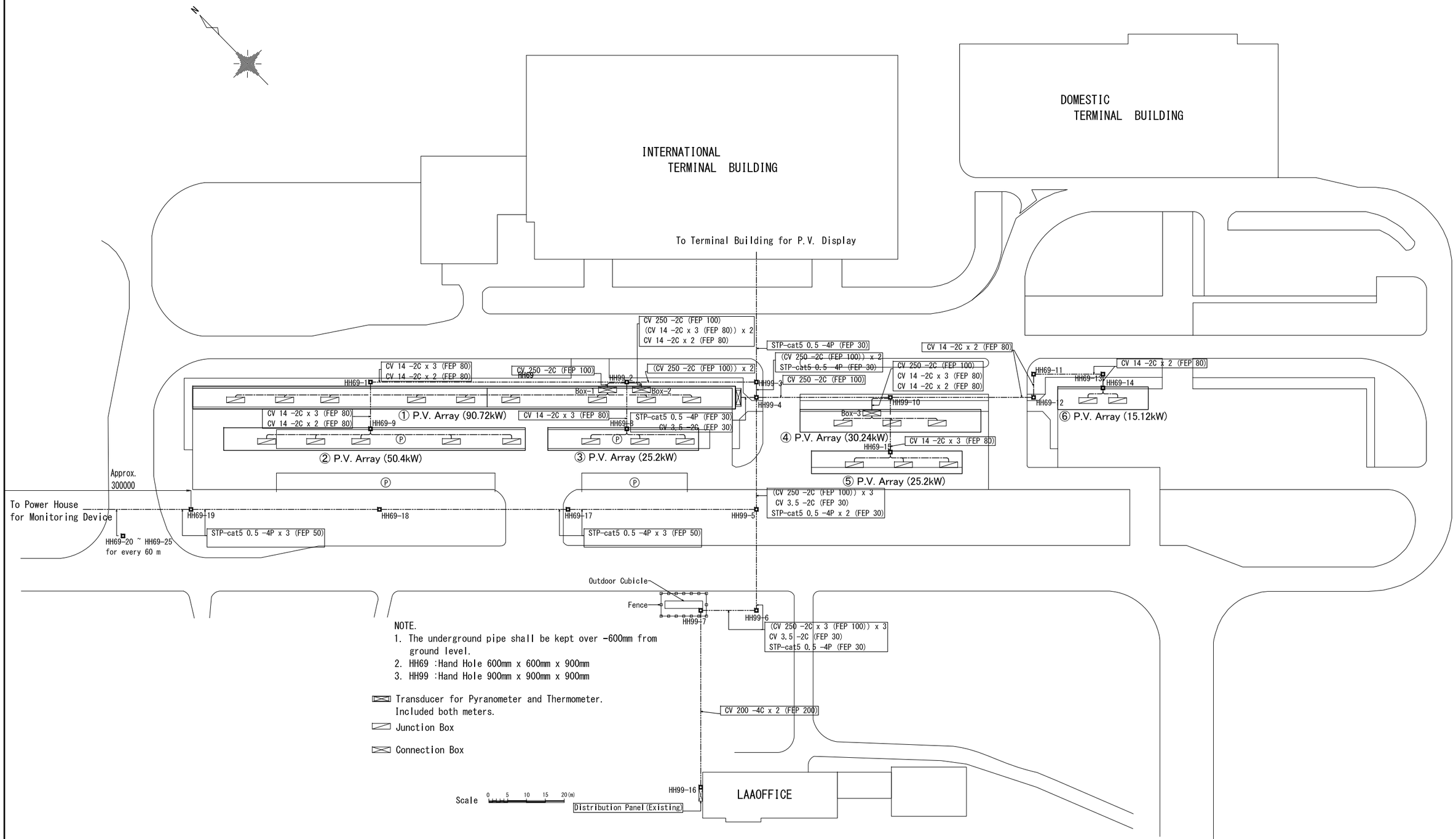
CO_2 emission reduction in Laos is not expected because almost 100 % of generation energy is produced by hydropower in Laos. However, for a small scale generation unit below 15 MW, UNFCC/CDM has its rule to use a diesel engine generator for the baseline. Based on the above rule, the expected CO_2 emission reduction is estimateed provided that diesel engine generators in Laos produce the same power energy with those of PV system by using the unit CO_2 emission rate for burning fuel and for plant operation released by "Central Research Institute of Electric Power Industry". The result is demonstrated in Table 3-2.2 and the reduction of CO_2 emission is expected to be 198 ton-CO_2 per annum.

Table 3-2.2 Reduction of CO_2 Emission by the Project (Laos)

	Generation Type	Installed Capacity	Energy Generation	CO_2 Unit Emission		
				By fuel burning (E1)	by plant operation (E2)	E1 + E2
		MW	MWh	g/kWh	g/kWh	kg
Energy Generation in 2007	HFO-fired plants	0	0	704	38	0
	DO-fired plants	1	4,504	704	38	3,341,968
	Hydropower	672	3,363,635	0	11	
	Isolated PV system	0	1,501	0	53	
	Total	673	3,369,640			3,341,968
	Diesel Plant (kg/MWh)		4,504			742
PV System (236 kW)			288	742	-53	198,432

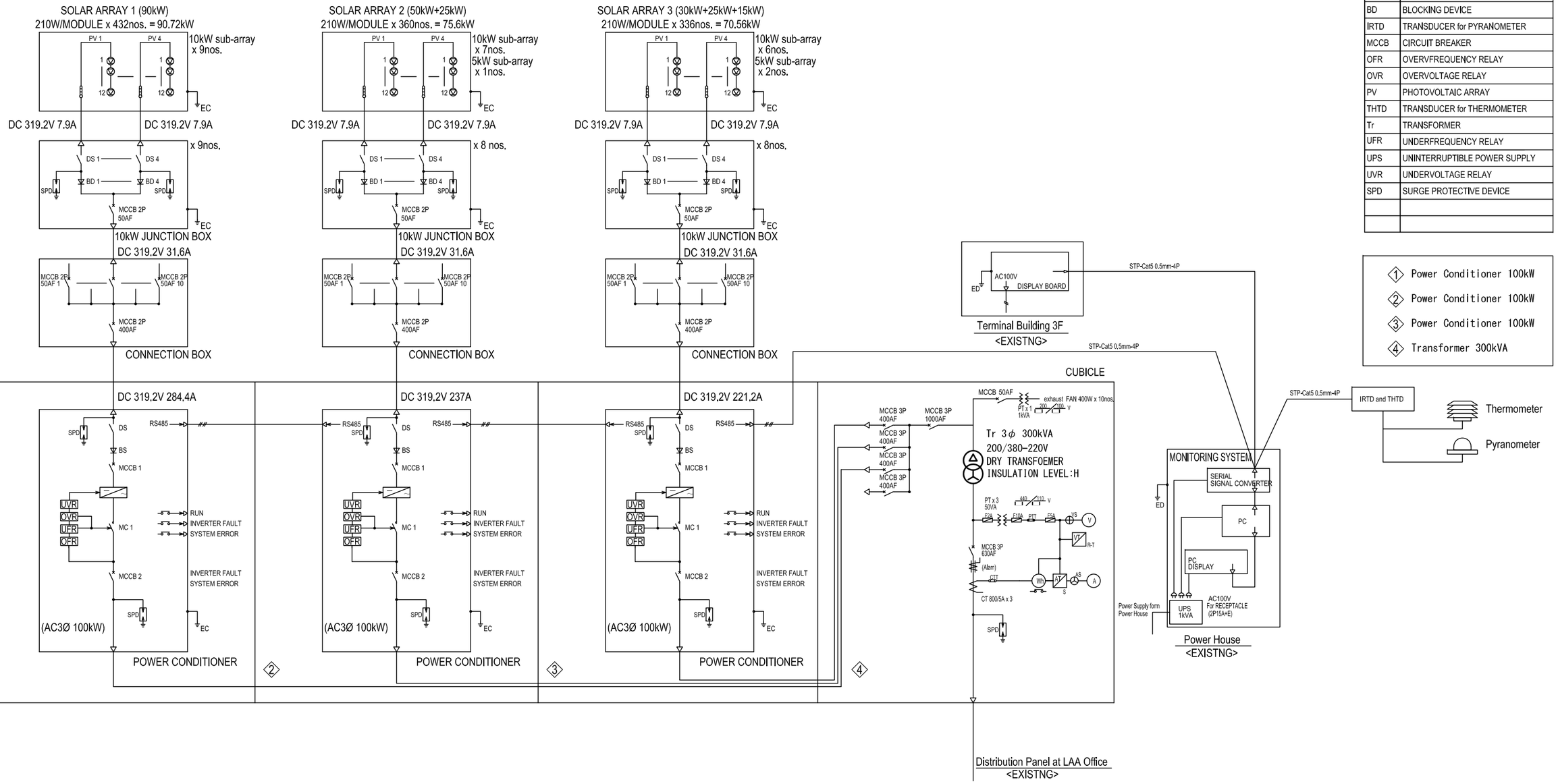
Source: EDL Annual Report 2008, page 17, Electricity Statistics Year Book 2007 of Lao PDR, page 3

DRAWINGS



JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	Overall Layout at Wattay International Airport (NEW) (Scale: 1:1000)	PWT-01

SOLAR SYSTEM (236kW)

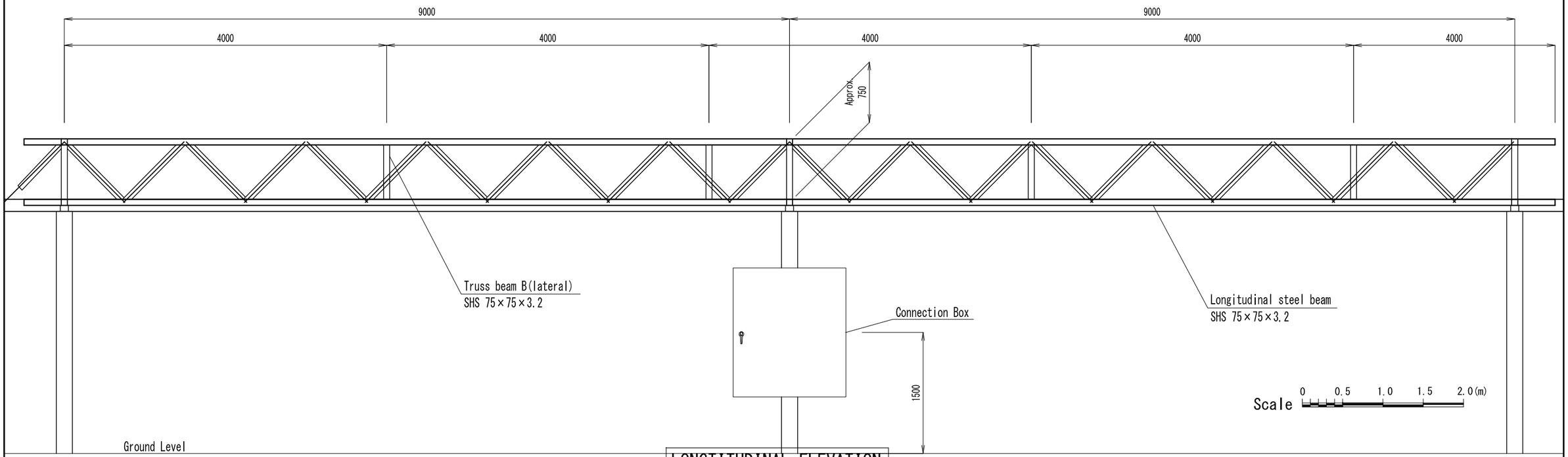


LEGEND

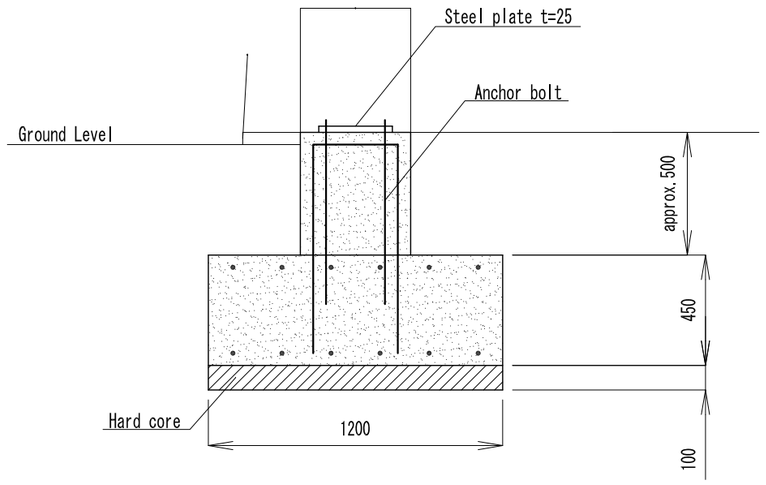
SYMBOL	DESCRIPTION
BD	BLOCKING DEVICE
IRTD	TRANSDUCER for PYRANOMETER
MCCB	CIRCUIT BREAKER
OFR	OVERVFREQUENCY RELAY
OVR	OVERVOLTAGE RELAY
PV	PHOTOVOLTAIC ARRAY
THTD	TRANSDUCER for THERMOMETER
Tr	TRANSFORMER
UFR	UNDERFREQUENCY RELAY
UPS	UNINTERRUPTIBLE POWER SUPPLY
UVR	UNDERVOLTAGE RELAY
SPD	SURGE PROTECTIVE DEVICE

1 Power Conditioner 100kW
2 Power Conditioner 100kW
3 Power Conditioner 100kW
4 Transformer 300kVA

	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
JAPAN INTERNATIONAL COOPERATION AGENCY	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	SINGLE LINE DIAGRAM FOR PHOTOVOLTAIC POWER PANEL (Airport) (Scale: NONE)	PWT-02

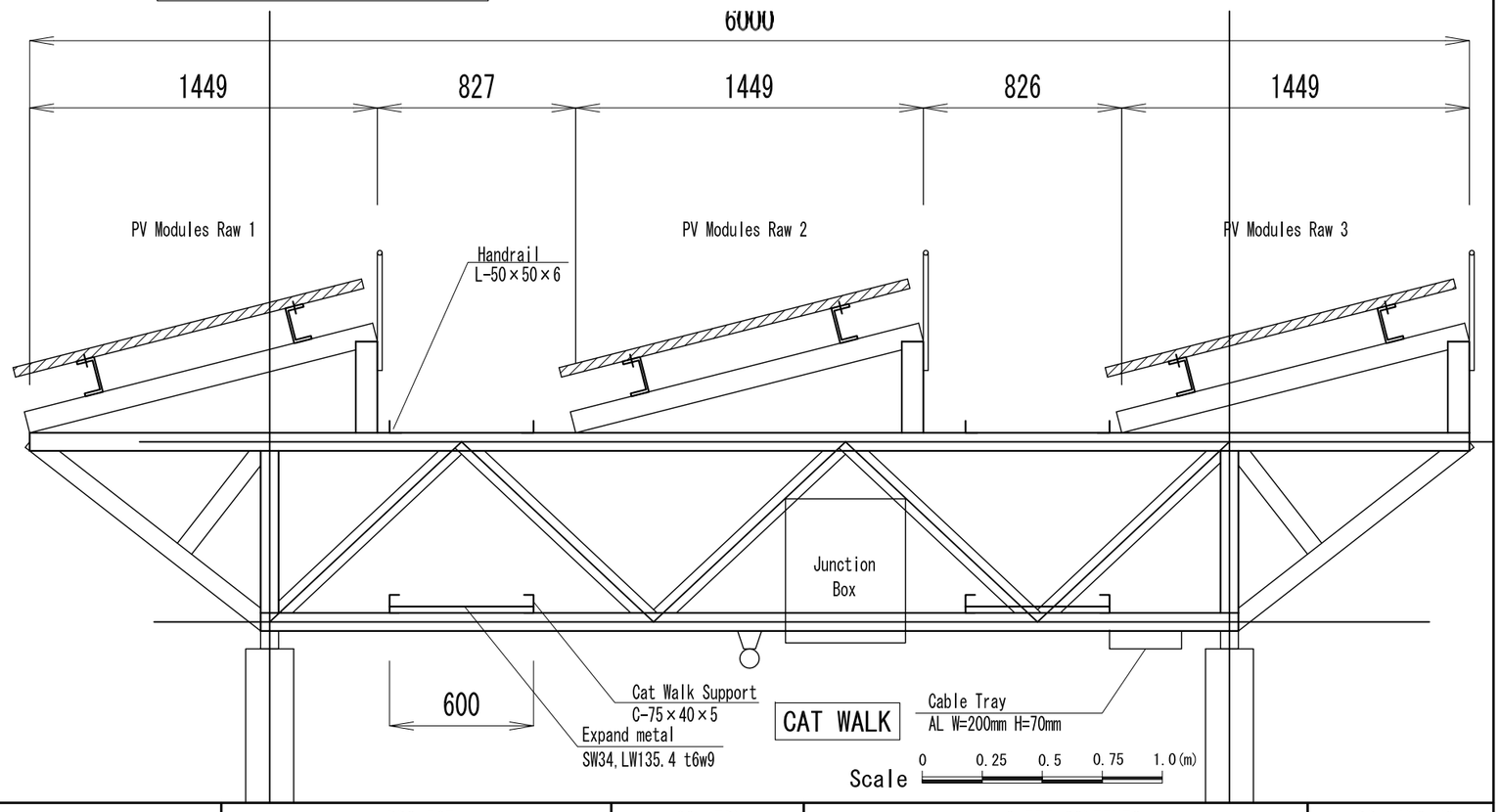


LONGTITUDINAL ELEVATION



FOUNDATION

Scale 0 0.25 0.5 0.75 1.0(m)



CAT WALK

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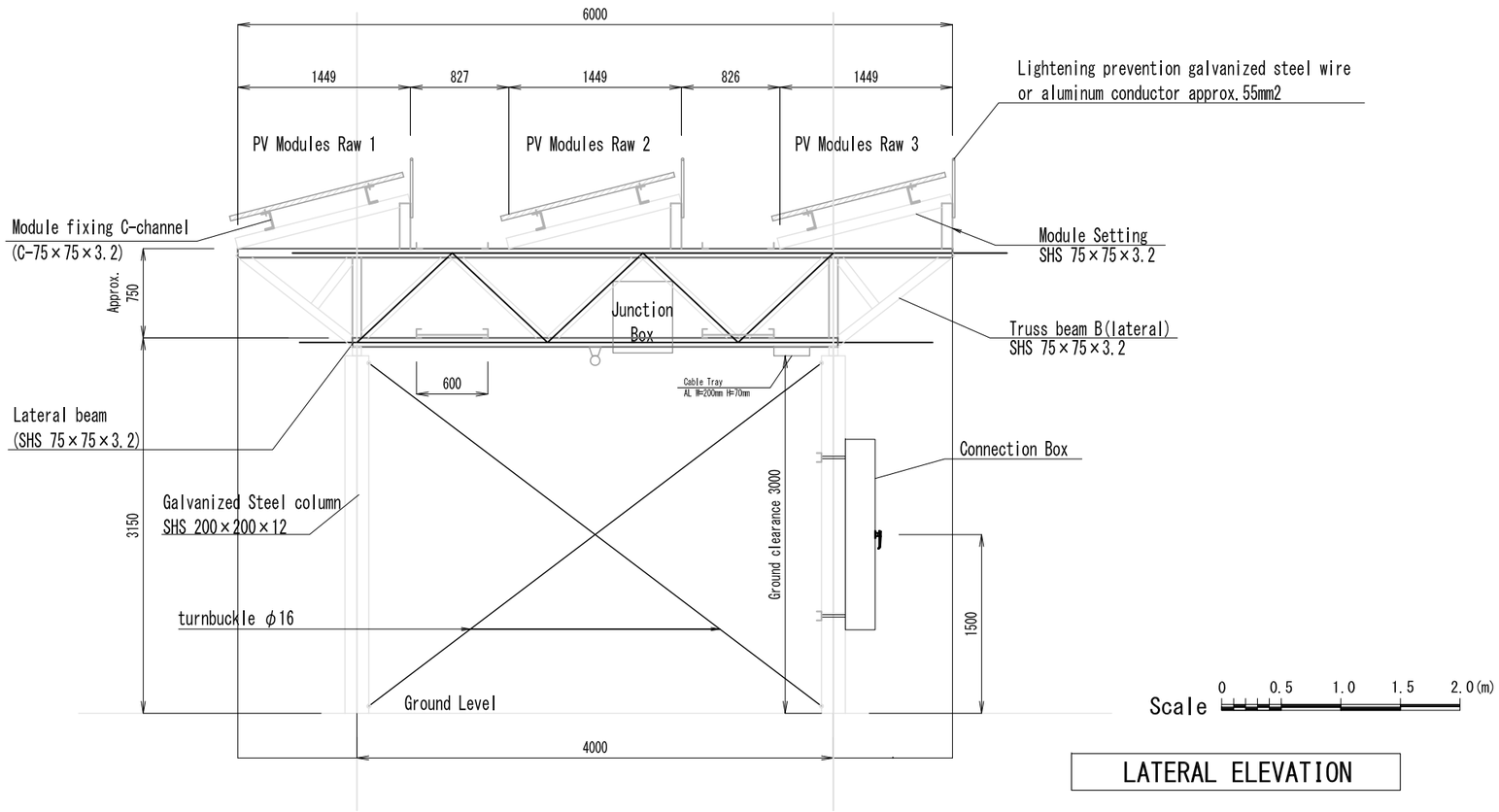
JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	Airport 236kWp PV array and steel structure arrangement Elevation and foundation drawing (Scale: 1:50, 1:25)	PWT-03

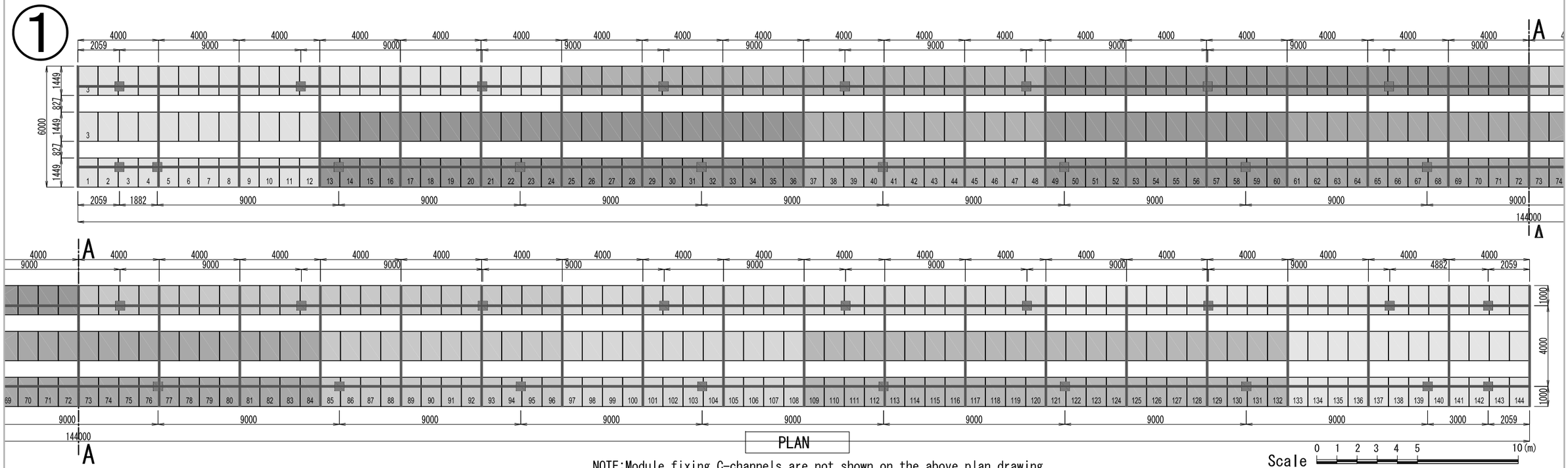


Scale 0 0.5 1.0 1.5 2.0(m)

LATERAL ELEVATION

SUMMARY				
Array Maximum Output	:	236.88	kWp	
Numbers of 10kW sub-arrays	:	22	nos.	
Numbers of 5kW sub-arrays	:	3	nos.	
Numbers of junction boxes	:	25	nos.	
Array Dimensions	:	376x6	m	(2,256m2)
				(144m+80m+40m+48m+40m+24m =376m)
Numbers of modules	:	1,128	nos.	(12 nos.x 94 strings)
				(376 nos.x 3 rows)
Numbers of foundations	:	98	nos.	
Numbers of Steel columns	:	98	nos.	(approx.H=3150mm)
Truss beam A(Longitudinal)	:	752	m	(376 m x 2 rows)
Truss beam B(Lateral)	:	100	nos.	(1 nos./6 m)
C-channel(approx.C-150)	:	2,256	m	(376 m x 6 nos.)
Cat walks	:	752	m	(376 m x 2 rows)
		Including handrails,climbing steps stairs and etc.		

①

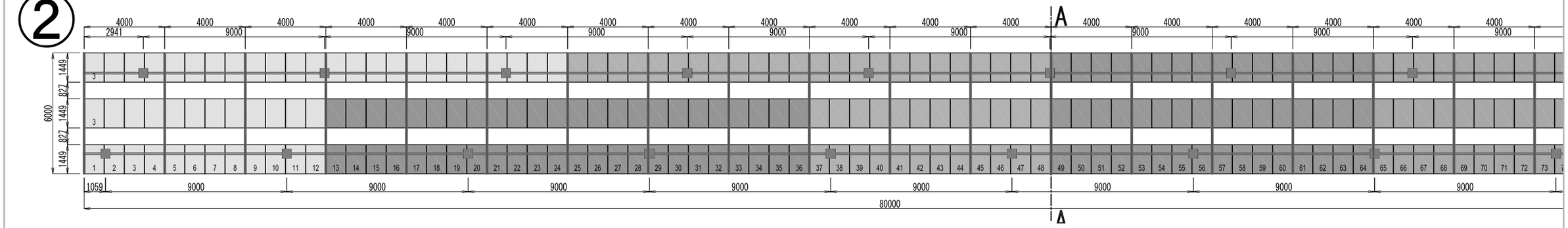


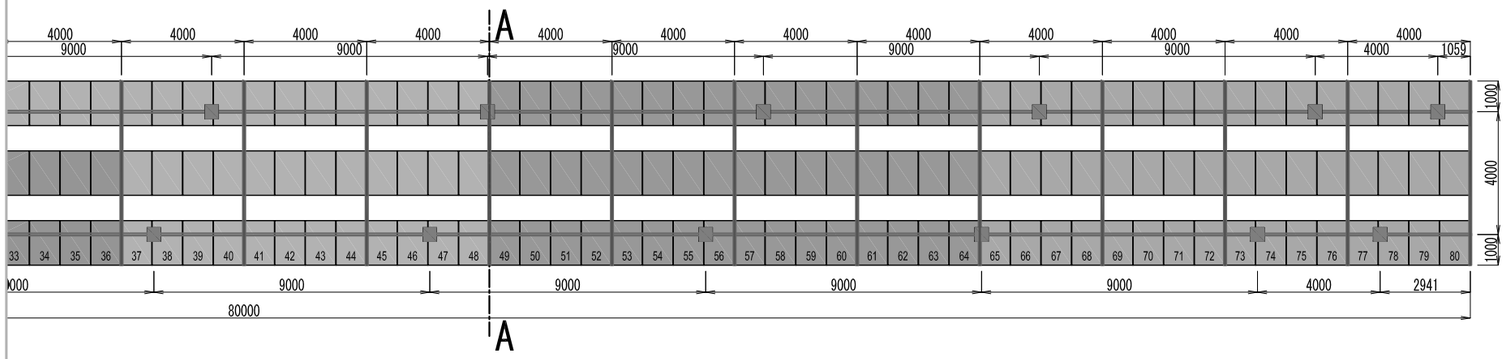
NOTE:Module fixing C-channels are not shown on the above plan drawing

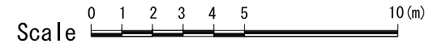
Scale 0 1 2 3 4 5 10(m)

JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	Airport 236kWp PV array and steel structure arrangement Plan and Elevation drawing steel member arrangement Plan (1/3) (Scale: 1:50,1:200)	PWT-04

②







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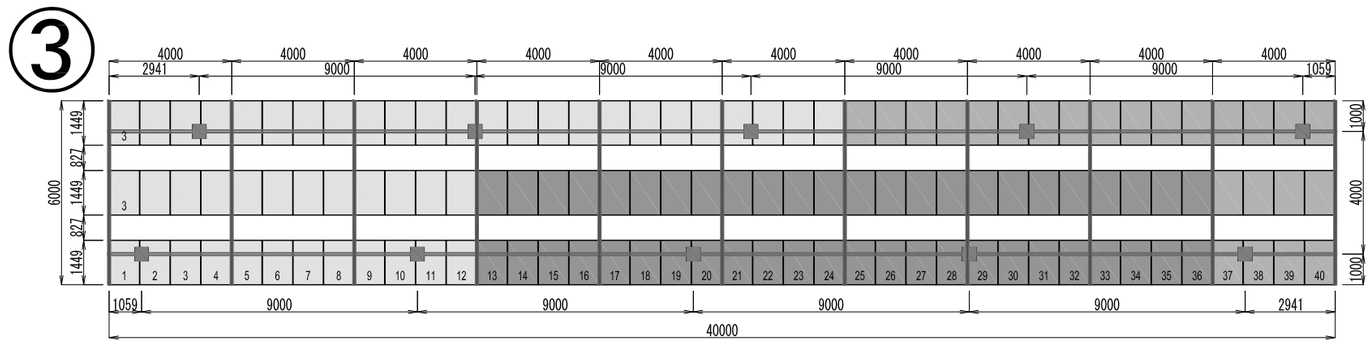

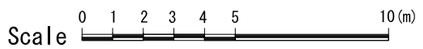

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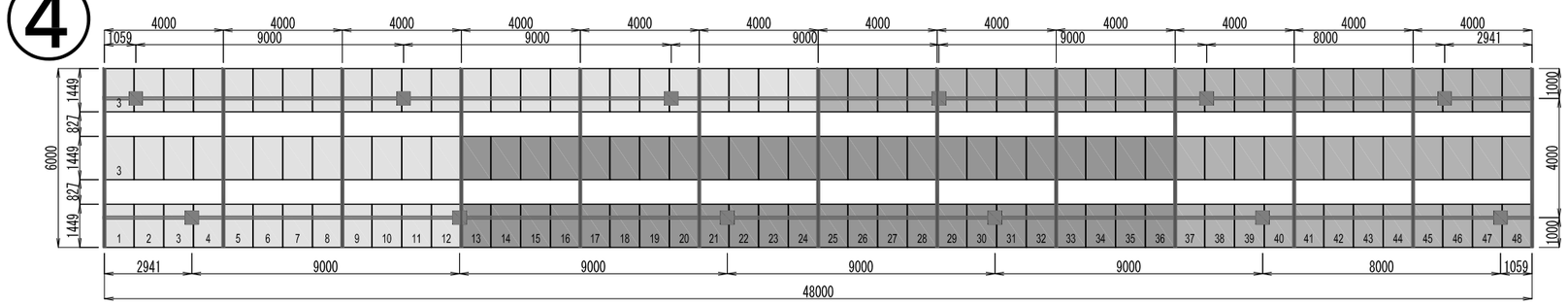
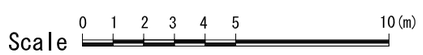


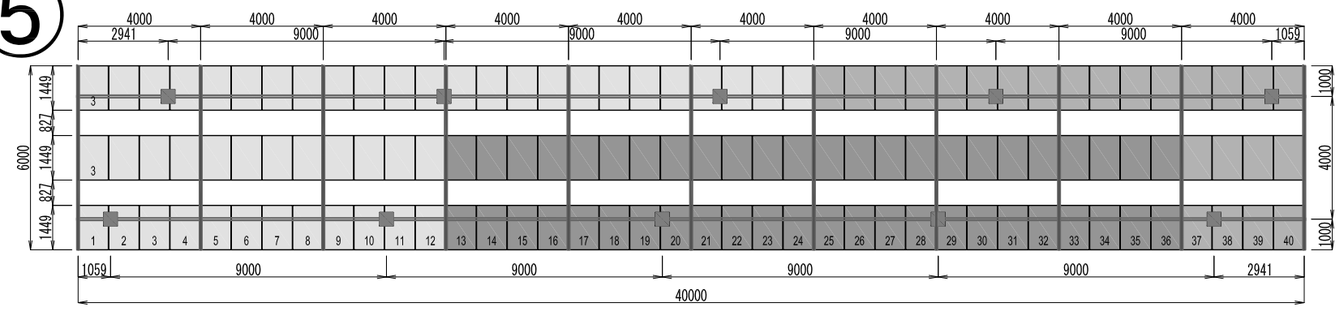


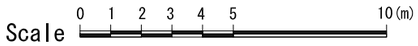
PLAN

NOTE:Module fixing C-channels are not shown on the above plan drawing

JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	Airport 236kWp PV array and steel structure arrangement Plan and Elevation drawing steel member arrangement Plan (2/3) (Scale: 1:50,1:200)	PWT-05

5





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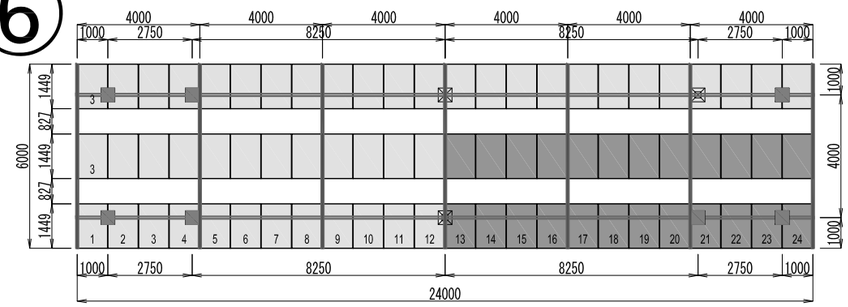

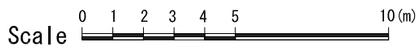

PLAN

NOTE:Module fixing C-channels are not shown on the above plan drawing

JAPAN INTERNATIONAL COOPERATION AGENCY	PROJECT	COUNTRY	SHEET CONTENTS	DRAWING NO.
	Preparatory Survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System	The Lao People's Democratic Republic	Airport 236kWp PV array and steel structure arrangement Plan and Elevation drawing steel member arrangement Plan (3/3) (Scale: 1:50, 1:200)	PWT-06