BELIZE
Ministry of Finance
Ministry of Works

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

Preparatory Survey Report

October 2010

Japan International Cooperation Agency

NIPPON KOEI CO., LTD.

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PREFACE

Japan International Cooperation Agency (JICA) conducted the Project for Introduction of Clean Energy by Solar Electricity Generation System in Belize.

JICA sent to Belize a survey team from August 9th to August 25th, 2009 and June 14th to July 4th, 2010.

The team held discussions with the officials concerned of the Government of Belize, 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 Belize from August 28th to September 6th, 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.

I wish to express my sincere appreciation to the officials concerned of the Government of Belize for their close cooperation extended to the teams.

October 2010

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

Summary

Summary（Belize）

1. Country Overview

Belize is located on the Central American mainland, forming part of the Yucatan Peninsula. It is bounded to the north by Mexico, to the west and south by Guatemala and to the east by the Caribbean Sea. The total land area is 22,960 sq. km. (8,867 square miles) of which 95% is located on the mainland and five per cent is distributed over more than 1,060 islands. Most of the northern half and much of the southern third of the country, plus the entire coastal area and all the islands, are flat and low-lying. Large sections of the coastline have an elevation of less than one metre to a distance of several kilometers inland. The central part of the country is dominated by the Maya Mountain/Mountain Pine Ridge massif, rising to 1,124m at its highest point. Total population is approximately 310,00 (2007).

Belizean economy is no large, essentially private-enterprise economy, tourism is the number one foreign exchange earner followed by exports of marine products, citrus, cane sugar, bananas, and garments. The government's expansionary monetary and fiscal policies, initiated in September 1998, led to sturdy GDP growth averaging nearly 4% in 1999-2007, though growth slipped to 3% in 2008 and -1.5% in 2009 as a result of the global slowdown, natural disasters, and the drop in the price of oil. Oil discoveries in 2006 bolstered the economic growth. Exploration efforts continue and production increased a small amount in 2009. Major concerns continue to be the sizable trade deficit and unsustainable foreign debt equivalent to nearly 70% of GDP.

In February 2007, the government restructured nearly all of its public external commercial debt, which helped reduce interest payments and relieve some of the country's liquidity concerns. A key short-term objective remains the reduction of poverty with the help of international donors.

2. Background of the Project and Outline

The Program Grant Aid for Environment and Climate Change of the Government of Japan (GoJ) is introduced as assistance to developing countries that are aiming to achieve both economic growth and reduction of greenhouse gas emissions, and are working to contribute in achieving climate stability. As one measure, Japan established a new financial mechanism. Through this mechanism, Japan decided to cooperate actively with developing countries' efforts to reduce emissions and promote clean energy. At the same time, Japan extended assistance to developing countries suffering severely from adverse impacts caused by climate change. According to the initiative of this mechanism, the Japan International Cooperation Agency (JICA), in consultation with GoJ, decided to conduct a Preparatory Survey on the Project for Introduction of Clean Energy by Solar Electricity Generation System in Belize.

In Belize, national power supply service is depends on the BEL (Belize Electricity Limited), a power distribution company. For these three years, the peak power increases approximately 5% every year. A peak power of 2008 was 74.3MW, and that in 2009 is 76.17MW which recorded at 2:00 p.m. In 2009, total installed capacity of national electric utility becomes 117MW by the connection with some new stand alone power station. The capacity is surpassed 76MW of the maximum national demand. In the condition, it is possible to supply domestic electricity demand. The import power is procured from the Federal Power Commission (CFE: Comisión Federal de Electricidad) of the Mexico. However, a serious accident occurred in a main power station and power supply to Belize was temporarily stopped in April, 2009. Afterwards, power was supplied restrictively. Electric power purchase statement of mutual agreement (PPA:Power Purchase Agreement) was canceled in October of the year. CFE continues supply power to BEL as far as possible. However, compare to power purchase unit price of domestic IPP, the unit price of Mexico is more economical. Therefore, amount of import power from CFE is still high as about half of national generation sources.

In the national development plan of Belize (2006 to 2010), the objective of the power supply plan is to increase the electrification rate and exportation of electricity as contribution to national economic development. There are geographical differences on electrification rates in Belize. Electrification rate in urban areas has reached 85%, while that of rural areas is only 30%. Therefore, around 770,000 people are still living in un-electrified conditions. Meanwhile, there is abundance of natural resources in Belize, and hence, there is enough potential to export electricity to its neighboring countries. However, the resources are not developed yet. In the national development plan, four political strategies on electrical services are mentioned as discussed below.

From the mentioned above, Belizean Government seeking for introduction of alternative energy sources such as hydro, biomass, PV and wind which not to depend on import electric power and the fossil fuel. The number of installed PV system is limited in Belize. It is considered that there is potential demand of the rural electrification by the stand-alone small PV system and wind power generation because electrification rate is high as 90% in Belize. On the other hand, it is considered the dissemination of PV system for grid connection is difficult, one of the reasons is the high initial investment cost of equipments.

In the agreement requested by the Government of Belize (GoB), the necessary equipment for grid-connected solar PV system will be introduced in the project. The Ministry of Finance is the responsible organization while Ministry of Works acts as the implementing organization for the project. The equipment should be procured according to necessity, adequacy and sustainability of climate change mitigation. The plan consists of scheduled equipment procurement and soft component (technical assistance).

3. Outline of Preparatory Survey and Project Contents

JICA, in consultation with GoJ, decided to conduct a Preparatory Survey on the Project for Introduction of Clean Energy by Solar Electricity Generation System in Belize (the Project).

JICA sent the Preparatory Survey Team (the Team) to Belize, and stayed in the country from 9 August 2009 to 25 August 2009. The Team held discussions with concerned officials of GoB and conducted a first field survey. The first survey report was subsequently submitted to JICA. The second survey was then carried out from 23 November 2009 to 15 December 2009. However, The Study Team received an information indicating that the social security office does not allow the use of the land for this project. Based on the results, the third priority area in UB was agreed with the Belizean side. JICA sent fourth site survey from 14 June 2010 to 4 July 2010 Then, the Draft Outline Design Report was prepared in Japan based on discussions, field survey and technical examination of the second survey result. In order to explain and consult with the concerned officials of the GoB regarding the component of the Draft Final Report, JICA dispatched the Team from 28 August 2010 to 6 September 2010.

It is clarified that the 350kW PV system will be installed in University of Belize.

The following are the concerns on the project formulation policy:

1) Showcase effect

2) Introduction of advanced technology and know-how of Japan

3) Establishment of sustainable O&M structure

The project is carried out based on the framework of the Environmental Program Grant Aid by GoJ. The main equipment to be procured, which includes installation and testing, are the PV module and mounting structure, power conditioner and step-up transformer medium-voltage equipment.

The table below shows the capacity of the PV system and necessary ground area.

Capacity of PV system and Necessary Land Area

Land	350 kWp
Width (m)	95
Length (m)	87
Necessary Area (m^2)	8,265(2.04 Acer)

(JICA Study Team)

Main equipment such as PV module, power conditioner and transformer are purchased from Japan.

It is necessary to obtain spare parts for continuous operation during the initial stage. In this project, spare parts are not available locally. Therefore, it is necessary to procure from Japan. As for the PV modules, 3% of the total quantities have to be procured as spare parts anticipating short periods of shutdown due to lightning or breakdown. Power conditioner is the most important component of the PV system. In this project, one complete set of power conditioner with a capacity of 100 kW will be supplied as a spare unit. In addition, arrester, fan and filter will be procured as spare parts. As for the medium-voltage equipment, one set of arrester (3 phases), circuit breaker (3 phases), protection relay and meters will be procured for each.

4. Implementation Schedule and Cost

The tendering period is estimated around 4 months. The construction period is estimated to be 12 months from the contract with tenderer up to the completion of the Project.. The demarcated cost of the Belizean side is estimated to be around ¥3,320,000 for site clearance, access road and security.

5. Project Evaluation

1) Conformity with the national strategy on energy sector

The Government of Belize (GOB) needs to have the promotion of renewable energy projects under a long-term policy as objective. Also, the development of a law on grid-connected renewable power generation systems such as Independent Power Producer (IPP) is being considered to be established by January 2011. Thus, this Project is in conformity with the national strategy.

2) Showcase effect

The UB campus is located in Belmopan City, which is the capital of Belize and located approximately at the center of the country. The UB has around 3,400 students. Population of Belmopan City is approximately 16,000. In addition, visitors are expected such as the UB staff and those taking part in study visits. It will also further contribute in showcasing the effects of the system. Therefore, some UB staff should be able to guide visitors to the PV system. The showcase effect is expected to be high since the installation site is inside the UB campus.

3) Introduction of advanced technology and know-how of Japan

There were experiences on small-scale autonomous solar systems, mainly in the rural areas. However, there is limited experience on installation of grid-interconnected power generation system. On the other hand, grid-interconnected solar PV systems are widely used in Japan. In this project, the advanced technology of Japan in solar PV systems and grid-interconnected technology can be applied.

4) Establishment of sustainable O&M structure

In the project, the person in-charge of O&M will be trained under the manufacturer's engineer and the soft component program because there is limited experience on O&M of grid-interconnected solar PV system in the country. The technical transfer will be conducted with MOW as the counterpart and implementing organization. Establishment of a sustainable O&M structure will thus be expected to promote renewable energy projects.

5) Influence on environment

Construction works are carried out inside the UB campus. Therefore, it is important to consider taking safety measures to protect the students, UB personnel and visitors from outside. There is no influence to surroundings if the site is segregated using fences and putting danger plates around the construction site.

As mentioned in the above key issues, the adequacy of implementation in an environmental program grant aid by the GOJ is of great significance in this Project.

The supply of power output and reduction of CO_2 emission are considered as the quantitative benefits of the project implementation. Details are as follows:

Table Effective Index and Target Value

Index	Standard Value (2010)	Target Value (2013) {3 years after project completion}
Annual Estimated Power Output (MWh/year)	0	460 MWh/year
CO_2 Emission (t/year)	0	142 ton/year

(JICA Study Team)

As a qualitative benefit, it is expected (1) introduction of renewable energy, (2) Demonstration effect, (3) Rising awareness.

Location Map(Belize, Belmopan）

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

PREPARATORY SURVEY REPORT

CONTENTS

Chapter 3 PROJECT EVALUATION

TABLE LIST

FIGURE LIST

ABBREVIATIONS

A/A	:	Agent Agreement
AC	:	Alternate Current
ACB	:	Air Circuit Breaker
ANSI	:	American National Standards Institute
A/P	:	Authorization to Pay
APEB	:	Association of Professional Engineer in Belize
B/A	:	Banking Arrangement
BAS	:	Belize Audubon Society
BEL	:	Belize Electricity Limited
CCCCC	:	Caribbean Community Climate Change Centre
CDM	:	Clean Development Mechanism
CFE	:	Comisión Federal de Electricidad
COP	:	Conference of the Parties
CT	:	Current Transformer
CV	:	cross-linked polyethylene vinyl sheathed (cable)
CVT	:	Current Voltage Transformer
CVV		Control-use Vinyl insulated Vinyl sheathed (cable)
CVVS	:	Control-use Vinyl insulated Vinyl sheathed annealed copper tape (cable)
DC	:	Direct Current
DER	:	Directional Earth-fault Relay
DS	:	Disconnecting Switch
EIA	:	Environmental Impact Assessment
E/N	:	Exchange of Notes
ES	:	Earthing Switch
FEP	:	Perfluoro (ethylene-propylene) plastic pipe for underground cable
FIT	:	Feed in Tariff
FOB	:	Free on Board
F/S	:	Feasibility Study
G/A	:	Grant Agreement
GDP	:	Gross Domestic Product
GEF	:	Global Environmental Facility
GNI	:	Gross National Income
GVT	:	Grounding Voltage Transformer
GWP	:	Global Warming Potential
IT	:	Information technology
IDB	:	Inter-American Development Bank
IEA	:	International Energy Agency
IEC	:	International Electro-technical Commission
IEE		Initial Environmental Examination
IEEE	:	Institute of Electrical and Electronics Engineers
IMF	:	International Monetary Fund
IP	:	International Protection (standards)
IPCC	:	Intergovernmental Panel on Climate Change
IPP	:	Independent Power Producer
JCS	:	Japan Cable Standard
JEC	:	Japanese Electromechanical Committee (standards)
JEM	:	Japan Electrical Manufacturers' (standards)
JICA	:	Japan International Cooperation Agency
JIS	:	Japan Industry Standard

LA		Lightning Arrester
LED	:	Light Emitting Diode
MCCB	:	Molded Case Circuit Breaker
MD	:	Minutes of Discussions
MDF	:	Main distribution frame
MOF	:	Ministry of Finance
MOW	:	Ministry of Works
NASA	:	National Aeronautics and Space Administration
NEC	:	National Electrical Code
NGO	:	Non Governmental Organization
NMS	:	National Meteorological Service
O&M	:	Operation and Maintenance
OCR	:	Over Current Relay
OCGR	:	Over Current Ground-fault Relay
ODA	:	Official Development Assistance
OFR	:	Over Frequency Relay
OLADE	:	Organization Latin America Energy
ONAN	:	Oil immersed, natural flow, air cooling system
ONAF	:	Oil immersed, natural flow, forced air cooling system
OVGR	:	Over Voltage Ground-fault Relay
OVR	:	Over Voltage Relay
PC	:	Power Conditioner
PC	:	Personal computer
PF	:	Power Factor
PPA	:	Power Purchase Agreement
PUC	:	Public Utilities Commission
PV	:	Photovoltaic
PWM	:	Pulse Width Modulation
SA	:	Surge Arrester
SHS	:	Solar Home System
SPC	:	Steel plate cold rolled
SPHC	:	Steel plate hot rolled commercial
SS	:	Steel structure
T/D	:	Transducer
TR	:	Transformer
UB	:	University of Belize
UFR	:	Under Frequency Relay
UNDP	:	United Nations Development Program
UNCED	:	UN Conference on Environment and Development
UNFCCC	:	UN Framework Convention on Climate Change
UPS	:	Uninterruptible Power Supply
USAID	:	United States Agency for International Development
UVR	:	Under Voltage Relay
VCB	:	Vacuum Circuit Breaker
WB	:	World Bank
WB PHRD	:	World Bank Policy and Human Resource Development (Fund)
XLPE	:	Cross-linked polyethylene (cable)
ZCT	:	Zero-phase Current Transformer

UNIT

Distance	mm	:	Millimeters
	cm	:	Centimeters (10.0 mm)
	m	:	Meters (100.0 cm)
	km	:	Kilometers (1,000.0 m)
	feet	:	12 inch = 0.30303 meter
Square measure	cm^2	:	Square-centimeters (1.0 cm x 1.0 cm)
	m^2	:	Square-meters (1.0 m x 1.0 m)
	km^2	:	Square-kilometers (1.0 km x 1.0 km)
	ha	:	Hectare (10,000 m^2)
	acre	:	1 acre=4,046.86 Square-meters
Cubic measure	cm^3	:	Cubic-centimeters (1.0 cm x 1.0 cm x 1.0 cm)
	m^3	:	Cubic-meters (1.0 m x 1.0 m x 1.0 m)
Weight	g	:	grams
	kg	:	kilograms (1,000 g)
	ton	:	Metric ton (1,000 kg)
	kN/m^2	:	kilo Newton per Square meters
	kgf/cm^2	:	kilo grams foot per Square-centimeters
Time	sec.	:	Seconds
	min.	:	Minutes (60 sec.)
	hr.	:	Hours (60 min.)
Currency	BZ$	:	Belize Dollars
	US$	:	United State Dollars
	J¥	:	Japanese Yen
Electricity	V	:	Volts (Joule/coulomb)
	kV	:	Kilo volts (1,000 V)
	A	:	Amperes (Coulomb/second)
	kA	:	Kilo amperes (1,000 A)
	Ω	:	Ohm
	MΩ	:	Mega-ohm
	Hz	:	Hertz
	W	:	Watts (active power) (J/s: Joule/second)
	kW	:	Kilo watts (10^3 W)
	MW	:	Mega watts (10^6 W)
	Wh	:	Watt-hours (watt x hour)
	kWh	:	Kilo watt-hours (10^3 Wh)
	MWh	:	Mega watt-hours (10^6 Wh)
	GWh	:	Giga watt-hours (10^9 Wh)
	VA	:	Volt-amperes (apparent power)
	kVA	:	Kilo volt-amperes (10^3 VA)
	MVA	:	Mega volt-amperes (10^6 Wh)
	var	:	Volt-ampere reactive (reactive power)
	kvar	:	Kilo volt-ampere reactive (10^3 var)
	Mvar	:	Mega volt-ampere reactive (10^6 var)
	Wp	:	Watt-peak
	kWp	:	Kilo Watt-peak

Chapter 1
BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Current Situation and Background

1.1.1 Current Situation and Problems

(1) Implementation Setup

In 1992, a global environmental summit was held in Rio de Janeiro, Brazil. Belize participated in the summit with other Central American countries and signed the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED). The National Meteorological Service (NMS), under the meteorological division of the Ministry of Natural Resources and Environment, was appointed by the Belizean government as a technical advisory organization on climate change. A national meteorological committee was established since it has become important to include climate change issues in the national development process. Advisories on climate change have thus been issued to related governmental organizations. Belize signed the Kyoto protocol on the 26th of September 2003, and therefore, it is necessary to establish an organization that works on climate change issues relating CDM (Clean Development Mechanism) and the Kyoto protocol. In addition, Belize joined as a member of OLADE (Organization Latin America Energy), which was formed by 18 Latin American countries in November 2009. OLADE held training and workshops on renewable energy particularly to prevent global warming. The organization can be expected for dissemination of renewable energy, including solar PV, in Belize since it had become a member country.

1) Organization for Climate Change

The Chief Meteorologist of the National Meteorological Service under the Ministry of Natural Resources and Environment is Belize's focal point in all matters related to climate change. The following figure shows the organizational chart.

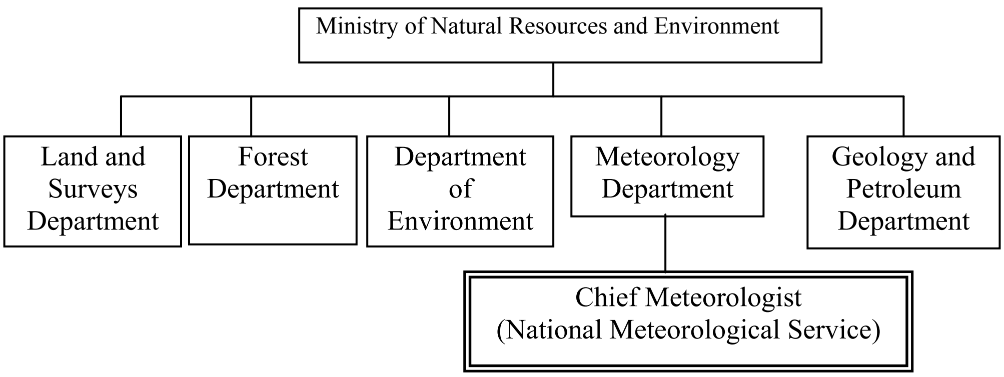


Figure1-1 Organizational Chart on Mitigation of Climate Change

(Source: JICA Study Team, Government of Belize)

2） Renewable Energy

For the mitigation of climate change, it is important to consider the introduction of renewable energy technology to reduce emission of greenhouse gas (GHG) which aims to prevent further global warming. Through the cooperation of UNDP and the Public Utilities Commission (PUC) of Belize, a policy proposal which stated the reduction of dependency on fossil fuel for stable supply of electricity was developed.

Currently, power stations are operated by renewable energy, thus hydro and biomass power stations are already installed in Belize. Bagasse, which is a residue of sugarcane, is the main source of energy for the biomass power station. The installed capacity of this biomass power station is 13.5 MW and was installed in September 2009. In addition, a wind power station can be considered although there are no experiences except the installation of small wind generators. There is a candidate site for wind development at Blady Beacon, although it is still necessary to conduct wind monitoring.

According to the 2009 annual report of BEL (Belize Electricity Limited), the annual power output of the hydraulic power generation section, Hydro Maya is 2% of total generated energy in 7.8GWh, Mollejon and Chalillon(Hydroelectric facilities(BECOL) is 38% of total generated electricity in 158GWh. A hydropower station with capacity of 18 MW has been constructed in Vaca of the Macal River from 2006 and was completed in the first quarter of 2010. The annual power output from the hydro station is estimated to be 80 GWh. Therefore, the power output from hydraulic power stations becomes 250 GWh in total, which is approximately 60% of the total generated energy. Power output from hydraulic power decreases in the dry season, therefore, it is necessary to compensate by importing fossil fuel and electricity. The hydraulic power generation reduces dependence on fossil fuel and it can contribute to emission reduction of GHG. In Belize, renewable energy technologies are not yet disseminated because there are still no incentives and state policy for the introduction of renewable energy.

3） Solar Photovoltaic

In Belize, the introduction of the photovoltaic (PV) system is limited. According to PUC, the installed capacity of PV system is only 0.003% of the total installed capacity of power generation in Belize. In remote areas where grid extension is not available, the PV systems were installed by an Italian project and a collaborative project of Belize and Cuba. In the project, 100-Wp capacity of PV module, battery charge controller, inverter and battery are installed in 85 households and public facilities in non-electrified areas which are far from the existing power network. This project was carried out in 2004 and introduced by NMS on the web.

The number of installed PV systems is limited in Belize. It is considered that there is potential demand for rural electrification through stand-alone small PV systems and wind power generation because the electrification rate is as high as 90% in Belize. On the other hand, the dissemination of the PV system for grid connection is considered difficult, as one of the reasons is the high initial investment cost of equipment.

(2) Power Sector

The national power supply service in Belize depends on BEL (Belize Electricity Limited), a power distribution company. For the past three years, peak power increases by approximately

5% every year. The peak power in 2008 was 74.3 MW, and that in 2009 is 76.17 MW, which was recorded at 2:00 p.m. In 2009, the total installed capacity of the national electric utility became 117 MW due to the connection with some new stand-alone power stations. The capacity has surpassed 76 MW of the maximum national demand. In this condition, it is possible to supply the domestic electricity demand. The import power is procured from the Federal Power Commission (CFE: Comisión Federal de Electricidad) of Mexico. However, a serious accident occurred in a main power station, after which power supply to Belize was temporarily stopped in April, 2009. Subsequently, power was supplied restrictively. An electric power purchase statement of mutual agreement (PPA: Power Purchase Agreement) was canceled in October of the same year. CFE continues to supply power to BEL as far as possible. However, compared to the unit power purchase price from domestic IPP, the unit price from Mexico is more economical. Therefore, the amount of imported power from CFE is still high as about half of the national generation sources. Figure 1-2 shows the generation sources in Belize.

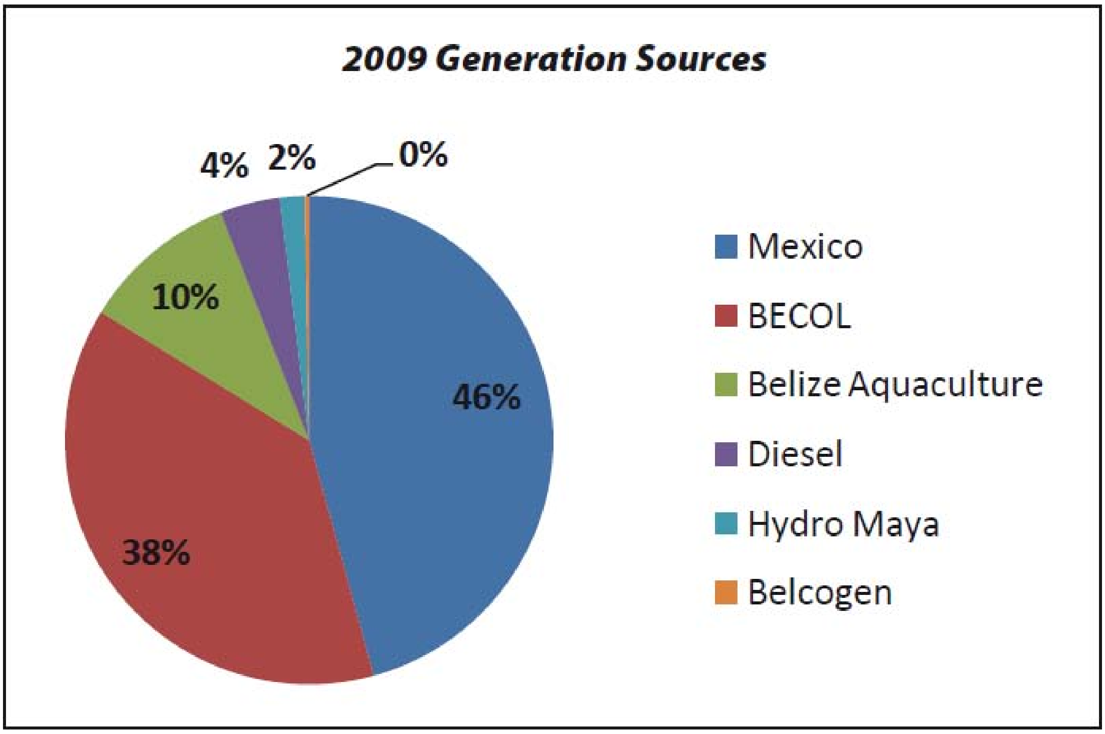


Figure 1-2 Belize Generation Sources (BEL Annual Report 2009)

BEL purchased 54% and 46% of its electricity from CFE in 2008 and 2009, respectively; 3% in 2008 and 2% in 2009 from Hydro-Maya; and 41% in 2008 and 38% in 2009 from BECOL. Finally, BEL generated only 2% and 4% of its electricity by diesel generator in 2008 and 2009, respectively. In total, BEL purchased 463 GWh and 473 GWh of electricity in 2008 and 2009, respectively.

Power output from hydraulic power station decreases in the dry season, therefore import of electricity from Mexico becomes the unfavorable trade balance. There is an impact on the stable supply of electricity due to the fluctuation of international crude oil prices. In addition, there are considerable numbers of blackout (around 30 times a year) by accident or blackout of the power grid of Mexico, from which almost half of the national power demand is imported. At that time, power is generated by emergency diesel generators to compensate. From the above mentioned situation, the Belizean government is seeking for the introduction of alternative energy sources such as hydro, biomass, PV and wind, which do not depend on imported electric power and fossil fuel.

1）National Grid

Figure 1-3 shows the national grid of Belize. The grid voltage is 115 kV and connected from Mexico to the southern part of country. In each area, the voltage is stepped down to 69 kV, 34.5 kV, 22 kV and 11 kV for distribution.

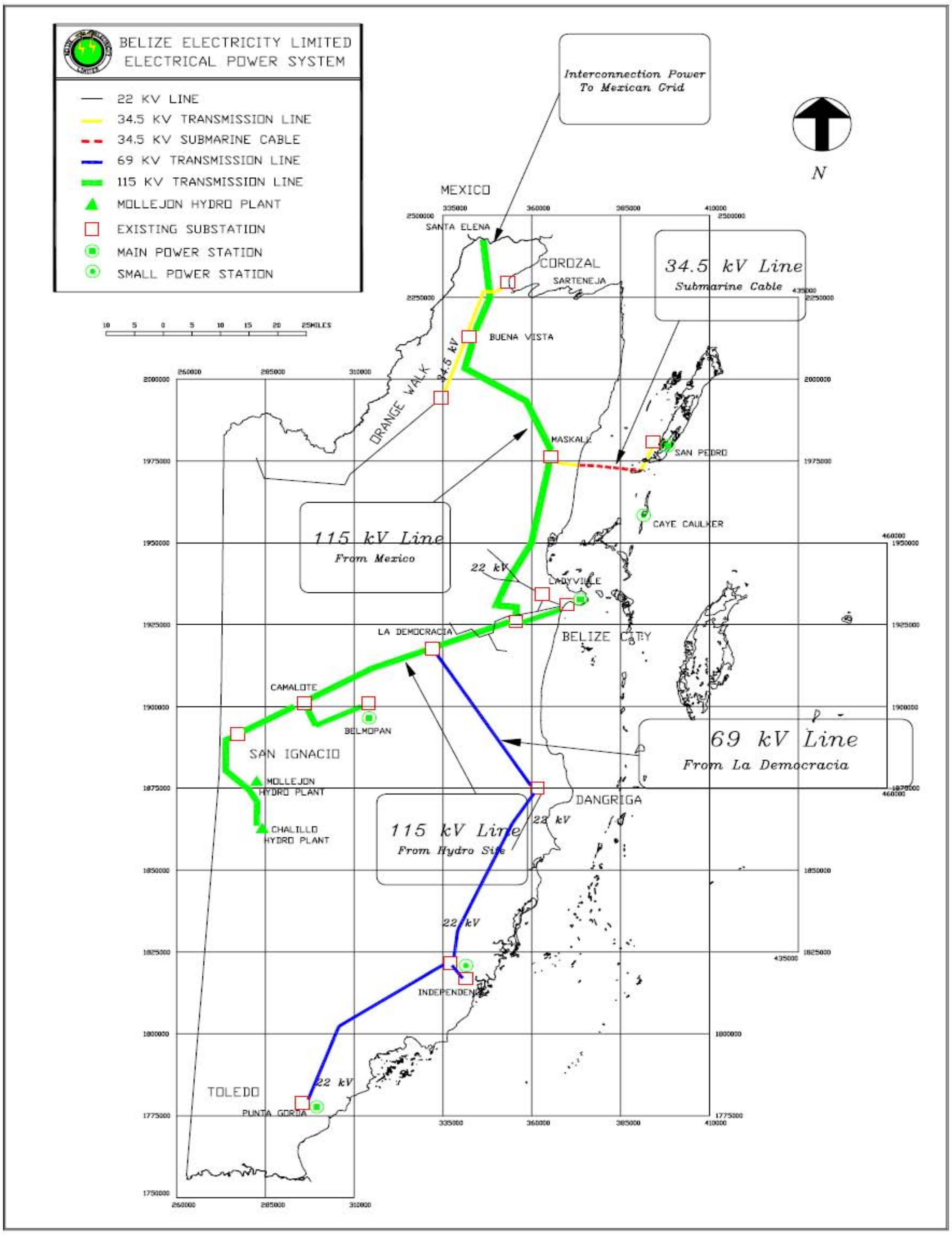


Figure 1-3 National Grid (Source: BEL)

2) Power Supply

The daily load curve of Belmopan by BEL and annual load curve from an electricity rate collection bill from the Ministry of Finance is shown below.

(a) Daily Load Curve

Figure 1-4 shows the daily load curve of Belmopan substation in Belize. The figure shows the typical Belmopan load profile (April 6, 2009 measurement data). The following figure is prepared based on the measured power every 3 hours at each feeder.

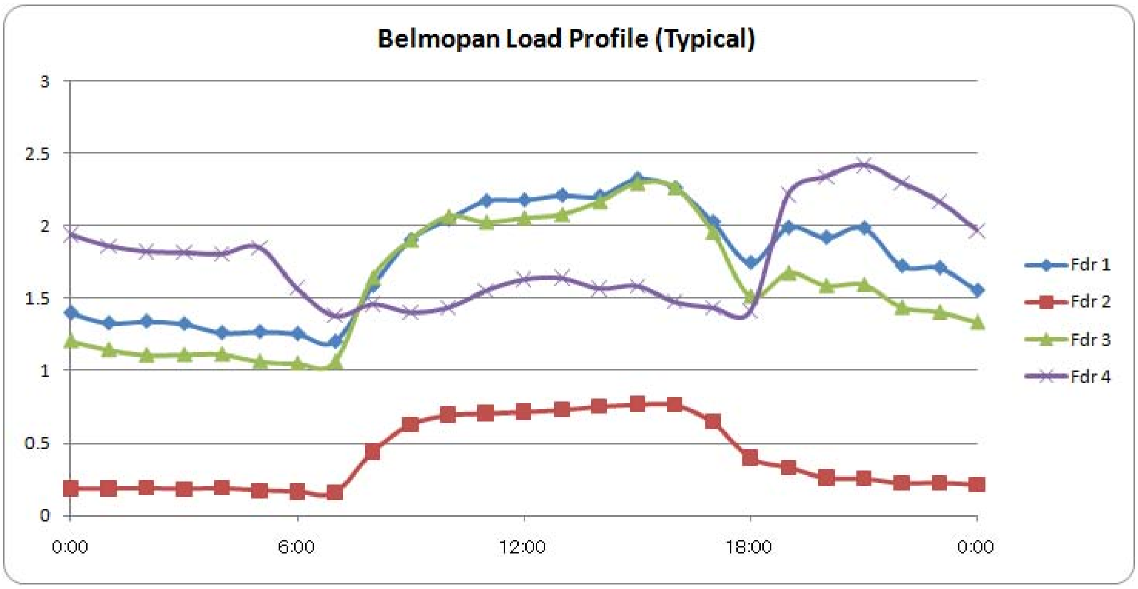


Figure 1-4 Daily Load Curve (Belmopan Sub-station)

(Source: BEL)

The following conclusions can be deduced from the daily load curve:

(i) At the Belmopan substation, electric power is consumed well from 9:00 to 18:00, and the consumption decreases from 0:00 to 8:00. The electric power increases from 9:00 to 18:00 are attributed to increases in loads due to air conditioners and lighting in offices or stores. There are many offices around the governmental buildings in Belmopan, and more electricity is consumed during the daytime. It seems that the population moves to the environs by nighttime.

(ii) In particular, from 12:00 to 16:00, Feeder-1 to Feeder-4 become overloaded, i.e., the total load is over the rated capacity of the transformers (Rated 5.6 MW, Max. 7.0 MW).

(b) Annual Load Curve

Figure 1-5 shows the annual load curve of governmental buildings in Belize. The figure is prepared based on electricity rate collection bill of the MOF. The figure shows the annual load curve from June 2007 to July 2008. In addition, it was supposed that the electricity consumption was almost proportional to the electricity rate and calculated the electric energy at an average of 1 kWh = Bz$0.4. (Exchange rate: 1 Bz$ = 46 J¥)

The monthly electricity rate of the whole Belizean government is J¥52.7 million as the maximum and J¥42.5 million on the average. It is expected that the main load supply from the Belmopan substation is for governmental buildings. The following matters can be estimated from the annual load curve: The annual electric power consumption increases in summer (from May to October), and decreases during the winter season (from November to April). Power consumption increases in summer because of the operation of air conditioners in offices. It seems that operation of air conditioners decreases in the winter season, with the lighting in offices, personal computers, and refrigerators mainly comprising the general loads.

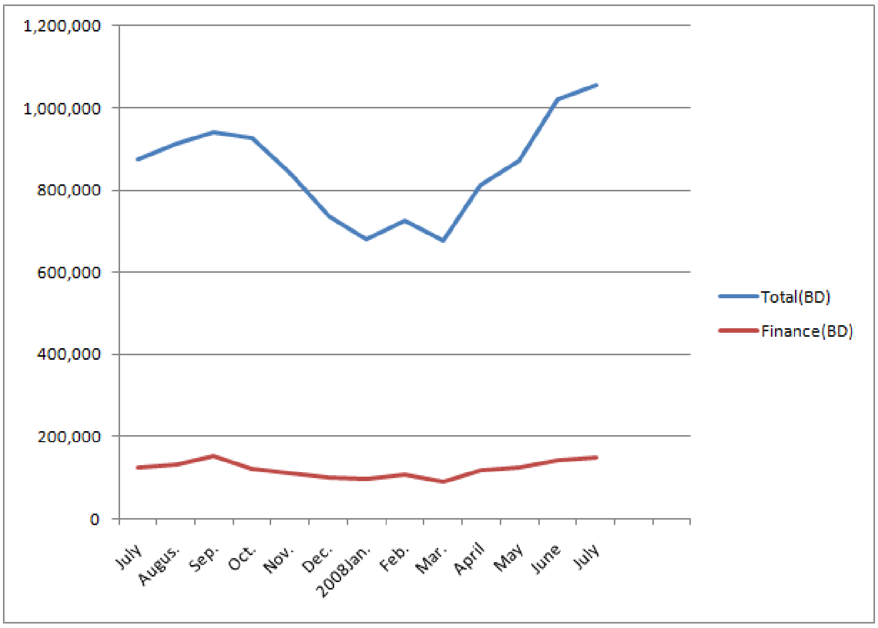


Figure 1-5 Annual Load Curve (Belmopan Sub-station)

(BD: Belize Dollar) (Source: MOF)

3) Power Tariff

The power tariff structure (Approved Tariff Rates: April, 2007) by BEL is divided into the following six types presented in Table 1-1. In the structure, the unit price of power decreases with the increase of power consumption. The table shows the unit price of electricity by classified power demand. In addition, the real average of the selling power price was BZ$0.441/kWh in 2009. Unit price of street lighting is highest and was paid by the Belizean government.

Table 1-1 Power Tariff Structure

Power Demand	Unit Price (Bz$/kWh)
1)Social Rate Customers	
Minimum Monthly Charge3	$4.00
0 – 50kWh	$0.26
2)Residential Customers	
Minimum Monthly Charge3	$5.00
Monthly Service Charge	$0.00
0 – 50 kWh	$0.35
51 – 200 kWh	$0.44
Above 200 kWh	$0.47
3)Commercial Customers	
Monthly Service Charge	$100.00
0 – 10,000 kWh	$0.45
10,000 – 20,000 kWh	$0.44
Above 20,000 kWh	$0.43
4)Industrial 1 Customers	
Monthly Service Charge	$100.00
Monthly Demand Charge per kVa	$35.00
Off Peak Energy rate per Kwh	$0.33
Peak Energy Rate per kWh	$0.33
5)Industrial 2 Customers	
Monthly Service Charge	$100.00
Monthly Demand Charge per kVa	$21.00
Off Peak Energy Rate per kWh	$0.28
Peak Energy Rate per kWh	$0.28
6)Street Lights	
Energy Rate per kWh	$0.55

(Source : BEL)

4）Organization

Figure 1-6 shows the organizational structure of BEL.

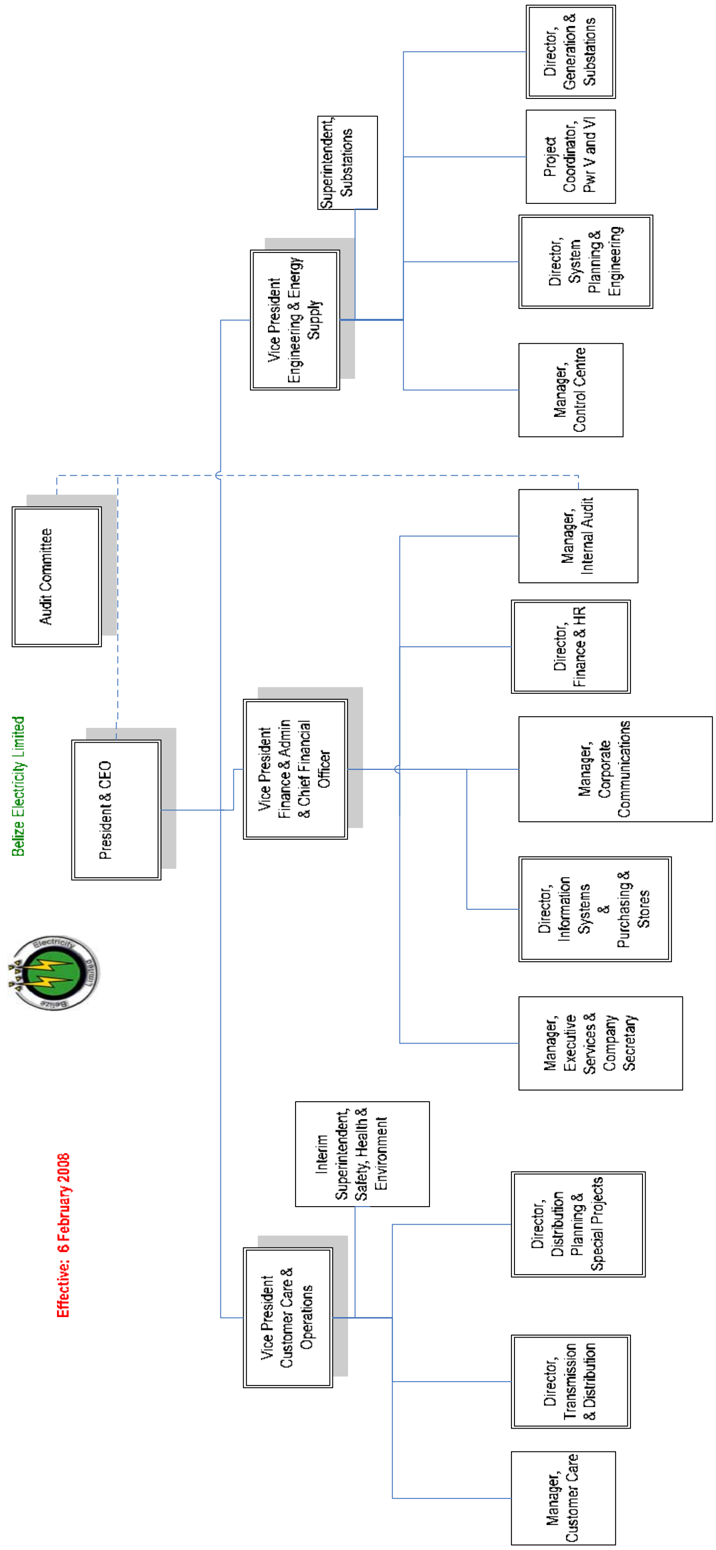


Figure 1-6 Organizational Structure of BEL (Source: BEL)

(3) Natural Conditions

Belmopan is the capital of Belize. Built in 1970, it is the seat of government and has been classified as the Garden City of the country. It was created following the extensive damage to the former capital Belize City caused by Hurricane Hattie in 1961. Belmopan is geographically located at the center of the country, some 80 kilometers on a higher ground to the southwest of Belize City. It serves as a hurricane refuge for Belizeans and has the largest number of hurricane shelters in the country. Its population today is estimated at 16,000 and is increasing as more people relocate to the capital. However, Belize City still remains the hub of commercial activities and one of the most urbanized centers of Belize, with a population of 58,000 people.

The climate of Belize is characterized by marked wet and dry seasons separated by a cool transitional period. The rainy season begins in the south in the middle of May and arrives in the north in mid June. It continues through to November, but most locations experience a drier period in August. Some 60% of annual precipitation occurs during this season, produced primarily by tropical systems, including tropical cyclones. The cool transition period occurs from November through February. Rainfall declines and approximately 12 cold fronts cross Belize during this period. The true dry season is from February to April and is produced by strong anticyclones in the Atlantic that generate a persistent stable south-easterly airflow across the country.

Average maximum temperatures are near 85°F and the lows are in the low 70s. Summers are about 8 degrees warmer than winters. The diurnal temperature range in the interior is greater than that along the coast, where it is moderated by the sea breezes. For example, minimum temperatures in the interior are about 5 degrees cooler than those at coastal locations. The mountainous regions are also cooler, exhibiting a fall in temperature of 10°C/km (5°F/1,000 ft). Humidity hovers around 80% throughout the year, although it is somewhat lower during the months of the dry season.

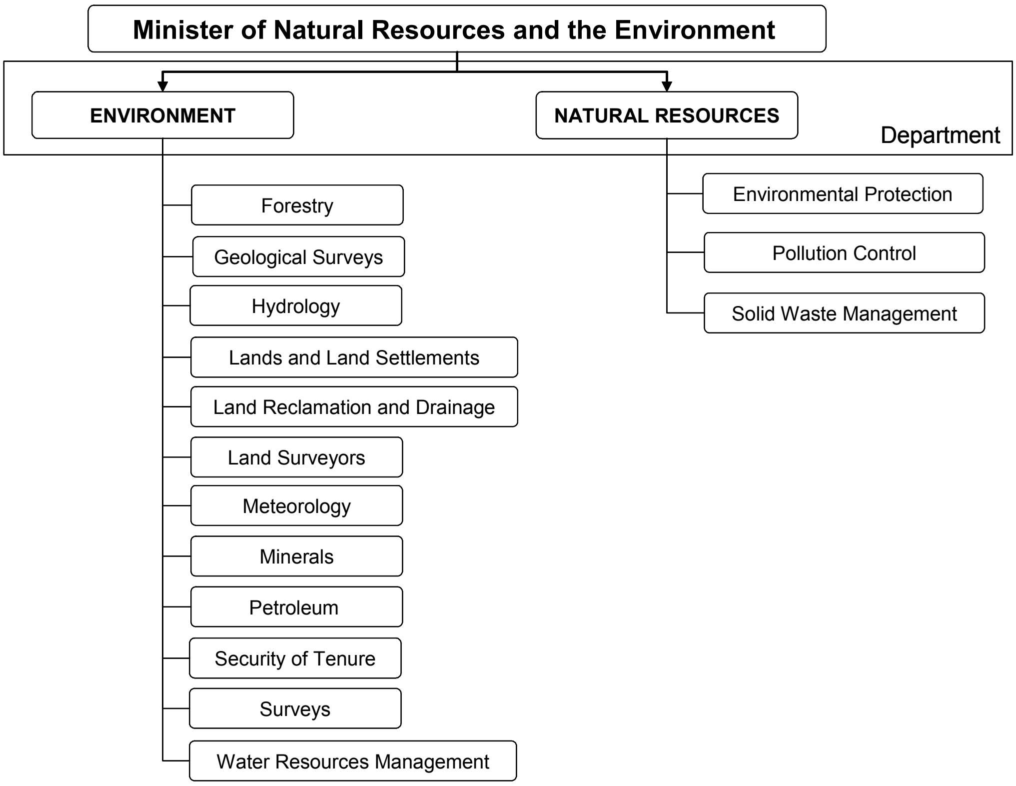
(4) Environmental and Social Considerations

1) Environmental Impact Assessment

a) Organization of the Ministry of Natural Resources and Environment

The governing agency for environmental problems and environmental impact assessment in Belize is the Ministry of Natural Resources and Environment. The ministry's organizational chart is shown below. The responsible section for EIA is the Department of Environment, which advises and administers issues concerning the environment. It is responsible for 27 specific areas, including the following important functions:

- Responsibility for continuous and long-term assessment of natural resources and pollution, and
- Administrative powers such as issuing of licenses, conducting research, maintenance of a register of wastes, discharges and emissions, undertaking investigations and inspections to ensure compliance with the Act, undertaking public awareness campaigns, monitoring environmental health, advising government on forming policies related to good environmental management, advising on any aspect of conservation and the effects of any sociological or economic development of the environment.



(Source: The Ministry of Natural Resources and Environment)

Fig.1-7 Organization of the Ministry of Natural Resources and Environment

b) Regulation of Environment Impact Assessment (EIA)

The environmental impact assessment (EIA) system in Belize was enacted on 1995. Its basic principle is set down by the basic environment law, Environmental Impact Assessment (Amendment) Regulations, Statutory Instrument No.24 of 2007. The regulations was made by the Minister responsible for the environment in the exercise of the powers conferred upon him by Sections 21 and 44 of the Environmental Protection Act (Cap. 328 of the Revised Laws of Belize 2000), which is the most significant advancement in the environmental laws of Belize. The Environmental Protection Act covers the preservation, protection and improvement of the environment, sustainable use of natural resources, and control of pollution.

c) Target Projects (Type of industry, Land size, Water utilization, etc.) of EIA

The environmental regulation required that EIA projects are divided two categories, Schedule I and Schedule II. Schedule I categorized projects iinclude 12 types, and each categorized project shall have a completed EIA for the project, program, undertaking or activity. Schedule II categorized projects total 19 and others may require an EIA or limited level environmental study depending on the location and size of the project.

d) Environmental Impact Assessment of the Project

The project type was categorized ‘Energy Generation and Distribution Projects’ Since the project scale is smaller than those in the regulation scale (the electricity generation scale is under 15MW), the project has no required EIA process,

As already stated above, it is assumed that no negative impact would affect the surroundings of the project area at central campus of University of Belize, because its scale is not large, and the project area is vacant.

2) Activities for Mitigation of Greenhouse Gas Effects in Belize

a) Public Policy and Climate Change Adaptation at National Level

Belize signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it in 1994. In view of the possible opportunities presented by mechanisms developed under the convention, Belize has attempted to keep abreast of developments to the degree its resources permit. There are Belizean representatives on the IPCC working groups and delegates regularly attend IPCC meetings. Delegates also attend the Conferences of the Parties (COP) and Subsidiary Body Sessions of the COP of the UNFCCC, and most regional meetings involving the Central American and CARICOM states. It does not, however, have any formal climate change office. The National Meteorological Service is the focal point for all matters related to climate change.

b) National Emissions in Terms of CO_2 Equipment

Total GHG emissions do not, however, reflect the relative impacts of the different gases on the atmosphere. Methane (CH_4) has a greenhouse effect 24.5 times, and nitrous oxide (N_2O) 320 times, more powerful than CO_2. This can be captured by converting the tonnage of each gas to its CO_2 equivalent by multiplying by the appropriate global warming potential (GWP) factor. The GWP is based on the relative radiative forcing of each gas and its lifetime within the atmosphere. This emphasizes the importance of methane and nitrous oxide sources, and changes the picture substantially. The emissions by gas and their CO_2 equivalents are given in the following table.

Table1-2 Greenhouse Gas Emissions by Type of Gas

GHG	CO_2	CH_4	CO	NOX	NMHC(Non methane volatile organic compounds)	N_2O	SO_2
Global Warming Potential Factor	1	24.5	N/A	N/A	N/A	320	N/A
CO_2 Equivalent	2589.668	6652.044	N/A	N/A	N/A	190.72	N/A

Note: First National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change (July 2002)

c) Efforts on Clean Development Mechanism

Belize has no CDM projects that have received any national approval letter at the project ideas.

According to WILBER SABIDO, who is the Chief Forest Officer of the Forest Department, there is no existing CDM project in Belize. The BELCOGEN biomass project may be the only project that can qualify for CDM in Belize. Other projects such as the proposed landfill project at the Miles 22 dumpsite is still in the conceptual stage. A feasibility study on a wind generation project located in the Mountain Pine ridge area of Cayo District is presently being considered. Likewise, a feasibility study on cellusite is presently being carried out.

3) Environmental Education

a) National Policy for Environmental Education.

According to Mr. WILBER SABIDO, Belize has no existing policy for environmental education. Each department formulates its own strategy in disseminating environmental issues and concerns.

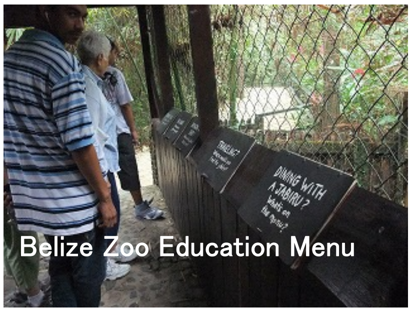
b) The CCCCC

According to Mr. CARLOS FULLER, Deputy Director of the CCCCC, the center has an environmental education program for World Climate Change. They are carrying out environmental education using the program for school and high school students in Belmopan City. And because CCCCC is organized by 15 Caribbean countries, government officials of these countries sometimes visit their center. The CCCCC is interested in the project, and thus have offered to cooperate with the Study Team to prepare a new environmental education program for the PV system and implement environmental education using the program.

c) NGOs in Belize

NGOs play an important role in environmental conservation mostly in the areas of education and the establishment and management of protected areas on both land and sea such as Belize Audubon Society (BAS). The BAS seeks funding from international NGOs and foreign governments to carry out its environmental education program. It builds museums and visitor centers, cabins, restrooms and other facilities in the protected areas it manages. BAS manages a total of six protected areas and runs environmental education programs directed at school children, with focus on the beauty and diversity of nature and the need for conservation.

The Belize Zoo and Tropical Education Center is primarily directed at education, organizing in-school programs as well as encouraging school visits to the zoo itself. They also conduct breeding programs, such as of the iguana and the great curassow. They also work in partnership with other groups.


Belize Zoo Education Menu

4) Construction Waste

At the project construction site, effective recycling and utilization should be promoted in general, to reduce waste amount as much as possible.

Waste management is managed by the local government, and collection and transportation for the final disposal site have also been carried out by local governments. Belmopan City, where the project area is located, has a final disposal site; appropriate recycling of other materials by the project constructor would also be implemented, with the permission of Belmopan City.

The regional waste disposal project of IDB, namely the 'Western Corridor Solid Waste Management Project' is currently in progress.

1.1.2 Development Plan

(1) Energy Policy

There is no energy policy on renewable energy in Belize. However, development of renewable energy such as hydraulic and biomass power generation has been carried out from 1991. In the Energy Policy Recommendations Report, the following policies are mentioned.

- A comprehensive National Energy Policy should be developed, using the multi-stakeholder dialogue process.

- An Office of Energy should be created under the Office of the Prime Minister, with the responsibility for the oversight and planning of the approach on energy issues.

- Energy data should be collected and analyzed on a regular basis.

- Regional energy networks and initiatives that have potential benefits to Belize should be identified.

1.1.3 Social and Economic Status

Belize is located as part of Central America and Yucatan Peninsula between north latitude 15°45’ to 18°30’ and west longitude 87°30’ to 89°15’. There is a border with Mexico in the northern part of the country, while there are borders with Guatemala in the western and southern parts. The eastern part faces the Caribbean Sea. Among the 2,960 km^2 of national land, 95% is located on mainland and 5% are located on over 1,060 islands. The whole national region, including territorial waters, is 46,620 km^2. More than half of the northern area and most of the southern area, in total one-third or more, are territories along the coastlines or islands with flat low land. Most of the area which is located far from the coastlines is lowland less than 1 m above sea level. In the northwestern side of the country, there is an area with an altitude of approximately 250 m above sea level. The Maya and Pine mountain chains ridges lie in the central region, with the highest spot at 1,124 m above sea level.

Belize is made up of plural races, and according to the census of 2000, 48.7% of Mestizo, Creole 24.9%, Maya 10.6%, Garifuna (hybrid race peculiar to Central America) 6.1%, and others 9.7%. In the past 100 years, the population of Belize increased rapidly by birth and immigration. In Belize, the youth population increases by a high birth rate and a low mortality rate, and those 15 years or younger comprises 42% of the country’s population. The life expectancy of people is prolonged through the improvement of the medical care conditions, and there is some tendency for those 65 years old or older to further increase the population, too.

The economic size of Belize is not large. Tourism is the biggest business that provides foreign currency revenue for private enterprises. It is followed by the export of aquatic products, citrus, sugarcane, sugar, banana and clothing. The average growth rate of the GDP was approximately 4% per annum for the term from 1997 to 2007. This was led by the expansive monetary policy and fiscal policy of government starting in September 1998. On the other hand, economic growth was promoted by the discovery of oil fields in 2006. Petroleum production quantities increased in 2009 through contentious exploratory research and production. However, there is a large amount of trade deficit equivalent to approximately 70% of GDP. Moreover, the serious problem on foreign liability is a continuing concern. The government decreases the paying interest of commercial debts and reduces the national liquidity fund. It aims at the reconstruction of the public external commerce debt. Poverty reduction through the aid of an international donor is included to achieve the goal in the short term.

1.2 Background and Outline of Program Grant Aid for Environment and Climate Change

The Program Grant Aid for Environment and Climate Change of the Government of Japan (GoJ) is introduced as the assistance to developing countries aiming to achieve both emission reduction of GHG with economic growth, and climate stability. As one measure, Japan established a new financial mechanism called "Cool Earth Partnership". Through this mechanism, Japan decided to cooperate actively with developing countries in their efforts to reduce emissions, such as promoting clean energy. At the same time, Japan is extending its hand of assistance to developing countries suffering from adverse impacts as a result of climate change. In accordance with the “Cool Earth Partnership” initiative, the Japan International Cooperation Agency (JICA), in consultation with GoJ, decided to conduct the preparatory survey on the Project for Clean Energy Promotion Using Solar Photovoltaic System in Belize.

The main objective of this project is to reduce GHG emissions using grid-interconnected PV system, which is introduced to Belize for the first time. The PV system, having an output capacity of 350 kW, is installed inside the University of Belize in Belmopan City. Therefore, it is necessary to assist the operation and maintenance personnel through the use of a soft component (technical assistance) which is required for the technical training on the operation and maintenance of the PV system.

1.3 Assistance by GoJ

There is no official development assistance project in a related sector by GoJ.

1.4 Assistance by Donor Countries and International Organizations

In Belize, biomass power generation and solar thermal projects have been carried out. However, there is a few experience of project using photovoltaic power generation. In 2004, the Solar Home Systems (SHS) were installed at non-electrified areas in Belize and Cuba through the national aid of Italy. The aid amount is unidentified. There is no experience of any project on mitigation of climate change and PV system that was implemented by other international agencies or donor countries.

Chapter 2
CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

(1) Upstream Plan and Objectives of the Project

1) Upstream Plan

In Belize, a national policy or strategy on energy sector has not been formally established. Through the cooperation of UNDP and the Public Utilities Commission (PUC) of Belize, the "Energy for Sustainable Development toward a National Energy Strategy for Belize" was developed as a policy proposal in 2003. For the establishment of the basic policy on energy, preparatory work is being conducted.

As an optimum option for the reduction of environmental load, the introduction of renewable energy, including solar, is considered since technical and economic aspects are improving and is more feasible now. Moreover, the introduction of renewable energy is recommended in the proposed policy on energy, which is already under preparation. In PUC, the development of a law on grid-connected renewable power generation systems such as Independent Power Producer (IPP) is being considered to be established by January 2011.

2) Objectives of the Project

Under the project on grid-interconnected solar PV system, it is possible to contribute to the reduction of greenhouse gas (GHG) emission through the reduced consumption of fossil fuel during peak power demand, which is supplied using the diesel engine generator of Belize Electricity Limited (BEL). Such situation is realized during power overloading in the Belmopan governmental area. Therefore, this project will contribute to the mitigation of climate change in Belize, being among the beneficiaries of the cool earth partnership initiative of Japan.

As mentioned above, the Government of Belize (GOB) needs to have the promotion of renewable energy projects under a long-term policy as objective. In this project, the capacity of the 350kWp system will be introduced as the first grid-interconnected solar PV project in Belize. This will contribute to supply electricity to the University of Belize (UB) and other consumers connected to the grid. In addition, the project will contribute in providing technical training for solar PV system and raising awareness activities on environmental aspects.

3) Summary Description of the Project

In the agreement requested by the GOB, necessary equipment for grid-interconnected solar PV system will be introduced in the project. The equipment should be procured according to necessity, adequacy and sustainability of climate change mitigation. The scheduled equipment and technical supports are as follows:

<u>Equipment：Grid-interconnected solar PV system</u>

(Application)：Grid-interconnected solar PV system. Generated power will be supplied to the existing distribution network.

(Necessity)： Under the energy policy of the GOB, it is possible to contribute to the reduction of GHG emission and reduce consumption of fossil fuel for power generation, by operating a grid-interconnected solar PV system.

<u>Soft Component (Technical Assistance)：Solar PV technology</u>

(Contents)：
- Basic knowledge on solar PV
- Management skills for solar PV plant
- Technology of grid-interconnected PV system
- Operation and Maintenance (O&M)

(Necessity)：
- Limited number of solar PV Engineers
- First project on grid-connected solar PV system

2.2 Outline Design of the Requested Japanese Assistance

2.2.1 Design Policy

(1) Basic Policy

This project introduces the solar PV system as a renewable source of energy, which is intended to reduce environmental loads and contribute to climate change mitigation in Belize. Introduction of grid-interconnected solar PV system is the first project of this kind in Belize. Therefore, it is necessary to consider maximizing the project effects within the short- and long-term periods for the establishment of basic plan. In general, the silicon crystalline type and amorphous type of PV modules are mainly disseminated in the market. For the basic design of this project, selection of module type is necessary, considering the following conditions on expressing effective benefits. In this project, aside from power generation by solar PV, reduction of GHG emission is among the important results. Monitoring display board which indicates operational condition will be installed at the entrance of the Jaguar Building of the UB Central Campus site. The situation of generated power indicated through the monitoring display board is expected to effectively raise awareness of students and personnel of UB, on issues such as PV system and environment. Considering project sustainability, human resource development for O&M staff and introduction of awareness-raising scheme on environmental aspects will be the important components.

(2) Policy of Natural Conditions

Solar PV system will be installed at Belmopan, 80 km away from the coast and about 80 meters above sea level. The temperature in the city is 26 °C in summer and 24 °C in winter. Annual precipitation is not small with around 2500 mm. Relative humidity reaches as high as 85% throughout the year. The wind speed recorded is 73.7 m/sec (Category - 5) in 1955 and 2007, near the airport at Belize City. Considering hurricane occurrences at the site, design wind speed adopted is 60 m/sec (Category-3), which is the same as the design wind speed for the distribution line. As countermeasure, protection board will be used against uplift wind pressure.

The following meteorological conditions will be considered in the plan.

1) Ambient Air Temperature

Maximum Ambient Temperature:	40 ^{o}C
Minimum Ambient Temperature:	5 ^{o}C
Annual Average Ambient Temperature:	25.4 ^{o}C

2) Latitude and Longitude

Latitude: 17° 01' north
Longitude: 88° 05' west

3) Altitude

Altitude: 80m above sea level (Belmopan)

4) Relative Humidity

Relative Humidity: 75 to 92% (no seasonal variation)

5) Rainfall

Annual Mean Rainfall: 2500 mm

6) Wind Velocity

Maximum Wind Velocity: 60 m/sec

7) Solar Irradiation

Annual Horizontal Irradiation for Design: 4.5 kWh/m^2/day

8) Earthquake Factor

Earthquake Factor: 0.1

9) Salt erosion: none

(3) Environmental Impact Assessment (EIA) of the Project

The Department of Environment under the Ministry of Natural Resources and Environment (MoNE) is the agency responsible for IEE (Initial Environmental Examination) and EIA (Environmental Impact Assessment), under the GOB. The project type is categorized as 'Energy Generation and Distribution Projects'. However, the EIA process is not required for projects involving generation capacity below 15 MW. IEE have been approved by Department of Environment on 3 September 2010. Issues on environment notice are to be considered tree cutting and glare by solar array.

(4) Policy for Social and Economic Status

Belize is located in the Central American mainland, forming part of the Yucatan Peninsula. It is bounded on the north by Mexico, to the west and south by Guatemala, and to the east by the Caribbean Sea. Most lands in the country are flat and low-lying. The central part of the country is dominated by the Maya Mountain/Mountain Pine Ridge massif, rising to 1,000 m as its highest point.

In Belize, the national economic market is small. Its source of exchange is largest in tourism, followed by the export of marine products, and then agricultural products. Annual growth rate of GDP has been sustained at 4% from 1999 to2007. Growth then slipped to 3% in 2008 and -1.5% in 2009.

According to the annual report of Belize Electricity Limited (BEL), imported electricity from Mexico is decreasing from 54% in 2008 to 46% in 2009 in Belize. Thus, basic design will follow that generated power by PV system will be used effectively.

(5) Policy for Situation of Construction in Belize

It is the first project to introduce grid-interconnected solar PV system in Belize. Most electric companies in Belize are conducting electrical works on distribution lines. However, since this is the first grid interconnected PV system, they have no work experience on solar PV system with over 350 kWp capacity. Most of the electrical companies are relating with the work on distribution line. Nevertheless, said electrical companies may possibly support the installation of solar PV system. However, it seems that there is a problem with regards to hiring workers in Belmopan since its population is limited to 16,000. Procurement of workers from Belize City can therefore be considered. In this project, all engineers have to register with APEB(Association of Professional Engineer in Belize), after that, engineers and wire men from Japan or other countries have to register with PUC. On the other hand, construction materials such as reinforcing bars and cement are available in the local market.

As mentioned above, installation is included in the scope of the Japanese contractor. The contractor will send a supervisor for the installation work while the workers will be hired at the site.

(6) Ability of Implementing Organization

Most of the technical staff in the implementation organization, Ministry of Works (MOW), are civil engineers. They have no electrical staff and their mechanical staff's role is dedicated to O&M of traffic signals all over the country. They have no experience on O&M of electrical equipment which are operated by high voltage in MOW and other public organizations. Meanwhile, BEL as the local electric company, operates and maintains high voltage equipment.

There is a plan to organize the O&M staff under MOW as a counterpart organization for this project. It is necessary to carry out technical training and support for the O&M of high voltage electrical equipment and PV system. It is necessary to consider contracting out O&M to BEL before the installation works.

The table below shows the role allotment of the organizations concerned on O&M of PV system. The Ministry of Finance (MOF) will be the responsible organization in charge of cost management for O&M works. MOW, as the implementing organization, will be in charge of management of the system operation and data. Maintenance staff from UB or MOW will be in charge of daily maintenance of PV system, while BEL will be in charge of periodic inspections and repairing of the PV system. Moreover, UB will be in charge of guiding visitors to the PV facility and providing brochures to the visitors.

Table 2-1 Allotment of O&M Roles

Organization	Role
MOF	O&M cost management
MOW	Management of operation (including safe guarding of O&M manual and inspection reports) and data (which is monitored by PV system such as generated power and the amount of CO_2 emission reduction)
UB or MOW	Daily inspection of O&M; Introduction of facility; Raise awareness on the system
BEL	Periodic inspection of PV system, Repairing

(JICA Study Team)

The table below shows the list of main daily inspection items which will be conducted by UB or MOW staff under the project. Basically, complicated daily inspection is not necessary since PV system operates automatically. However, daily inspection is necessary to find out malfunctioning parts as early as possible. Furthermore, it is necessary to generate stable power output. The frequent daily maintenance prevents stolen and intentional damages to the PV system. The O&M staff of UB has been periodically conducting O&M works on the equipment in the university. The procedure for the daily inspection of PV system will be transferred to the O&M staff through technical assistance.

Table 2-2 List of Daily Inspection Items

Equipment	Visually Inspected Items
PV Array	Dirty and breakage of module surface
	Corrosion and rust of mounting structure
	Damage of outside cable
Junction Box	Corrosion and rust of box
	Damage on outside cable
Power Conditioner and grid-interconnection equipment	Corrosion and rust of outside surface
	Damage of outside cable
	Abnormal noise and sound during operation
	Clogging of filter at ventilator exit
	Surrounding circumstance（humidity、temperature）
Grounding	Damage of outside cable

Power Generation	Check operational conditions through the display meters and indicators
Surrounding Condition	Damage of fence, growth of vegetation, bird's nest, etc.

(JICA Study Team)

The table below shows the list of items subject to periodic inspection, which will be conducted every two months. Meanwhile, the detailed items to be periodically inspected will be instructed by the manufacturers of the installed equipment. The procedures for periodic inspection will be transferred to the O&M staff of BEL or a private company.

Table 2-3 List of Periodic Inspection Items

Equipment	Visually Inspected Items	Measured Parameters
PV array	Dirty and break of module surface	Insulating resistance（ ）MΩ
	Corrosion and rust of mounting structure	
	Damage of outside cable	Open circuit voltage （ ）MΩ
	Damage of grounding cable, tightness of grounding connection	
Connection Box	Corrosion and rust of box	Insulating resistance（ ）MΩ
	Damage of outside cable	
	Damage of grounding cable, tightness of grounding connection	
Power Conditioner and Grid Interconnection Equipment	Corrosion and rust of outside surface	Check function
	Damage of outside cable	
	Abnormal noise and sound during operation	Insulating resistance（ ）MΩ
	Clogging of filter at ventilator exit	
	Surrounding circumstance（humidity、temperature）	
	Damage of grounding cable, tightness of grounding connection	
Grounding	Damage of outside cable	Grounding resistance （ ）MΩ

(JICA Study Team)

It is necessary to confirm the contents of data monitored at the PV system. It is also necessary to store the data properly. When it is difficult to solve problems locally such as repair of parts that malfunctioned, MOW will take actions to get supports from manufacturers. Aside from the above management procedures, monitoring and data collection method of power generating condition and calculation of the amount of CO_2 emission reduction will be transferred. The table below shows the list of operational and data management items.

Table 2-4 Management of Operation and Data

	Items to be Supported
Operational Management	Operational condition
	Educational structure on O&M staff
	Coordination with manufacturers when necessary
Data Management	Monitoring of power generating condition
	Compile data of CO_2 emission reduction

(JICA Study Team)

PV system will be installed in the UB campus, which has around 3,400 students. In addition, visitors are expected such as the UB staff and those taking part in study visits. It is necessary for UB to designate personnel who will guide visitors to the PV facility. It will also further contribute in showcasing the effects of the system. Therefore, some UB staff should be able to conduct guiding of visitors to the PV system.

Table 2-5 Method of Raising Awareness

	Methods
Raising Awareness	Explanation of PV power generation system
	Hold a seminar
	Prepare and disseminate brochures on the PV system

(JICA Study Team)

(7) Policy on Procurement Process and Schedule

Main equipment components such as PV module, power conditioner and transformer will be procured in Japan. The procurement and construction work takes around 12 months after award of contract is certified. Almost of construction materials for foundation and fencing works are available in Belize city. Therefore, the foundation work shall be completed before arrival of procured equipment for smooth installation work. Procured equipment will be shipped through the Port of Belize City via Jamaica. After custom clearance, unloaded materials and equipment will be transported from Belize to Belmopan, which is around 80 km by inland transportation. It is necessary to consider the condition of access roads for transporting materials such as civil work items and equipment of the PV system.

(8) Policy for Planning Grid Interconnection

There is no guideline for grid-interconnected PV system in Belize. Therefore, the Study Team introduced the "Technical Guideline on Grid Interconnection for Securing Quality of Electricity" (prepared by the Agency of Natural Resources and Energy of Japan, 1st, Oct, 2004) to determine requirements for grid interconnection. Basic design of PV system should comply with the "Grid Interconnection Code" (JEAC-9701-2006) requirements, including the above guideline. This code applies to the installation of power generation system such as diesel engine, gas engine, gas turbines which generate alternative current, and PV system and fuel cell which generate direct current using inverter for grid interconnection.

1) Interconnection Plan to High Voltage Distribution Line

As the PV system has large capacity, the generated electricity will be fed to the existing distribution grid line of BEL as a condition of reverse current flow. Therefore, it can be said that this project adopts reverse current flow. The generated power will be supplied to 11 kV distribution line during daytime, and shortage of electricity for station service will be supplied from grid of BEL after sunset.

High voltage connection has economic advantage compared against low voltage connection because of the possibility of reducing power loss caused by distribution loss through simplified PV system.

In the "Grid Interconnection Code" of Japan, the interconnection which connects to the power generation system of over 50kW of installed capacity is categorized as high voltage or extra-high voltage interconnection.

2) Requirement for Grid Interconnection

The condition of grid interconnection for solar PV system is indicated as shown below.

(a) Power connection

Power conditioner has to supply power by three-phase three wires because distribution lines also consist of these wires.

(b) Power factor

Power factor at the connection point will be more than 85% as a reverse current flow condition, and it should not be the leading power factor from the viewpoint of the grid line.

(c) High harmonic distortion

The total current distortion rate is 5.0% or less. Each current distortion rate should be 3.0% or less.

(d) Coordination of system protection

The following protection devices will be equipped:

- Protective relay
- Over-voltage relay (OVR)
- Under-voltage relay (UVR)
- Over-frequency relay (OFR)
- Under-frequency relay (UFR)
- Island operation prevention relay
- Over-current relay (OCR)
- Over-current grounding relay (OCGR)
- Over-voltage grounding relay (OVGR)

In addition to the above requirements, the following functions and equipment will be implemented for ensuring electric quality and preventing power suspension.

(e) Installation of insulation transformer to prevent DC current flow to the connected grid.

(f) Circuit breaker cannot be closed to prevent supply of electricity during power failure. After the recovery from power failure, the circuit breaker cannot be closed for a certain period.

(g) Auto-reclosing system is equipped for 11kV distribution line at Belmopan Substation. Therefore, detecting device for no voltage of line will be required to install at power conditioner according to the "Grid Interconnection Code" (JEAC-9701-2006).

3) Influence of PV system to the grid line

There are influences of PV system to the grid line in the aspect of quality of electricity such as voltage fluctuation, frequency fluctuation and harmonic distortion.

(a) Voltage fluctuation

In the "Grid interconnection Code", the range of proper voltage fluctuation is limited within ± 10% for grid connection of high voltage. The standard range of voltage fluctuation is 11 kV ± 5 % according to the distribution company BEL. This range of fluctuation is within the permissible voltage range of automatic voltage adjustment function on PV system. Therefore, it is considered that the fluctuation will not affect both PV system and customers.

(b) Frequency fluctuation

There is no indication of frequency fluctuation range in the "Grid Interconnection Code". Frequency fluctuation range which is applied by Japanese electric companies is 50 Hz ± 0.2 Hz or 60 Hz ± 0.2Hz. However, according to the distribution company of Belize, the range is explained at 60 Hz ± 0.2Hz. Therefore, it is considered that the fluctuation will not affect both PV system and customers.

(c) Harmonic distortion

In the guideline, harmonic distortion rate stated is 5% or less in total current, and 3% or less in each current. According to the distribution company, the harmonic distortion rate is the same or smaller than that stipulated in the "Grid Interconnection Code". Therefore, it is considered that fluctuation will not affect both PV system and customers because harmonic distortion rate is within the appropriate range.

(9) Policy on the Relation of Laws and Regulations and Standards.

1) Laws and Regulations

A set of new electrical regulations is planned to be published in July 2011. On the basis of the information from PUC, the new regulations will not affect the implementation of the project on the grid-connected PV system. It is necessary to get permission from PUC before the General Procurement Notice on the installation of power generation facilities with the capacity of 75 kW and over. The applicant will be published a copy of the application within 14 days after submission of application. Required contents of application are as follows:

(a) Purpose (supply electricity to himself or sell to a distributor)

(b) Route for transmission line and land acquisition

(c) Environment impact application

(d) Description of the principal components for PV system, specification and drawings

(e) Generated power per annual, and total cost

(f) Identify the human capital for the Contractor and operation and maintenance

(g) Test items

Requirements for grid-connected PV system are not mentioned in the laws and regulations, such as electric system, voltage fluctuation, power factor and preventing run-off operation. Thus, the Study Team adopts the conditions for grid interconnection based on the "Grid Interconnection Code".

2) Applicable Standards

The following standards will be applied for the design, manufacturing inspection and test for procurement of sets of equipment.

(a) Electrical equipment and materials

In principle, Japanese standards such as Japanese Industrial Standards (JIS), Japan Electric Machine Industry Association (JEM), Japanese Electrical Committee (JEC) and Japanese Cable Makers' Association Standard (JCS) will be complied with for the main electrical equipment and materials which will be procured in Japan. Other equipment and materials will comply with IEC, ANCI, IEEE and Japanese standards such as JIS, JEM, JEC and JCS.

(b) Equipment for high voltage grid interconnection

It is recommended that the equipment for high voltage connection complies with the regulation and standards of electric companies in Belize because of maintenance and availability of spare parts. The Japanese standards such as JIS, JEC, JEM and other international standards such as IEC, ANSI, IEEE, as well as electric company standards, will be complied with for high voltage equipment for grid interconnection.

(c) Construction codes and rules for electrical works

The installation works, cabling works, and site tests for the PV system will be in accordance with Japanese standards to facilitate prefabricated installation. International standards such as IEC, NEC will also be applicable.

2.2.2 Basic Plan (Facilities Plan/Equipment Plan)

2.2.2.1 Facilities Plan

(1) Site Plan

Three sites were proposed by the Belizean side. The details of the proposed three sites are shown in the Table 2-6.

Table 2-6 Candidate Sites for PV System Installation

No.	Candidate Site (Area) (Ownership)	Site Condition	Surrounding Area
1.	Beside the Social Security Office (Land area: 40,000 m^2) (Social Security)	・Because there are no trees, it is not necessary to cut trees.	・This site is located along the ring road of Belmopan City. There is the Caribbean Community Climate Change Centre across the road. Showcase effect is very high.
2.	Backside of governmental building complex (Land area: 50,000 m^2) (Social Security)	・There are trees in the area. It is difficult to install PV system without felling trees. ・The proposed site is a place where gatherings are held.	・There is a ring road near the site, and it is located at the back of the government office building. Hence. awareness-raising effect is relatively high.
3.	Central Campus of UB (Land area: 8,000 m^2)	・This site is almost flat with low slope down to the north. ・The proposed site requires cutting of trees and repairing of access road.	・Because the site is located in a campus, the awareness-raising effect on students and personnel is high.

(JICA Study Team)

Finally, it was decided to select the campus of UB for the installation of the PV system. The process of selection is explained below:

(i) In the first site survey, three candidate sites were agreed with the Belizean side. The contents of the agreement were confirmed and signed on 14th August 2009. Thereafter, the study target area is agreed to be beside the social security as the first priority. Security of the land is requested from MOW as the implementing organization.

(ii) In the second survey, the Study Team prepared a technical note which was signed on the 10th of December 2009 with the agreement. In the technical note, the project site proposed is beside the social security office. This was confirmed and a site study for design was carried out. MOW submitted the request letter for land use to social security office on the 25th of November 2009.

(iii) The Study Team received an information indicating that the social security office does not allow the use of the land for this project.

(iv) In the third site survey, the difficulty of using the land beside the social security office was confirmed. Therefore, it was planned to select the project site from the other two candidates, which was agreed on 14th August 2009. In the re-selection procedure, land area, the certainty of securing land, showcase effects and grid interconnection point are considered. Second priority area is required to remove of many trees. Based on the results, the third priority area in UB was agreed with the Belizean side.

(v) In the fourth site survey, the acceptance letter for use of the land was issued by UB to GOB.

The following points are considered for the project formulation policy:

1) Showcase effect

Belmopan City is the capital of Belize and located approximately at the center of the country. Belmopan City has been developing as the center of government offices. Its population is approximately 16,000. Related organizations' interest in PV power generation is high. The showcase effect is expected to be high since the installation site is inside the UB campus.

2) Introduction of advanced technology and know-how of Japan

There were experiences on small-scale autonomous solar systems, mainly in the rural areas. However, there is no experience on installation of grid-interconnected power generation system. On the other hand, grid-interconnected solar PV systems are widely used in Japan. In this project, the advanced technology of Japan, such as in solar PV system and grid interconnected technology, can be applied.

3) Establishment of sustainable O&M structure

In the project, the person in charge of O&M will be trained under the soft component program because there is no experience on O&M of grid-interconnected solar PV system in the country. The technical transfer will be conducted with MOW as counterpart and implementing organization.

(2) Adequacy of the Installed Capacity

At the project site, it is possible to state that the adequate capacity of PV is 350 kW maximum based on the following conditions:

The silicon crystalline type modules with capacity of 180 to 210 W have conversion efficiency of around 14% to 19%. Meanwhile, amorphous type modules with the capacity of 80 to 130 W have conversion efficiency of around 6% to 9%. As a conclusion from the above conditions, the required area by amorphous type is 1.6 times larger than that of silicon crystalline type with the same rated capacity. However, periods of installation work have to be extended with the increase of required area. Therefore, the installation cost using amorphous type is around 20% higher than that of silicon crystalline. In this project, the available area is around 8,000 m^2 and hence, it is impossible to install the amorphous type of PV modules for 350 kWp. However, the silicon crystalline type module is adopted because of its high conversion efficiency. In this study, based on typical performance of 180 Wp capacity PV module, the necessary area and power outputs are estimated. The dimension of the sample module is 1 m x 1.5 m, and the optimum operational voltage is 30 Volts.

(3) Plan for Power Generation and Grid-interconnection

1) Power grid in project area

Regarding the distribution line around the UB where the PV system is planned to be installed, electricity is being supplied from the 115 kV/11 kV Belmopan Substation, which located in the west of Belmopan City and managed by BEL. Said substation is located at approximately 3.7 km from the PV system installation site. Furthermore, power is being supplied to neighboring institutions and customers. The capacity of transformer at the Belmopan Substation is 5,600 kVA (Oil transfer air cooling: Max.7,000 kVA). BEL is under construction of additional transformer with the capacity of 10/16 MVA (ONAN/ONAF II) at next to the Belmopan Substation. It will be completed by the end of September 2010.

Voltage fluctuation in PV side is caused by transformer, line, impedance of condenser and others, and load current as power demand. However, the reverse flow from the PV system to grid line is limited to 5.3% of grid capacity. PV system will be connected to Feeder-3 of BEL distribution line. The load in midnight is 1000 kW, and 2,400kW in daytime. Nominal voltage fluctuation is calculated in 1.4 % on light load and 3.0% on heavy load at 11kV. It is considered that there is no adjacent effect to increase the voltage at the substation because the voltage fluctuation will be within ± 10 %.

2) Grid interconnection and reverse flow

An isolated transformer of 11 kV / 230-400V (400kVA) will be installed at the installation site of the solar PV system. The power output from the PV system is connected to a low voltage distribution board. The low voltage distribution board is connected to the low voltage side of a step-up transformer for 11kV distribution line. The reverse power flow from the PV system will be supplied to the 11kV grid line of BEL. Since there is no grid-interconnected PV system in Belize, the "Grid Interconnection Code" will be applied.

The generated electricity from the PV system will be supplied as a reverse power flow to the power grid with 11kV. While operating the PV system at night time, low voltage electricity for operational equipment will be received from the existing grid. The demands for low voltage power are from data logger, lights, air conditioner and other equipment in the control house. In accordance with the results of discussion with BEL, it is necessary to provide space for the installation of the watt-hour meter supplied by BEL.

3) Estimated Power Output

In the project, appropriate tilting angle of solar module is estimated at 20 degrees for power output based on the location (latitude: 17.1, longitude: −88.5) and considering easy O&M. The direction of module is facing the South due to the located north hemisphere. The table below shows the estimated monthly power output. In the estimation, data of irradiation was obtained from NASA database.

Table 2-7 Estimated Power Output

Month	days	Irradiation angl 20 (kWh/m^2-day)	Ambient Temp (℃)	350 kWp	
				Power Output (kWh/day)	Monthly Output (kWh/Mo)
Jan	31	4.51	23.3	1,147	35,551
Feb	28	5.17	24.1	1,309	36,665
Mar	31	5.60	25.3	1,410	43,697
Apr	30	5.75	26.1	1,441	43,222
May	31	5.53	26.5	1,382	42,854
Jun	30	5.20	26.6	1,301	39,035
Jul	31	5.11	26.2	1,280	39,674
Aug	31	4.85	26.3	1,214	37,628
Sep	30	4.86	26.3	1,216	36,482
Oct	31	4.76	25.7	1,195	37,043
Nov	30	4.58	24.7	1,155	34,645
Dec	31	4.27	23.7	1,084	33,609
Average		5.01	25.4	1,260	38,342

Annual (350kWp): 460,106 (kWh/year)

(JICA Study Team)

4) Estimated CO_2 Emission Reduction

Solar PV system leads to reduction of CO_2 emission and serves as substitute to a power station which is operated by using fossil fuel.

The amount of CO_2 emission reduction is calculated based on the estimated power output. In Belize, there is no registered Clean Development Mechanism (CDM) project and unit of CO_2 emission reduction. National power generation consists of 53.4% of imported power from Mexico, 44.4% of hydropower from Hydro Maya and BECOL, and 2.3% of diesel generation. Each reduction unit is adopted in accordance with "CO_2 Emissions from Fuel Combustion - Highlights", which was published by IEA. As for the unit for diesel power generation, the representative figure of the unit in Central and South America area in 2007 was applied. The following shows the reduction unit of each type of power source:

Imported Power from Mexico: 0.547 (kg-CO_2 / kWh)

Hydro Power Station: 0 (no emission of CO_2)

Diesel Power Station: 0.762 (kg-CO_2 / kWh)

As a result of the general calculation shown below, the amount of CO_2 emission reduction through the use of PV system with 350 kWp capacity is approximately 142 tons per year.

Annual CO_2 emission reduction = emission reduction unit × Annual power output

= Import Power×CO_2emission reduction unit

+ Diesel Power ×CO_2emission reduction unit

＝245,697 (kWh/year) ×0.547 (kg-CO_2/kWh)

＋10,582 (kWh/year) ×0.762(kg-CO_2/kWh)

= 134,396 (kg-CO_2/year)＋8,063 (kg-CO_2/year)

=142,459 (kg-CO_2/year) **approx. 142 (ton-CO_2/year)**

(CO_2 Emission Reduction Unit＝0.547, 0.726 kgCO_2/kWh)

5) Power Generation and Demand

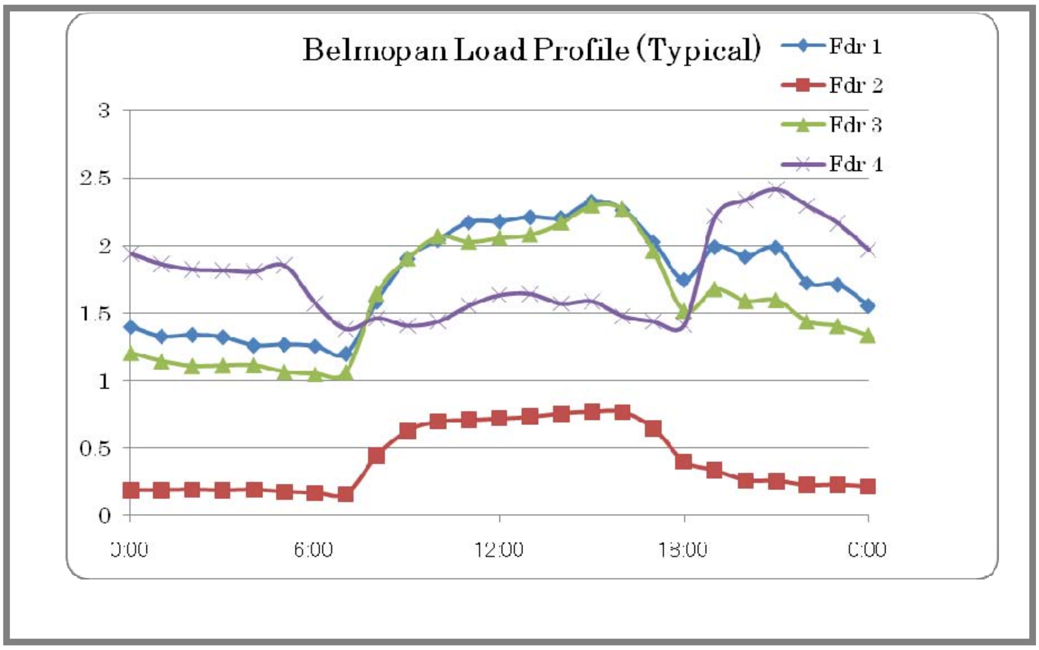
The following can be considered based on the daily load curve of the Belmopan Load Center of BEL in April 2009:

(a) The daily load curve of Belmopan Substation shows that the power consumption becomes approximately 6,600 kW from noon to 3:00 p.m. The consumption exceeds a rating capacity of the transformer to be 5,600 kVA. Overloaded capacity is supplied by diesel generators, which are being operated to accommodate the excess demand of electricity.

(b) The planned PV system with 350 kWp capacity will supply 420 MWh to meet the peak demand at daytime. This is effective to reduce generation facilities' capacity.

(c) The amount of CO_2 emission reduction by introducing the PV system with 350 kWp capacity becomes approximately 130 tons per year.

(d) Feeder 2 shows load curve for government offices, indicating that electricity consumption decreases after 18:00 hrs. On the other hand, Feeder 4 shows the load curve for suburban consumers, indicating that electricity consumption increases after 18:00 hrs. In the government office, units that require electricity such as air-conditioner decrease after 18:00 hrs. It is understood that electricity consumption due to use of nightlights and air-conditioners increases at homes or buildings in the suburbs. UB is connected to Feeder 3, indicating a peak of load curve during daytime, same as Feeder 2.



(Source: Belmopan Load Center in BEL)

Figure 2-1 Daily Load Curve of Belmopan Load Center

6) Layout and Arrangement of Equipment

(a) PV module

In this study, based on the typical performance of PV module with 180 Wp capacity, the necessary area and power outputs are estimated. The dimensions of a sample module are 1 m x 1.5 m, and the optimum operational voltage is 30 V.

(b) Layout of PV Array

Required installation area for the PV system is calculated assuming a PV array capacity of 50 kW. For the array, connected modules are 4 in cascade and 75 in horizontal. Site design of the array is assumed as 1 line and 7 rows. The PV modules orientation is to the south, with tilting angle of 20 degrees to generate power output effectively and avoid accumulation of dust on the surface. In the above condition, required area for necessary power output was calculated. There is no large difference of power output from the PV system even if the shadow on the surface does not appear from 9 AM to 3 PM in midwinter day. Therefore, the condition of the shadow from said hours was estimated on midwinter of 22nd December. It was found that the length of the shadow of the PV array is around 1.2 times of the height. Necessary spaces were designed as 4 meters at the south of each PV array. Moreover, the space for O&M was designed as 5 meters at the north side of the area. A space of ten meters for the control house for the installation of equipment, such as the power conditioner and transformer for grid connection, was estimated. Table 2-8 shows the capacity of PV system and necessary land area.

Table 2-8 Necessary Land Area

Land	350 kWp
Width (m)	95
Length (m)	87
Necessary Area (m^2)	8,265(2.04 Acer)

(JICA Study Team)

7) Geological Condition of the Candidate Site

The following table shows the soil bearing capacities in the UB site. It seems that there is no problem to install the PV system at the site since the bearing capacities are sufficient.

Table 2-9 Bearing Capacity in University of Belize

Depth (feet)	Undrained Shear Strength Range (kN/m^2)	Equivalent N value	PRESUMED BEARING VALUES (kN/m^2 or kgf/cm^2 x 100) for each foundation width		
			1 m	2 m	4 m
3' 0"	150 - 350	28	400 - 800	300 - 500	150 - 250
6' 0"	350 - 600	44	800	600	400
9' 0"	600	>50	800	600	400

(Source: MOW)

2.2.2.2 Equipment Plan

(1) Design Standard

In Belize, the international standard of IEC is applied to the design of electrical equipment. However, under the international cooperative program for industrialized countries, other standards at a certain level can be accepted in general. In the case of procurement of Japanese Grant Aid project, there is no problem to apply JIS, JEC, JEM and JCS.

However, the standard of BEL (IEC) will be applied for 11 kV cable (22 kV in specification), high voltage board of 11kV and 11kV/ 400V, 230V transformer, which are all connected to the high voltage line of BEL.

(2) Equipment for PV system

The table below shows the list of necessary equipment, specifications and quantity of the PV system.

Table 2-10 List of necessary equipment

Name	Item	Specifications	No.	unit
PV System	1) PV Module	(a) Type: Silicon Crystal (b) Module capacity: 180Wp and over (c) Maximum power: *180W (d) Maximum power voltage: *23.7V (e) Maximum power current: *7.6A (f) Open circuit voltage: *30V (g) Short circuit current: *8.4A (h) Total array capacity: 350 kWp and over	1	set
	2) Support Structure for PV Module	(a) Type: Support structure for PV module (b) Material: SS400 hot dip galvanizing (c) Configuration: Base channel, Truss structure	1	set
	3) Junction Box	(a) Configuration: Outdoor, hanging type (b) Material: SPC steel sheet (c) PV input voltage: *DC800V (d) PV input current: *12A/circuit (e) Input circuit: *Max. 4 circuits (f) Output circuit: 1 circuit (g) Contained equipment: cable breaker, circuit breaker, lightning protection (class 2)	1	set
	4) Power Conditioner	(a) Configuration: Indoor, Autonomous type (b) Main circuit type: self-exciting voltage type (c) Switching type: High frequency PWM (d) Insulation type: Insulation transformer (e) Cooling: forced air cooling (f) Rated power output : 120 kW x 3 nos =360 kW and over (total) (g) Rated input voltage: *DC600V (h) Maximum input voltage: *DC900V (i) Input voltage operating range: ＊DC420V～850V (j) Maximum power point tracking range: *DC500V～700V (k) Type of output power: *3 phase 3 line, or 3 phase 4 line (l) Rated output voltage: *AC400V or 230V 60 Hz	*1	set

		(m) AC output current distortion factor: total harmonic distortion 5% and under, each harmonic distortion, 3% and under (n) Power control type: Maximum power point tracking (o) Efficiency: *90% and over (p) Function: Automatic voltage adjustment、in-out current regulation, output regulation, soft start (q) Grid-interconnection protection function: UVR, OVR, UFR, OFR、islanding operation prevention (passive, active detection）, prevent power supply after recovery (r) Communication: Operating condition・malfunction・monitoring signal （RS485)		
Other Equipment	5) Outdoor Transformer	(a) Rated power output: 400 kVA and over (b) Primary /secondary voltage: 11kV/400V/230V 3 phases 4 lines, 60Hz (c) Particular specification Outdoor, Oil self-cooling type, Wiring : Δ-Y, neutral ground, Total load capacity tap ±2.5%, ±5%	1	set
	6) 11 kV Switchgear for Grid Connection	(a) Outdoor type metal enclosed cubicle type switchgear (b) 11 kV CB Rating: 11 kV 400A 12.5 kA (c) Standard: IEC, JIS (d) Enclosed Equipment a)Voltage Current Transformer(VCT) b)Disconnecting Switch (DS) c)Lightning Arrester (LA) d)Measuring Transformer (VT, CVT) e)Zero -phase Current Transformer (ZCT) f)Vacuum Circuit Breaker (VCB) g)Current Transformer (CT) h)Protective Relay: OCGR, OVGR, OCR i)Meter: V, A, W, PF, WH	1	set
	7) Load Distribution Board	(a) Configuration: indoor-hanging or autonomous (b) Material: SPHC steel sheet (c) In-out circuit: input 1 circuit, output：*10 circuits (d) Contained equipment: Molded case circuit breaker (MCCB), Surge Absorbers (class 2)	1	set
	8) Monitoring Display	(a) Configuration: Outdoor self standing type (b) Material：SPHC steel sheet (c) Display data*: power output/day (kWh), instantaneous power potential（kW), irradiation (kW/m^2), Ambient Temperature (°C), CO_2 emission reduction (kg-C) (d) Size: *W800xL600xH60	1	set
	9) Data Management and Monitoring System	(a) Pyranometer: ISO9060、Second Class 6 - 8mV/(kW・m-2)* (b) Thermometer: resistance temperature sensor Pt100Ω, 4 lines type,－50℃～＋100℃ (c) Data logger a)Configuration: Outdoor hanging type b)Material: SPHC steel sheet c)Input signal: irradiation (0～10mV）,Thermometer（Pt100Ω） d)Output signal: 4～20ｍA e)Power source: AC230V, Battery & Charger (DC48V) f)Contained equipment: pyranometer converter (T/D）、thermometer T/D、power T/D、potential T/D（selling, buying electricity） (d) Monitoring equipment (indoor) a)Data monitoring: monitoring cycle: 6 seconds, Collected data: irradiation, temperature, power output b)Equipment: PC, signal converter, UPS c)Software: display of instantaneous value, figure,	1	set

		form, condition of PC, accident, others d) output signal: BEL monitoring system (inverter and the others)		
	10) Control House	(a) *Size: W2,400xL7,200xH2,460 (b) Accessory: door, light, air conditioner, dial thermometer （with contact point） (c) Contained equipment : Power conditioner, load distribution board, Monitoring board	1	house
Construction Materials	1)Cable 2)Grounding, etc.	(a) Cable : 22KV CV-60 sqmm-3 core, 600V CV250, 5.5, 2 sqmm 600V CVVS-2.0sqmm (b) Grounding terminal, PE piping materials, steel conduit etc.	1	set

*: reference value, applied manufacturer's standards (JICA Study Team)

(3) Basic design of PV system

The basic design criteria of the PV system are as follows:

1) PV Module (Array)

A PV array is a linked collection of PV modules. The total capacity of PV system has to be over 350 kWp.

The PV module will be selected from the "silicon crystal PV module: JISC8918" and other modules with equivalent performance.

2) Mounting Structure for PV Module/Connection Box

(a) The cost of the construction of the mounting structure for the PV module and connection box with wiring work is almost 20% of the total cost.

(b) The mounting structure for the PV module is designed based on the "Standard Design of Support Structure for PV Array: JISC 8955". It is necessary to install the PV system to resist a gale force wind at 60 m/s and to prevent the wind force from the back side of the PV array by installing a shielding board in the case of 20 degrees tilting angle.

(c) The base of mounting structure depends on the combination of PV modules. In the case of support for eight of 180Wp modules such as four in cascade and two in parallel, vertical load becomes around 160 kg. Therefore, a concrete foundation is necessary to support the mounting PV array.

(d) Junction box consists of breakers for distribution line, input circuit switch, output circuit switch, backflow prevention diode, and lightning protection and/or surge protection devices (class 2) at each outside circuit. A connection box is used for interconnecting PV arrays and used for disconnection of circuit during the maintenance and repair. It is necessary to install reverse flow diode, lightning protector and surge protection device (class 2) at each outside direct current circuit.

3) Power Conditioner (including protective devices for grid interconnection)

(a) Power conditioner converts direct current from PV array to alternating current and consists of inverter and protective devices for grid interconnected operation.

(b) Power conditioner is selected according to the "Power Conditioner for Small Photovoltaic Power Generation System (JISC8980)" and "Grid Interconnection Code".

(c) As function of power conditioner, there are regulations for the protection of PV system, power converter and grid connection. The main functions are as shown below. In grid interconnected PV system, reverse flow to the grid is possible. However, islanding operation is not affordable.

(i) Accuracy of output voltage : AC 400V or 230 V ±10 %

(ii) Accuracy of output frequency : ±0.2 Hz

Accuracy of output frequency(grid interconnected operation) : ±1 Hz (Adjustable range)

(iii) Distortion factor of AC voltage : Total 5% and below (linear rated load connection)

Distortion factor of AC current : Total current is 5% and below (rated output)

: Each harmonic is 3% and below (rated output)

(iv) Power factor (grid interconnected operation) : 0.90 and over

(except emergency cases such as to prevent voltage rises)

(v) Total Efficiency : 90% and over

(vi) Output voltage unbalanced ratio (isolated operation) : 10% and below

(vii) Grid interconnected operation and protection

: Voltage / frequency monitoring

: Maximum power point tracking function

: Islanding operation prevention function

: Automatic voltage regulation function

: DC output protection function (insulating transformer)

: DC earth detector

:UVR, OVR, UFR, OFR, island operation prevention (passive, active detection), prevent power supply after recovery

4) Outdoor Transformer and High Voltage Grid Interconnection System

Outdoor transformer converts AC power output voltage from power conditioner to high voltage for grid interconnection. "IEC 60076 Standard" and "BEL Standard" are applied to the design of transformer. Outline of specifications for the transformer and 11-kV switchgear is as follows:

<u>Transformer</u>

- Type: Outdoor oil immersed transformer (ONAN)
- Rated power output: 500 kVA and over
- Primary voltage / Secondary voltage: 11 kV/400-230 V, 3 phases 4 wires, 60 Hz
- Withstand voltage (impulse withstand voltage): 1.2 x 50 micro-second, 95 kV
- Commercial withstands voltage: 38 kV, 1 minute
- Particular specification: Outdoor, Oil self-cooling type; Wiring: Δ-Y, neutral ground, Total load capacity tap ±2.5%, ±5%

<u>Metal Enclosed Switchgear</u>

- Type: Outdoor Type Metal Enclosed Switchgear
- Lightning Arrester: 12 kV, (10.2 MCOV), IEEE standard
- Circuit Breaker (CB): 11 kV, 12.5 kA

- Disconnecting Switch (DS): 11 kV, 1250 A

- Protection Relay: OCR, OCGR, OVGR,

- Measuring Device: VCT (class 0.3), CT, ZCT

<u>Watt-Hour Meter</u>

It is necessary for BEL to install watt-hour meters, in the cubicle as part of their contract with their customers. Said equipment installation should comply with the following specifications. Therefore, installation space will be provided inside a metal cubicle. Power consumption is estimated by BEL to be not more than 3 watts.

Elster Alpha+meter, Form 5S(35S), CL-20, 120-480V, 3 wire, 60 Hz

Type-A1RLQ+(Stored load profile reading and can be downloaded to laptop computer) or ,

Type-A1D (Energy and demand readings only; no storage of energy class 0.3 or better)

5) Load Distribution Board

Load distribution board will receive electricity from PV system during its operation in day time. During night time, the load distribution board will receive electricity from the grid. The power will be consumed for air conditioning, lighting, data logging, monitoring display, and others. The total capacity will be around 5 to 10 kW. The load distribution board will be a box made of steel sheets and equipped with power indication lamp. Molded Case Circuit Breakers (MCCB) shall be provided for each load.

6) Monitoring Display Board

A monitoring display board will be installed at the left side entrance of Jaguar Building in the central campus of UB. This monitoring display board serves an important role to enhance the showcase effect of the system.

In the monitoring display board, the following information will be shown through digital display. Other information meanwhile will be suggested by the contractor.

－Power output /day (kWh/day)
－Instantaneous power potential (kW)
－Solar irradiation (kW/m^2)
－Ambient temperature (°C)

－CO_2 emission reduction (kg-C)

7）Management and Monitoring System of Operational Data

Operational data management and monitoring system will be installed in a control room to clarify the performance of the PV system.

(a) Outdoor performance of solar irradiation and ambient temperature are as follows:

－Pyranometer：ISO9060/2nd Class, input signal: irradiation (0～10mV)
－Ambient thermometer：Pt100Ω JISA

(b) Monitoring data

The following data and the suggested data from manufacturers will be logged:

－PV output voltage (V)
－PV output current (A)
－Inverter output voltage (V)
－Inverter output current (A)
－Inverter output potential (kW)
－Inverter power output (kWh)
－Inverter operational condition
－Grid interconnection condition

(c) Failure information

－Grid interconnection failure (grid interconnection protection function)
－Inverter failure
－Protection function in inverter
－Breaker trip for wiring of load distribution

(d) Data logging system

Generated power, consumed power from the distribution line, and reduction of CO_2 emission will be calculated and stored in the computer, including the time, day, month and year the information were recorded.

7) Control House

Power conditioner , Load distribution box, data management and monitoring system will be installed in the control house. Container will be used as a control House. In addition of above, the entrance door, air conditioner, dial thermometer with contacts, lighting inside and outside entrance and spare power conditioner are equipped in the control house.

2.2.3 Outline Design Drawings

The basic design drawings for the project are shown below:

Table 2-11 Basic Design Drawings

No	DWG No.	Title
1	BZ-E-101	SINGLE LINE DIAGRAM
2	BZ-E-102	PV SYSTEM ARRANGEMENT
3	BZ-E-103	CIVIL WORKS & PV SYSTEM FOUNDATION
4	BZ-E-104	LAYOUT DRAWING OF PV SYSTEM (350 kW)

(JICA Study Team)

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The project is carried out based on the framework of the environmental program grant aid by the Government of Japan (GOJ). Figure 2-2 Project Implementation System shows roles and relations with each organizations on this program.

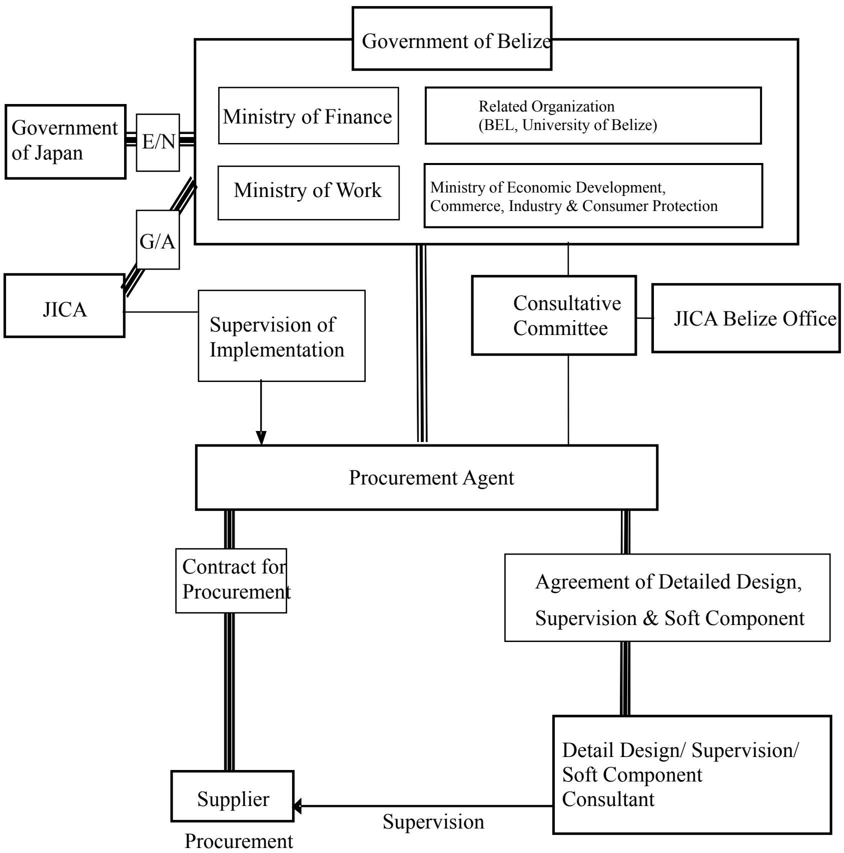


Figure 2-2 Project Implementation System

(JICA Study Team)

For the implementation of this plan, the basic issues and work items to be considered in particular are as follows:

a) Land filling and leveling, access road, fencing, construction work such as types of foundations, etc.
b) Procurement, supply, installation, test and hand over of the PV system
c) Procurement, supply, installation, test and hand over of the 11 kV high-voltage grid interconnection equipment

All work items need to be executed in good coordination. Fundamental subjects and items that need special attentions are discussed below.

(1) Executing Agency of the Belizean Side

In this project, the responsible organization and implementing organization are as follows:

- Responsible organization: MOF

- Implementing organization: MOW

MOF is a responsible organization and MOW is an implementing organization as a focal point. MOF's roles include acquisition of land, establishment of procedures on imported goods and import tax exemptions, and securing the budget for the execution of this project such as cost for extension of distribution line, ensuring safety, land leveling and access road. For the establishment of the O&M organization, MOF should make an agreement with UB or MOW for the daily maintenance activities, and with BEL for the periodic inspection of O&M works. Meanwhile, MOW's roles include tree cutting, ensuring availability of warehouse, leveling of the land and construction of access road, and management of O&M works in the central campus of UB.

(a) Arrangement of necessary budget and staff for executing the demarcated work of the Belizean side

Some of the works under this project are to be executed by the Belizean side. Such assigned works need to be executed timely with good coordination with other related works. The necessary budget and staff must be secured for this purpose.

(b) Transfer of technology

In this plan, the O&M staff of the Belizean side should participate as observers during installation works of the PV system. In the subsequent series of works, the basic principles of the PV system equipment, and method of assembling the PV system will be transferred to the Belizean side. It is necessary for the Belizean side to understand that participation of their engineers and technicians is required not only for the execution of their duties but also to hone their skills in O&M works for future operation.

(2) Implementing Contractors

On the basis of the framework of the environmental program grant aid of the GOJ, procurement and installation of equipment will be carried out by the implementing contractor selected through a bidding process, which is initiated by the procurement agency. In this plan, civil works, installation of the PV system and grid connection will be executed in the project site. Each work shall be related closely on the aspect of operation and schedules. Therefore, on the aspect of ensuring quality, guarantee of characteristics, defects liability and schedule management, a Japanese contractor will implement the whole series of works.

In accordance with the specifications prepared by the consultant, the contractor will carry out civil works, design, manufacture, factory inspection, packing for export, transport to site, erection, site tests and hand-over of the PV system. During site construction, equipment erection works and tests, the contractor will perform transfer of technology to Belizean staff.

2.2.4.2 Implementation Conditions

(1) Matters of Note on Implementation Works

Various kinds of site work such as erection of heavy equipment, PV module installation works, control house, working near to the existing high voltage line and other works, will be executed simultaneously in the same premises of UB. Therefore, utmost care must be taken to secure safe working conditions. In particular, during the transportation of equipment inside the UB, utmost caution must be taken to ensure security of students and passengers.

Before commencing site works, detailed work plans shall be prepared through detailed discussions among working groups, personnel in charge from MOW, and UB staff, Moreover, safe and efficient working environment, including confirmation of high voltage line, shall be established by providing danger warning signs, safety fences and so on.

In addition, it is necessary to confirm mutual interferences of islanding operation detector of power conditioners when installing more than three units.

It is necessary that Japanese or foreign engineers and local engineers involved in the construction works be registered with APEB and PUC. Registered electrician shall be employed for the construction work in Belize.

In the project installation site, various site works such as civil works, steel structures assembly works, erection of PV system facilities and electrical facilities, installation of underground cables and others must be executed under excellent coordination. Civil works must be completed before the commencement of the PV system installation.

The PV system will be installed in the central campus of UB. Thus, it is necessary to carry out various works in parallel to complete the project without delay. It is necessary to prepare effective implementation plan with work schedule to ensure timely completion of site works.

Therefore, it is necessary for the consultant and contractor to effectively coordinate each process of work. Moreover, the safety of students, UB personnel and workers has to be considered as part of quality control. The implementation plan must be prepared by the contractor to ensure efficient and smooth implementation of works under the cooperation of all concerned.

(2) Concerns on Procurement Works

For the design of the PV system, it is necessary to investigate the site conditions. Main equipment for PV system such as PV modules, power conditioner, and transformer will be procured from Japan. Furthermore, during the procurement stage, it is necessary to confirm the origin of the other main parts before approval of the drawings. Said parts should be procured from an eligible country.

It is important to manage procurement and transportation for timely execution of construction. It is necessary for the implementing contractors to perform procurement, manufacture, transport and delivery based on a consistent procedure.

The PV module will be installed at a location where the design wind speed is 60 m/s. Therefore, it is necessary to consider the countermeasures against strong winds such as installation of wind shield at the north side of the module.

BEL plans to change the system voltage from 11 kV to 22 kV at the Belmopan area in the near future, although such plan is not yet clear. On the basis of the agreement with BEL, specifications on high voltage underground cable shall be 22 kV on the rated voltage.

2.2.4.3 Scope of Works

(1) Demarcation of Construction Works

In this project, all works related to the construction of the PV system facilities will be carried out by Japanese contractors as shown in the table below.

Table 2-12 Demarcation of Construction Works

No.	Item	Japanese side	Belizean side
1)	Acquisition of necessary land for construction work		X
2)	Land clearance, construction of access road to site premises, securing site security and warehouse for storing spare parts		X
3)	Fencing work, Gravel laying	X	
4)	Foundation works and structure assembly	X	
5)	Construction of PV module and control house	X	
6)	Construction, testing, and commissioning of PV system	X	
7)	Construction, testing, and commissioning of 11 kV switchgear	X	
8)	Extension of distribution line and installation of load break switch		X
9)	Installation of watt-hour meter		X
10)	Installation of 22 kV cable	X	

(JICA Study Team)

2.2.4.4 Construction Supervision Plan/Procurement Supervision Plan

This project will be implemented after the E/N between two countries is concluded(14 December 2009). After that, it will be accepted as an environmental program grant aid by the GOJ, which will recommend a procurement agency to GOB to manage the project. As for the supervision of the project, the following should be considered:

(a) Understand the background of the project implementation.
(b) Confirm the contents of the preparatory survey study.
(c) Understand the framework of grant aid assistance of Japan.
(d) Confirm the contents of the E/N agreed between the two governments.
(e) Site working conditions are to be fully taken into account.
(f) Confirm stakeholders in this project and future plans.
(g) Understand necessity of soft component (technical assistances) and their implementation.

Taking into account the above, the contents of consulting services, members of consultants and the necessary organization for execution are mentioned below.

(1) Basic Policies of Construction Supervision

The consultant shall manage and supervise the whole phases of work execution of the contractors to ensure that the project works will be executed on schedule, consideirng the three basic principles given below:

(a) Schedule Management

(i) For each facility, progress of manufacture, transport and erection of equipment and materials must be reviewed all the time. The progress of the Belizean side works shall also be confirmed.

(ii) Process of works by both of the Japanese contractors and Belizean authorities shall be confirmed and coordinated.

(iii) Scheduled meetings shall be held appropriately to tackle overall schedule management and its necessary adjustments. Said meetings shall be held weekly during site erection period and daily during the site test period.

(b) Safety Management

(i) Contents of daily site work and safety measures shall be explained and confirmed to the MOW and UB personnel in charge of the project implementation.

(ii) Safety arrangement of site works shall be confirmed before starting works.

(iii) In case that many works are executed at the same place, necessary safety measures shall be taken to avoid accidents by confirming working methods and schedules of concerned parties.

(iv) Transporting equipment in and out of the site along the access road shall be executed under the supervision of a safety manager.

(v) Before transporting, the position of the stockyard of facilities shall be explained and confirmed by authorities of the Belizean side (MOW).

(vi) Site works near the electrical live parts shall be executed under the supervision of a safety manager.

(vii) The areas shall be secured with safety ropes around the openings and electrically live parts, to avoid accidents.

(c) Quality Control

(i) The implementing contractor shall submit drawings, specifications, calculation data, etc. for approval of the consultant, who will review the documents to confirm conformity to applied standards, contract specifications, etc.

(ii) The consultant will witness factory tests before shipment of major equipment to confirm whether the utilities have been manufactured according to the applied standards and contract specifications.

(iii) The completed works will be tested at site before hand over.

(2) Procurement Management Plan

(a) It is necessary to manage the tax exemption for the PV system equipment in Belize, when said equipment is imported to the port of Belize City.

(b) It is necessary to manage exemption or refund tax for locally procured materials.

(3) Consulting Services

(a) Detailed Design and Review of Tender Documents

Based on the results of the preparatory survey, the detailed design, accumulated costs and implementation plan will be reviewed. Moreover, technical parts of tender documents have to be finalized based on the reviewed documents. The tender documents shall then be finalized and combined with other related documents prepared by the procurement agency.

(b) Construction Supervision

(i) Tendering

In the tendering process, activities include tender invitation, questions and answers, tender conferences, evaluation of tender results, assistance in contracts negotiation and finalization..

(ii) Site Supervision

In the site supervision process, activities include meetings among concerned parties before commencing site works, approval of design drawings, factory inspection before shipment, supervision of installation works, preparation of progress report during site construction, issue of interim certificates, and witnessing of site tests before hand over.

(iii) After Completion of Installation Works

Upon completion of installation works, issuance of completion certificate, hand over, preparation of final report and defects liability test (a year after installation) will be carried out.

(4) Members of the Consultant

For the execution of necessary services indicated in above item (3), it is necessary to select a project manager who sufficiently understands the project scope and with abundant experiences on similar works. In addition, it is necessary to assign a staff to conduct tendering procedures, review and approval of design, factory inspection and site supervision.

(a) Project Manager

The project manager should manage the overall project activities with understanding of the background and objectives. It is necessary to grasp the progress of works according to the implementation schedule. He should also provide instructions and necessary advices to the team members.

(b) Detailed Design Engineers

On the basis of the established basic design, it is necessary to review the specifications of equipment, layout design, detailed design, construction plan, and cost estimation.

(c) Engineers in the Tendering Process

The consultant shall prepare the tender documents, invite tenderers, replies to queries, accept tender submittals, evaluate submitted tenders, and assist in negotiating and concluding the contract.

(d) Consultants for Design Review and Factory Inspection

The consultant shall examine the submitted drawings, specifications, instruction manuals and other documents received from the contractor. The consultant should also inform the contractor if the submitted materials are approved or need to be modified.

(e) Site Supervision Engineers

Supervising engineers have to manage the entire works at the project site from commencement to the end of construction works. In addition, electrical and/or civil engineers in charge of site works have to be dispatched to supervise works.

2.2.4.5 Quality Control Plan

(1) Quality Control of Equipment and Materials

Quality of equipment and materials to be supplied under the project will be controlled in the following steps:

(a) Review and Approval of Drawings and Specifications

The consultant will examine the acceptability of the documents such as the drawings, specifications and calculations, to ensure compliance to the approved standards and contract specification. If no significant problems are found, the documents should be approved accordingly with necessary comments, if any. Such engineering works will be conducted in Japan. All equipment will be manufactured after approval of the documents.

(b) Factory Inspection

After the assembly of the equipment, inspection will be conducted in the factory before delivery to site. It is necessary to conduct inspection to confirm the manufacturing process of equipment. The equipment should be manufactured in accordance with the approved standards and contract specifications. Generally, visual inspection and characteristics tests are carried out. The consultant should observe the inspection of main equipment units. Belizean engineer meanwhile will observe inspection of other important equipment units.

(c) Site Supervision and Completion Test

Under the cooperation with the Belizean side, the consultant manages the construction works which have to be conducted in accordance with the contract specifications. The completion tests have to be conducted before the handing over of the project. It is necessary to confirm the performance as per the specifications.

(2) Quality Control of Civil Works

(a) Review and Approval of Construction Drawings

Based on the basic design, the structural design and construction drawings shall be prepared by the contractor. The documents will be submitted to the consultant for review. If no problems are found on the submitted documents, these will be approved and returned to the contractor. Review of the documents will be conducted in Japan and at site.

(b) Inspection of Materials

The consultant will inspect all the materials before construction. These tests will be carried out either at the source country or at site.

(c) Construction Supervision

With the cooperation of MOW engineers, the consultant will carry out construction supervision, of soil excavation and filling, concreting (concrete quality and arrangement of steel bars), steel framing, foundation works, etc., including inspection of other work items.

2.2.4.6 Procurement Plan

(1) Purchasing Source

The PV module, power conditioner and transformer are to be purchased in Japan.

(2) Scope of Spare Parts

It is necessary that spare parts are readily available for continuous operation with initial conditions. In this project, since spare parts for the main equipment are not available locally and should be procured in Japan, it is necessary to procure in advance. As for PV modules, 3% of the total quantities have to be procured to serve as spare parts considering minor shut down periods caused by lightning or breakdown. Power conditioner is the most important component of the PV system. In this project, one complete set of power conditioner with the same unit capacity will be supplied as a spare unit. In addition, spare parts such as arrester, fan and filter will be procured. As for the high voltage equipment, a set of arrester (3 phases), protection relay and meters will be procured.

(3) Particulars of Defect Liabilities

In this project, it is necessary to have provisions on defect liabilities for installed facilities after the hand over. In case defects are found because of the project execution, this will be covered by the defects liabilities provision. Defect liability period shall be one year after the site acceptance.

2.2.4.7 Initial Training and Operation Management

Initial training and operation management will be executed and explained by the manufacturer. Moreover, the soft component (technical assistance) is planned by the consultant as a form of technical transfer of basic technical knowledge, maintenance of data and analysis of records of software for the PV system. With regard to the daily and periodic maintenance, technical transfer will be carried out using a maintenance manual to be prepared by the consultant based on the manufacturer's instructions.

At the initial technical training, it is recommended to involve participation of management staff from MOW, BEL's maintenance staff performing regular inspection, and, UB's or MOW's daily maintenance staff. Table 2-13 shows the contents of the initial training and of soft components (technical assistances).

Table 2-13 Contents of Initial Training

	Contents of Initial Training	Contents of Soft Component
MOW	1.Handling of PV system 2.Operation & maintenance 3.Handling of data logger	1.Basic knowledge of PV system 2.Operation management 3.Analysis and compile of monitored data 4.Safe guard of O&M manual
UB or MOW	1.Handling of PV system 2.Operation & maintenance 3.Handling of data logger	1.Basic knowledge of PV system 2.Daily maintenance 3.Analysis and compile of monitored data
Private Company (BEL)	1.Handling and operation method 2.Operation & maintenance 3.Handling of data logger	1.Basic knowledge of PV system 2.Maintenance of high voltage equipment 3.Periodical inspection

(JICA Study Team)

2.2.4.8 Soft Component (Technical Assistance) Plan

(1) Background of Soft Component

"The Project for Introduction of Clean Energy by Solar Electricity Generation System in Belize" aims to introduce solar PV system with 350 kW capacity to be installed in the area of University of Belize (UB) in Belmopan City. The generated power will be supplied to the existing power grid. This project is the first attempt towards the installation of grid-connected solar PV system in Belize. Therefore, it is necessary to assist capacity improvement and basic technical training for engineers in the aspect of technical transfer.

(a) Current condition

Belize imports electricity for approximately 50% of its national power consumption from the neighboring country of Mexico. The rest of the required electricity is supplied by hydropower and diesel power stations in the country. The problem of electrification still remains in areas which are far in distance to the national grid.

(b) Need for soft component

This is the first attempt to introduce a grid-connected solar PV system in Belize. To secure smooth operation, it is necessary to introduce further technical information, documents and human resources on PV system as shown below.

i. Lack of technical engineers who work on O&M and repair.
ii. Lack of manuals on the training for O&M engineers.
iii. Lack of human resources to act as guide to visitors of PV system and enable them to explain the effect.

Thus, following activities have to be conducted for (i) smooth operation in initial stage and (ii) secure the sustainability of project outcomes as soft component program.

i. Training for O&M engineers.
ii. Prepare and organize necessary manuals for O&M
iii. Training for the person in charge of guiding visitors to the facility and explaining its effectiveness.

The details of activities to be implemented are explained below.

A. Operational Management / Monitoring

An appropriate management structure system on solar PV system is necessary to secure sustainability of the project outcome. Therefore, the Ministry of Works (MOW) and UB have to confirm the activities by referring to O&M reports submitted by daily and periodic maintenance staff members of BEL (Belize Electricity Limited) and UB. In addition, it is necessary to collect data on power generation and the amount of CO_2 emission reduction for analysis.

B. Basic Technology / O&M / Troubleshooting

It is necessary to transfer appropriate O&M skills for sustainable use of solar PV system. It is desirable to conduct repair or replacement of faulty parts of the PV system locally. Therefore, in addition to O&M techniques, troubleshooting techniques have to be transferred. A troubleshooting table has to be prepared in the project. Moreover, it is necessary to maintain the manuals on O&M and troubleshooting, which will be utilized as materials for training technicians locally.

C. Education / Awareness-Raising

As for the PV system which was introduced in this project, a show case effect of the Japanese technical cooperation is expected. It is necessary to train the persons in charge of guiding visitors to the installed facility and explaining its effects. In the project, brochures have to be prepared as guide to those visiting the installed facility.

(2) Objectives of Soft Component

The following objectives have to be accomplished within two months during and after installation of the PV system.

- Management of operation and monitoring of data can be conducted by MOW and UB staff.
- Daily inspection can be conducted by MOW or UB staff.
- Periodic inspection can be conducted by the staff of BEL.
- Finding of malfunctioning parts and determining corresponding countermeasures can be conducted by BEL.
- Visitors can be guided to by UB personnel to see the PV system.

(3) Output of soft component

A. Operational Management / Monitoring

Management of operation and monitoring data at the PV facility are conducted by MOW and UB. It is necessary to transfer the technology for confirming operational data such as power output, solar irradiation and the amount of reduction of CO_2 emission. In addition, inspection reports written by O&M staff have to be confirmed and adequate countermeasures have to be carried out.

- Understanding of PV system, power conditioner, grid connection technology
- Understanding of the inspection report, countermeasure of the troubles
- Analysis of monitored data (power output, irradiation, CO_2 emission reduction)
- Training system of O&M technicians

B. Basic Technology / O&M / Troubleshooting

The technical staff of UB and BEL will understand basic technology of solar PV to carry out O&M appropriately. In accordance with the prepared manual, periodic inspection has to be conducted by BEL. The process of installation and O&M training will be filmed for use as technical training documents for dissemination and accession of transferred technologies. In addition, a troubleshooting table will be prepared to find malfunctioning parts and the corresponding countermeasures. The outputs through the above training are expected as shown below.

- Understanding of the PV system, power conditioning, and PV system technology
- Understanding of daily maintenance and confirmation of generating condition
- Acquirement of knowledge on maintenance check points such as operating panel, indicator panels, and protection instruments and detailed operational instruction for each facility and equipment
- Acquirement of knowledge on measurement device for maintenance, equipment adjustment device, special tool, machine proof, adjustment, etc.
- Acquirement of reporting skill for operation records, accidents, repairs and inspection
- Acquirement of knowledge on management of spare parts and tools
- Acquirement of knowledge on locating faulty parts and their corresponding replacement
- Acquirement of knowledge on the forecast of the exchange period for parts; identification of faulty parts and the necessary countermeasures.

C. Education / Awareness-Raising

Using the installed solar PV system in UB, explanation on installed system and the effectiveness will be conducted to visitors and concerned people. Brochures which introduce the installed facility will be prepared. Furthermore, a trial seminar to raise awareness will be held using the developed brochure. The outputs through the above training are expected as shown below.

- Development of the person in charge of guiding visitors to the installed system
- Development of human resources who can explain the effectiveness of the installed system
- Brochures for the activities mentioned above are developed.

(4) Contents and Activities of Soft Component

Two persons participate from each organization for soft component. Depending on the role of organization, required technologies to be transferred are different.

Table 2-14 shows the contents of activities, number of attendance and organization for the soft components. During the training at site, mainly practical training will be conducted. Since there are no electrical technicians in the Belizean Government, BEL which is publicly recognized as the only power supply organization in Belize, can be one of the candidates who will participate during the implementation of the soft component.

As an implementation organization, the person in charge of the project in MOW has to have knowledge on O&M for its management. Technical transfer will be conducted using prepared manuals and the troubleshooting table.

Table-2-14 Number of participants according to technical transfer

Technical transfer		No. of participants	Organization (no.)
A	Operational Management/Monitoring	4	MOW (2), UB (2)
B	Basic technology of PV system / O&M /Trouble Shooting	4	BEL (2), UB (2)
C	Education / Awareness-Raising	2	UB (2)

(JICA Study Team)

Details of the technology transfer work items are presented and discussed below.

A. Operational Management/Monitoring

Technical skills on operational management and monitoring will be transferred. After training, it is possible to confirm contents of the O&M report and monitoring data such as the power output. The table below shows the details of training.

Table2-15 Operational Management/Monitoring

	Item	Contents and Activity
1.	Basics of Solar PV	Basic knowledge of solar PV
2.	Operation and Maintenance	Contents of O&M reports based on daily and periodic maintenance; Understand necessary procedure for carrying out countermeasures against malfunctions.
3.	Data Analysis / Operational Management	Confirm procedure for data collection and analysis in the PV system.

(JICA Study Team)

B. Basic technology of PV system / O&M / Trouble shooting

The basic technology of a PV system is taught. At first, a comprehension test on basic knowledge of the PV system is conducted to grasp current knowledge level of the trainee. Training items and contents are shown in the table below.

Table 2-16 Basic Technology of PV System

	Item	Contents and Activities
1.	Comprehension test	Confirmation of the basic technical knowledge of trainee
2.	Basics of the PV system	Actual system; international trend
3.	PV system, Power conditioner	Specifications and details of the PV system and power conditioner
4.	Grid connection	The principle of the grid-connected system, its specifications and details

(JICA Study Team)

After completion of the trial operation, O&M training will be conducted with emphasis on the purpose of improvement of O&M and troubleshooting skills. The training will be conducted by a consultant and a qualified engineer on management and O&M. The important training activities will be filmed/recorded as training documents. Training items and contents are as shown in the following table.

Table 2-17 O&M and Troubleshooting Training Activities

	Item	Contents and Activities
1.	Daily maintenance	Confirmation of generation facilities, operational and surrounding conditions.
2.	Periodic inspection, maintenance	Periodic inspection, maintenance
3.	Handling of measuring equipment and special tools	Handling of electrical and adjustment equipment.
4.	Reporting	Report writing related to O&M
5.	Operating inspection	Operating inspection and testing Testing and confirmation of safety operation
6.	Troubleshooting	Determining probable troubles/problems
7.	Repair and replacement of faulty parts	Prepare table guide for troubleshooting
8.	Manual and video document	Prepare manual and video documents as guide for installation and O&M
9.	Confirmation of O&M	Confirmation of the results of soft component

(JICA Study Team)

C. Education / Awareness-Raising

Brochures for introduction of the PV system and manuals on raising awareness will be developed. Consequently, each staff officer can guide the PV facility and explain the effectiveness. Training items and contents are shown in the table below.

Table2-18 Awareness- Raising Activities

	Item	Contents and Activities
1.	Comprehension test	Confirmation of basic knowledge
2.	Preparation of brochure for awareness-raising activity.	Preparation of brochure on solar PV and the project for dissemination to visitors.
3.	Hold an awareness-raising seminar	A seminar for the La Paz City staff is conducted using the prepared manuals and brochure.

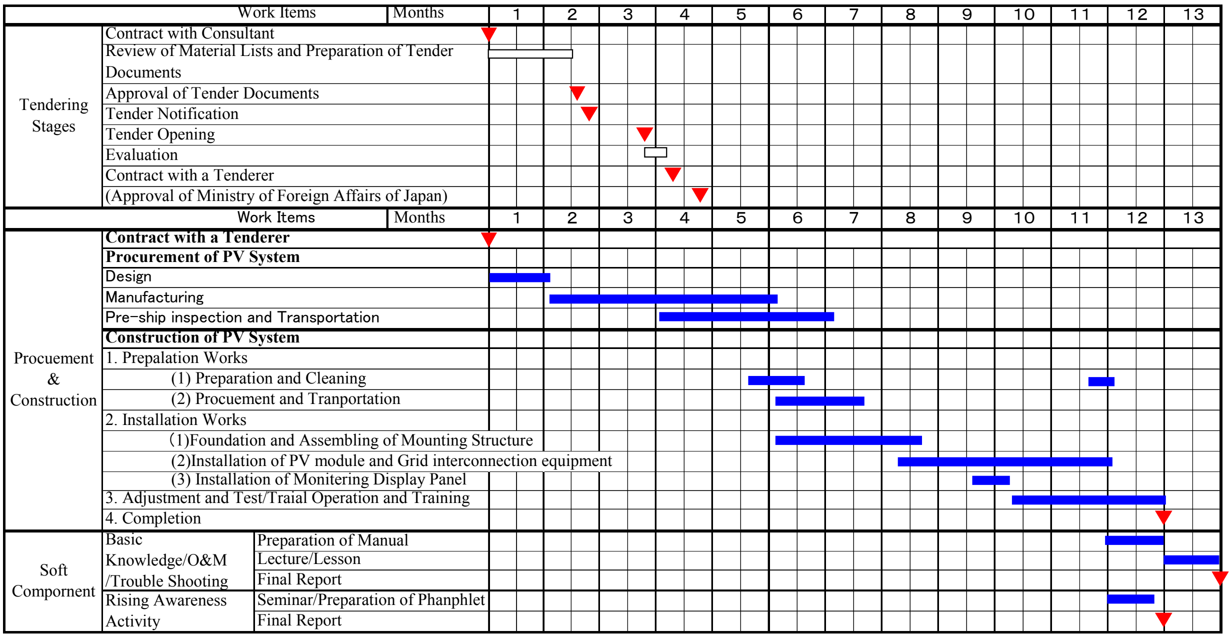
(JICA Study Team)

2.2.4.9 Implementation Schedule

The work execution of this project will require 12 months from the design for manufacturing up to completion of the project. There is possibility to overlap with Hurricane season from June to November. Therefore, It is necessary to formulate the construction schedule considering Hurricane season.

The estimated implementation schedule is shown in Table 2-19.

Table 2-19 Implementation Schedule



(JICA Study Team)

2.3 Obligation of Recipient Country

Items to be executed by the Belizean authorities, in case that an environmental program grant aid by Government of Japan is executed, are as follows:

(a) Banking arrangement (B/A)

(b) Authorization to pay (A/P)

(c) Obtaining license for import of PV system facilities to Belize and payment of necessary fees

(d) Tax exemption on services of Japanese personnel engaged in the project works and hand tools to be used for work execution, etc.

(e) Obtain rights to enter the project area

(f) Obtaining permissions from related authorities in relation to the project works

(g) Acquisition of land necessary for the PV system; ensure availability of warehouse

(h) Site clearance and leveling of site, construction of access road to site, extension of 11 kV distribution line and installation of load break switch

(i) Formulation of O&M organization, ensure site security and installation of night illumination (if required)

(i) Settlement of conflicts with inhabitants in the surrounding area

(j) Other items that cannot be provided under the grant aid

Table 2-20 shows the major undertakings to be taken by each Government and related organizations.

Table 2-20 Major Understandings to be taken by Each Party

No.	Items	To be Covered by Japanese Grant	To be covered by MOF	To be covered by MOW	To be covered by UB	To be covered by BEL
1	To secure land		●	●		
2	To clear, level and reclaim the site			●		
3	To construct gates and fences in and around the site			●		
4	To construct a parking lot if necessary			●		
5	To construct roads					
	1) Within the site	●				
	2) Outside the site and Access road			●		
6	To construct the facility and install the equipment	●				
7	To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities if					

No.	Items	To be Covered by Japanese Grant	To be covered by MOF	To be covered by MOW	To be covered by UB	To be covered by BEL
	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.)	●				
	4) Gas Supply					
	a. The city gas main to the site	n/a	n/a	n/a	n/a	n/a
	b. The gas supply system within the site	n/a	n/a	n/a	n/a	n/a
	5) Telephone System					
	a. The telephone trunk line to the main distribution frame/panel (MDF) of the building			●		
	b. The MDF and the extension after the frame/panel	●				
	6) Furniture and Equipment					
	a. General furniture			●		
	b. Project equipment	●				
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 unloading and customs clearance at the port of disembarkation in the recipient country					
	1) Marine or air transportation of the products from Japan or third countries to the recipient	●				
	2) To ensure all the expense and prompt execution of unloading, tax exemption and customs clearance of the products at the port of disembarkation		●	●		
	3) Internal transportation from the port of disembarkation to the project site	●				
10	To accord Japanese nationals and / or nationals of third countries, including persons employed by the agent whose services may be required in connection with the Components such facilities as may be necessary for their entry into recipient country and stay therein for the performance of their work.		●	●		

No.	Items	To be Covered by Japanese Grant	To be covered by MOF	To be covered by MOW	To be covered by UB	To be covered by BEL
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 Belize		●	●		
12	To maintain and use properly and effectively the facilities that are constructed and the equipment that is provided under the Grant					
	1) O&M cost management		●			
	2) Management of operation			●		
	3) Daily inspection of O&M			●	●	
	4) Periodic inspection and repair					●
13	To bear all the expenses, other than those covered by the Grant and its accrued interest, necessary for the purchase of the Components as well as for the agent's fees.		●			
14	To ensure environmental and social consideration for the Programme.		●	●		
15	To ensure to get permission from PUC for installation of PV system			●		
16	To ensure Electricity Tariff Agreement		●			●
17	Land agreement for Plant installation		●	●	●	
18	Land arrangement for temporary equipment stockyard			●		
19	Land leveling if required			●		
20	Security gates and fence around the site			●		
21	Construction of road					
	1) Outside the site and access road			●		
22	Terminal point of grid interconnection					
	1) Extension of 11kV distribution line (28m)		●	●		●
	2) Installation of Load Break Switch		●	●		●
	3) Connection of Power Cable to 11kV distribution line	●				
23	Responsibility of coordination during design stage					
	1) Electrical works		●	●		
	2) Civil and building works, if any		●	●		

(JICA Study Team)

In relation to the implementation of the project, the following services and works are to be executed by the Belizean side.

(1) Acquisition of Land for the PV system

The land owned by UB will be acquired by the Belizean side for the installation of the PV system. The PV system with a total capacity of 350kWp will be installed in the central campus of UB. The necessary land area for system installation is estimated to be around 8,265 m^2.

Table 2-21 Candidate site for PV installation

Site	Land Area(m^2)	Estimated Capacity (kWp)
University of Belize	8.265 (2.04 Acer)	350

(JICA Study Team)

(2) Participation to Installation and Commissioning Tests

As for the technical transfer on operation and maintenance of PV system, it is necessary to for the candidate O&M staff to participate in the installation process. It is also important for said staff to understand the assembly of PV system, through the cooperation of manufacturer's engineers.

2.4 Project Operation Plan

(1) Establishment of O&M system

Since MOF is the owner of the PV system, it is necessary to establish a capable and appropriate organization for the sustainable O&M of PV system. Aside from recruitment of necessary staff, it is necessary to maintain operation manuals and various forms for systematic reporting of operation, inspection, maintenance, faults and so on. At present, guard men is located in UB. Therefore, layout of guard men for security will be stated in the agreement of land lease after completion of the project.

(2) Assignment of Staff with Appropriate Educational Level

It is necessary to have technical knowledge on operation and management of the introduced PV system. It is required to assign staff with technical high school and higher educational attainment as future core staff of the O&M team. MOW has to organize the staff before commencement of the installation. Required staff and roles of each on operation and maintenance are mentioned as follows;

Table 2-22 O&M Staff and Corresponding Roles

Intended Organization	O&M Staff	Role
MOW (Road Maintenance Section)	Civil Engineer and Mechanical Maintenance staff	Operation/management (Safeguard of manuals, procurement of spare parts, coordination with UB and BEL) Data analysis and compilation
Private Organization or BEL (Substation Section)	Electrical Engineers for Substation	Periodic inspection and repairs
UB or MOW (Maintenance Section)	Maintenance staff	Daily maintenance (Visual checks, cleaning of modules and site, reporting of malfunctions to MOW and BEL)
UB(Administrative Section)	Administration staff	Guide to PV system, preparation of brochure

(JICA Study Team)

(3) General Training of Technology During Construction

In Belize, there is no experience on construction of PV system. During the construction period, one of the effective training tools is the instructions from manufacturer's supervisor and the consultants at the sites. Therefore, it is requested for all O&M candidate staff to participate during the construction work and tests at site.

(4) Assistance by Private Organization (BEL, etc.)

When the PV system starts operating after installation, the electrical engineer will be required to become part of the maintenance staff, and will carry out periodic inspection and repair of PV system and high voltage grid interconnection equipment. BEL (Substation section) intends to make a contract with GOB on the technical maintenance works such as periodic inspection and repair of PV system.

In this project, O&M works have to be conducted by the O&M team which has no experience on the O&M of grid-interconnected PV system. It is necessary to review the plan considering the items mentioned above, including the soft components which will be conducted by the consultant.

2.5 Project Cost Estimation

2.5.1 Project Cost Estimation

(1) Demarcated Cost of the Belizean Scope

In case the environmental program grant aid project by GOJ is implemented, demarcated cost of Belizean's scope is shown in Table 2-23. It is necessary to complete the demarcated works before starting civil works for PV system at the project site.

Table 2-23 Demarcated Cost of Belizean's Scope

1US$＝¥92.35

Required Works	Scope of Work	Estimated Cost
Repair of access road	Drainage pipe (5m) Laying gravel (thickness approx. 15cm(6 inch), length 500m)	US$ 8,000 (M¥ 0.74)
Extension of 11kVdistribution line (approx. 28m)	11kV dead end pole, stay and cross arms, conductor and insulators, load break switch	US$ 9,000 (M¥ 0.83)
Security Illumination	4-corners of fence, pole height 3.5m, 150W mercury lump with stabilizer, foundation and cabling from control house	US$ 6,500 (M¥ 0.60)
Total Amount		US$ 23,500 (M¥ 2.17)

(JICA Study Team)

In addition to the above, the expenditures for B/A and A/P for obtaining import permit from the government and the others will be required. For smooth execution of such duties, MOF and MOW needs to secure necessary budget beforehand.

2.5.2 O&M Cost

(1) O&M Works

O&M works are summarized into the following three categories:

1) Daily O&M (one time per day)

- Cleaning of site and array of the PV system
- Visual checking of operating conditions, alarms and corrosion on array, power conditioner, 11 kV switchgear and transformer

2) Regular Service (every 2 months)

Regular service will be carried out periodically according to the manufacturer's instructions.

3) Repair and Replacement of Parts (depending on necessity)

(2) Assignment Plan for O&M Staff

The assignment plan for the O&M staff is as shown in Table 2-24.

Table 2-24 Assignment Plan for O&M

Tasks/ Staff Assigned	Number of O&M Staff	Organization
Management/ Engineer or Technician	2	MOW (Maintenance Section)
Regular Service/repairing Engineer or Technician	2	MOF (to contract out) (BEL Substation Section)
Daily O&M/ O&M work	2	UB or MOW (Maintenance Section)
Total	**6**	

(JICA Study Team)

1) Assignment plan for daily O&M staff

Two operators from UB or MOW are assigned to perform daily checking of operating conditions, alarms and cleaning of site and array of PV system. They are expected to inform any abnormal situations to MOW and BEL maintenance staff.

2) Assignment plan for regular service and maintenance staff

Maintenance staff will conduct periodic inspection of PV array, power conditioner, 11 kV switchgear, transformer and power cables to maintain the PV system in good condition. MOF will contract out regular services to hired engineers who will perform the main roles. They must submit maintenance reports to MOW after carrying out each regular service.

3) Contract out maintenance works

The maintenance works for the government buildings are carried out by private contractors. The GOB is going to take similar measure and will contract out to BEL.

4) Management staff

An engineer or a technician shall be nominated from among the maintenance staff of MOW to ensure proper operation of traffic signals and road lighting. Engineer from MOW have a role to safe guard the O&M manual and manage related works with UB (or MOW staff). Sustainable maintenance services meanwhile will be contracted out to capable contractors.

(3) Personnel Resources

The required personnels for O&M are as follows:

1) Daily O&M (one time per day visual checking, and cleaning) by UB or MOW staff
2) Regular Service (every 2 month) to be contracted out to BEL
3) Repair and replacement of parts (depending on necessity) to be contracted out to BEL
4) Management tasks by MOW staff

(4) O&M Cost

Equipment Maintenance Cost

Maintenance cost per year is estimated to be 0.1 % of the equipment cost.

Employment Cost

As an implementing organization, electrical engineers are limited in MOW. It is considered to assign two engineers or technicians from the maintenance section of MOW. Also, O&M staff from UB or MOW and BEL maintenance staff are the targets for the technical training. They will be trained by the contractor's engineer during construction and testing activities to become skilled O&M staff. In addition, technical training by the consultant as a soft component shall be executed at the end of the construction period.
According to the above explanation, six staff members are required to be assigned to manage and perform O&M of the PV system. Therefore, employment cost may be required for contracted out services and UB personnel.

Costs for Contracting out Services

It is necessary to have a budget for regular maintenance works of PV system. Costs for contracting out services are estimated based on regular maintenance period (6 times per year).

Land Lease Cost

A lease agreement will be prepared including security matters between GOB and UB on approximately two acres (8,000 m^2) premises at the UB central campus site in Belmopan. The cost will be mentioned in the agreement.

Management and Other Costs

In general, the management and other costs are estimated to be 1% of the generated power (kWh). Cost of management and other costs for the newly installed PV system are calculated using the same percentage. The O&M cost will be estimated as 1% of the result of multiplying the annual power output by unit power tariff. Hence, the O&M cost becomes around BZ$ 2,000 (BZ$ 0.44 / kWh in case of purchasing from BEL).

In total, O&M cost per year is estimated as shown in table 2-25.

Table 2-25 Total Maintenance Cost (per year)

	US$	BZ Dollars (BZ$)
Land Lease Cost	2,500	5,000
Equipment Maintenance Cost	5,000	10,000
Contract out Cost for BEL	6,500	13,000
Management Cost and others	1,000	2,000
Total	**15,000**	**30,000**

(JICA Study Team)

GOB will accumulate sufficient funds by selling electricity to BEL for procurements of spare parts and emergency accident in future.

Chapter 3
PROJECT EVALUATION

CHAPTER 3 PROJECT EVALUATION

3.1 Recommendations

3.1.1 Preconditions for Implementation of Project

The following undertakings/activities shall be executed by MOF prior to the implementation of this project.

1) Conclusion of the Memorandum of Understanding (MOU) for the land requirement of the PV system installation prior to Tender Notice.(including security guard operation),
2) Agreement with BEL for the PPA (Power Purchase Agreement), and
3) Establishment of the operation and maintenance structure for the PV system.

The following activities shall be executed by MOW prior to the implementation of this project.

1) Approval from PUC regarding the permission of the installation of the PV system, due to its generation capacity of over 75 kW,
2) Removal of trees, land leveling and construction of access road for the candidate site,
3) Building a warehouse for spare parts inside of the site, and
4) Installation of vibration sensors with alarm and night illumination as countermeasure for theft and security.

3.1.2 Outstanding Issues for Accomplishment of the Project Plan

In order to realize sustainable operation of the installed PV system, its effective maintenance is essential. The following outstanding issues will need to be addressed and executed by the Belizean side.

(1) In PUC, the development of a law on grid-connected renewable power generation systems such as Independent Power Producer (IPP) is being considered to be established by July 2011. However, the tariff of the buyback program is not promoted by any regulation in Belize. It is recommended to promote to give incentives for the introduction of renewable energy using Feed-in Tariff (FIT).

(2) The operation and maintenance will be implemented by MOW, UB and BEL. It is necessary to keep a reasonable budget to maintain continuous operation of the PV system. It is recommended for MOF to collect income from BEL by selling the electricity generated from the PV system.

(3) Schedule of inspection period shall be planned for the purpose of keeping the system functional and for MOW, UB and BEL to detect any malfunction. It is necessary to educate maintenance staffs and maintain the manual for operation and maintenance. Furthermore, inspection records and failure records shall be keep as data base for future purchasing of spare parts and maintenance work.

JICA has training courses as technical assistance for CDM by inviting participants from least developed countries. According to this system, if JICA follows to invite Belizean staff to Japan for participation in organized training courses such as "Technical Training on PV System" and/or "Grid Interconnection Technology for Renewable Power Generation System", it is expected that the above technical training in Japan will bring more effective benefits to this Project.

There is no other project directly related to this solar electricity generation system. However, many renewable power generation systems such as hydroelectric power and biomass generation systems are utilized in Belize. Therefore, introduction of clean energy through solar electricity generation system will encourage to raise awareness and interest for clean energy introduction.

3.2 Project Evaluation

3.2.1 Project Adequacy

Key issues for adequacy of this project implementation are as follows:

1) Conformity with the national strategy on energy sector

The Government of Belize (GOB) needs to have the promotion of renewable energy projects under a long-term policy as objective. Also, the development of a law on grid-connected renewable power generation systems such as Independent Power Producer (IPP) is being considered to be established by January 2011. Thus, this Project is in conformity with the national strategy.

2) Showcase effect

The UB campus is located in Belmopan City, which is the capital of Belize and located approximately at the center of the country. The UB has around 3,400 students. Population of Belmopan City is approximately 16,000. In addition, visitors are expected such as the UB staff and those taking part in study visits. It will also further contribute in showcasing the effects of the system. Therefore, some UB staff should be able to guide visitors to the PV system. The showcase effect is expected to be high since the installation site is inside the UB campus.

3) Introduction of advanced technology and know-how of Japan

There were experiences on small-scale autonomous solar systems, mainly in the rural areas. However, there is limited experience on installation of grid-interconnected power generation system. On the other hand, grid-interconnected solar PV systems are widely used in Japan. In this project, the advanced technology of Japan in solar PV systems and grid-interconnected technology can be applied.

4) Establishment of sustainable O&M structure

In the project, the person in-charge of O&M will be trained under the manufacturer's engineer and the soft component program because there is limited experience on O&M of grid-interconnected solar PV system in the country. The technical transfer will be conducted with MOW as the counterpart and implementing organization. Establishment of a sustainable O&M structure will thus be expected to promote renewable energy projects.

5) Influence on environment

Construction works are carried out inside the UB campus. Therefore, it is important to consider taking safety measures to protect the students, UB personnel and visitors from outside. There is no influence to surroundings if the site is segregated using fences and putting danger plates around the construction site.

As mentioned in the above key issues, the adequacy of implementation in an environmental program grant aid by the GOJ is of great significance in this Project.

3.2.2 Project Effectiveness

(1) Quantitative Benefits

The supply of power output and reduction of CO_2 emission are considered as the quantitative benefits of the project implementation. Details are as follows:

Table 3-1 Effective Index and Target Value

Index	Standard Value (2010)	Target Value (2013) {3 years after project completion}
Annual Estimated Power Output (MWh/year)	0	460 MWh/year
CO_2 Emission (t/year)	0	142 ton/year

(JICA Study Team)

(2) Qualitative Benefits

1) Introduction of Renewable Energy
Introduction of a grid-interconnected PV system is the first project of this kind in Belize. After this project, other renewable energy projects will be expected to be promoted and selling electricity. The soft component, including O & M and troubleshooting technology on the PV system, contributes to train the maintenance staff, and not only the PV engineer but also the grid interconnection engineer.

2) Demonstration Effect
UB has many divisions, with the Division of Information and Communication Technology having interest in this project. A monitoring display panel indicating power output and solar irradiation will be installed in front of the Jaguar Building (auditorium), and also monitoring data will be indicated on the website. This monitoring plan will have an effect of appeal to Caribbean countries.

3) Raising Awareness
As for the PV system which was introduced in this project, it is expected that it will raise awareness on climate change and understanding of the efficient usage of solar energy through the soft component in this project.