MOEJ/GEC JCM Feasibility Study (FS) 2014
Summary of the Final Report

"Small Scale Solar Power Generation"

(Implementing Entity: INTER ACTION Corporation**)**

1. Overview of the Proposed JCM Project

Study partners	JAPAN NUS Co., Ltd	Subcontractor	Supporting the development of JCM and MRV methodologies and consulting services
	BIJ Corporation	Subcontractor	Selecting construction materials, construction method analysis, and making decisions regarding installation of solar roof panels on project site buildings.
	Fortec Consultants	Subcontractor	Site survey, participation in interviews with relevant parties, supporting studies of the local electricity situation
Project site	Republic of Palau		
Category of project	Renewable energy		
Description of project	This project involves installation of a 160 kW solar power generation system for the Palau International Coral Reef Center, a non-profit public corporation in the State of Koror, Palau. The introduction of solar power generation systems in areas already electrified by diesel generators will reduce the use of fossil fuels for power generation and lessen the emission of greenhouse gases.		
Expected project implementer	Japan	INTER ACTION Corporation	
	Host country	Palau International Coral Reef Center: PICRC	
Initial investment	*1 128,000,000 Yen	**Date of groundbreaking**	November 2015
Annual maintenance cost	*1,664,000 Yen	**Construction period**	12 months after contract

Willingness to investment	Introduction of a solar power generation system	**Date of project commencement**	October 2016
Financial plan of project	As PICRC is a public corporation, the budget will be allocated and executed by the Ministry of Finance (MOF), Palau. If there is a budget shortage, a loan application will be submitted to NDBP (loan rate: 6%). PICRC is being asked to finalize the budget before April 2015 when the application for the grant-aided JCM facility project is made.		
GHG emission reductions	Substitution of the power currently supplied from the grid to the project site: 100 tCO_2 per year 180 (MWh/y) * 0.698 (tCO_2e/MWh) * (1-0.2) = 100 (tCO_2e)		

*1 Reduced due to available funding. In response, the solar power generation system capacity was reduced to 160 kW

2. Study Contents

(1) Project development and implementation

1) Project planning

This project involves installation of a 160 kW solar power generation system for the Palau International Coral Reef Center (PICRC), a non-profit public corporation in the State of Koror, Palau, to supply electric power. PICRC is currently purchasing electric power, via the grid, from the Palau Public Utilities Corporation (PPUC) for its consumption. Because this system is expected to fulfill part of the day and night demand, lithium-ion batteries are to be included to achieve self-consumption through solar power generation. The surplus power generated by solar power generation after individual use will be sold to PPUC, in accordance with the conditions of PPUC's surplus power purchasing system; this will reduce the power supplied to the grid from diesel generators in Palau.

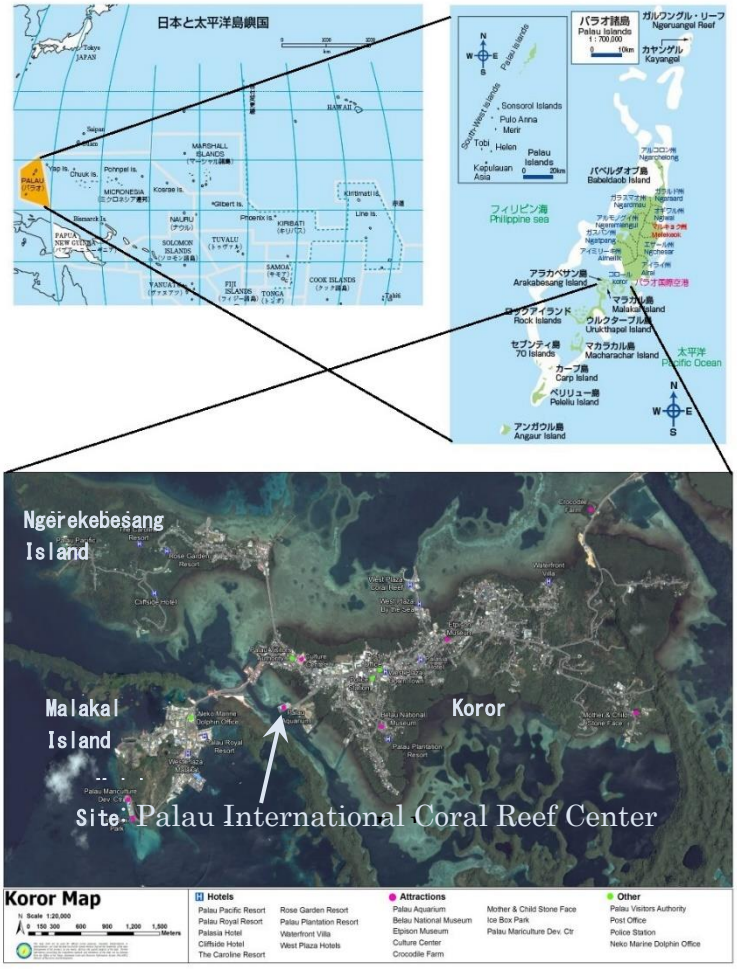

Figure 1 Map of the Republic of Palau

Figure2 View of the PPUC site

The initial investment for the introduction of the 160 kW solar power generation system is approximately 128 million yen. The project plan assumes that 50% of the initial cost will be financed by a subsidy granted by Japan; the remaining 50% will be borne by PICRC, the project implementing body. As a non-profit public corporation, the budget will be executed according to predefined procedures for the project site. PICRC is responsible for fully financing 50% of the initial investment using its own money but it may also be necessary to obtain financing from local banks, Japanese banks, and/or the National Development Bank of Palau (NDBP) depending on the circumstances.

As a guideline, the overall plan forecasts the system specifications and construction methods to be finalized by November 2015 and the installation to be completed by July 2016, including the period of financing. The system is to be operational in October 2016.

Regarding the MRV system, measurement (M) and reporting (R) will be conducted by the body that will operate the small-scale solar power generation system, and verification (V) will be conducted by a certified third party entity (TPE). As there are four such certified TPEs in Palau, just one will be selected. It is assumed that the operator at the project site will be PICRC. Because no dedicated engineer will be positioned at the site to maintain the facility, inquiries to the PPUC relevant to financing for a maintenance service contract (to be made after the installation of the solar power generation system) will be necessary in order to realize a sustainable business.

PICRC is receiving an appropriation from the government. A budget bill will be submitted to the government every April, and the appropriation will be made after Diet approval and the signature of the president. The trend has been for the appropriation budget to continue to decrease annually, gradually increasing the portion of independent financing. PICRC’s financial situation returned to the black in fiscal 2012 following a continuation of deficits that lasted until 2011. This was due to partially stopping the operation of the chiller system used in the water tank to reduce the energy bill, in addition to a subsidy granted specifically in fiscal 2013. This subsidy was granted for the "Project for Sustainable Management of Coral Reefs and Island Ecosystems: A Response to the Threat of Climate Change," the fiscal 2012 research topic for the joint program "Science and Technology Research Partnership for Sustainable Development (SATREPS)" by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA). For this project, PICRC conducted a joint study with the University of the Ryukyus. The five-year study lasts from April 2013 to March 2018.

It is anticipated that the implementation of this project will contribute to the improvement in financial management, as electric bills for power from the grid will be reduced through the use of solar energy.

According to a cash flow analysis, the internal rate of return (IRR) will be 8.49% for the 20 year investment, when just 160 kW solar panels are installed (without batteries). When a 140kW solar panel system is used together with 27kWh lithium-ion batteries, the IRR will be 2.10%, and profitability is apparently reduced. The advantage of this configuration, however, is that the batteries can be used as emergency power when there are power interruptions. Clean renewable energy is also available during the night. Since lithium-ion batteries will be used, the impact on the environment can be minimized when the batteries are discarded.

To cope with implementation risks, it is desirable to buy an international insurance plan that covers natural disasters as well as theft and man-made disasters. If the amount of energy generated falls below the expected amount due to insufficient sunshine, a sufficient margin has already been assumed during a power generation simulation as the basis for developing the financing plan. In view of any reduction in output power due to age or deterioration of the equipment, only solar panels with a guaranteed output power will be used. To avoid malfunction or fire as much as possible, the equipment to be procured will be in compliance with the relevant IEC and/or other equivalent standards. The power conditioner has a service life generally assumed to be 10 years; the cost of replacement after 10 years is included in the financing plan. To provide uninterrupted service, a valid maintenance scheme will also be established based on the maintenance contract with PPUC, which has sufficient technical knowledge and the human resources appropriate for solar power generation systems. Because the PICRC project site is located near the coast, the equipment will need anti-rust and anti-corrosion treatments, such as thick hot-dip galvanizing as well as anti-corrosive aluminum and stainless steel materials. In general, the profitability of solar power generation services is heavily dependent on government policy, especially at a fixed price and the period for purchasing the energy generated. While any change in government renewable energy policy can become a risk, it is not considered to be a significant one because the Republic of Palau has a plan to increase the share of renewable energy to 20% by 2020.

Table 1 Cash Flow Analysis -- Option Cases and 20 years IRR Calculation

Option Cases	IRR
Case 1 160 kW solar panels	8.49%
Case 2 140 kW solar panels and 27kWh lithium batteries	2.10%
Case 3 140 kW solar panels and 35.8kWh lead-acid batteries	5.10%

2) Permits and License for the project development and implementation

The approval and authorization procedures regarding the installation of the solar power generation system shall be carried out in accordance with the guidelines published by the PPOC: "Guidelines, Standards and Regulations for Renewable Energy Generation Systems Connecting to the Palau Central Grid". The project implementing body must submit the application documents as specified in the guidelines to PPUC for approval. Construction can be initiated only after approval has been obtained. After completion of the installation, the system must be inspected by PPUC before interconnection with the grid and the service begins to generate power.

The Environmental Quality Protection Board (EQPB) was asked about compliance regulations for constructing a car park type pedestal for mounting solar panels. It was determined that permission for civil engineering and construction would be necessary. As of December 2014, there were no major regulations regarding installation of lithium-ion batteries.

3) Advantage of Japanese technology

As of October 2014, solar power generation was not popular in Palau because of the relatively small number of solar power generation companies in operation. Most of the existing solar power generation facilities have been built using subsidies granted by developed countries; no solar power generation facility has been developed for business purposes only.

According to data provided by PPUC, the status of solar power generation in Palau is as follows: The government of Palau has a target to achieve a renewable energy share of 20% by 2020 and has already achieved a share of 5% in August 2014. Aggressive introduction of solar power generation is considered advantageous from the viewpoint of higher cost-performance when compared to wind, geothermal, biomass, and other power generation systems, as well as the shorter time and lower costs for installation, operation, and maintenance. There are no wind farms in Palau, but actual wind conditions have been studied at Melekeok, Ngaraard, and Ngardmau since January 2013. Data on wind has been collected for about one year, meaning that it will take longer before wind power generation systems can actually be implemented; solar power generation can be quickly implemented based on successful past results.

The solar power generation system for this project will use lithium-ion batteries that are made in Japan; lithium-ion batteries have a lower environmental load, better storage characteristics, a longer cycle life, and are designed to charge quickly. With experience as the world's first mass producer of electric vehicles, Japanese manufacturers have a

high 79% market share. Note that the market size in 2011 was about 110 billion yen. It is expected that large-sized lithium-ion batteries will increasingly be used for stabilizing the output power of solar power generation systems. Once realized, the use of lithium-ion batteries in solar power generation systems will serve as a model to demonstrate the superiority of Japanese technologies.

4) MRV structure

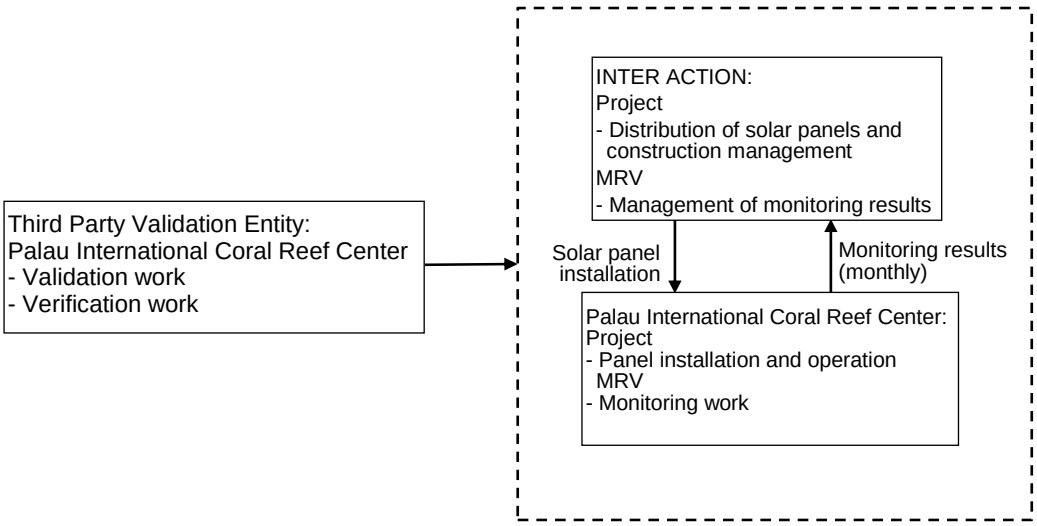

Figure 3 MRV System

It is assumed that PICRC will be responsible for Measurement (M) and Reporting (R) as the project implementing body and that a third party verification entity will be responsible for Verification (V). The measuring equipment to be used in MRV is listed in the following table. The watt-hour meter, Mitsubishi Electric model EMU4-HD1-MB, will measure the electric energy (kWh) generated by the solar power system.

The measurements are recorded in an SD memory card in real time, and the recorded data is imported monthly to a PC at PICRC so that the data can be organized using spreadsheet software such as Microsoft Excel. When actually implementing the MRV framework, the measuring equipment will be further studied and selected in consultation with the third party verification entity to finalize the devices to be used.

Table 2 Specification for major devices used for measuring the electricity consumed

	Device Name	Manufacturer	Model	Specifications
1	Watt-hour meter	Mitsubishi Electric Corporation	EMU4-HD1-MB	Phase/Wires Single phase, two-wire/Single phase three-wire system/ Three phase, three-wire/four-wire systems, common use
				Voltage rating: 63.5VAC/110VAC to 277VAC/480VAC, common use
				Current rating: AC 50A, 100A, 250A, 400A, and 600A (Dedicated clamp current sensors are used. Each figure indicates the current in the sensors primary coil.)
				Frequency: 50/60Hz
2	Current sensor	Mitsubishi Electric Corporation	CW-5SL 800/5A	Rated primary current 800A
				Secondary current: 5A
				Maximum voltage/withstand voltage: 0.46kV/3kV
				Over-current strength 40 times

5) Environmental integrity and Sustainable development in host country

When implemented, this project will reduce the power supplied from the grid and consumed at the project site and will result in a reduction of GHG emissions from the diesel power plant and will have a positive effect on the environment.

Because this study recommends the use of lithium-ion batteries instead of the lead-acid type, any adverse impact on the environment due to the use of lead-acid batteries can be eliminated. The lithium will be recycled by handing over old or depleted batteries to Palau Waste Collection, a local company in Palau, following 10 years of use (life expiration), for export and recycling in China.

The project supports and contributes to the realization of Palau's renewable energy policy, i.e., to achieve a 20% share of renewable energy. When installing the solar power generation system, local construction companies will be employed and this will create local jobs. By outsourcing maintenance services to PPUC (the public utility), it is expected that new jobs will be created and that the technical skills of engineers will improve through on-job training. Promoting electrification in Palau will stimulate the development of hotels and other commercial facilities and indirectly contribute to employment creation and activation of the local community.

6) Toward project realization (planned schedule and possible obstacles to be overcome)

The project will continue according to the future plans described in Table 3. The first issue to be looked at is how to secure funding. While PICRC is working on possible loans from the Ministry of Finance and NDBP as the primary sources of funding, it is being asked to finalize the budged before April 2015, when the application for the grant-aided JCM facility project is to be made.

The second issue is the necessity of following the bidding process if equipment is to be procured using PICRC funds. Because PICRC partially operates under a Ministry of Finance budget, it is necessary, in principle, to have open and public bidding, which involves a complicated process. At present, PICRC is looking for an alternative method that will not require bidding, such as signing an MOU, jointly submitting a proposal, etc.

The third issue is the finalization of the equipment specifications. Two option cases have been presented to PICRC: (1) 140 kW solar power and 27 kWh lithium-ion batteries or (2) 160 kW solar power only. PICRC has been asked to review the cost effectiveness to determine a final solution.

Table 3 Project Schedule (Draft)

Time	Action
After June 2015	Selection as a grant-aided JCM facility project by the Ministry of the Environment
November 2015	Finalization of the specifications
December 2015	Collection of quotations and starting the equipment procurement
April 2016	International transport
June 2016	Customs clearance and local transport in Palau
July 2016	Completion of construction work
August 2016	Commencement of commercial operation Commencement of JCM monitoring services
July 2021	Completion of JCM monitoring services

(2) JCM methodology development

1) Eligibility criteria

The following six eligibility requirements have been established for the development of the draft JCM methodology:

Eligibility requirement 1	The power generation service shall use solar power generation.
Eligibility requirement 2	The project site shall be in an area where electricity is supplied by the Palau Public Utilities Corporation (PPUC).
Eligibility requirement 3	Electric meters shall be installed to measure the electricity consumption.
Eligibility requirement 4	The modules used shall have certification for relevant IEC standards for performance and safety.
Eligibility requirement 5	The solar conversion efficiency of the modules used shall be 15% or higher.
Eligibility requirement 6	The maximum power temperature coefficient for any module used shall be greater than -0.45%.

(1) Eligibility requirement 1: The power generation service shall use solar power generation.

The introduction of solar power generation has been established as one of the eligibility requirements for application to JCM as solar power generation and is the most feasible for Palau and thus emission reductions can be effectively realized.

(2) Eligibility requirement 2: The project site shall be in an area where the electricity is supplied by the Palau Public Utilities Corporation (PPUC).

In Palau, PPUC is supplying electric power to most of the inhabited areas including isolated islands such as Peleliu. On the isolated islands, power generation dependent on fossil fuels is not so efficient because the capacity of the generators tends to be small due to the relatively small number of people who use electricity and the additional fuel transport costs. The introduction of solar power generation would be an advantage for these isolated islands. In order to be applicable to isolated islands such as Peleliu, all the areas where electric power is supplied by PPUC are considered to be eligible, including off-grid areas, in addition to those areas supplied from the main grid.

(3) Eligibility requirement 3: Electric meters shall be installed to measure electricity consumption.

In order to accurately and objectively measure the reduced amount of GHG emissions, installation of electric meters that can be used to check the consumed amount of solar generated electric power is established as one of the requirements. By requiring the installation of electric meters, the reduction of GHG emissions can

be accurately and reliably monitored for verification by a third party entity (TPE).

(4) Eligibility requirement 4: The modules used shall have certification for relevant IEC standards for performance and safety.

To ensure that high quality solar panels that reliably reduce emissions throughout the project period are chosen, certification for relevant performance and safety standards of the IEC (International Electro-technical Commission) has been set as one of the requirements.

(5) The solar conversion efficiency of the modules used shall be 15% or higher.
This draft methodology sets the performance requirement for the solar panels installed to have a certain conversion efficiency to generate power as one of the eligibility requirements.

(6) The maximum power temperature coefficient, or nominal operating cell temperature (NOCT) of any module used shall be greater than -0.45%.

The nominal operating cell temperature (NOCT) is an indication of the percentage increase of the maximum output power when the panel temperature is increased by 1º C. As the annual average temperature is high in Palau, i.e., 27º C, the nominal operating cell temperature of the solar panels used is an important indicator. Accordingly, this draft methodology specifies the nominal operating cell temperature of the solar panels as one of the eligibility requirements.

2) Calculation of GHG emissions (including reference and project emissions)

After studying the reference and project scenarios according to the JCM guidelines, the following formula that calculates the amount of GHG emission was obtained:

$$RE_y = EG_{PJ,y} \times EF_{CO2,def,y} \times (1 - CF)$$

RE_y	Reference amount of annual emissions in year Y（tCO_2e/y）
$EG_{PJ,y}$	Electric energy consumption substituted by the project activities in year Y (MWh/y)
$EF_{CO2,def,y}$	Default emission factor of the electric energy substituted by the project activities (tCO_2e/MWh)
CF	Conservativeness factor (20%)

In this methodology, as the project will not produce emission, PEy = 0.

According to the above specified formula to calculate the reference emission, the estimated reference emission of this project is calculated here. The electric energy consumption substituted by the project activities in year Y (EGPJ, y) is expected to be about 180 MWh per year, when a system capacity of 160 kW is assumed. The default emission factor of the electric energy substituted by the project activities (EF CO_2, def, y)

is 0.698 (tCO_2/MWh) and the conservativeness factor (CF) is 20%. Therefore, it is calculated as follows:

REy (tCO2e/y) = 180 (MWh) x 0.698 (tCO2/MWh) x (1-0.2)
= 100 (100.512) (tCO2e/y)

As the project emission PE = 0,

ER = 100 (RE) - 0(PE)
= 100

Therefore, the reduction of GHG emission is estimated to be 100t CO_2e per year.

3) Data and parameters fixed *ex ante*

For the proposed draft JCM methodology, the following parameters are required for calculating the amount of GHG reduction:

- Electric energy consumption substituted by project activities (EGpj,y)
- The CO_2 emission factor for power generation of the grid to which the substituted power is supplied (EF_{CO2},def,y)
- The conservativeness factor (CF) for the calculated reference emission to be less than BaU

The electric energy consumption substituted by the project activities (EGpj,y) is measured by electric meters specified in eligibility requirement 3 "Electric meters shall be installed to measure electricity consumption". In addition, as generated electric energy is sold to PPUC, PPUC also needs to measure the amount of electricity bought. Although electric meters installed could be shared with PPUC, even if they are not, it is still possible to cross check the amount of consumed energy as substituted by the solar power generation using the related documents on the energy purchase, as agreed with PPUC.

The CO_2 emission factor for power generation of the grid to which the substituted power is supplied ($EF_{CO2,def,y}$) is specified based on PPUC's 2013 default value because there is no officially approved and published emission factor in Palau. The resulting default CO_2 emission factor is 0.698 tCO_2/MWh.

The conservativeness factor (CF) is set to be 20% assuming that the targeted policy of Palau to increase the share of renewable energy to 20% by 2020 can be realized.