Project commissioned by the Ministry of the Environment in 2023

Commissioned Task for project of the City-to-City Collaboration for Zero-Carbon Society in 2023
(Support Project for Developing a Sustainable Eco-friendly City: An Intercity Collaboration between Urasoe City and Airai State)

Report

March 2024

JAPAN NUS Co., Ltd.
Urasoe City

Table of Contents

List of Tables

List of Figures

Table of Abbreviations

Abbreviation	English	Japanese
ADB	The Asian Development Bank	アジア開発銀行
AIFFP	Australian Infrastructure Financing Facility for the Pacific	オーストラリア・インフラストラクチャー・ファイナンス・ファシリティ
BCP	Business Continuity Plan	事業継続計画
BEMS	Building and Energy Management System	ビル・エネルギー管理システム
COP26	The 26th Conference of the Parties	第 26 回気候変動枠組条約締約国会議
DR	Demand Response	需要応答
DX	Digital Transformation	デジタル変革
EPC	Engineering, Procurement and Construction	設計・調達・建設
GHG	Greenhouse Gas	温室効果ガス
HEMS	Home Energy Management System	ホーム エネルギー マネジメント システム
IPP	Independent Power Producer	独立系発電事業者
IRENA	The International Renewable Energy Agency	国際再生可能エネルギーアソシエーション
JANUS	Japan NUS Co., Ltd.	日本エヌ・ユー・エス株式会社（本都市間連携提案事業者）
JCM	Joint Crediting Mechanism	二国間クレジット制度
JICA	Japan International Cooperation Agency	独立行政法人国際協力機構
PPA	Power Purchase Agreement	電力販売契約
PPUC	The Palau Public Utilities Corporation	パラオ電力公社
PV-TPO	Photovoltaic Third-Party Ownership	太陽光第三者所有モデル
PWA	Palau Energy Water Administration	パラオ政府財務省エネルギー・水管理組織
LED	Light Emitting Diode	発光ダイオード
MG	Motor and Generator	モーター発電機
NDBP	The National Development Bank of Palau	パラオ開発銀行
NDC	Nationally Determined Contribution	国が決定する貢献（国別温室効果ガス削減目標）
SPPP	Solar Pacific Pristine Power Inc.	ソーラーパシフィック・プリスティン・パワー
TPO	Third Party Ownership	第三者所有モデル
REO	Reliance Energy Okinawa Corp.	株式会社リライアンスエナジー沖縄

VPP	Virtual Power Plant	仮想発電所
WiFi	Wireless Fidelity	無線 LAN
4R	Reduce, Reuse, Recycle and Refuse	減らす、再利用、リサイクル、断る（ゴミ減量の考え方）

1. Background, Purpose and Implementation Structure of This Project

1.1. Background and Purpose

With a consensus document produced at the 2022 United Nations Climate Change Conference (COP27) held in November 2022, the importance of keeping the increase in air temperature from the level before the industrial revolution from exceeding 1.5℃. The Global Stocktake (GST), which evaluates the global progress toward his goal, was conducted for the first time after the enforcement of the Paris Agreement. In order to attain the goal, each country needs to accelerate initiatives at various levels, including provincial, municipal, and ward levels. Japan, too, declared that it would aim to realize a decarbonized society by reducing net GHG emissions to zero by 2050, and the number of municipalities that have declared that they would achieve virtually zero CO_2 emissions increased rapidly to over 1,000 (as of December 28, 2023). Under the regional decarbonization roadmap formulated in 2021, the initiatives for creating pioneering measures in each region and applying them nationwide are ongoing.

Accordingly, the roles of cities and local governments in discussing and implementing specific local climate change measures and projects are becoming increasingly important. In order to realize a decarbonized society all over the world, it is necessary to accelerate the movement toward building a sustainable decarbonized society, especially in Asia where economic growth is remarkable. There is a growing international movement to support the efforts of cities to decarbonize and lower the carbon footprint of their activities, as these cities are the places that support social and economic development.

The Republic of Palau, which is a subject country in this project, set a goal of generating power all from renewable energy by 2032. To attain this goal, they plan to formulate a new roadmap in 2024, and are strengthening governmental measures. Against this background, Urasoe City, Okinawa Prefecture will support the Airai State, the Republic of Palau in decarbonization aimed at distributing renewable energy and making it mainstream by utilizing the experience of the city in this project, as the Airai State aims to develop environment-conscious towns with technologies for renewable energy and energy saving, which are in high demand.

Specifically, upon enlisting the cooperation of SeED Okinawa LLC, a company in the Okinawa Electric Power Group, which has signed a comprehensive cooperative agreement with Urasoe City, we will consider promoting “PV-TPO,” a charge-free service for installing third-party-owned solar panels and storage batteries, which is being rolled out by the Okinawa Electric Power Group in Urasoe City. In addition, we aim to expand the use of renewable energy by introducing and promoting technologies for

tiltable wind power generation in Palau. Furthermore, we will discuss the development of infrastructure for distributing renewable energy through the stabilization and control of power grids while enlisting cooperation from NEXTEMS, which is conducting a demonstration experiment on the remote monitoring and control of distributed power sources and controllable loads.

In this survey, we aim to utilize the JCM equipment subsidy program in the stages of equipment installation and business implementation. We will carry out the following activities to receive the JCM subsidy for each project.

① Charge-free service of installing solar panels and storage batteries owned by third parties (PV-TPO)

Large-sized independent power producers (IPPs) specializing in solar power have entered the market in Palau. In order to maximize the use of renewable energy, it is indispensable to distribute privately-consumed solar power among consumers. Initial investment is required for distributing privately-consumed solar power, so the financial power of consumers determines the potential of distribution. “PV-TPO,” a charge-free service of installing solar panels and storage batteries owned by third parties, allows third parties to conduct the initial investment in solar power generation systems and recoup the investment with electricity charges. Accordingly, this measure can be said to be effective for distributing solar power without relying on the financial power of consumers. Palau set a goal of installing rooftop solar panels for generating 3 MW, three times the current output, and a goal of installing storage batteries for storing 9.4 MWh by 2025. In the Airai state, there are many public, commercial, and industrial facilities, including public schools, so the cooperation from provincial governments, etc. can be expected. On the other hand, the constraints on connection to grids in Palau would hinder the adoption of solar power generation that assumes the connection to the grids. Therefore, we will discuss the commercialization of the PV-TPO model targeted at Palau Pacific Resort (hereinafter referred to as “PPR”), which owns and manages the independent grids in Palau, as a model combining solar power generation and grid control.

Figure 1-1　Palau Pacific Resort

In this survey, we will study the following items to assess the feasibility and effects of the model.

- Design of a solar power generation system in PPR
- Discussion on the utilization of the JCM equipment subsidy program
- Identification of potential sites other than PPR, and estimation of the scale of adoption
- Search for local business operators that could offer the PV-TPO service

② Tiltable Wind Power Generation Field

Palau has ample wind power resources. Nevertheless, wind power generation has not spread, because it has issues characteristic of a remote island such as frequent typhoons and a shortage of engineers who can repair equipment. Okinawa Electric Power's tiltable wind power generation technology is ground-breaking renewable energy technology for such areas. This technology was introduced into the Kingdom of Tonga in 2018.

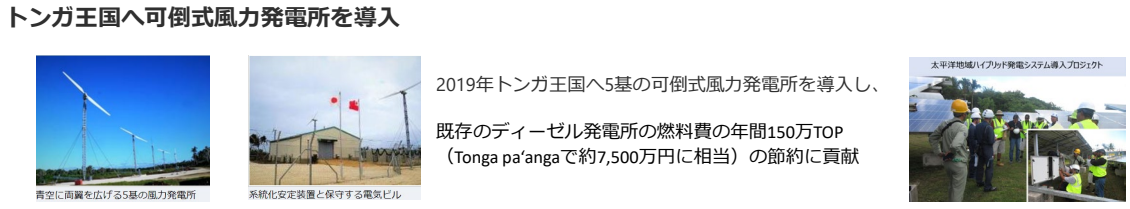


Figure 1-2　Introduction of Tiltable Windmills to the Kingdom of Tonga

The Government of Palau also has a high level of interest in tiltable wind power

generation technology. For example, it made a request to Okinawa Electric Power for cooperation in FY 2018. That means the groundwork to execute and realize this project in this survey is already there.

In this survey, we will assess its feasibility and effects by studying the following items. For its details and scheme, please refer to Reference 1-P9.

- While focusing on the spots where the power grid is shared with the Airai state, we will narrow down the potential sites found in the previous fiscal year. In addition, we will search for potential sites in the entire area of Palau.
- We will grasp and summarize the effects of introduction and problems, and then discuss a plan for introducing tiltable windmills.

③ Introduction of High-efficiency Air Conditioning and Hot Water Supply Equipment (Energy Services) for Commercial and Public Facilities, and Potential Fields of Hydrogen Production

As there is demand for air conditioning and hot water supply in PPR, which aims to adopt solar power generation, we discussed the possibility of use of waste heat from existing diesel generators.

We also discussed the distribution of hydrogen for use, based on based the FY 2021 Three-country Collaboration Project for the Manufacture and Use of Hydrogen (Three-country Collaboration Project for the Manufacture and Use of Hydrogen in the Bilateral Credit Scheme Funding Support Program). For its details and scheme, please refer to Reference 1-P10.

- We will discuss the possibility of use of waste heat from diesel power generators to meet the demand for air conditioning and hot water supply in PPR.
- We will discuss the minimization of dependence on existing diesel power generators and the maximization of energy efficiency through waste heat utilization, while considering the switch to fuel cells, etc. based on the linkage with the FY 2021 Three-country Collaboration Project for the Manufacture and Use of Hydrogen (Three-country Collaboration Project for the Manufacture and Use of Hydrogen in the Bilateral Credit Scheme Funding Support Program).

④ Grid Stabilization Field in Anticipation of the Introduction of the Proposed Technologies and Services

Integrated control with various power sources across the country is needed for the introduction of the three technologies/services (PV-TPO, tiltable wind power and energy services) in this proposal. Moreover, introducing a control system (area aggregation) for controllable loads on the consumer side such as the PV-TPO service and energy services would also contribute to grid stabilization on the demand side. Therefore, it can be expected to lead to further grid stabilization.

In this survey, we will assess the feasibility and effects of grid stabilization by studying the following items. For its details and scheme, please refer to Reference 1-P11.

- Various institutions have implemented a broad range of initiatives for grid stabilization. Firstly, it is necessary to summarize ongoing initiatives and discuss a support program while considering the master plan and policies for electric power. In this survey, we will extract problems by analyzing the existing initiatives and the master plan for electric power.
- We will consider the possibility of introducing an area aggregation system as a measure for controlling electric power supply and demand.

⑤ Policy Proposals

We introduced “Urasoe City Basic Environmental Plan,” “Urasoe City Action Plan for Measures against Global Warming,” etc. formulated by Urasoe City, and our efforts for waste disposal, energy saving, and environmental education at the recycling center of the city, and exchanged opinions in order to promote the decarbonization measures of the Airai state.

⑥ Initiatives for promoting C2P2

Clean City Partnership Program (C2P2) is intended for offering comprehensive, synergetic support to solve urban issues facing partner cities, such as climate change, environmental pollution, recycling economy, and nature restoration, in cooperation with multilateral development banks (MDBs), while involving Japanese municipalities, private enterprises, financial institutions, etc. In this project, we decided to discuss the fields of environmental pollution, recycling economy, and nature restoration, in cooperation with Urasoe City, while implementing decarbonization measures as main activities. The discussion themes are as follows.

(1) Support for waste management

Palau has waste problems unique to islands like other Pacific countries. In Pacific countries, the recycling of resources, including materials, has no advantage of scale and there are no options other than waste disposal at landfills. Palau is no exception, and they have no choice but to dispose of most solid waste in landfills. We studied the possibility of initiatives for contributing to the recycling of resources for promoting C2P2. In the field of waste, support has been offered mainly by Japan, and we are getting results. We have conducted discussions that would strengthen such existing initiatives.

(2) Promotion and decarbonization of agriculture, forestry, and fisheries

In addition to energy issues, Palau is faced with the problems with food security. They depend on import for most food, so food prices are affected by the fluctuations in energy prices, and they lack the capability of producing agricultural products to satisfy the demand for food in the sightseeing industry. Therefore, they are missing opportunities to return profit to Palau.

As the background of these problems, there is the shortage of personnel, there are few commercial farmers, and farmers who are partly self-sufficient ship surplus crops to markets, so agriculture as business has not been established. Regarding fisheries, most fishermen just sell the remaining catch after self-consumption.

The Airai state has policies for energizing its economy through the supply to the sightseeing industry and promoting agriculture and fisheries to increase employment opportunities for young people. Accordingly, it can be considered that there exist strong needs for development of advanced and decarbonized agriculture and fisheries, and we assessed the feasibility of smart agriculture and fisheries in this survey.

The project scheme is as shown below.

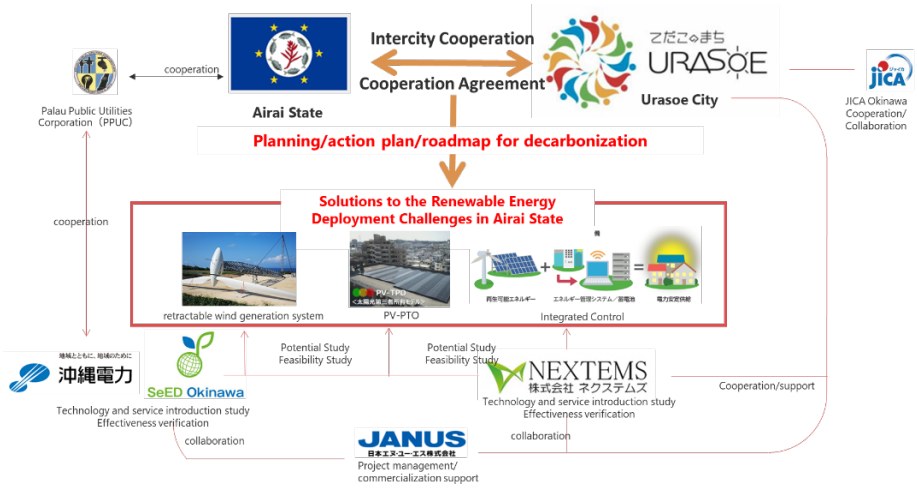


Figure 1-3　Intercity collaboration project scheme

2. Discussion on a Commercialization Plan

2.1. Overview of Palau and Measures against Climate Change

The Republic of Palau (hereinafter referred to as "Palau") is a country located in the western Pacific, and composed of over 200 volcanic islands and coral islands, most of which are surrounded by a single barrier reef. Its total area is 459 km^2, and its population is about 18,000 people. Palau used to be a United Nations trust territory managed by the United States, and became independent in 1994. In 2006, its capital was changed from Koror City to Ngerulmud, Melekeok, located in Babeldaob, which is the largest island in Palau.

Palau has nurtured rich unique culture and history while being influenced by Spain, UK, Germany, Japan, and the U.S. It joined the United Nations, and forged diplomatic relations with Taiwan.

Its economy is based on mainly the sightseeing industry utilizing rich natural resources. Palau engages in the promotion of the sightseeing industry in harmony with natural resources with the goal of growing the sightseeing industry in a sustainable manner.

The Airai state, which is the subject municipality of this project, is located in the southern coast of Babeldaob. This state has the second largest population after the state of Koror, and has the highest population density in Palau. Most citizens reside on the low-altitude wave-cut bench along the coast. For the state, a governor is elected as a chief executive, and legislature members are elected every four years. Citizens elect one of members of the House of Delegates of Palau.

In the Airai state, there are at least 11 remains of traditional villages, including the oldest bai (a meetinghouse of men) built 200 years ago, which is famous.

Palau and Okinawa Prefecture have deep historical and cultural connections, and are cementing their friendly relation. In 2022, they signed a memorandum for strengthening their friendly relation and fostering a cooperative relationship for the future. This partnership is important from the viewpoint of security of Japan in the Indo-Pacific region, so it is meaningful to maintain or strengthen the cooperative relationship for national interests. The two regions are expected to grow further, through courtesy calls, consultation, and strengthening of cooperation.

Their relation with Okinawa Prefecture dates back to the pre-war period. It is said that more than 40% of the approximately 11,000 Japanese residents living in Palau in the 1940s were from Okinawa Prefecture. There are still many Palauan people with roots in Okinawa Prefecture who are descendants from them.

In recent years, Governor Tamaki of Okinawa Prefecture issued a congratulatory message upon the inauguration of the President of Palau in 2021. It was announced at that

time that the two sides would promote exchanges and joint efforts for the resources and technologies they possess. This helped the conclusion of the above-mentioned memorandum for cementing the friendly relation.

Amid such diplomatic exchanges, the Okinawa Electric Power Group received a letter for requesting technological cooperation in the installation of tiltable windmills from the Minister of Energy of Palau, and dispatched engineers to Palau, to conduct a survey there. Like this, they have maintained a good relationship.

The Okinawa Electric Power Group is enthusiastically working on technical cooperation overseas. The JICA Okinawa program has been accepting overseas trainees every year since FY 2003. It strives to improve the skills of the engineers who will play a leading role in each country.

JICA Okinawa has been running a program since approximately 40 years ago to accept approximately 400 trainees a year from overseas. The program has so far accepted 13,000 trainees from 164 countries. It has accepted a total of over 120 trainees from Palau. For further information on cooperation between JICA Okinawa and Palau, please refer to Reference 2-P19.

The head offices of JICA Okinawa and Okinawa Electric Power are located in Urasoe City. The city has a cooperative relationship with them. In particular, Okinawa Electric Power entered into a comprehensive cooperative agreement with the city in 2021. It is proactively working on the utilization of environmentally-friendly energy, for example, by introducing solar power into public facilities under this agreement. For further information on the cooperation between the Okinawa Electric Power Group and Urasoe City, please refer to Reference 1-P2.

Palau has been faced with issues with security and stable supply of energy, and improvement in access to energy, because it is an island country. They implement energy policies focused on sustainability, so they revised the “long-term national energy policy” in 2015 and formulated the “Palau energy roadmap” in 2017. These policies include a plan for adopting renewable energy, in which they considered solar power generation, hydroelectric power generation, solar heat utilization, etc. Furthermore, they engage in initiatives related to infrastructure development, including a plan for establishing a power grid, while enlisting support from Japan, etc.

The government of Palau set a goal of increasing the ratio of renewable energy to 45% by 2025, and is preparing for setting a goal of increasing the ratio of renewable energy to 100% by 2032. As a new roadmap is scheduled to be completed in March 2024, Palau Energy & Water Administration is formulating it with reference to the case of the state of Hawaii, which is a sister city. In addition to the measure of adopting renewable energy to

cope with climate change, concrete measures for tackling environmental issues, including waste, improving resilience, and promoting industries are expected.

2.2. Urasoe City, measures against climate change, and connections with Palau

Urasoe City enacted the basic ordinance for the environment in 2011, formulated "the basic plan for the environment" under the ethos of the ordinance, and engages in related activities. This plan envisions an ideal environment, and describes concrete measures to be taken based on the cooperation among citizens, civic groups, business operators, visitors, and the city (administration) and the course of action. In addition, a "general plan of Urasoe City" was formulated with the aim of realizing "a comfortable environment-conscious city that ensures safety, security, and solace." This plan mentions systems for disaster prevention, fire-fighting, and emergency services, the development of environments for preventing crimes, improving traffic safety, etc., landscapes, planting, parks, environmental conservation, and a recycling-oriented society.

While recognizing "the basic plan for the environment" and the "general plan of Urasoe City" as superior plans, Urasoe City formulated the first-phase plan of "Urasoe City's action plan for coping with global warming (clerical project edition)" in FY 2009, updated it, and then produced the third-phase plan in FY 2018. This plan includes concrete measures, such as the installation of highly efficient equipment in municipal facilities, the promotion of energy-saving efforts, government-wide efforts to cope with global warming, and the reduction of greenhouse gas emissions. In addition, they take measures for grasping and disclosing the progress of reduction of greenhouse gas emissions from Urasoe City in accordance with their regional action plan. The two plans are based on "the Act on Promotion of Countermeasures against Global Warming," and specify the roles of local governments, the roles that should be fulfilled by citizens and business operators, and methods for estimating emissions to disclose them.

Figure 2-1 Basic plan for the environment and the general plan of Urasoe City

Urasoe City actively promotes diverse people, including citizens, to participate and cooperate in regional decarbonization measures.

In particular, the collaborative initiatives with Okinawa Electric Power, which takes central roles in the energy industry of Okinawa Prefecture, are noteworthy. In 2021, they concluded “an agreement for comprehensive cooperation” with the aim of solving regional issues and developing a sustainable town. They would cooperate in the following four fields:

1. Stable and appropriate supply of energy
2. Adoption of or shift to environmentally-friendly energy
3. Development of disaster-resistant towns
4. Regional next-generation education

A concrete example of cooperative measures is the introduction of “the charge-free service of installing solar panels and batteries owned by third parties” of Okinawa Electric Power to a junior high school in Urasoe City. This is the first case of the provision of the service of Okinawa Electric Power to a municipality.

Figure 2-2 “Charge-free service of installing solar panels and batteries owned by third parties (PV-TPO)”

Urasoe City also disposes of waste in its unique way. The municipal waste disposal facility “Urasoe City Clean Center” had taken central roles for disposing of waste inside the city, but the deterioration of the facility has progressed recently. Accordingly, Urasoe City had discussions with other municipalities that considered extending the lifespan of their waste disposal facilities or constructing new facilities, and reached an agreement for “wide-area waste disposal.” This enables municipalities in a wide area to jointly construct and operate a new waste disposal facility and implement measures. They are currently preparing a basic plan for establishment and conducting assessment, etc.

Clean Center sorts non-combustible waste and bulky trash, and recovers and recycles metal with a crushing machine. Containers, such as glass bottles, steel cans, and plastic bottles, are sorted at Recycle Plaza, and sold to recycling enterprises. They have established a system in which non-combustible waste and containers are separated from combustible waste, and materials are recycled as much as possible.

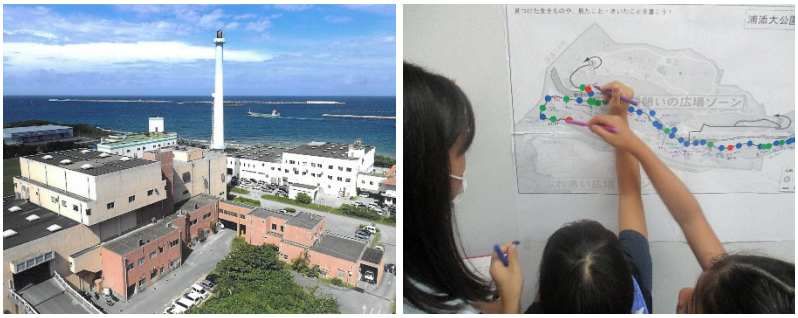


Figure 2-3　Urasoe City Clean Center and environmental education

Urasoe City puts energy into the education of next-generation personnel regarding environmental conservation. Believing that personnel education will pave the way for settlement of environmental issues, they have offered “environmental lectures” to elementary school pupils for over 20 years, while holding facility tours, nature observation, and exchange of opinions to foster learning habits. They also prepared a “course for training environmental education planners” for grown-ups who would plan and practice environmental education by themselves in each region or group.

2.3. Potential Technologies and Survey Results

2.3.1. Free Installation Service of Third-Party Owned Solar Panels and Storage Batteries (PV-TPO)

Palau has decided to install mega solar power plants and has just completed construction, with the goal of increasing the ratio of renewable energy to 45% by 2025. On the other hand, the adoption of solar power generation by customers for private consumption has also been promoted with assistance from international organizations. In expanding renewable energy sources, the challenge lies in understanding the current electricity supply and demand and how to operate them stably.

This section presents the results of a survey on the power generation and supply-demand situation in the PPUC and plans for PV installation in PPRs.

(1) Electricity Generation and its Supply/Demand in Palau

In Palau, electricity is supplied by two diesel power plants. Two diesel generators are in constant operation at the Malakal Power Plant and one at the Aimeliik Power Plant. The generator configuration of both power plants is shown in the table below.

Table 2-1 Generators at Malakal and Aimeliik Power Plants

発電所	発電機	定格出力 (kW)	出力電圧 (kV)	回転数 (rpm)	運用開始年
Malakal	Mitsubishi 12	3,400	13.8	720	1997
	Mitsubishi 13	3,400	13.8	720	1997
	Wartsila 1	2,000	13.8	1200	1996
	Caterpillar 1	1,825	0.48	1800	2006
	Caterpillar 2	1,825	0.48	1800	2006
	Niigata 14	5,000	6.6	720	2005
	Niigata 15	5,000	6.6	720	2005
	Mitsubishi 1	500	0.48	1800	2012
	Mitsubishi 2	500	0.48	1800	2012
	Mitsubishi 3	500	0.48	1800	2012
	Mitsubishi 4	500	0.48	1800	2012
Aimeliik	Mitsubishi 6	5,000	13.8	720	2013
	Mitsubishi 7	5,000	13.8	720	2013
	CAT 3516	2,000	0.48	1800	2012
Total		36,450			

出典：PPUC

Source: Japan International Cooperation Agency, " Preparatory Survey Report on The Project for Upgrading Power Grid in the Republic of Palau," August 2022.

The company aims to gradually decrease the number of diesel generators in operation

and eventually reduce it to one as renewable energy sources become more widely available.

However, a test in which all units at the Aimeliik Power Plant were shut down and only two units at the Malakal Power Plant were operated resulted in voltage drops around Aimeliik. Henceforth, when two units are to be operated, the policy is to operate one unit at the Aimeliik Power Plant and one unit at the Malakal Power Plant. Even with the reduction of diesel power generation, the issue of ensuring grid stability remains, so measures to stabilize the grid while promoting the spread of renewable energy are required.

The current power system diagram of Koror-Babeldaob is shown below.

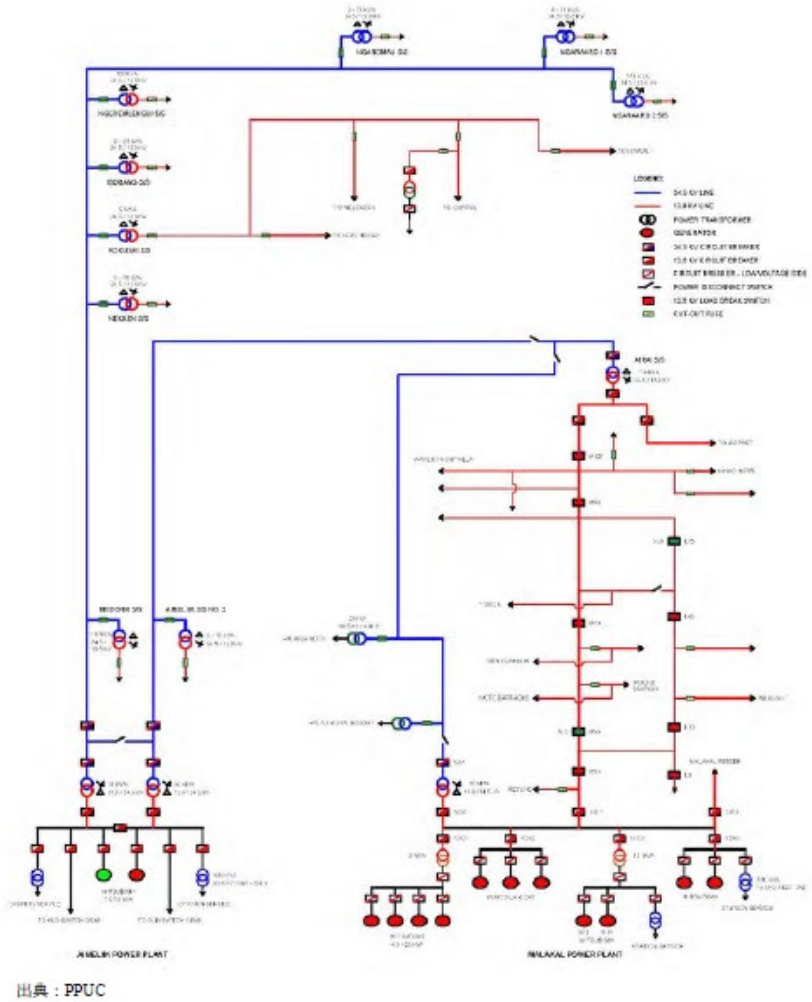


Figure 2-4 Diagram of Koror-Babeldaob Island Power System

Source: Japan International Cooperation Agency, " Preparatory Survey Report on The Project for Upgrading Power Grid in the Republic of Palau," August 2022

Regarding renewable energy, a large-scale solar power generation project by an IPP has recently been completed, which could significantly impact the Koror-Babeldaob grid. The location of the PPA project is almost at the center of Babeldaob Island and it operates the largest utility-scale solar and battery storage facility in the Western Pacific and the first in Palau, funded by Australian ODA. The IPP operator is SOLAR PACIFIC of the Philippines, and construction was completed, and trial operations began in May 2023. The installed capacity is 15.3 MWp with a battery capacity of 10.2 MWac/12.9 MWh, which is over 25% of the country's electricity demand. The solar panels are made in the U.S., the inverter is made by SMA of Germany, and the battery is believed to be made in China, using technology from SA of France. The engineering and construction company is Juwi Renewables Energies PTE Ltd, and the subcontractors are Surangel & Sons Company and WESPAC. The project is expected to reduce CO_2 emissions by 10,244 t-CO_2/year.

Since the impact of the connection on the grid is an issue and the trial operation is currently being coordinated in cooperation with the diesel power plant of PPUC, the power generation is being curtailed to 1 MW, and trial operation is underway. The power generation of each power plant is being monitored in the same manner as the central control center to be established at the Malakal power plant, and a system is being established to adjust power output through mutual communication.

(2) PPR Electricity Survey

For the PPR, located in Koror, Palau, the entire infrastructure of the facility is managed by dedicated hotel staff, and all electricity is generated at the facility during normal operations. The electricity in the facility is mainly generated by diesel fuel, but about 1% of the electricity is generated by solar power. This project examined the installation of additional solar panels and storage batteries to maximize the percentage of solar power generation in the PPR. This study is expected to serve as a model case for the future spread of solar panels in Palau.

This fiscal year, we studied the capacity of solar panels and storage batteries to be installed in the PPR.

In a simplified study conducted in August 2023, the PV capacity was estimated at 400 kW based on the allowed range of load fluctuation within the PPR and the load status of the PPR. Therefore, in the December survey, we conducted a detailed investigation and confirmed the validity of the PV capacity of 400 kW. When we checked the frequency characteristics of the 1,200-kW diesel generator currently used at PPR, we found that

according to domestic technical standards, if the PV output is within approximately 900 kW, it is assumed that overspeed emergency shutdown of the diesel generator due to PV output fluctuations will not occur.

In addition, the results of the study on whether or not storage batteries should be installed showed that if a 400-kW PV system is installed in addition to the current 1200-kW diesel generator, even if the lower output limit of the diesel generator is set at 300 kW, the demand in the PPR will exceed approximately 500 kW at the rated output of the PV system, so storage batteries should be installed to utilize the PV surplus power. Hence, it was found necessary to utilize PV surplus power by installing storage batteries. Therefore, it was confirmed that the combined use of PV and storage batteries can improve the PPR's energy self-sufficiency ratio.

From the above results, we were able to confirm that it is possible to install solar panels with a PV capacity of around 400 kW and that it is beneficial to install storage batteries. The PV capacity and storage battery capacity that will actually be used will need to be considered after taking into account costs and other factors.

(3) Discussion on JCM commercialization

In this project, Tokyu Land Corporation, an investor in PPR, will be the representative operator of the JCM equipment subsidy program, and PPR and Seed Okinawa LLC will participate in the project as an international consortium operator. In operation, Seed Okinawa LLC will bear the costs beyond the subsidies and will be responsible for facility operation and management, and PPR will recover its investment in the form of electricity charges.

We conducted a simulation of the amount of power generated by the solar equipment based on the daily cumulative solar radiation and temperature at the site. The calculation formula is shown below.

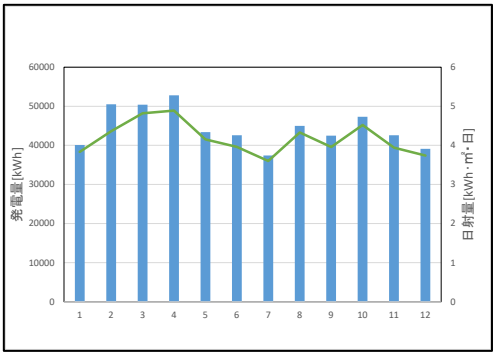
発電量算出式 $Epd = \frac{U \cdot P}{Po} \cdot K' \cdot Kpt \cdot K''$

Epd： 発電量(kwh/日)
U： 日積算日射量(kwh/㎡・日)
P： 太陽電池容量(kw)
P0： 放射照度(1kw/㎡)
K'： 補正係数(JIS)
Kpt： 温度補正係数
K''： 補正係数(JIS以外)

As mentioned above, the scale of the installation is assumed to be 400 kWp. The following results were obtained from the simulation of the amount of electricity generated through solar power on this scale.

Table 2-2　Simulation results of solar power generation

月	日積算日射量 [KWh/㎡/日]	気温	Kpt	発電量 日発電量 [kwh/日]	月当たり日数 [日/月]	月発電量 [kwh/月]
1月	4.01	28.2	0.907	1236.6	31	38,335
2月	5.05	28.4	0.907	1557.3	28	43,605
3月	5.04	28.3	0.907	1554.2	31	48,181
4月	5.28	28.8	0.908	1630.0	30	48,901
5月	4.34	28.6	0.908	1339.8	31	41,535
6月	4.26	28.4	0.912	1320.9	30	39,628
7月	3.74	27.8	0.913	1161.0	31	35,990
8月	4.5	27.8	0.913	1396.9	31	43,304
9月	4.25	28	0.913	1319.3	30	39,579
10月	4.73	28.4	0.907	1458.6	31	45,218
11月	4.26	28.6	0.907	1313.7	30	39,411
12月	3.91	28.5	0.907	1205.8	31	37,379
平均	4.45	28.3	合計		365	501,065
年間発電量		501,065				kWh/年



The site is not connected to Palau's electricity grid and will replace the existing diesel power generation facility. Since it is necessary to obtain fuel consumption figures from existing diesel power generation facilities for the past few years and set emission factors, we are in the process of obtaining such data from PPR. Here, we conservatively calculated the emissions by referring to Palau's electricity grid emission factor of 0.533 t-CO_2/MWh.

The simulation results show that the annual power generation is 501,065 kWh/year, so the emission reduction is 501,065 kWh/year/1,000 (unit adjustment) × 0.533 = 267.06 t-CO_2/year. Since the useful life of the facility is 17 years, the total emission reduction is 267.06 t-CO_2/year × 17 years = 4,540.15 t-CO_2.

In the future, we will calculate emission factors based on the fuel consumption of diesel power generation facilities as described above and aim to build a project with higher emission reduction effects by combining the use of exhaust heat for cold/heat supply, etc., as described below.

2.3.2. **Tiltable Wind Power Field**

As mentioned above, it is mostly solar power which has spread among renewable energies in Palau. We have also touched upon the fact that large-scale projects have been progressing with support from Australia, the ADB and Japan in recent years. On the other hand, although it is possible to expect an increase in the amount of solar power generated during the day in the dry season, the amount of power generated declines or it cannot be generated during the rainy season or at night. That means there are many issues in terms of grid management and backup in promoting renewable energy with solar power only. Combined use with other renewable energy sources which can be expected to generate power at night and during the rainy season is essential to achieve the target of a renewable energy ratio of 45% by 2025, which is the policy target.

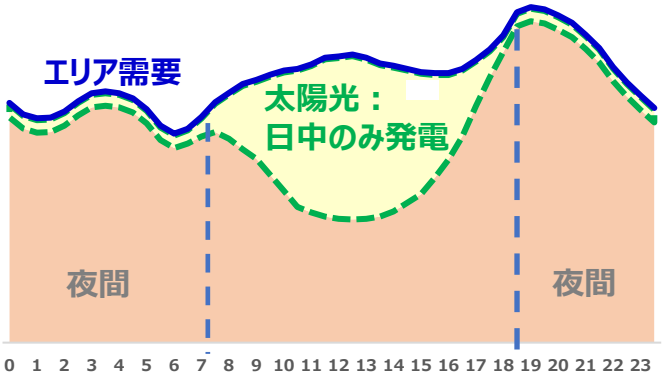


Figure 2-5 Restrictions on Solar Power Generation for Meeting Electric Power Demand

Wind power is a candidate as a source of renewable energy other than solar power. Palau has been confirmed to have abundant wind power resources. However, there are concerns that equipment damage due to typhoons will lower operating rates and increase repair costs with conventional wind turbines. Accordingly, they have yet to be introduced into the country. In addition, there are issues with maintenance and management in large-scale conventional turbines. For example, there are the issues of securing large cranes and workers necessary for construction and maintenance.

The Okinawa Electric Power Group has faced similar issues on the remote islands of Okinawa Prefecture. Consequently, it has developed tiltable wind turbines which solve such issues facing island regions. Tiltable wind turbines have a structure that allows strong winds to be avoided by tilting the support and wind turbine up to an angle of nearly 90 degrees. Moreover, large cranes are not necessary at the time of installation. That means it is also possible to install them in hilly areas. Work at the ground level is possible without having to work at heights during maintenance by tilting the wind turbines.

As stated at the beginning of this report, the Okinawa Electric Power Group has a track record of introducing seven tiltable wind turbines (total: 1,715 kW) in remote islands in Okinawa Prefecture. It also introduced five tiltable wind turbines (total: 1,375 kW) in Tonga in 2019.

Figure 2-6 Tiltable Wind Power Generator and Maintenance Work after Tilting

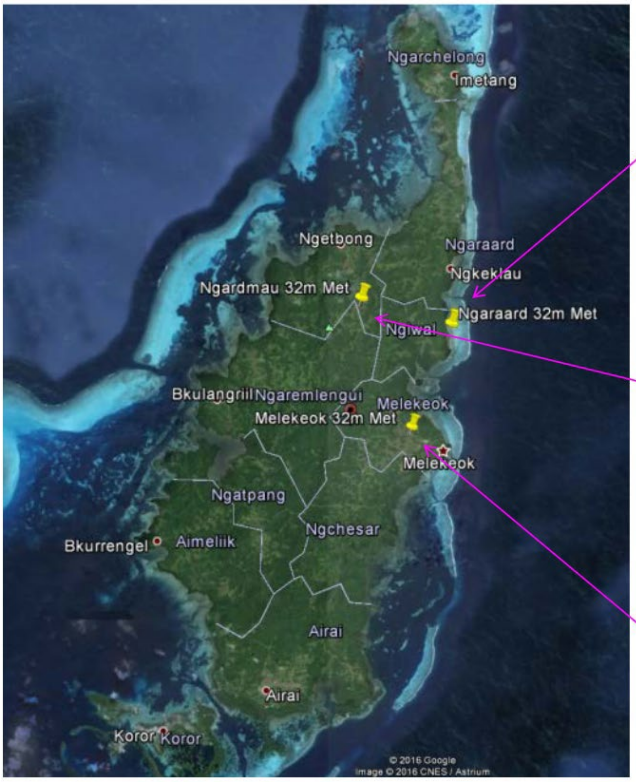
Table 2-3 Introduction Record

Island Introduced	Tiltable WT	Area	Population	Max Demand
Aguni	245 kW×1	7.6 km^2	689	800kW
Minami-Daito	245 kW×2	30.5 km^2	1,257	1,900kW
Tarama	245 kW×2	19.8 km^2	1,099	1,200kW
Hateruma	245 kW×2	12.7 km^2	496	800kW
Tongatapu	275 kW×5	260.4 km^2	74,611	

According to a wind condition survey conducted in Palau, the wind conditions in the northern part of Babeldaob are relatively favorable. In addition, there is also a plan to increase the grid capacity. Therefore, candidate places will increase, and we will find the possibility of introduction.

Multiple surveys have already been conducted on the wind conditions in Palau. We will discuss potential sites by referring to survey results by the National Renewable Energy Laboratory of the US Energy Agency in 2016 among those.

Three observation points were established on Babeldaob in this survey. The wind conditions were then observed. The following shows the sites and measurement results.



32m Met Towers installed at 3 sites:

Ngaraard

Variable	Value
Latitude	N 7.654617
Longitude	E 134.641300
Elevation	50 m
Duration	20 months
Wind power density at 50m	293 W/m²

Ngardmau

Variable	Value
Latitude	N 7.573417
Longitude	E 135.587017
Elevation	153 m
Duration	16 months
Wind power density at 50m	126 W/m²

Melekeok

Variable	Value
Latitude	N 7.503556
Longitude	E 134.614855
Elevation	62 m
Duration	21 months
Power density at 50m	157 W/m²

Figure 2-7 Wind Condition Survey Points and Measurement Results by the U.S. Energy Agency

The results of the wind direction measurement at the three sites reveal there is also no wind from the southwest at the Ngwal site. It is assumed that this is due to the inland location and topography. On the other hand, wind from the northeast and southwest have been observed at Ngaraard and Melekeok, which are located on the east coast. The intensity of wind from the southwest is slightly higher. The turbulence intensity factor is 0.11 at Ngaraard with 15 m/s. That is a low level.

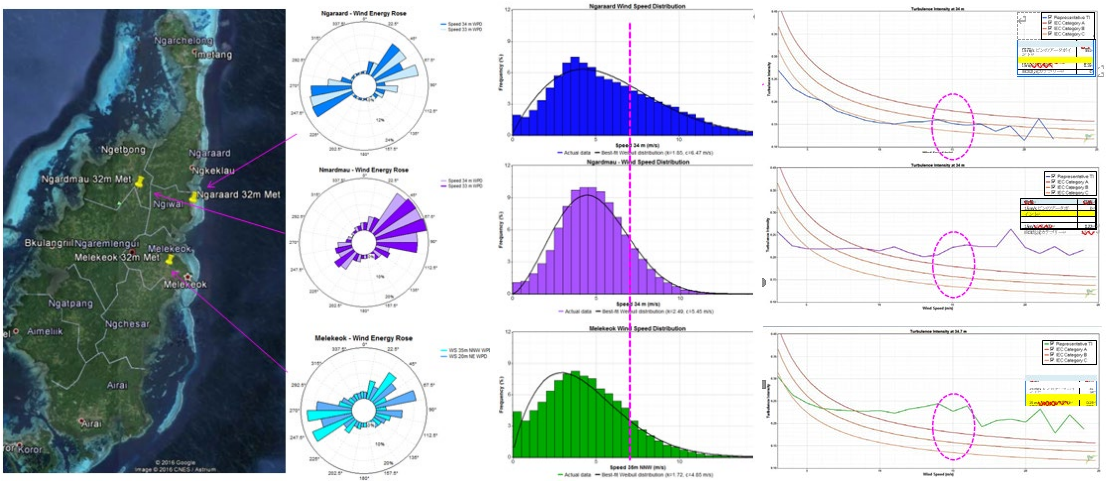


Figure 2-8　Wind Direction, Wind Speed Distribution and Turbulence Analysis at the Observation Sites

It was predicted based on these previous surveys that the east coast where strong winds with relatively little turbulence blow in from the northeast sea would be an ideal site to install wind turbines.

During the last fiscal year's on-site investigation, surveys were conducted with a focus on these sites, and the on-site status was checked at the site (1), the northernmost highland, and the site (2) and the site (3) on the northeastern and northwestern coasts, respectively, of Babeldaob Island's northern region (Ngarchelong state). Simple wind speed measurements were performed at these sites during the on-site investigation in August of this fiscal year (Figure XX).

- At the site (1), the wind condition was subjectively breezy (wind direction: north-northeast (not constant)), and although it is located on a hill with sufficient area, there is a managed historic site (a lighthouse of the Japanese military used during World War II). The access road to it is steep and unpaved with narrow width, thus requiring consideration for feasibility of transportation.
- At the site (2), there was a constant perception of the wind (wind direction: north-northeast), and although there are playground equipment and a gazebo, a space of approximately 20 m × 50 m was observed. The Eco Park appeared to be closed, but an additional survey is required to determine the usability of land on the Eco Park side. As measured on August 25, wind speed was 0-2.0 m/s and the wind direction was west-southwest.
- At the site (3), there was a constant perception of the wind (wind direction: north-northeast), and an area of about 50 m × 70 m was observed. According to interviews

with nearby residents, the wind blows throughout the year. According to the measurement on August 25, wind speed was 4.7 m/s or over, consistently around 5 m/s, and the wind direction was west-southwest.

- The survey site in the Airai State is located in the eastern hills of the state, with sufficient area and access roads allowing the entry of heavy-duty trucks, despite being unpaved, ensuring workability. According to the measurement on August 25, the wind speed at the site (1) was 4.0-5.1 m/s, with the north-northwest wind direction. At the site (2), wind speed was 0.9-1.8 m/s, also with the north-northwest wind direction.

To narrow down potential wind power generation sites, simple wind speed measurements were performed from November 28 to December 4, 2023, at two locations in the Ngarchelong State, one location in the Airai State, and one location in the Ngardmau State.

Figure 2-9　Potential sites for wind power generation

- Site (1) [Airai State]

Installation will require ground leveling because the site is the mound overlooking the sea. Being distant from the national highway's power grid, wiring work will also be necessary. The measured wind speed of 4.0-5.1 m/s (north-northwest) is favorable. According to the measurements on November 28, wind speed was 2.0-5.0 m/s, and the wind direction was northeast.

*Places in the region lower than the site (1) were also considered as potential sites. There is a resting area nearby, presumably belonging to a local farmer, and connection points for power distribution lines were identified. Although wind speed was low, ranging from 0.9 to 1.8 m/s (north-northwest), the wind speed and direction measured on November 28 ranged from 2.0 to 5.0 m/s and northeast, respectively.

・Site (2) [Ngarchelong State]

Located within the Eco Park, there are tourist information centers, rest areas, and playground equipment. Although wind speed was low, ranging from 0 to 2.0 m/s (south-southwest), the wind speed and direction measured on November 28 ranged from 2.5 to 4.0 m/s and northeast, respectively.

・Site (3) [Ngarchelong State]

Located near the wharf close to a national highway. Relatively high potential with a wind speed of 4.7 m/s or over (usually 5 m/s from the west-southwest). According to measurements performed on November 28, wind speed ranged from 2.0 to 4.0 m/s and wind direction was northeast.

・Site (4) [Ngardmau state]

Located a short distance away from a national highway, but with confirmed power distribution lines. This wharf, maintained by a foreign investment project, features resting areas, restrooms, and an old Japanese military watchtower. There is a perceptible presence of the wind. According to the measurement on December 4, wind speed was 3.0-5.2 m/s and wind direction was northeast.

In interviews with PEWA and the PPUC, it was noted that while there are promising locations identified through the wind condition surveys, many pieces of Babeldaob Island's land are privately owned. Meanwhile, the potential sites in the Ngarchelong State, specifically the wharf, are under state management. Information suggests that wind power generation projects have not progressed due to land issues. Therefore, alongside detailed surveys of wind conditions, investigations into land ownership and environmental assessment procedures will be conducted to assess the possibility of commercialization.

Additionally, Palau is renowned for its rich natural environment and is also a tourism resource, leading to the establishment of protected areas. However, the proposed project sites are not designated within these protected areas. Nevertheless, cultural considerations on traditional land inheritance and so on are necessary. In particular, careful consideration is essential for land use. Since land usage by national and state governments is practical, inquiries will be made to the state government or relevant authorities regarding these sites to clarify land ownership.

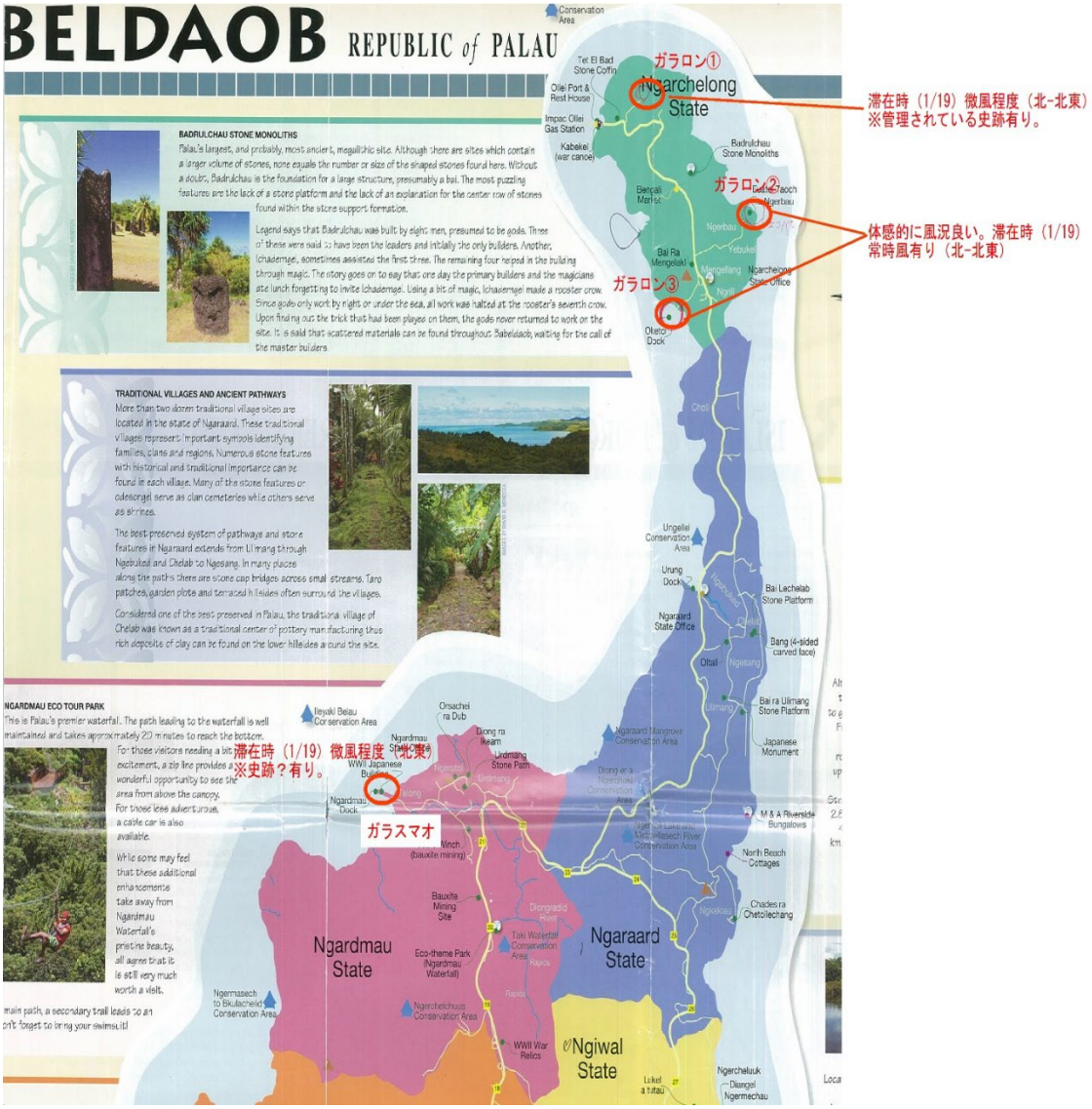


Figure 2-10　Map of wind condition surveys in Palau

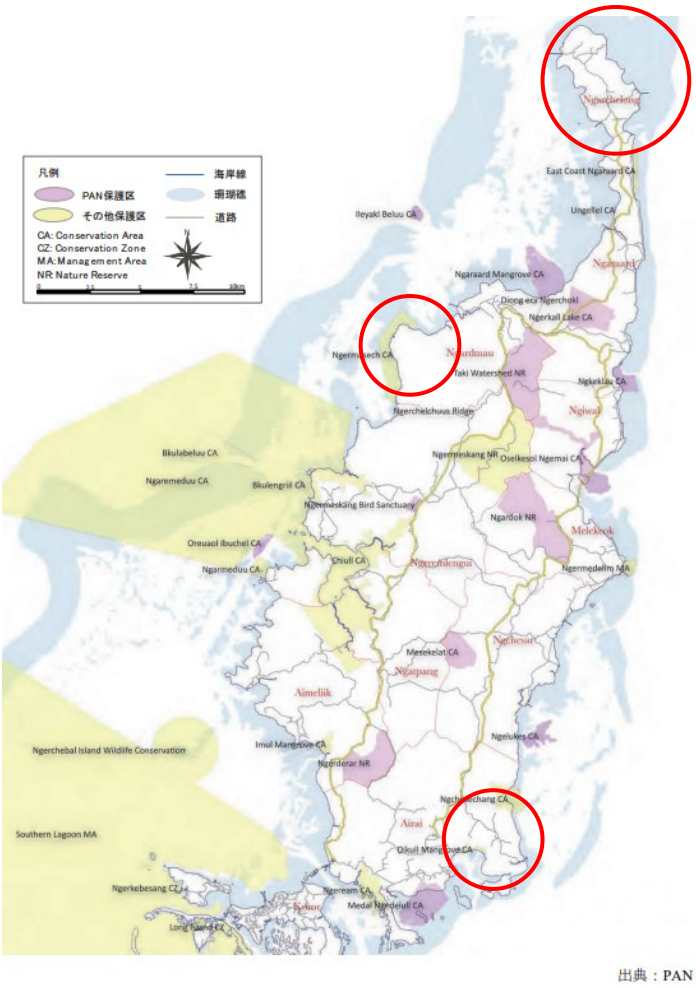


Figure 2-11　Protected regions in Palau and surveyed areas in this project

It is necessary to discuss the decarbonization effect based on more detailed wind conditions. It is estimated to be about 545 MWh, using the already obtained data on local wind conditions. The amount of reduction in emissions is estimated to be 290.5 t-CO_2 per year with a grid emission factor of 0.533 t-CO_2 per MWh in Palau. Over the 17-year service life of the equipment, the amount of reduction would total 4,938 t-CO_2.

Assuming installation in five locations, the amount of reduction would be approximately 1,450 t-CO_2 per year. It would total approximately 24,690 t-CO_2 over the service life of the equipment.

We assume the installation costs will be approximately 1 billion yen per five wind turbines in terms of the equipment excluding the cost of grid stabilization measures.

There is no track record of wind power generation business in Palau. The subsidy would cover 50% of the cost. The upper limit of the subsidy would be approximately 100 million yen for 4,000 yen per t-CO_2 that is the guideline of cost-effectiveness. The

economic performance depends on the PPA contract with the PPUC. However, it seems realistic to assume a certain level of grant.

2.3.3. Introduction of Highly-efficient Air Conditioning and Hot Water Supply Equipment in Commercial and Public Facilities

The demand for electric power in Palau is growing as a whole. In particular, the growth of the demand in the commercial sector stands out.

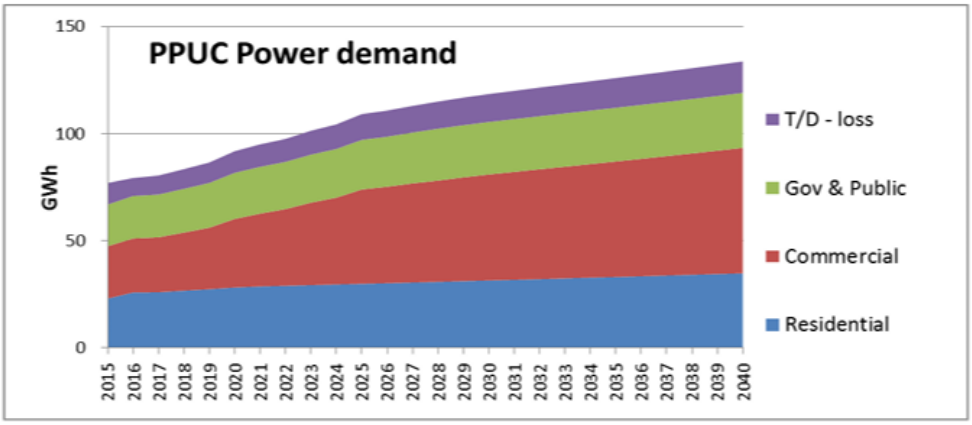


Figure 2-12 Predicted growth of demand for electric power in Palau

The forecast of demand in each state indicates that the demand for electric power will keep increasing in the Airai state.

Table 2-4 Forecast demand for electric power in each state

Table 3-19 Power demand forecast by state

Unit: kW

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Aimeliik	388	366	377	391	408	369	381	398	400	403	404	405	407	408	409
Airai	2,628	2,854	2,904	2,938	3,131	2,796	3,437	3,651	3,752	3,854	3,946	4,039	4,144	4,188	4,240
Koror	7,944	7,857	7,948	7,974	8,292	7,201	7,567	8,389	8,553	8,782	8,983	9,188	9,448	9,544	9,642
Melekeok	449	451	470	478	494	439	457	484	489	494	640	674	743	781	855
Ngaraard	92	88	88	88	97	85	89	95	96	98	132	145	337	349	398
Ngardmau	36	35	37	38	39	34	36	38	38	39	39	39	40	40	40
Ngaremlengui	100	90	93	99	105	94	97	102	103	104	105	105	106	107	108
Ngatpang	62	59	63	62	65	58	60	63	64	64	65	65	65	66	66
Ngchesar	53	53	56	59	63	56	58	61	62	62	63	63	64	64	65
Ngarchelong	76	68	74	77	85	76	79	83	83	84	96	108	119	131	143
Ngiwal	54	56	58	58	63	56	58	61	61	62	62	63	63	64	64
Koror+Babeldaob (Net peak)	11,882	11,977	12,167	12,262	12,841	11,263	12,319	13,425	13,702	14,046	14,535	14,894	15,537	15,743	16,030
Koror+Babeldaob (Gross peak)	12,534	12,634	12,835	12,935	13,546	11,881	12,995	14,161	14,453	14,817	15,332	15,711	16,389	16,606	16,910

Under these circumstances, saving energy is also an important pillar of the electric power policy in Palau. On the other hand, government agencies and large commercial facilities have yet to adopt systematic energy saving. Energy saving is planned for public

facilities, commercial facilities and homes in the future. For example, there will be a promotion of energy saving in buildings and lighting-related energy saving in government buildings and commercial facilities and energy-saving electrical appliances used in homes.

We first conducted interviews about facilities where provision of this service is possible by visiting Airai State in the on-site survey conducted in January 2023.

The results suggested that there are not many buildings or groups of buildings that can be said to consume large amounts of energy even though an airport and commercial facilities are located in the Airai state. The hotels located in the state are mainly the villa type. In addition to not having many guest rooms, they are located where there are no large facilities such as supermarkets.

In PPR, where the adoption of solar power generation is under consideration, it has been confirmed that there is demand for thermal energy for hot water for hotel guests and laundry heating. The heat for laundry is provided by a steam boiler, while hot water is prepared by utilizing the waste heat from diesel generators, although this application of waste heat is limited. It was confirmed through consultations that using part of this waste heat for heat exchange in water heating is inefficient compared to the energy saving with absorption chillers for cooling. Therefore, PPR is considering the installation of absorption chillers for improving energy efficiency. Nonetheless, waste heat usage is not widespread due to the rarity of businesses equipped with generators like those at PPR. Energy conservation efforts require a tailored approach, assessing the energy consumption trends of users to identify the most suitable equipment.

Therefore, PPR's approach can serve as an example of optimizing energy use to suit the facility's characteristics, showcasing how similar energy-saving assessments and optimal technology applications can be promoted.

For PPR's stable power supply, maintaining the use of some diesel generators is necessary, as a 100% solar and battery system is technically and economically challenging. This is due to solar power's lack of inertial force to prevent frequency drops at the time of trouble, making reliance on the rotational energy of synchronous generators like diesel generators a current best practice from both economic and technical perspectives.

Sojitz Corporation, Dai Nippon Consultant Co., Ltd., and CS Energy Ltd. are leading a pilot project under the Ministry of the Environment's "Third Country Cooperative Project for Hydrogen Production and Utilization." This initiative aims to advance green hydrogen production in Australia, its transportation to Palau, and its application through fuel cells and fuel cell vessels. Moving forward, should the project successfully enable

hydrogen supply to Palau, the project anticipates the replacement of diesel generators with hydrogen fuel cells, promoting the exchange of information among the stakeholders.

Considering these developments, the utilization of diesel generators' waste heat is seen as an interim measure, and we aim for a transition to hydrogen and other next-generation energy sources, after minimizing the dependence on diesel generators and maximizing energy efficiency with waste heat, etc.

This fiscal year, data on demand for cooling and heating in PPR was gathered, leading to a detailed analysis of optimal energy use. Future plans include compiling proposals that incorporate economic considerations.

Regarding energy saving, it is possible to curb energy consumption just by replacing individual equipment, such as devices for air conditioning, hot water supply and lighting with energy saving equipment in commercial businesses and homes for energy saving in some cases. We can discuss the possibility of replacement based on the usage of equipment currently being used in hotels, markets and restaurants.

Waterworks have been established in Palau. However, the source of water is in Airai State. Consequently, electric power is used to drive pumps. We were asked whether it would be possible to consider the adoption of micro-hydroelectric power generation at the water intake site in a reservoir when holding interviews with the Airai State Government. Accordingly, we would like to also consider utilizing such renewable energy and setting it aside for the power source to drive the pumps in the future. The poor flow rate stability of the rivers in Okinawa Prefecture means that hydroelectric power generation has not been developed there. However, there is a track record of installing micro-hydroelectric power generation utilizing the current of water being conveyed for irrigation and regulating reservoirs at Kurashiki Dam Management Office, Nishihara Purification Plant and Fukuchi Dam. We will consider the possibility of introducing micro-hydroelectric power in Palau utilizing this knowledge.

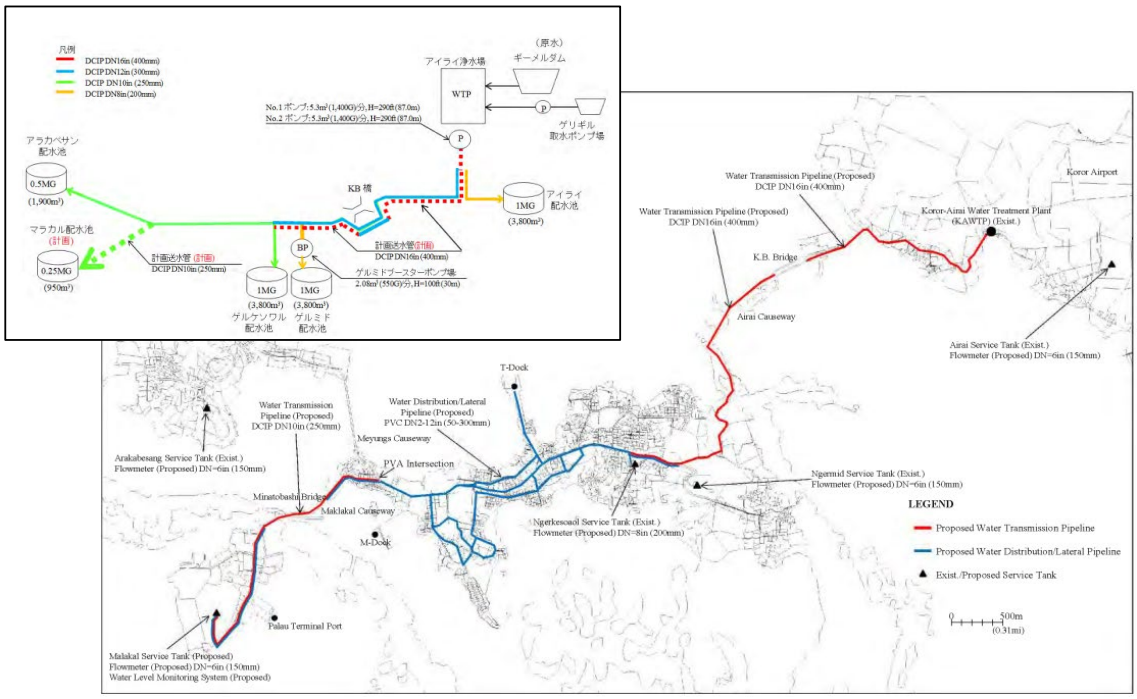


Figure 2-13 Waterworks in Palau

2.3.4. Grid Stabilization Field in Anticipation of the Proposed Technologies/Services

Like other small island nations, Palau has no large-scale power plants with great economies of scale due to its low electricity demand, and diesel power generation is the main source of electricity supply. Accordingly, high power generation cost is reflected in electricity charges, placing a heavy burden on consumers and businesses. As mentioned above, electricity rates are 40-65 yen/kWh, and the introduction of renewable energy would allow the initial investment to be recouped sufficiently.

In addition, various aid organizations, including the Asian Development Bank, UNDP, Japan's ODA, the JCM equipment subsidy program, ODA from Taiwan, EU, the U.S., and Australia, have promoted projects to introduce renewable energy, mainly solar power generation.

On the other hand, there are still situations where the penetration is not sufficient, and this is due to constraints in the power grid.

The facilities of the Koror-Babeldaob power grid are becoming obsolete and are poorly maintained, which is hindering the stable supply of electricity, and at the same time, there is no capacity to accept renewable energy, so immediate measures are needed.

In order to improve this situation, the Palauan government requested Japan's technical cooperation in the formulation of a master plan for updating power transmission and distribution facilities based on the introduction of renewable energy, as well as measures against power outages and the reduction of power transmission and distribution losses. “The Project for Study of Upgrading and Maintenance of the National Electrical Power Grid of Palau” was implemented by JICA.

The feasibility study was completed in 2019, the preparatory survey was completed in 2022, and the grant agreement (G/A) was concluded in the same year.

The grant aid includes consulting services, detailed design, bidding assistance, and procurement and construction management, and covers the construction of new transmission and distribution lines (double circuit between Malakal Power Station and Airai Communication Station, and approximately 35 km between Kokusai Communication Station and Airai Communication Station (via State of Ngchesar)), strengthening of Malakal Communication Station and Airai Communication Station (complete set of transformers and switchgear), and buildings for switchgear at Malakal, Airai, and Kokusai Communication Stations.

While the above projects are expected to establish the infrastructure to accept renewable energy, it is necessary to pay attention to the equipment and know-how required to control, manage, and monitor the grid according to fluctuations in the amount

of renewable energy generated.

As renewable energy becomes more widespread, the following issues will arise in grid operations.

- Curbing of the output of renewable energy due to restrictions of the lower limit of operation of diesel generators

  It is necessary to reduce the output of diesel generators due to supply and demand when the output of renewable energy increases. However, there are mechanical restrictions of the lower limit of output from diesel generators. Therefore, it is necessary to curb output for the surplus of renewable energy. (That means restrictions on renewable energy generation opportunities.)

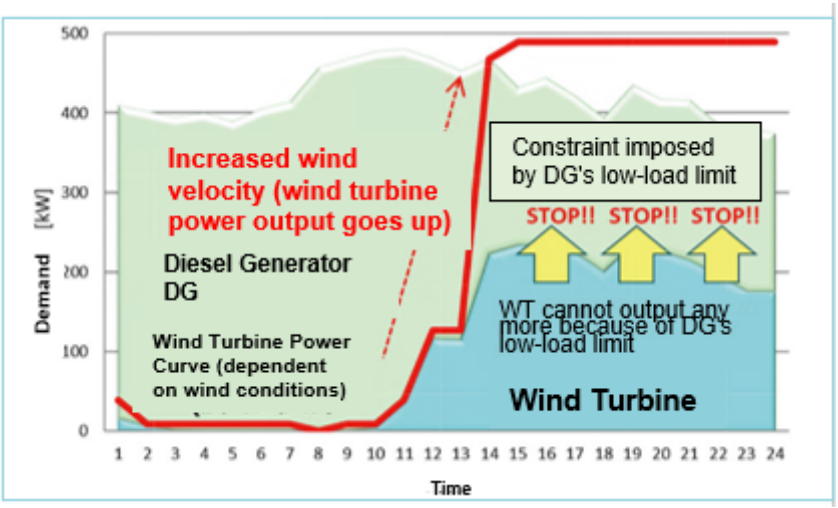


Figure 2-14 Restrictions on Renewable Energy Output due to Combined Use with Diesel Generators

- Risk of Wide-area Power Outages due to a Reduction in Inertial Force

  The number of diesel generators in operation will decrease with the spread of renewable energy. If a grid accident occurs while inertial force is decreasing, the generators will not be able to keep up with the target frequency, which may lead to wide-area power outages. (It will not be possible to secure inertia with storage batteries.)

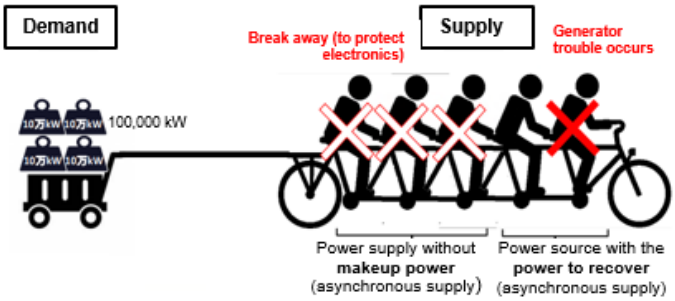


Figure 2-15　Synchronous Power Sources (with Inertial Force) and Asynchronous Power Sources

Source: Agency for Natural Resources and Energy: Study toward achieving carbon neutrality in 2050, December 21, 2020

- Failure of the Function to Protect against Accidents

  If the number of generators in operation decreases and the short-circuit capacity drops, the protection (relay) function may not work when there is an accident. That means it will not be possible to detect the accident.

An effective solution to these issues is to introduce grid stabilizers which can maintain the inertial force of the grid while maximizing the utilization rate of renewable energy.

Okinawa Electric Power is operating existing power generation equipment (diesel generators, wind power generators and storage batteries) together with demonstration equipment (MG set) on the island of Hateruma. It has experience of conducting demonstration experiments for practical operation, such as confirming effectiveness and identifying issues.

Specifically, utilizing the surplus of renewable energy to charge storage batteries would alleviate restrictions on the output of renewable energy. At the same time, combining motors and generators would provide pseudo inertia to enable operation as an alternative to diesel generators. That is a mechanism which would prevent a decrease in the inertial force and short-circuit capacity. There is a track record of achieving 10 days of 100% renewable energy operation combined with a tiltable wind turbine in the demonstration experiment on Hateruma.

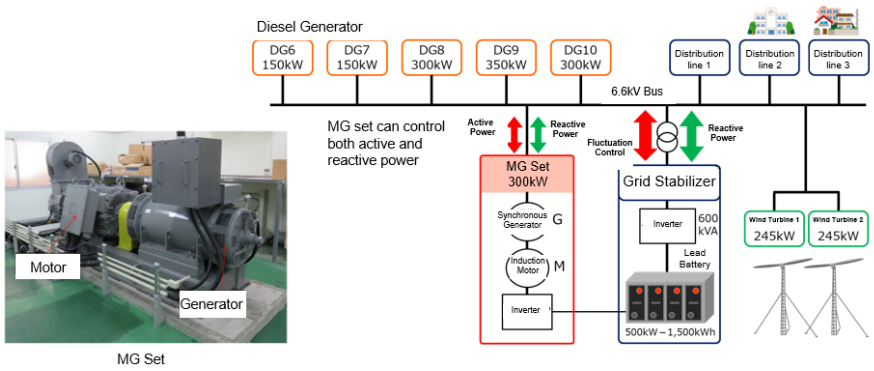


Figure 2-16　Grid Stabilization with an MG Set Demonstrated on Hateruma

There is a need for technical discussions on Palau's weather conditions, electric power demand forecasts, electric power grid analysis, transmission/distribution facility plans, and environmental and social concerns. In this project, we summarized the problems with the grid in Palau, in order to find effective measures based on the long experience of integrated control in the islands of Okinawa.

We met with the PPUC, which manages the electric power system, in the field survey in January 2023, and discussed the feasibility of this initiative. The PPUC told us they are aware that grid management will become an issue as renewable energy is increasing, so the company plans to set up a National Control Centre as a measure against that.

On the other hand, it is possible to monitor supply and demand and issue orders to power plants to make adjustments in the control center, but if the system as a whole lack the ability to make adjustments, there will be limits to the measures that can be taken, and it may be necessary to take measures to prevent the maximization of renewable energy use, such as the cutting of peak power from renewable energy.

Under these circumstances, we were able to obtain a high level of interest in the grid stabilization effect with the adoption of the MG set.

Figure 2-17　Interview with the PPUC (Jan. 2023)

Palau plans to start a low-interest financing program for solar power kits for commercial facilities with the support of the ADB. It was considered noteworthy that grid management will become even more complicated.

Therefore, during the field survey in August 2023, we inspected the progress of the above-mentioned load dispatching center and the mega solar power plant that has already been constructed, and examined the issues.

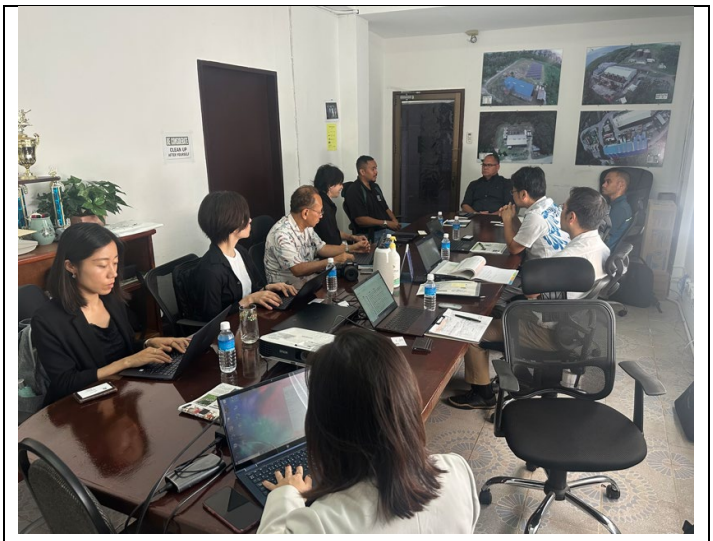


Figure 2-18　Scene of a meeting with PPUC (Aug. 2023)

・ Load dispatching center

The load dispatching center will have a dedicated room on the grounds of the Malakal Power Plant, and will be equipped with a real-time monitoring system to monitor the

power generation status of mega solar power plants run by Philippine companies and the existing Aimeliik power plant managed by the PPUC. As of August 2023, only a dedicated room and a monitor were available, and it was not operational. In addition, the control center is only capable of monitoring, and the operational plan is to control each power plant by communicating with each power plant and power distribution station via telephone communication.

In an interview with the PPUC, they said that in the future they expect to install infrastructure that will allow control of power plants from a Central Load Dispatching Center, such as SCADA, but that they have not yet formulated a master plan.

Figure 2-19 Malakal Power Station and Control Room

・ Philippine Company's Solar Power Plant

The plant was built by Solar Pacific in the Philippines with funds from Australian ODA and equity financing, and has an installed capacity of 15.3 MWp with a battery capacity of 10.2 MWac/12.9 MWh. It is the largest solar power plant in Palau, and its solar panels are made in the U.S. (First Solar). The inverters are made by Germany's SMA and the battery appears to be made in China, using technology from the French company SA. The engineering and construction company is Juwi Renewables Energies PTE Ltd., and the subcontractors are Surangel & Sons Company and WESPAC. The facility was completed and connected to the grid in May 2023, but trial runs are still ongoing to diagnose the

impact on the grid and study control protocols. A control room has been set up within the power plant to monitor each major power plant, and preparations are underway for operation in coordination with PPUC and Malakal Power Plant.

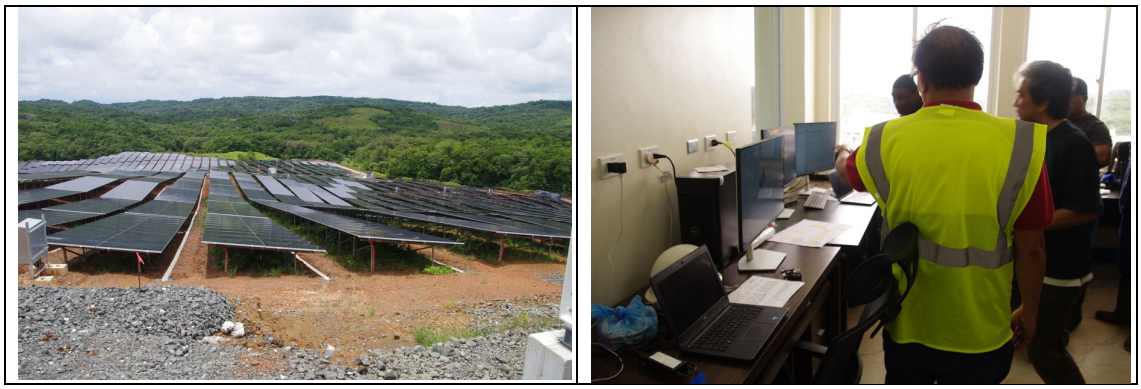


Figure 2-20 Solar Pacific's power plant and control room

Regarding Solar Pacific's facilities, the required equipment for control and monitoring was confirmed, and the impression was that stable operation would be possible if the control with Malakal Power Plant/Aimeliik Power Plant was smooth. On the other hand, in addition to the fact that the central load dispatching center on the PPUC side has not been completed in time, PPUC believes there are issues regarding back-up skills for control, and it is expected that it will still take some time for full-scale operation.

According to the survey in January 2024, Solar Pacific's power plants had not yet been fully connected.

In order to accelerate decarbonization, the President of Palau has mentioned the possibility of increasing the ratio of renewable energy to 100%, which will require the installation of control systems and improved management capabilities in the electricity infrastructure to accommodate more renewable energy.

The PPUC is concerned about the lack of technology and systems for optimal operation of distribution facilities and renewable energy power sources, which will be installed by various donors, and has confirmed its willingness to welcome assistance in the form of control systems and grid management know-how.

The Okinawa Electric Power Group has expertise in system construction and operation of load dispatching centers and control centers, as well as experience in supporting engineer training. While it is possible to cooperate in resolving these issues, it is also necessary to examine the improvement plan and master plan for Palau's electricity system as a whole, and then create an optimal cooperation plan tailored to that stage.

In Palau, there is a master plan for infrastructure development, "PALAU NATIONAL

INFRASTRUCTURE INVESTMENT PLAN 2021 to 2030," and an electric power system maintenance plan, "Electrical Power System Prioritization Plan 2021-2025 (2021-2025). The plan includes the "Electrical Power System Prioritization Plan 2021-2025," which is an electric power system conservation plan. Proposals for future activities must be consistent with and promote the plan.

In the "PALAU NATIONAL INFRASTRUCTURE INVESTMENT PLAN 2021 to 2030," projects are identified based on Multiple Correspondence Analysis (MCA) as priority infrastructure development projects. Projects in the electric power sector are listed below.

Table 2-5 Power sector projects in the infrastructure development master plan[1]

No.	Project Name	Project Scope	Estimated Cost	Annual mainten ance cost	Prioritization score based on MCA
1	Upgrade and rehabilitation of existing diesel power plants	Diesel power plant upgrading/refurbishment	$8,000,000	$160,000	53
2	Reconstruction of 13.8-kV transmission lines	To reconstruct 13.8-kV power lines and build them along accessible roads	$5,600,000	$112,000	52
3	34.5-kV transmission line construction to connect IPP	To construct new transmission lines	$3,600,000	$72,000	52
4	Rehabilitation of 34.5/13.8-kV stations	To revamp all existing stations and install 34.5-kV circuit breakers	$1,750,000	$35,000	51
5	Construction of 34.5-kV transmission lines to improve system stability	To construct new transmission lines	$9,000,000	$180,000	50
6	Smart meter	To replace existing meters with smart meters	$1,700,000	$34,000	50

Of the above, the measures for power transmission lines in No. 2, 3, 4, and 5 will be implemented through the JICA grant aid project.

On the other hand, in the "Electrical Power System Prioritization Plan 2021-2025" developed by PPUC, the following 21 priority projects have been derived.

Table 2-6 Priority projects in "Priority Plan for Electric Power Grids 2021-2025"[1]

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
#1 Strengthening of Small Loop Transmission Lines	34.5-kV transmission loop connecting the Airai and Kokusai substations. This consists of a 34.5-kV	Improvement of network reliability	· When implemented on a properly maintained grid, such network loops can improve network	· Installing additional transmission without addressing critical issues (such as protection) may	$6.5 million (Refer to JICA Master Plan Report)

[1] See "Preparatory Survey Report On The Project For Upgrading Power Grid In The Republic Of Palau" issued by Japan International Cooperation Agency in August 2022.

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
	transmission spanning 16.2 miles (26 km) between the Airai and Kokusai substations.		reliability.	not fully enhance grid reliability and could simply add more failure points.	
#2 Strengthening of Large Loop Transmission Lines (Including Enhancement of Marukyoku Substation)	· A 34.5-kV transmission loop from the Malakal Power Plant to the Garardo Substation via the Marukyoku Substation (about 29.4 miles/47.4 km). Enhancement of Marukyoku Substation including one 34.5/13.8kV transformer (5 MVA), switchgear, bus bars, fencing, pads, and set up facilities.	Improvement of network reliability	When implemented on a properly maintained grid, such network loops can improve network reliability. · Transmission to Marukyoku improves the capital's reliability.	Modifying transmission without enhancing underlying reliability is ineffective. Other options exist for significantly reducing the reliability of power in remote areas. This enhancement was intended to facilitate distributed PV generation. However, since PPUC concluded the development of a few large centralized PV facilities, the value of enabling many small-scale PV sites will be substantially reduced.	$13.1 million (Based on the JICA Master Plan Report and assumed substation enhancement costs of $1.4 million)
#3 Construction of Koror Substation	· Construction of a substation in Koror, consisting of one 34.5/13.8kV transformer (10 MVA) and related equipment.	Improvement of network reliability	This would alleviate the load on the Airai Substation and potentially improve the reliability of supply to Koror Island's load center, especially in case of faults at the JP Bridge.	· Actual line flows at the substation need to be verified before any enhancement.	$1.9 million (Refer to JICA Master Plan Report)
#4 Realignment of Existing Transmission Lines Along the Compact Road	· Realigning existing 34.5-kV transmission lines so that they are in parallel with the Compact Road, including: Airai Substation to Aimeliik Substation (5.6 miles/9 km) Aimeliik Substation to Garardo 2 Substation (22.5 miles/36.2 km)	Improvement of network reliability	· • Existing transmission lines experience outages due to trees, making maintenance increasingly difficult. · • Reconfiguring this line improves power system reliability and facilitates maintenance.	• It requires a substantial budget, potentially preventing the implementation of other high-priority projects. · • PPUC has the capability of performing this work and can incorporate it into KB Grid's O&M.	$12.7 million (Refer to JICA Master Plan Report)
#5 Construction of Esarl Substation	· Construction of a substation in Esarl through the relocation of one 34.5/13.8 kV transformer 5 MVA from Koksai to Esar and the installation of related equipment. This task is only worthwhile if a small loop is constructed.	Improvement of network reliability	Enhancement of power reliability in Esarl and Marukyoku. It can reduce transmission losses.	· Considering the existing Koksai substation, this may not be urgently needed.	$1.4 million (Refer to JICA Master Plan Report)
#6 A 34.5-kV Transmission Line from the Malakal	· Construction of the second 34.5-kV transmission line from	Improvement of network reliability	· Potential to enhance power reliability by providing some	· May not be urgently needed as it is not expected that overloads will occur	$2.3 million (Refer to JICA Master Plan Report)

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
Power Plant to the Airai Substation	· Malakal Power Plant to the Irai substation (5.7 miles/9.2 km).		· redundancy in the transmission network.	· on existing lines in the near future.	
#7 Comprehensive Review and Enhancement of Palau's Protection System to Support the Proposed RET	To facilitate the shift to 100% daytime solar power generation, which is Palau's renewable energy target, it is necessary to comprehensively review the existing protection system, formulate new protection strategies and install new equipment (such as intelligent electronic relays). Previous studies were focused on the suitability of protection systems operating solely on thermal power generation, and revealed issues with the adjustment of existing protection systems.	System stabilization with renewable energy	· This enhancement is necessary and crucial for attaining Palau's renewable energy targets. Without this enhancement, it would be necessary to control thermal power generation online or install synchronous capacitors to maintain high levels of fault current. · This enhancement will allow IPP Project Phase 1 to operate more effectively and is a vital prerequisite for the effective implementation of IPP Project Phase 2.	· If implemented by IPP, it could become inefficient and less reliable.	$1.7 million (400,000 US dollars for the study and 1.3 million US dollars for the enhancement. The existing protection system is quite old, and comprehensive completion may require significant enhancement, thus increasing the cost. The estimate is based on industry experience.)
#8 Review and Evolution of the Power Factory Model	The existing power factory model (developed by IRENA in 2010) is known to have limitations, including the method for producing a model of existing DG. This model has not been examined. As an initial scope, it is recommended to update the model to assess the following: o 34.5-kV network o 13.8-kV network o Malakal Power Plant o Aimeliik Power Plant	System stabilization with renewable energy Cost reduction (through optimization of investment)	With the updated Power Factory model, PPUC will be able to produce a model of potential network changes before implementation and determine the best approach. Since Power Factory can produce models of both distribution and transmission networks, PPUC can maximize the scope of studies conducted on a single software platform.	· Given the significant cost for a relatively small network, a modest implementation may be sufficient in some cases. · PPUC needs to actively maintain and develop the model.	$300,000 (Costs are based on industry experience. Note that it depends on the scale of the modeling work)
#9 Automation of Starting/Stopping of Small MITSUBISHI Generators (4 × 0.4 MW) at Malakal Power Plant	To enhance the control system of Malakal Power Plant to enable the automatic starting and stopping of small MITSUBISHI units (M1-M4). Automation of large DG/s (such as Niigata 14 and 15) is of limited value due to the expected decrease in reliance on these units in the future, which also restricts	System stabilization with renewable energy	· The ability to automate the start/stop of existing generators allows for more flexible dispatching. For example, several small sets of generators may be activated to manage short-term fluctuations in load.	· The power system that needs to be managed becomes even more complex. For example, power system operators will need to be trained to operate the new system.	$1.3 million (Valuation: $300,000; enhancement: $1,000,000. Prices are based on industry experience. Note that costs vary depending on the size of the enhancement)

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
	their start, stop, and ramp capabilities.				
#10 Development of a High Voltage (HV) Grid Code	Palau does not have an HV grid code. The grid code specifies connection requirements for all generator (and possibly HV load) connections. These requirements include items such as power quality, modeling, and standards.	System stabilization with renewable energy Cost reduction	The input requirements and capabilities of generators will be more standardized. Future connection agreements could be streamlined.	Proper implementation requires time and careful consideration. If inadequate, the requirements may be unattainable, or technically inadequate systems may be connected.	$200,000 (based on actual data)
#11 Asset Optimization Review for Malakal and Aimeliik Power Plants	A comprehensive review of the condition and maintenance procedures of existing generators on the KB grid.	Cost reduction (through the curtailment of operating costs)	Potential to reduce long-term operating costs of existing generators.		$300,000 (Reference value based on actual results)
#12 Review of Transmission and Distribution Line Losses	Current transmission losses and network analysis	Cost reduction (through the curtailment of operating costs)	Cost-effectiveness and output reduction to reduce transmission and distribution line losses.	In some cases, this may be difficult to do without detailed SCADA records.	$300,000 (Reference value based on actual results)
#13 Installation of High-Speed Diesel Generators (low-load operation possible)	The existing DG fleet is very slow and inflexible. Installing fast-starting, ramp-adjusting, flexible DGs that can operate at relatively low loads will enable optimized grid operation. In this case, the addition of 4x 1.5-MW high-speed DGs at Malakal Power Plant are considered.	System stabilization with renewable energy Cost reduction (by minimizing PV suppression)	More flexible DG allows for better optimization of grid operation. For example, the presence of smaller, more reliable DGs can reduce the frequency with which a large 5 MW DG needs to be activated to respond to short-term demand fluctuations. · This maximizes PV utilization.	The adoption of additional thermal generation as part of a renewable energy program may be challenging. Space may be limited at Malakal Power Plant. Adding flexible DGs would add PV and storage to the power system, potentially turning many of the existing generator sets into stranded assets.	$5 million (Reference value based on actual results)
#14 Deployment of a New SCADA System to Enhance Visibility Across the KB Grid	The current SCADA system offers very limited visibility of the power system, due to limited data collection (both in terms of monitored locations and the data collected) and unreliable communication links. · A new SCADA system is needed to monitor the electric voltage and current in all generators and major substations. Additionally, remote switching will be enabled at major network locations. The data will be transmitted to the National Control	System stabilization with renewable energy Improvement of network reliability Cost reduction (through the curtailment of operating costs)	Increased visibility of the power system allows for more efficient management of the power system. Examples are as follows: More efficient distribution of thermal and inverter-based generation · Better management of the network Faster diagnosis of network failures and quicker restoration of power	Must be properly implemented to function. Failure to successfully implement a SCADA system can lead to breakdowns and confusing information.	$2 million (Reference value based on actual results. Cost is highly dependent on the scale of the enhancement)

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
	Center via either optical fiber lines or 3/4G networks.				
#15 Comprehensive Deployment of Fiber Optic Cables for Better Communication	To develop optical fiber communication links between all nodes of the SCADA system.	System stabilization with renewable energy	· Once developed, they are very fast and reliable.	· Cost is high due to limited utilities that can be added.	$2 million (Reference values based on actual results. Varies depending on size and acces to existing fiber)
#16 Installation of High-Speed Data Recorders for Fault Analysis	· These recorders will measure and record details of system operation during faults. System stabilization with renewable energy	System stabilization with renewable energy	· When properly implemented, fault recorders can provide insight into the cause of a problem. · This allows for more targeted fault mitigation techniques.	· Data can be collected in other ways. · Careful data management is needed to make it valuable.	ACH of $50,000/electron. (based on industry estimates)
#17 Installation of Frid Forming BESS near Koror Road Center	· Installation of a grid forming BESS to provide the following grid enhancement services o Frequency control, including fast frequency response. o Voltage control o Load limiting o Operating reserve power · Operational redundancy	System stabilization with renewable energy	· It helps enable the grid to safely operate online with very low levels (about 0%) of diesel generation. · It assists in maintaining grid operation in scenarios where IPP Phase 1 (and IPP Phase 2) come online in parallel with one DG at Malakal Power Station, and the generators at Malakal Power Station go offline.	· PPUC lacks experience in owning and operating grid-scale BESS. · Delaying this expenditure might allow for funding through IPP Phase 2.	5 $5 million (Cost depends on size and capacity)
#18 Replacement of the Control System for NIIGATA Generators at Malakal Power Plant	Replacement of the control system to enhance PPUC's visibility, analysis, and troubleshooting capabilities of the control system. · The replacement is recommended by Niigata Power Systems (NPS). It's crucial that the survey and replacement of the protection system are well-coordinated with the overall system scheme and other protection investigations and enhancements.	System stabilization with renewable energy	· The risk of damaging generators due to incorrect control or protection is significantly eliminated.	· Proper implementation is necessary as a poorly implemented control system could simply increase the cause of failures. · A new SCADA system is essential for realizing the benefits of this task.	$2.5 million (based on NPS recommendations and estimates of works)
#19 Installation of Synchronous Capacitors	· Installation of synchronous capacitors to provide grid enhancement services such as o Physical inertia o Reactive power supply Fault current	System stabilization with renewable energy	· Synchronous capacitors help provide additional fault current that can limit the need for enhancements to fortify the protection system. · The physical inertia provided will improve the stability of the system.	· Building this infrastructure without investigating other means to improve grid reliability would increase the cost of bringing renewable energy to Palau's grid.	$1 million or more (Costs vary depending on size. Reference values based on actual results)

Tasks	Overview	Main Power System Features	Advantages	Disadvantages	Cost (US$)
#20 Update of Airai Substation including Transformer Replacement	Update of the Airai substation · It comprises a 34.5/13.8kV transformer with a 10 MVA capacity and related equipment.	Improvement of network reliability	Shortening the outage time by connecting the Irai substation through branching. The risk of accidents due to aged transformer failure can be reduced.	Construction planning may be complicated, to perform construction without power outages on distribution lines. Since the site is small and cannot be expanded, advanced technology is required to minimize power outages during construction. · The existing line needs to be upgraded.	$1.2 million (Refer to JICA Master Plan Report)
#21 Upgrade of Malakal Power Plant including Transformer Replacement	Upgrade of Malakal substation It comprises a 34.5/13.8kV transformer with a 10 MVA capacity and related equipment.	Improvement of network reliability	An additional switchgear is essential for improving small-loop transmission lines. The risk of accidents due to aged transformer failure can be reduced.	The existing line needs to be upgraded.	$1.2 million (Refer to JICA Master Plan Report)

In the JICA Grant Aid Project, the focus is on selecting and supporting high-priority projects in the above "Electrical Power System Prioritization Plan 2021–2025," especially those urgent or consistent with other donors' initiatives.

The specific projects earmarked for support include constructing a 34.5-kV transmission line from Malakal Power Plant to Koksai Substation, expansions at both the Malakal and Koksai substations, building a 13.8-kV distribution line, upgrading Airai Substation, and replacing transformers at Malakal Power Plant.

While the priority projects outside the scope of the plan are expected to continue to be considered for commercialization, preparations are also needed for the next phase of the plan as the plan's deadline of 2025 draws near.

As mentioned in the plan, the effects of initiatives aimed at grid stabilization vary depending on the order of implementation and the method of renewable energy distribution (large-scale or distributed small-scale setups).

For example, the "Large Loop Transmission Line Reinforcement," which includes the reinforcement of Marukyoku Substation and is considered as Task #2, was planned assuming small-scale distributed solar power plants, but it was pointed out that it does not provide sufficient installation value as of now, when priority is given to increasing the ratio of renewable energy through the adoption of mega solar power. However, it's crucial to ensure alignment with ongoing projects, like the ADB's JF-JCM project, which plans to install small-scale solar power plants for SMEs.

Accordingly, when formulating a plan for the next phase, it is necessary to discuss projects that should be prioritized for grid infrastructure for adopting renewable energy

while looking ahead to plans in which various donors would adopt renewable energy.

In this inter-city cooperation project, we intend to utilize the advantage of having the Okinawa Electric Power Group participate in the project to actively support the PPUC in addressing these issues and developing a plan, and at the same time, we intend to develop the base for a business environment for the adoption of PV-TPO and tiltable windmills, which is part of the proposal for this project.

In addition, given the current situation, as renewable energy is adopted further in Palau, it will become necessary for power generators, transmission and substation companies, and consumers to work together to adjust supply and demand. At this stage, an aggregation model will be considered.

NEXTEMS in Urasoe City sells solar power generation systems, storage batteries and EcoCute equipment. At the same time, it has conducted demonstration experiments for the remote monitoring and control of distributed power sources and controllable loads. The company aims to demonstrate and establish area aggregation that allows for flexible demand formation by adjusting the supply and demand balance in the electric power grid while making renewable energy the main power source.

We can expect that the business model of this company will function effectively in Palau where renewable energy is expected to expand at the power generation operator and consumer levels. Therefore, we agreed with the PPUC to continue discussing the construction of a Palau-style aggregation model based on the outlook for introducing renewable energy facilities and trends in demand, and consider the adoption while formulating a next power grid plan, a master plan, etc.

This is because, at the current stage, we should prioritize grid fortification, system enhancement, and operational capacity improvement, but in general, power generation facilities require a long time for investment recoupment (10 to 20 years), so it's necessary to set future visions and goals for 10 or 20 years from now and proceed with infrastructure development that matches the achievement of these goals.

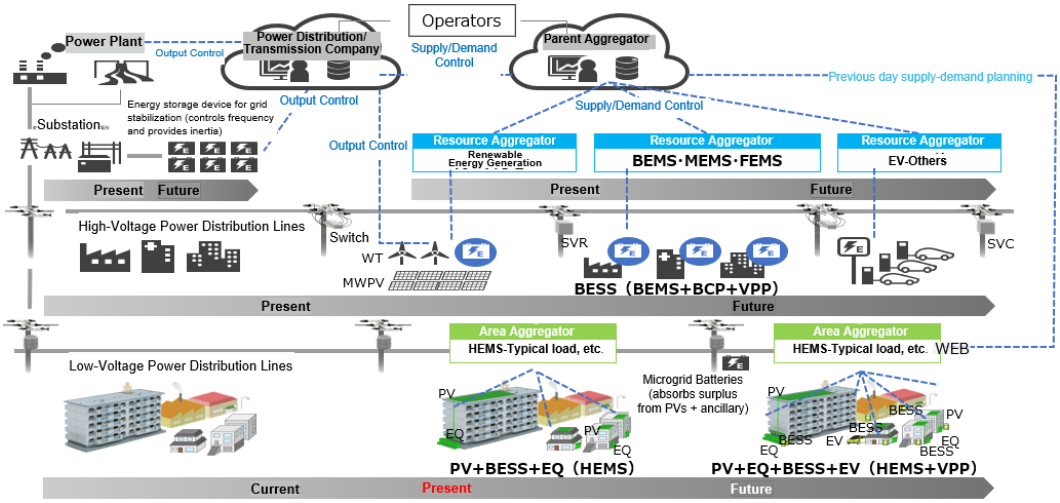


Figure 2-21　Diagram of the Aggregation Model

2.3.5. Policy Recommendations

In January 2024, a workshop was conducted in Palau, so that the Airai State and Urasoe City could share initiatives related to the environment and energy and exchange opinions about governmental measures.

At the workshop, we invited the State of Airai, Urasoe City, and stakeholders, as well as the Embassy of Japan in Palau, JICA Palau, PPUC, and the Climate Change Bureau, as observers, to present initiatives and exchange opinions.

Urasoe City gave a presentation on the city's plans for decarbonization, collaboration with Okinawa Electric Power Company, waste disposal status, and human resources development. Participants asked many questions about energy-saving measures that can be applied immediately, indicating a high level of interest in Urasoe City's steady efforts to decarbonize the city.

On the other hand, the State of Airai reported on the status of waste disposal and the installation of solar power generation facilities. In addition, the Governor of the State of Airai commented that it was valuable to have this opportunity to exchange opinions, and that he would like to continue the relationship.

The JICA Palau office pointed out that while efforts to increase renewable energy are frequently discussed, energy conservation receives less attention. From Urasoe City, there was a presentation on their energy conservation initiatives, which extend beyond municipal electricity saving to include educational programs for children and adults, designed to enhance their awareness of saving energy.

Additionally, the Japanese Embassy in Palau pointed out the necessity for citizens in Palau to take proactive steps toward their nation's progress. It was stressed that achieving

this requires enhancing awareness through activities that garner the understanding and cooperation of various local governments.

Figure 2-22 Scenes of the workshop

2.3.6. Efforts to promote C2P2

(1) Support for waste management

Palau, like other island countries and regions, faces many challenges regarding waste management. Generally, island regions have to face challenges such as the lack of economies of scale in resources circulation through materials recycling, and the lack of options other than landfill disposal. Palau is no exception, with most of its solid waste having to be disposed of in landfills. We surveyed the possibility of initiatives that contribute to resources recycling as part of efforts to promote C2P2. As described below, Japan has been the main supporter of the waste management sector for many years, and the results of this support have just begun to emerge. Therefore, a study was conducted to strengthen the existing efforts.

・Status of waste management

Regarding Palau's waste generation, Koror and Babeldaob (10 provinces) account for about 96% of Palau's waste generation, with Koror 20 t/day and Babeldaob's 10 provinces 6 t/day, totaling 26 t/day (Palau's plan is 30 t/day).

The Palau government's waste management department is Solid Waste Management Division (SWM) of the Public Works Department (BPW), which is within the Ministry of Public Infrastructure and Industry. The Environmental Quality Protection Board

(EQPB) is responsible for facilities, regulations, licensing, etc. This organization is similar to the Ministry of Environment in Japan, but is an independent agency separated from SWM.

SWM is a small institution with only about 10 staff members. On the other hand, Koror's waste management department is larger, with about 80 employees and a larger budget than the national government. In addition, no state other than Koror has an office of waste management.

Palau is working mainly with Kitakyushu City on technical measures for waste management, with the Kitakyushu Eco-Town project and the Recycling Center supporting Palau in the form of cooperation, which is supplemented by the introduction of technology at the private level and support from the Ministry of the Environment.

The main processing facility in Palau is the Koror State Waste Management Office ("Recycling Center"), which has beverage container recycling equipment, composting facilities, glass workshops, plastic oil processing facilities, and power generation facilities.

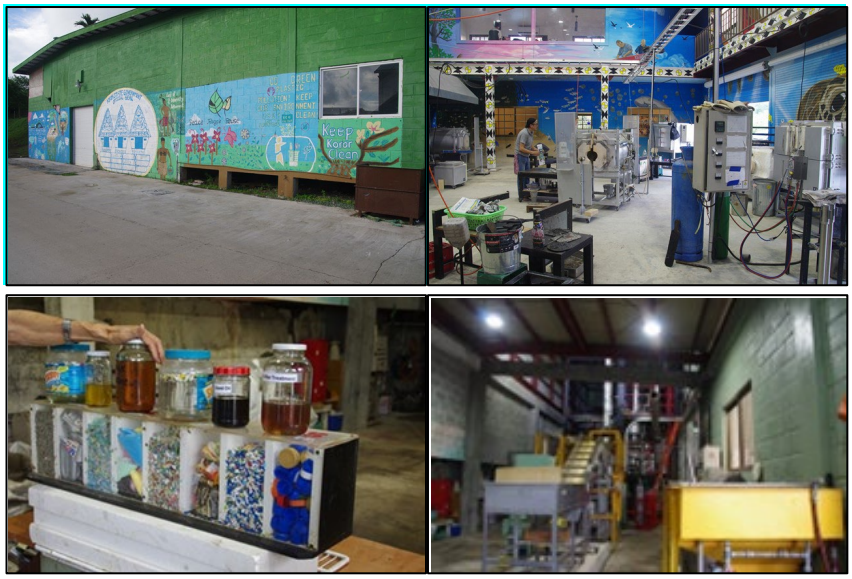


Figure 2-23 Koror State Waste Management Office (Recycling Center)

The recycling center only handles about 1/3 of the waste generated in Koror, and most of Palau's waste is disposed of at the country's largest landfill in Koror (commonly known as the "M-Dock"). Other is disposed of in landfills at the final disposal site in each state. In recent years, the remaining landfill capacity of the M-Dock is approaching its limit, and a new final disposal site (with a planned landfill period of 20 years or longer) has

been in operation in the state of Aimeliik since 2023 to handle all waste generated from Koror and the Babeldaob Island.

https://note.com/maikautsugi/n/n1c355ddb5ccb https://www.ctii.co.jp/project/detail/370

Figure 2-24 M-Dock (left) and the new final disposal site in the state of Aimeliik (right)

・Possibility of introducing renewable energy for waste management

As mentioned above, the recycling center is only able to handle about 1/3 of the waste in Koror. In addition, it is only about 10% of the total amount in Palau. In the future, Koror plans to move its recycling center to M-dock, where a transportation station will be set up to accept all waste materials and promote further recycling. Currently, this plan is still in the process of determining details, but as the center's functions expand, the amount of electricity consumed is expected to increase, and new power generation facilities within the center will be needed, so new renewable energy sources are expected to be introduced. In this regard, the technology for building an off-grid system by installing PV at the PPR (Palau Pacific Resort Hotel), which is under consideration in this project, could be applied.

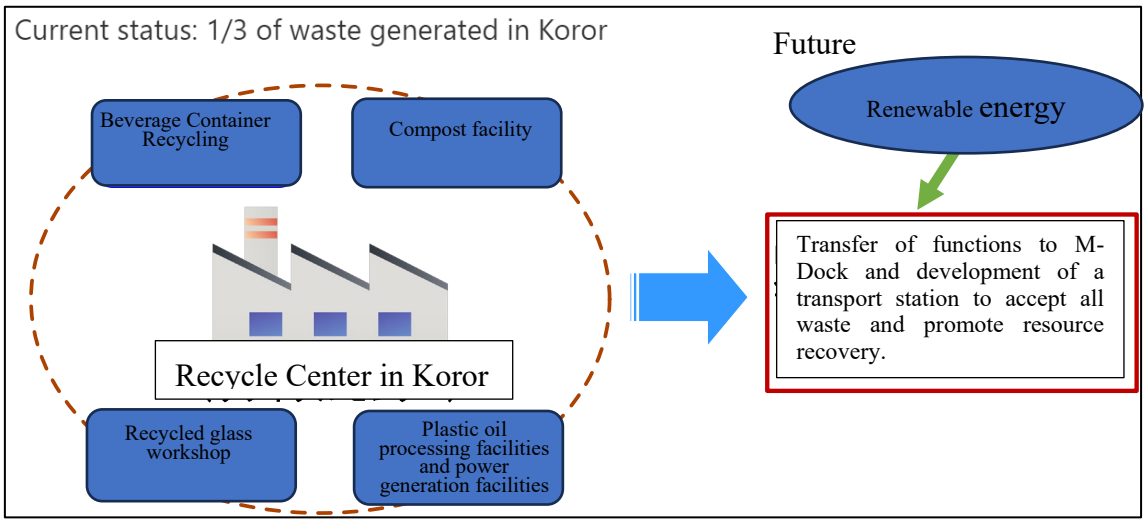


Figure 2-25 Overview of the expansion and relocation of recycling center functions

In addition, the expansion of the recycling center's functions is expected to increase the number of vehicles used for waste management (e.g., collection and transportation vehicles) and their operating rates, so a shift to EVs is expected. The shift to EVs for waste collection and transport vehicles under the current waste management system is being studied in the FY 2022 Intercity Cooperation Project for realization of a Decarbonized Society (Project for Promotion of Decarbonization and Creation of Co-Benefits through Introduction of EVs in Koror, Republic of Palau / Kitakyushu City - Koror Cooperation Project). We will continue to examine the possibility of initiatives that lead to collaboration and promotion, while clarifying the progress of these initiatives through interviews with related organizations.

Figure 2-26 Waste collection and transportation vehicles and charging systems

(Commissioned work for the FY 2022 Inter-City Partnership Project for Realization of a Decarbonized Society: Promotion of Decarbonization and Creation of Co-Benefits through the Introduction of EVs in Koror, Republic of Palau / Kitakyushu-City and Koror Collaboration Project)

(2) Promotion and decarbonization of agriculture and fisheries

In Palau, in addition to energy, food safety is also a challenge. Since most of the food is imported from the U.S. (Guam) and the Philippines and transported by sea, energy price fluctuations have a direct impact on food prices. In addition, the demand for food is associated with tourism, but due to the lack of domestic agricultural production capacity, they cannot seize the opportunity to return profits to the domestic market of Palau.

One of the reasons for this is the lack of workers in these fields. As Palau used to be a mandated territory of the U.S., it is relatively easy to go to college and obtain citizenship in the U.S. So, many young people are not interested in working in the agriculture and fisheries industries. In addition, there are almost no commercial farmers in Palau, and the main form of agriculture in Palau for self-sufficient farmers is to ship their surplus to the market, with farmers directly selling their products at roadside stands. Therefore, agriculture as a business has not been established in Palau. In the case of fisheries, most of them only sell the surplus of their catches for their own consumption.

In the state of Airai, the government has a policy on the promotion of agriculture and fisheries to promote the economy by supplying products to the tourism industry and to prevent the outflow of young people, and has been making efforts to do so. With this background, the commercialization of advanced, decarbonization-compatible agriculture and fisheries industries is considered to be strongly demanded for development, and as one of the efforts to promote C2P2, a study on the commercialization potential of smart agriculture and fisheries industries was conducted.

・Agriculture

Traditional agriculture in Palau was multi-layered agroforestry, which was conducted basically for subsistence. Although agroforestry currently comprises less than 3% of all land, there are people who practice traditional agriculture. The main crops are tubers such as taro.

Currently, Palau's agriculture is still dominated by self-sufficient farmers, who do not engage in commercial production, but rather are based on self-sufficiency and sell their surpluses. On the other hand, Palau is beginning to emphasize tourism, and the food supply in the tourism industry is dependent on imported food products.[2] The demand for these agricultural products is high, but the supply is low, and the insufficiency of commercial farmers is one of the challenges.

Palau's farmers reside in coastal areas due to the richness of the soil (Figure 2.29).

[2] JIRCAS(2021)Agriculture in Palau
https://www.jircas.go.jp/ja/publication/agriculture_in_palau

(Most of them are family-owned (Figure 2-29), and the largest production area is for fruit (3.12 km^2), followed by Betel Nut (2.15 km^2), banana (2.01 km^2), cassava (1.21 km^2), taro (1.16 km^2), and vegetables (1.15 km^2). In addition, the average farm area is as small as approximately 10 a. The Babeldaob Island, the largest island in Palau, has a lot of steep land, with flat land making up only 12% and sloping land where only a small manual tiller can be used accounting for 30%. Accordingly, it is considered difficult to realize mechanization and labor saving.[2]

Regarding water resources, which are usually difficult to secure in island regions, Palau has sufficient water resources for agriculture because of rivers and the constant rainfall throughout the year.

Regarding livestock production, pig farming is dominant, and in 2019, there were 40 pig farms with a total of 497 pigs. These farms are generally small-scale, with only two specialized pig farms raising 50 pigs each. It is common for pig farms to use piggeries where excrement is washed away with water, but some farmers adopted dry-laid piggeries to turn the manure into compost. In Koror, pig farming is legally prohibited, and pigs are raised mainly on the islands of Babeldaob, Kavu, Peleliu, and Angaur. Since the introduction of feed mixing facilities in Ngechesar Province in 2014, with the support of Taiwan, mixed feed has become available and meat quality has improved significantly. The mixed feed is sold at the Ngechesar State Branch of the Ministry of Agriculture for 30 US dollars per 30 kg. A HACCP-compliant slaughterhouse was constructed in Ngechesar Province with the support of Taiwan, and in October 2022, based on the Memorandum of Understanding on Japan-Palau Agricultural Cooperation, a slaughterhouse and a slaughterhouse complex integrating a processing plant and a laboratory are under construction with Japanese grant assistance. In poultry farming, because of the cheap influx of broilers through imports, the main focus is on egg-laying chickens, which can be harvested many times and cost of feed can be kept low.

In terms of waste disposal, regulations apply only to large-scale livestock farmers with 50 or more pigs or 120-150 or more laying hens.

There are few agricultural associations, and the only ones currently functioning are the Livestock Association and the Palau Taiwan Farmers Association (PTFA), which was established in cooperation with Taiwan. The objective is to purchase agricultural materials efficiently through the cooperative. Vegetable seeds are imported by local retailers mainly from the United States, Taiwan, and the Philippines.

The distribution of agricultural products in Palau is shown in Figure 2-29. There are three types of farmers in Palau: subsistence, semi-subsistence, and commercial farmers, with most farmers being semi-subsistence or subsistence farmers and fewer commercial

farmers. Semi-subsistence farmers bring their surplus products directly to street vendors and farmer's markets, where they are sold. The sales channels for agricultural products in Palau are these markets and modern supermarkets. Supermarkets sell mainly imported products, but also some local produce (Figure 2-31 and Figure 2-32). Both imported and local products lack freshness and supply stability.

There are four major challenges for agriculture in Palau: (1) development of commercial farmers, (2) development of workers, (3) food security, and (4) establishment and promotion of integrated farming. The development of commercial farmers in (1) is necessary to increase agricultural production because, as mentioned earlier, the majority of farmers are subsistence farmers. (2) In terms of developing the next generation of farmers, Palau needs to increase the number of young people entering the agricultural sector in order to sustain the farming industry, as farmers are aging and the population is flowing to urban areas. Currently, high schools and community colleges offer agriculture classes and are working to get young people interested in agriculture. Food security in (3) aims to increase and guarantee supply in the Palauan food situation, which is dependent on imported food, while supply is not keeping up with demand. Integrated farming in (4) is aimed at combining various crops and farming methods for more sustainable agriculture.

Fig. 29. Agricultural farms around Babeldaob island (Kitalong, C. unpublished data)

Figure 2-27 Distribution of farmers in the Babeldaob Island

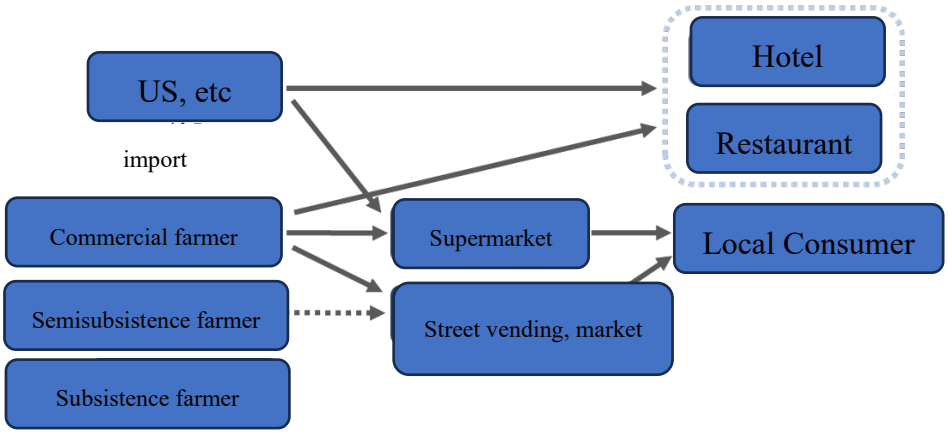


Figure 2-28 Supply chain of agricultural products in Palau

Figure 2-29 Shelves of imported agricultural products

Figure 2-30　Shelves of imported agricultural products

・Fisheries

In Palau, the fisheries industry accounted for 2.2% of the country's GDP in 2014, with a production amount of $5.5 million. In 2015, 13 fishermen engaged in aquaculture and 39 in coastal fisheries. Most of the coastal fisheries are for the domestic urban market, while the offshore fisheries are mainly tuna longline for export. These offshore fisheries are operated with foreign fishing boats that have local bases, mostly from Taiwan, China, and Japan.[3]

Regarding aquaculture, the Fisheries Department has research facilities for both giant clam and fish, and is also responsible for the supply of giant clam seedlings. As for giant clams, only aqua cultured products can be exported, natural products are prohibited to export. For fish farming, coral grouper reef fish and rabbit fish are cultivated at the sea surface. For aquaculture, suitable sites have been selected in each of the 16 states. Ngerdubech Corporation also farms milkfish in Ngatpang State, which is used as bait for longline fishing as well as for eating. Milkfish juveniles are produced by a community college project. The major costs for aquaculture are electricity charges and expenses for feeding. All of the feed is imported.

Urban areas have markets, and fishermen bring their catch to the market to sell. Local seafood is also sold in supermarkets, either fresh or as fillets. (Figure 2-33, Figure 2-34) In addition, Palau imports a large amount of marine products, and frozen fish is sold in supermarkets. Restaurants, hotels, etc. procure directly with fishermen.

[3] FAO Fishery and Aquaculture Country Profiles Palau https://www.fao.org/fishery/en/facp/plw

Figure 2-31　Local seafood section of a supermarket

Figure 2-32　Local tuna fillet

Figure 2-33　Frozen fillet of Philippines milkfish

・Decarbonization of agriculture and fisheries in Palau

Based on the visits and surveys, models for decarbonization in the agricultural and fisheries industries were examined.

In Palau, grid stabilization technology has not been established for the renewable energy that has been adopted, and if renewable energy is introduced rapidly in the future, grid stabilization will become a problem. Furthermore, there are areas with independent systems, and energy-using plant factories and land-based aquaculture facilities can be considered as resources for regulating power in these smaller systems. In previous

research,[4] power consumption was controlled within the range that does not affect plant growth by adjusting light and other parameters in the plant factories.

While agricultural land is scarce in Palau, intensive farming operations such as plant factories are considered suitable because hotels and restaurants are willing to buy products even at prices representing quality. In addition, agriculture using advanced technology may attract the interest of younger generations.

With the increasing availability of electricity from renewable sources, there is potential to use it to power refrigeration equipment and EVs for delivery. In Palau, where resources are limited, the introduction of renewable energy may contribute to stabilizing the management of costly plant factories and other operations.

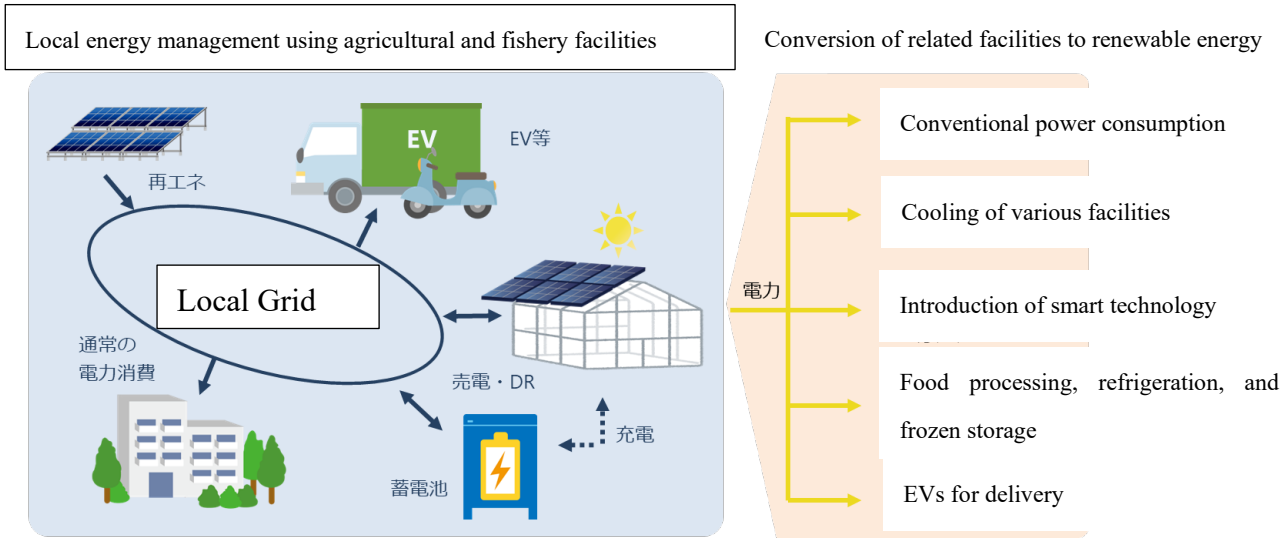


Figure 2-34 A model for the adoption of renewable energy using agricultural and fisheries facilities

[4] Central Research Institute of Electric Power Industry (2023) https://egsweb.denken.or.jp/wp-content/uploads/2023/10/NEDO%E6%A4%8D%E7%89%A9%E5%B7%A5%E5%A0%B4%E3%83%AA%E3%83%BC%E3%83%95%E3%83%AC%E3%83%83%E3%83%88_2023%E6%94%B9%E8%A8%82.pdf

2.4. Intercity Collaborative Activities

As part of this fiscal year's intercity collaborative activities, field surveys were conducted in August and November 2023 and in January 2024. The itinerary for each trip is shown below.

2.4.1. Field Survey in August 2023

Table 2-7 Field Survey Schedule

Date	Day	Activity content
20-Aug	Sunday	Narita - Guam - Arrive in Palau at 26:05
21-Aug	Monday	Palau Finance Minister Climate Change Department/Embassy of Japan in Palau
22-Aug	Tuesday	PPUC (Palau Electric Power Corporation), PPR (Palau Pacific Resort), Agriculture Bureau
23-Aug	Wednesday	Environment Bureau/Ministry of Finance Energy and Water Management Bureau/Island Engineering
24-Aug	Thursday	JICA Palau Office/MAKALAL POWER STATION/Marine Resources Bureau/Ministry of Public Infrastructure Industry
25-Aug	Friday	Airai State Government, Department of Marine Resources, Mega Solar Power Plant, Inspection of Candidate Sites for Installing Retractable Wind Power Systems
26-Aug	Saturday	Koror State Recycling Center/Plant Factory/Utiligence/Retractable Wind Power Candidate Site
27-Aug	Sunday	Visit to Peleliu Island
28-Aug	Monday	26:05 Departure from Palau - Guam - Arrival at Narita August 28th 14:25

During this survey, we had an opportunity to exchange opinions with various related organizations. The summary of the discussions with the main organizations we visited is as follows.

(1) Presidential Bureau of Climate Change

The bureau of climate change is an organization under the direct control of the President of Palau and is responsible for countermeasures for climate change in Palau and the JCM equipment subsidy program. As they expressed interest in the intercity collaborative project, we received the opinion that grid connection is an important issue in implementing PV-TPO and that it needs to be resolved. The staff of the Australian mega-solar project are currently requesting support from ADB for measures to stabilize

the power system. In addition, the lack of engineers at PPUC that perform grid connection is also an issue, indicating that the shortage of human resources is serious.

It was pointed out that when installing PV-TPO, it is necessary to carefully assess the resistance of the roof, as there are no building codes in Palau and the structure of the house roof is not resistant to typhoons.

Figure 2-35 Meeting and Interview with the Person in Charge of the Bureau of Climate Change

(2) PPUC (Palau Public Utilities Corporation)

A meeting was held with the CEO of Palau Public Utilities Corporation (PPUC), which is responsible for public works projects such as power generation, and the managers of the planning and promotion department and the power generation department.

As there is still a lack of infrastructure equipment such as SCADA that contributes to stable power distribution management in the Koror Island and the Babeldaob Island, system improvement with such equipment is demanded. Additionally, the National Control Center (NCC) that will manage IPP is to be constructed on the premises of the power plant in the Malakal Island, and is scheduled to start operations in May or June next year, but it is recognized that there are still many areas for improvement regarding supportive skills. As a master plan has not yet been formulated for the operation of the NCC, it is assumed that it will take time for it to have effective functions.

Furthermore, as a JICA project, there is a project plan to strengthen the substation (transformation and switching) in Airai State and create an electrical loop system in the Babeldaob Island to improve reliability. Airai State mentioned that they would welcome further cooperation from Japan, using the intercity collaborative project with Airai State as a partner city.

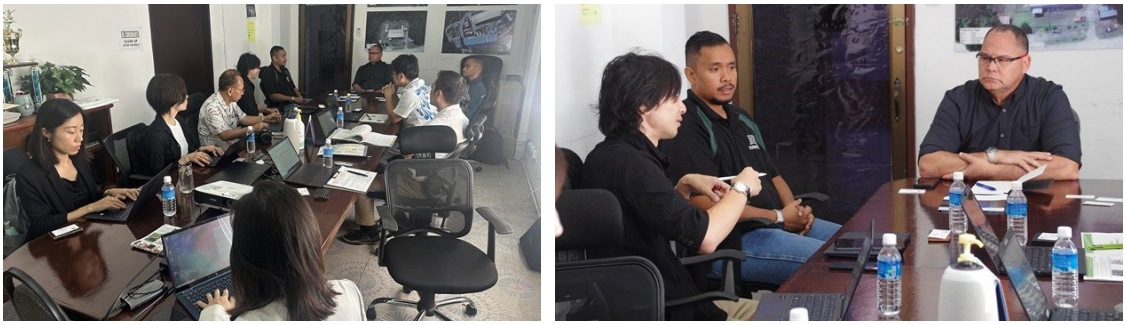


Figure 2-36 Interview with PPUC

(3) PPR (Palau Pacific Resort)

We met with the manager of Palau Pacific Resort and Japanese staff in charge of energy infrastructure. As PPUC's electricity is unstable and expensive, PPR has a diesel generator as its own power generation facility. Although solar power generation equipment, too, has been installed, its contribution ratio remains at about 1%. Power control is managed by dedicated staff. In recent years, due to aging of generators, heat exchangers, etc., PPR started using PPUC's electricity for emergencies and maintenance in 2021, resulting in unstable power supply. When installing equipment, the deciding factors will be: whether the equipment can be maintained independently, and whether it is possible to establish a system that allows engineers from within Japan or a neighboring country to respond immediately.

We acknowledged that Palau Pacific Resort is focusing on environmental friendliness and intends to increase the proportion of solar power generation.

Figure 2-37 Meeting with PPR Managers and Engineers

(4) Agriculture Bureau, the Ministry of Nature, Environment and Tourism

We met with the director of the Agriculture Bureau and received an explanation of the challenges facing Palau's agriculture. The four main issues are: developing commercial farmers, nurturing future farmers, food security, and establishing and promoting

integrated farming. Although there are three types of farmers in Palau: subsistence farmers, semi-subsistence farmers, and commercial farmers, there are almost no commercial farmers. Semi-subsistence farmers mainly ship their surplus to the market, and in most cases, farmers directly ship their produce at roadside sales outlets. While there are few cooperative organizations such as agricultural cooperatives, they have begun building a matching system between farmers and buyers, with the aim of establishing a system that allows buyers to grasp supply volumes and farmers to strategically select the items to cultivate.

Agricultural education is also being provided, including classes at high schools and community colleges to develop future farmers.

With support from FAO, the "Green Grow Plan" is being developed, which will include agriculture-related strategies.

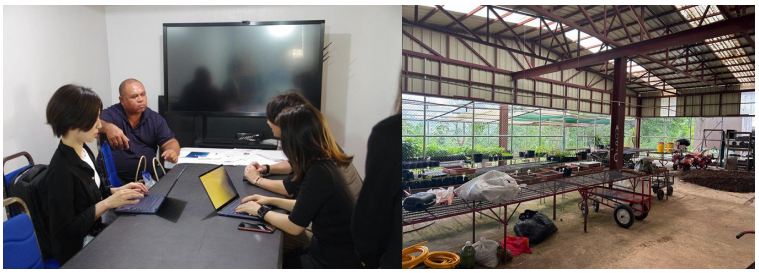


Figure 2-38 Interview with the Director of Agriculture, Test Cultivation Facility

(5) Fisheries Bureau, the Ministry of Agriculture, Forestry, Fisheries and the Environment

Aquaculture is centered around giant clams in Palau, and only cultivated ones are allowed to be sold and exported. They are also researching fish farming, focusing on breeding rabbitfish and other species. While fish farming is completely dependent on imports due to the cost of feed, surveys are being conducted to determine the suitable points for fish farming in each state. However, as there are no cold chains or processing plants, the entire value chain needs to be developed to make aquaculture a reality. Currently, the main distribution channels are the market or direct transactions with restaurants and hotels.

At the giant clam aquaculture center adjacent to the Fisheries Bureau, clam seeds are distributed from the national research institute, and aqua culturists grow them for four to five years before shipping them out. All that is required for cultivating giant clams is sunlight, aeration, and a seawater pump; no wastewater treatment is required, so the cost is mainly electricity for the pumps, etc. Since solar power generation has been introduced and the fishery is operated using net metering, it was seen that there is a possibility of

smart seafood production by strengthening these and combining systems such as automation and production efficiency.

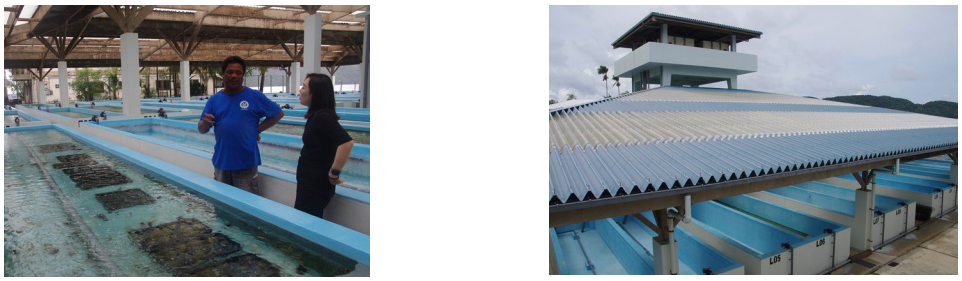


Figure 2-39 Aquaculture center and its rooftop solar power generation

(6) Environment Bureau, the Ministry of Agriculture, Forestry, Fisheries and the Environment

The Environment Bureau is under the control of the Ministry of Agriculture, Forestry, Fisheries and Environment, and consists of the Division of Protected Areas & Species and the Division of Forest, Land, & Water Management. EIA procedures are under the jurisdiction of the independent Palau Environmental Quality Protection Board (EQPB), and decarbonization projects are being implemented mainly by the minister in collaboration with the United States. The Environment Bureau has concerns about solar panels due to their high disposal costs. They also point out that, as lithium batteries still cannot be recycled within Palau, it is necessary to consider the disposal stage when it comes to the widespread use of storage batteries. In Palau, all natural resources are owned by the national government.

Figure 2-40 Interview with the Environment Bureau, and Central Government Office

(7) Palau Energy & Water Administration (PEWA), the Ministry of Finance

The meeting was held on August 23, and they shared information on the administration's initiatives while introducing examples of energy-related initiatives. We acknowledged that they are aware of the issue of stabilizing the electric system of PPUC,

and there is hope for countermeasures through the adoption of battery storage. Regarding the distributed installation of rooftop solar power plants, it was recognized that PV-TPO could be popularized as there are many unused rooftops. However, as the legal power service provider is limited to PPUC, it was pointed out that it is necessary to consider business models that are consistent with the system. Regarding wind power generation, they mentioned the land issue and made a supplementary point that offshore power generation would be treated as government-owned. In PEWA's opinion, renewable energy projects that have potential are PV and wind power, but the cost of FS to adopt wind power is high, so PV is the most realistic option with a proven track record. As for biomass, they recognized that the market being too small is an issue. Regarding green hydrogen, while they are considering it, due to its high cost, there are no concrete plans to adopt it yet.

Various measures are being discussed while enlisting cooperation from the state of Hawaii, the U.S., with which the administration has a collaborative relationship, and grid-related regulations are being formulated with support from the state. At the same time, there are plans to develop a new energy roadmap. In response to the president's wishes, it was also mentioned that Palau is making adjustments to set a goal of increasing the ratio of renewable energy to 100% by 2032.

(8) The Ministry of Public Infrastructure and Industry

On August 24, we had a meeting with the Minister Charles I. Obichang. We received comments that they were very interested in wind power generation in this project. Furthermore, there was additional information regarding the goal of increasing the ratio of renewable energy to 100% by 2032, which was also mentioned in the interview with PEWA. Achieving this will require support from experts in each country, and although the ongoing IPP projects will be able to raise the ratio of renewable energy to 20%, we agreed that achieving 100% will require further IPP projects and the popularization of self-consumption solar power generation systems among consumers. Moreover, they believe that there is potential to increase the ratio of renewable energy to 100% by fully utilizing Palau's solar resources.

From the perspective of public infrastructure, he also made references to transportation, especially the issue of traffic congestion due to the increase of private cars. He mentioned that it is necessary to improve public transportation and reduce CO2 emissions from transportation by introducing EVs.

(9) Airai State Government

On August 25, we paid a courtesy visit to the Governor Norman H. Ngira Techeboet in the Airai State, reported on the progress of this project, and exchanged opinions. Among the efforts to promote C2P2, he mentioned that the state also conducts cleaning activities for waste, and although it used to operate an incinerator, it was closed due to complaints from residents, leaving no choice but to use the landfill in Aimeliik, the neighboring state. Regarding the agricultural sector, he explained that there are issues in the value chain of agricultural products, and the Airai State is planning to establish a “Central Farmers’ Market.” Furthermore, from the perspective of promoting local agriculture and food education, the state aims to utilize locally produced foods in school lunches.

(10) Koror State Recycling Center

On August 26, at the Koror State Waste Management Office (hereinafter referred to as "Recycling Center"), we received an explanation of Palau's waste management status and future plans from the Director Fuji of the Recycling Center, who is also the Koror State Special Advisor and Economic Development Investment Ambassador.

Most of the waste generated in Palau is from Koror State, and the waste management department in the state is said to be a larger organization than the national government. Additionally, other states do not even have offices to manage waste. Most waste in Palau is treated at final disposal sites (mainly M-Dock in the Koror State until 2022 and a new final disposal site in the Aimeliik State from 2023), and this recycling center is operated as a treatment facility other than the final disposal site, handling one-third of the waste generated in the state. According to the Director Fuji, there is a plan to relocate and expand the recycling center and promote further recycling.

In addition, the Director Fuji mentioned that in Pacific countries, including Palau, 3R and landfill disposal are the main methods of waste management. He also noted that incinerators are avoided for reasons such as their environmental impact, high installation and operating costs, and the inability to perform sufficient on-site maintenance.

Figure 2-41　Koror State Waste Management Office (Koror State Recycling Center)

(11)　Plant Factory

We toured the only plant factory in Palau. Figure 2-42 shows the location of the plant factory.

Figure 2-42　Location and Aerial Photo of the Plant Factory (Google Maps)

This plant factory has been operated by Mr. Tova, who runs a travel company and a restaurant, since November 2022, and has been producing mainly salad vegetables and herbs such as lettuce, spinach, kale, and perilla as an EGAI (Eco Green Agriculture Innovation) brand. This is a solar-powered plant factory that performs nutriculture. The plant technology is imported from Israel, the nutrient solution from the United States, and the seeds from the Netherlands. As the inside of the plant factory is controlled by computers, operation is easy. After harvesting, the produce is processed and packed in refrigeration equipment in order to be shipped by refrigerated truck. Electricity is purchased, and the electricity bill is 1000 US dollars per month.

The reason for starting the operation of a plant factory is because the lettuce available in Palau was of poor quality and expensive. Currently, in addition to selling vegetables directly to hotels and restaurants, they wholesale them to supermarkets, and their products are highly evaluated. (Figure 2-43) Marketing is mainly done through word-of-mouth and Facebook.

Figure 2-43 EGAI Brand Logo Displayed in the Vegetable Section of a Supermarket

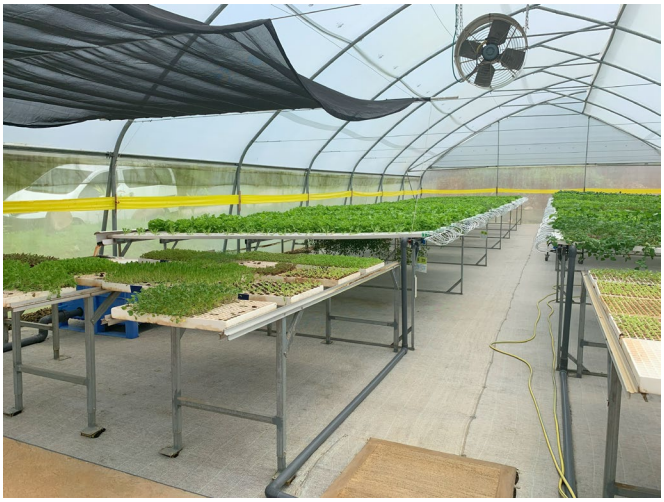


Figure 2-44 Inside the Plant Factory

(12) Land-based Aquaculture Facility for Giant Clams

We visited a land-based aquaculture facility for giant clams at the Palau Aquaculture Experiment Center. The location is shown in Figure 2-45.

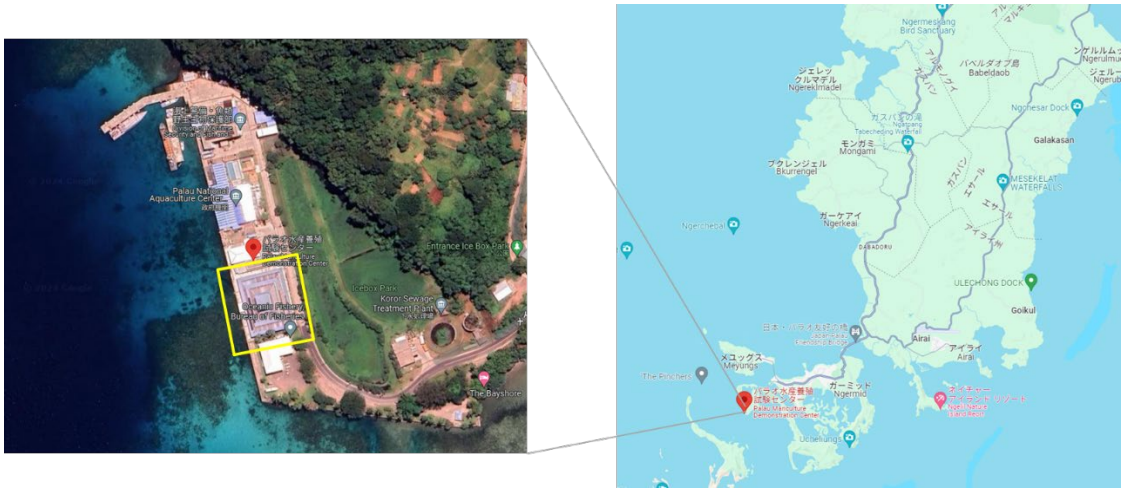


Figure 2-45 Location and Aerial Photo of Palau Aquaculture Experiment Center

This center is operated by the Fisheries Bureau as a giant clam research facility and clam seed production facility. Eggs are collected from giant clams in nature and cultivated within the center for 1-2 years to produce clam seeds. The seeds are then distributed to local aquaculture companies, where they are cultivated for about five years until shipment. (Figure 2-46) Eight types of giant clams, sea cucumbers, takase shellfish, etc. are also grown within the center. As giant clams live in symbiosis with algae, obtain nutrients through the photosynthesis of algae, and feed on plankton in the sea, they do not need food as long as there is sunlight. Additionally, there is no need to treat wastewater or control temperature. The only equipment required is aeration and a pump; the total cost is nearly equal to electricity charges.

There are solar panels installed on the roof of this center, and they generate a profit of about 30 US dollars/month through the sale of electricity, but they usually buy electricity.

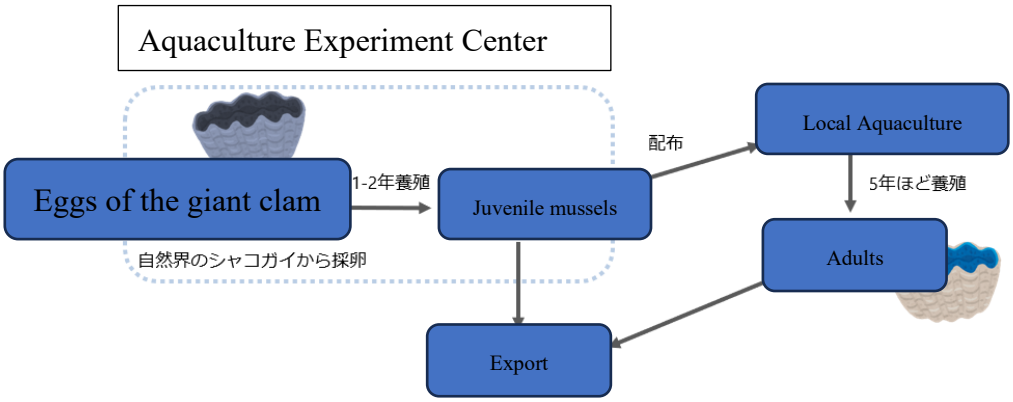


Figure 2-46　Flowchart of Giant Clam Production

Figure 2-47　Giant Clams Being Cultivated

Figure 2-48　Water Intake Pump in the Center

Figure 2-49　Solar Panels on the Roof of the Center

Figure 2-50　Appearance of an Aquaculture Farm

2.4.2. Field survey in January 2024

(1) Exchange of opinions with Airai State (on January 23 and 24)

We exchanged opinions with officers of Airai State on January 23 and with the governor and officers of the state on January 24. They told us that the state government would not be able to subsidize photovoltaic generation, but the National Development Bank of Palau (NDBP) was currently running a financing program funded by the Asian Development Bank (ADB) and would be able to offer subsidies. They explained that while electricity is supplied exclusively by the Palau Public Utilities Corporation (PPUC) in Airai State, sewage water was treated independently by the state. We told them that we

would like them to share various kinds of information concerning Airai State in order to design a decarbonization project, and they agreed.

Figure 2-51 Exchange of opinions with Airai State

(2) Exchange of opinions with the Embassy of Japan in the Republic of Palau (on January 24)

We had a meeting to exchange opinions with the secretary of the Embassy of Japan in the Republic of Palau on January 24. The facility of the embassy is connected to the power grid system operated independently by Palau Pacific Resort (PPR) and the embassy considered installing photovoltaic panels in its facility. Therefore, we shared opinions regarding plans and ideas for panel installation. With regard to an idea of installing photovoltaic panels on the rooftop of carports in the parking lot, they pointed out that it had to be kept in mind that carports were not covered by subsidies. The embassy advised us to take into account what advantages the PPUC would have when photovoltaic panels were installed and operated in PPR by SeED Okinawa LLC. We, thus, explained that technology and human resources developed in PPR would contribute to the initiatives pursued by the PPUC, and we came to an understanding. We gave an additional explanation about our intention to provide the PPUC with our technology and cooperate with them in enhancing the stability of power distribution in Palau after commercializing the project.

(3) Exchange of opinions with JICA Palau Office (on January 24)

We shared opinions with the JICA Palau Office on January 24. We told them that we would like to develop a model for solving the issues related to electricity distribution in Palau with reference to the projects of the PPR as we presented in the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28). JICA said that, currently, a number of entities, including our city, showed interest in

entering the field of electricity-related business, and while they were pleased to draw a growing interest, they were concerned about possible competitions among supporting organizations and business operators. They also indicated that there were numerous issues to tackle, such as failure in connecting to the electricity grid system even after successful development of power supply, and truly supportive effects would not be brought about unless the infrastructure was in harmony as a whole. We told them that we, Urasoe City, would like to foster our partnership with them and would work together with JICA Okinawa, an organization based in Urasoe City, as this project was the first international collaborative project that Urasoe City carried out. JICA offered details about how Palau currently collects and ultimately disposes of waste and JICA's initiatives regarding the field of waste treatment, which is one of the subjects covered with the aim of promoting the Clean City Partnership Program (C2P2).


Figure 2-52 Exchange of opinions with JICA Palau

(4) Exchange of opinions with the Recycling Center (on January 24)

We exchanged opinions with Mr. Katsuo Fuji, the head of the Recycling Center, on January 24. The Recycling Center gave details about how waste is treated currently in Palau. Because people in Palau do not have strong awareness of the importance of sorting garbage, they need to receive thorough education about why waste should be sorted out, how sorting of garbage helps treatment and effective use of waste, etc. Waste is gathered at the center after being sorted out, and some of them are processed into compost while plastics are converted into oil and then used for generating electricity of about 2,500 kWh per day. The generated electricity is used in the center, and surplus electricity is utilized effectively. The center earns revenue from tourism activities, such as manufacturing of glassware products and glassware workshops with waste glass. Suffering from a problem that there is no one to take over its business, it considers stabilizing and expanding the business through collaboration with private companies.


Figure 2-53 Exchange of opinions with the recycling center

(5) Exchange of opinions with the Palau Energy & Water Administration (on January 24)

We had a meeting to exchange opinions with the director of the Palau Energy & Water Administration (PEWA) on January 24. After we gave an explanation about the photovoltaic generation project at PPR, the PEWA advised us to communicate closely with the state and confirm required processes even in the planning phase because permits and licenses might be required for carrying out projects depending on the scale of the relevant project. Furthermore, the PEWA told us that there was a plan to draw an energy roadmap in March of this year and publish it in April as a national report in which the current achievement rate against the decarbonization target of 45% would be revealed. Under these circumstances, it said that it welcomed the initiatives of our project chiefly because if the target ratio of decarbonization in Airai State would be raised to 100%, an inspiring example would be set to future projects.


Figure 2-54 Exchange of opinions with the PEWA

2.5. Future course of action

In the survey conducted this fiscal year, we successfully exchanged opinions with and obtained information from a multitude of organizations involved in decarbonization projects, etc., and decided to commercialize the project of stabilizing PPR's power grid system as an example case of renewable energy optimization for independently operated systems, because grid stabilization is one of the issues that hinder the spread of renewable energy in Palau. We will provide know-how for operation of the power grid system managed by the PPUC in Palau by presenting how a system in which photovoltaic generation and the existing diesel generators are optimized works while showcasing what have been achieved in the project of PPR. With regard to tiltable wind power generation, we are selecting potential sites for installing relevant facilities, and have raised awareness and garnered attention of such organizations concerned as the PPUC, public infrastructure, and the ministry of industry, as an option of renewable energy sources that can be adopted in Palau other than solar power.

Furthermore, as part of the intercity collaborative project carried out this fiscal year, we had a chance to introduce our project at the Japan pavilion in COP28 held in the United Arab Emirates. The Climate Change Office, Palau, under the Office of the President of the Republic of Palau, and the Okinawa Electric Power Company, Incorporated took part in the presentation and reported on their initiatives, which made it an excellent opportunity of introducing our project to the world as an effort that follows the slogan of the Japan pavilion, "Together for action."

During the workshop held in January 2024, we had an opportunity for direct opinion exchange between Airai State and Urasoe City, which helped foster the cooperation between the two cities.

Based on what we have accomplished through these activities, we will continuously commercialize each subject and search for how to secure cooperation while keeping an eye on synergy through collaboration between the two cities.

Regarding the initiative for renewable energy optimization in PPR, in particular, we will endeavor to accelerate our effort to commercialize the project in view of utilizing the Joint Crediting Mechanism (JCM) equipment subsidy program and offer a successful example as soon as possible as a reference useful for the PPUC that is forging ahead with a plethora of initiatives for power grid stabilization. This project is aimed at realizing both electricity decarbonization and stable power distribution throughout Palau while focusing on bringing about synergy with equipment enhancement and support for planning of power grid stabilization. We will design the project so that it will increase the ratio of

renewable energy to 100%, which is the target to achieve by 2032 through these initiatives.

In addition, we will make efforts to promote C2P2 so that we can contribute to solving issues in Palau by taking advantage of the strengths of the intercity collaboration while continuously keeping in mind collaboration from the perspective of decarbonization.

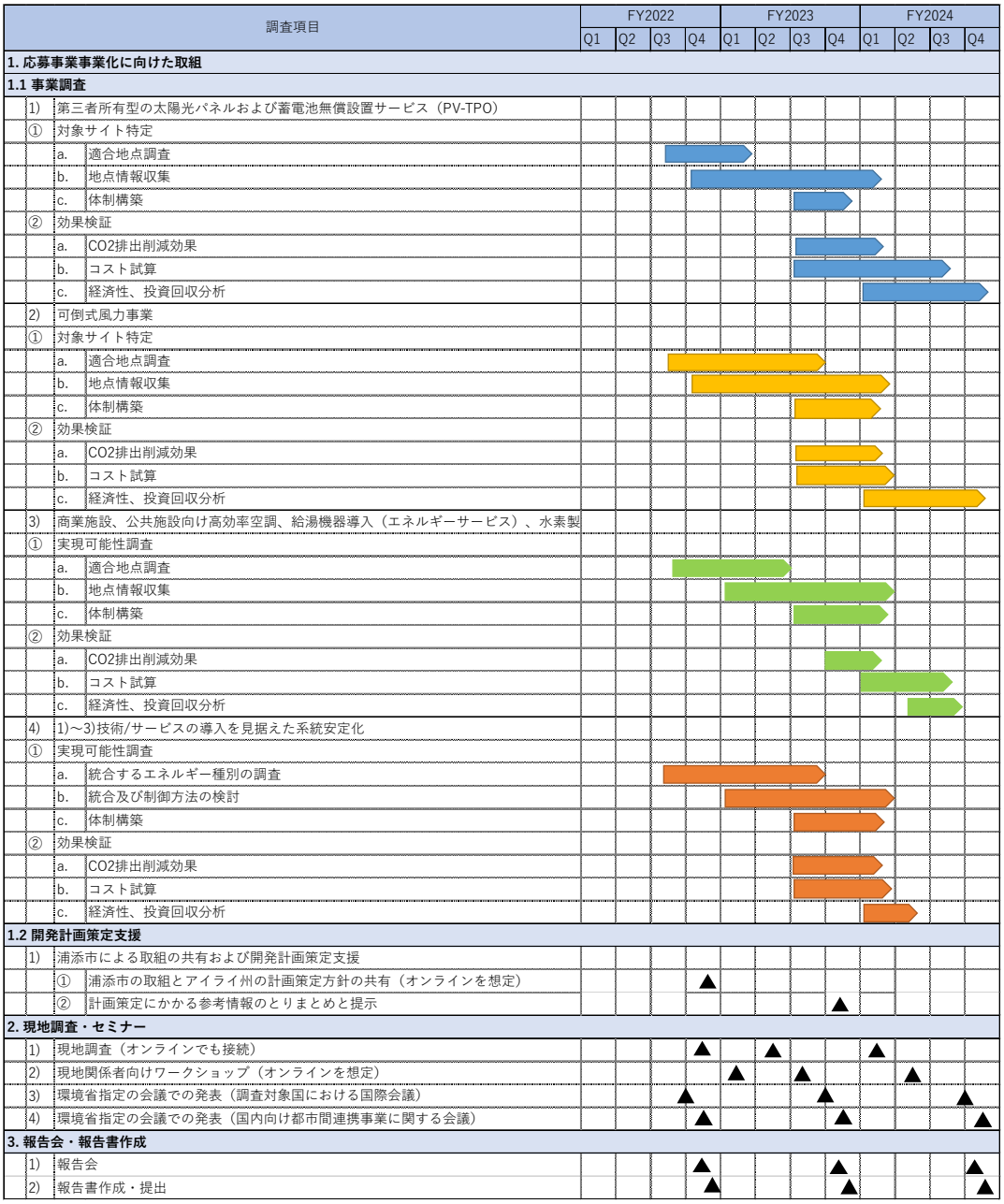
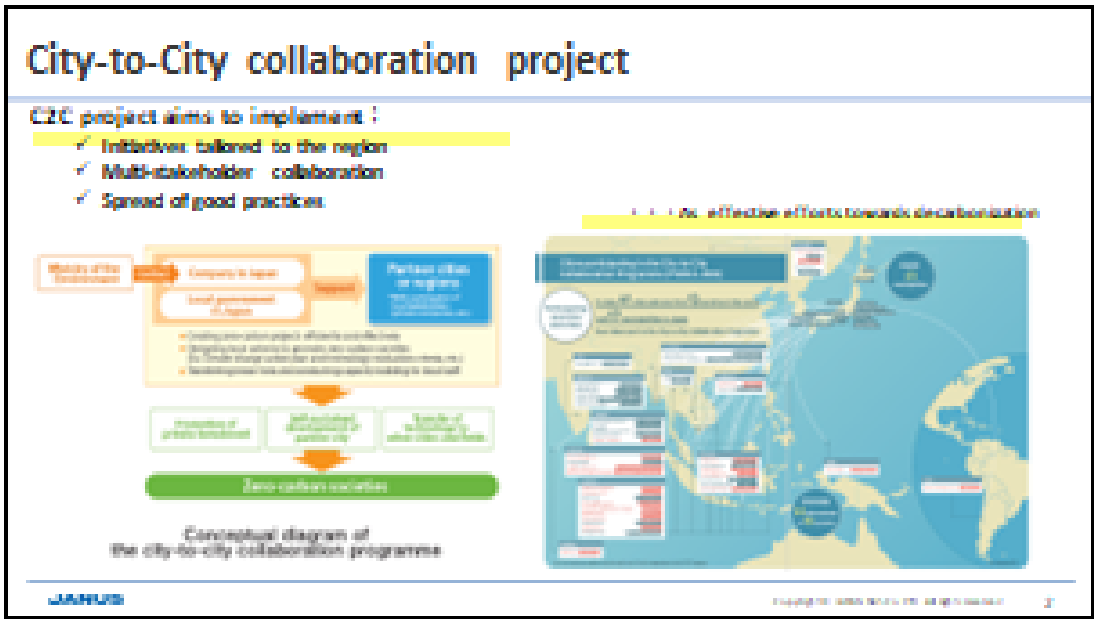


Figure 2-55 Plans for respective activities for the project

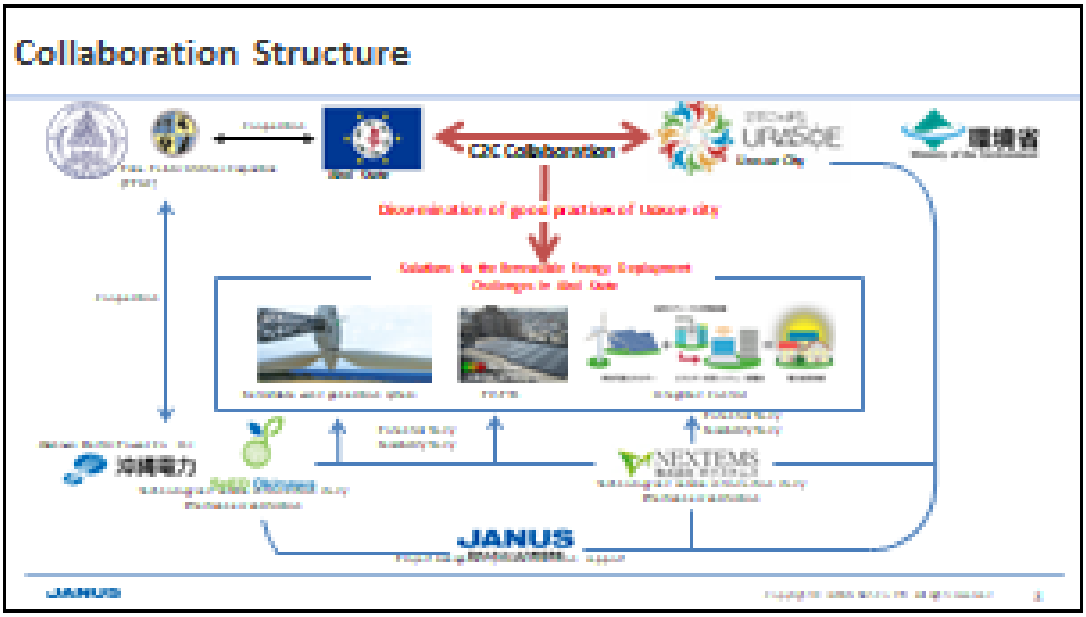
Reference 1　Material for a seminar for the workshop of the intercity cooperation project (material of JANUS)

1



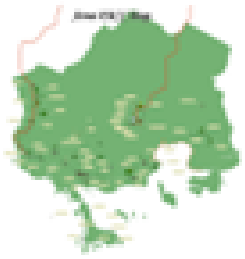
2

Collaboration Structure



Target area: The entire Republic of Palau centered on Airai State

- Airai State has the second largest population after Koror State and has central functions such as the location of airports and water sources.



→ While focusing on Airai State, since the supply potential of renewable energy is not confined to the domain of a single municipality, the project will also consider collaboration with multiple municipalities that have potential and with the central government.

Urasoe, Okinawa JAPAN

Concluded a comprehensive partnership agreement with The Okinawa Electric Power Co., Inc. to solve regional issues and develop sustainable communities

Overview of Urasoe City

- Population growth in remarkable, and commerce and industry are active.
- The fourth largest city in Okinawa, with a population of about 114,000.
- More than 10% of the 19.00㎢ area is occupied by US military bases.

JAHURS

Good practice of multi-stakeholder collaboration

5

INITIATIVE POLICY FOR THIS PROJECT

Issues

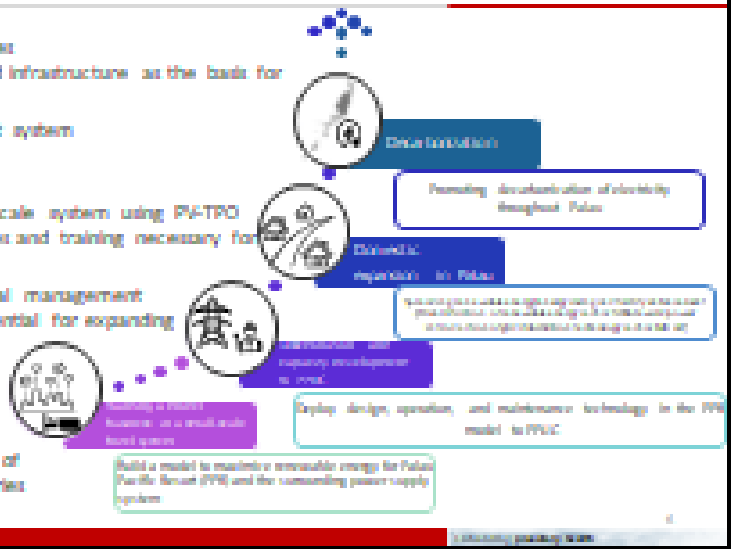
- ✓ Lots of projects in different phases
- ✓ Underdeveloped technology and infrastructure as the basis for introducing renewable energy
- ✓ Lack of operational management system

Initiative policy

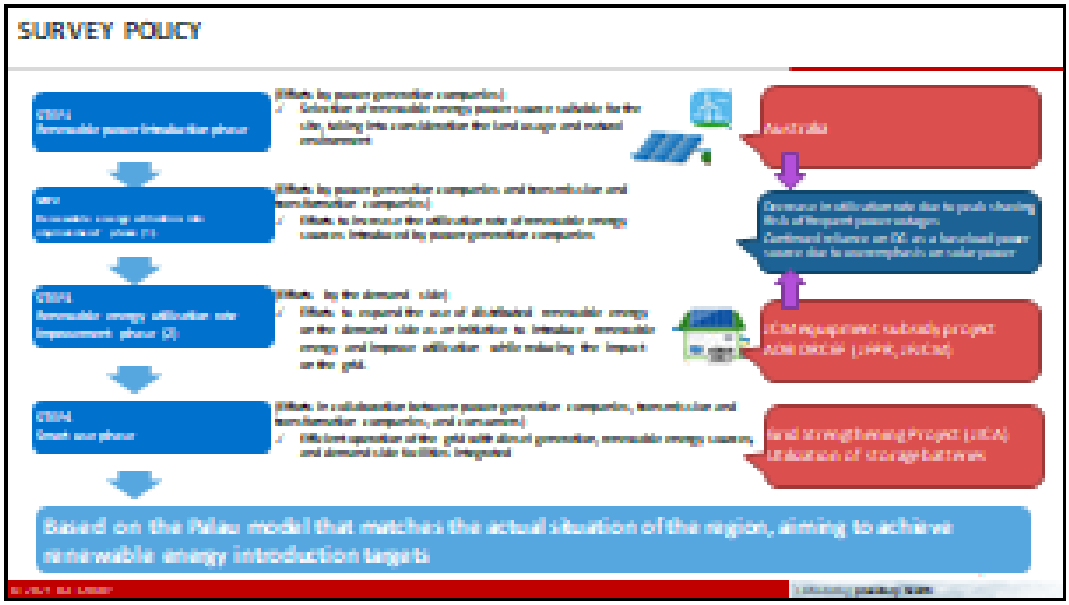
- ✓ Build a model case with a small-scale system using PV-TPO
- ✓ Introducing operational examples and training necessary for renewable energy management
- ✓ Contribute to improve operational management technology in PPUC, which is essential for expanding the spread of renewable energy

Initiatives to promote CZP2

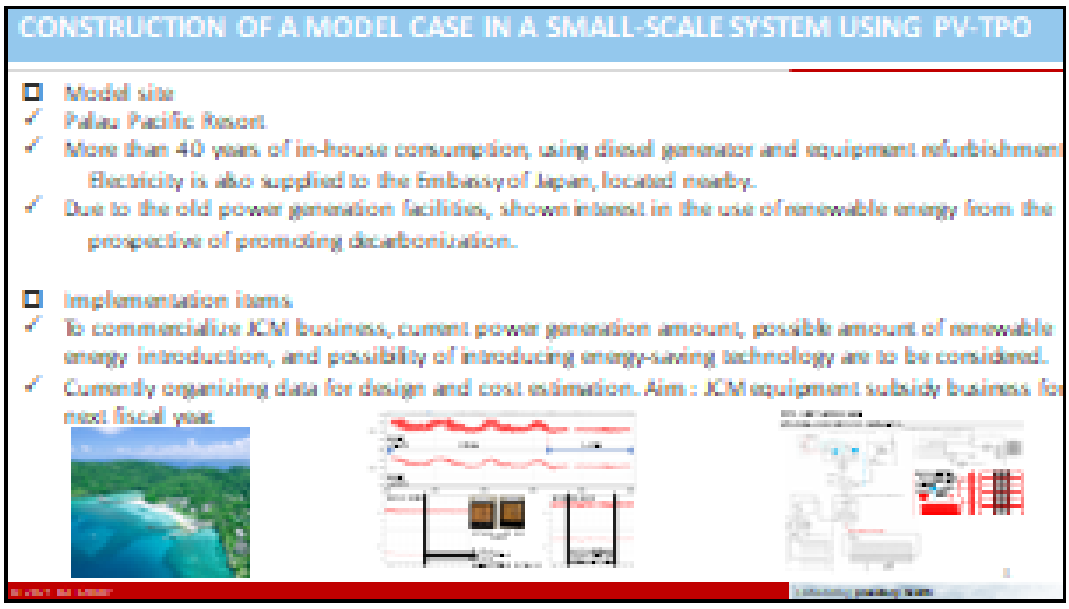
- ✓ Support waste management
- ✓ Promotion and decarbonization of agriculture and fisheries industries
- ✓ Extension of hydrogen, EV, etc.



6


SURVEY POLICY
Based on the Palau model that matches the actual situation of the region, aiming to achieve renewable energy introduction targets

7

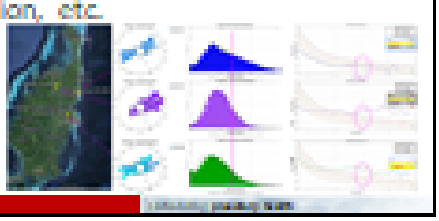

CONSTRUCTION OF A MODEL CASE IN A SMALL-SCALE SYSTEM USING PV-TPO
Model site
Palau Pacific Resort
More than 40 years of in-house consumption, using diesel generator and equipment refurbishment
Electricity is also supplied to the Embassy of Japan, located nearby.
Due to the old power generation facilities, shown interest in the use of renewable energy from the prospective of promoting decarbonization.
Implementation items
To commercialize JCM business, current power generation amount, possible amount of renewable energy introduction, and possibility of introducing energy-saving technology are to be considered.
Currently organizing data for design and cost estimation. Aim : JCM equipment subsidy business for next fiscal year.

8

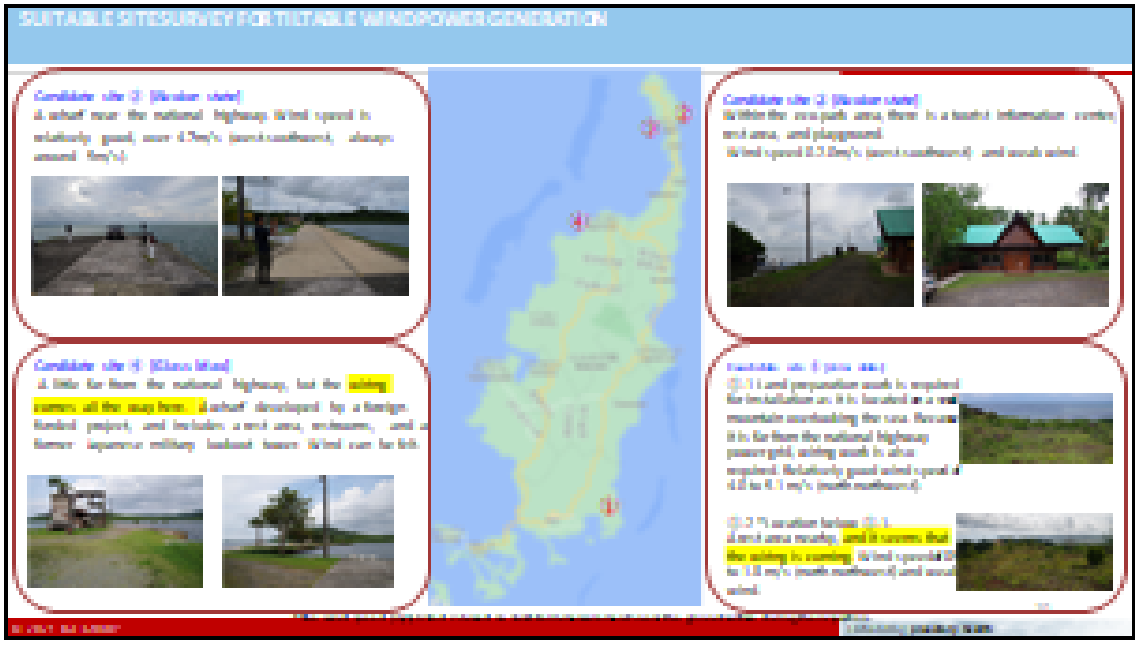
CONSIDERATION OF INTRODUCING TILTABLE WIND POWER

- ☐ Significance of the introduction and last year's survey results
  - ✓ Diversification of power sources is essential for achieving 100% renewable energy
  - ✓ Wind conditions in Palau : At a level to utilize wind energy.
  - ✓ Potential survey results by the US and PPUC in the past.
  - ✓ Issues: Countermeasures against typhoons and maintenance and operation know-how.

    Best option : Tiltable wind power generation, which local equipment can be utilized (Okinawa Electric Power Group : Track record in Tonga)
- ☐ Implementation items for this fiscal year
  - ✓ Identify potential sites, collect landowner information, etc.
  - ✓ Survey of wind condition, cost of construction



9



ENERGY SAVING/HYDROGEN USAGE

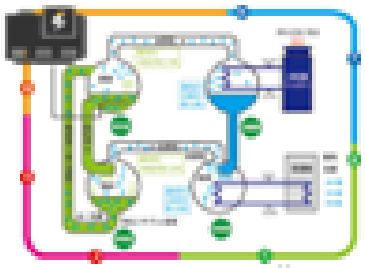
- Energy saving of air conditioning equipment with PPR
  - ✓ Exhaust heat from existing diesel generators can be used as a heat source for air conditioning and hot water (absorption type examples: water heaters and refrigerators)
  - ✓ The possibility of spreading energy saving air conditioning using similar equipment

- Implementation items for this fiscal year
  - ✓ Investigating air conditioning equipment at PPR
  - ✓ Calculate CO2 emission reduction effect /economic efficiency
  - ✓ JCM business

- Hydrogen usage/others
  - ✓ Sojitz/Dainippon Dia Consultation

Exchange of opinions with third country collaborative projects for hydrogen production and utilization

- ✓ Support : Hydrogen transportation routes
- ✓ Important: Decarbonization of vehicles, spread of EV



11

CITY-TO-CITY COLLABORATION

- Comprehensive and synergistic support for urban issues with C2P2 in mind

- Promotion of agricultural and fishery industry
  - ✓ Agriculture: Shortage of workers. Smart agriculture (hydroponic cultivation, etc.) is suitable for producing stable quality and stable quantities in small numbers of labor.
  - ✓ Fisheries: Shortage of workers. From the perspective of nature conservation, coastal fishing and marine aquaculture are difficult, and terrestrial aquaculture is suitable.

→ Hotels, etc. are considered as demand areas, and there is potential for small-scale production of high value-added items.

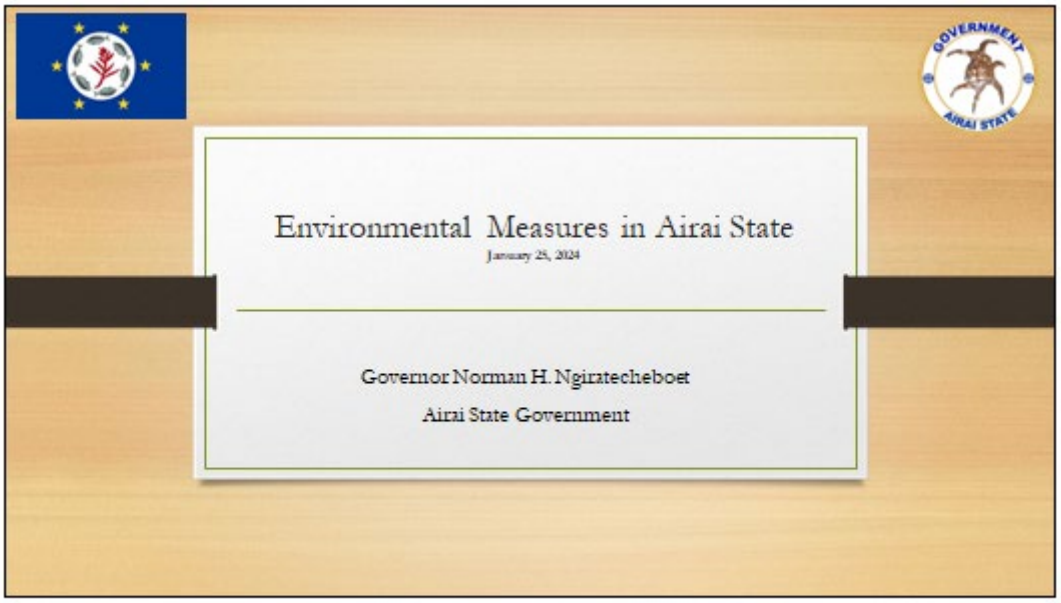
→ To promote : Agriculture and fisheries industry while decarbonizing the energy supply essential to smart agriculture and fisheries using renewable energy.

- Waste management support
  - ✓ Horizontal development of Urasoe City's coastal cleanup activities and environmental education achievements
  - ✓ Studying decarbonization of energy-demanding facilities




12

Reference 2　Material for a seminar for the workshop of the intercity cooperation project (Material of the Airai State)

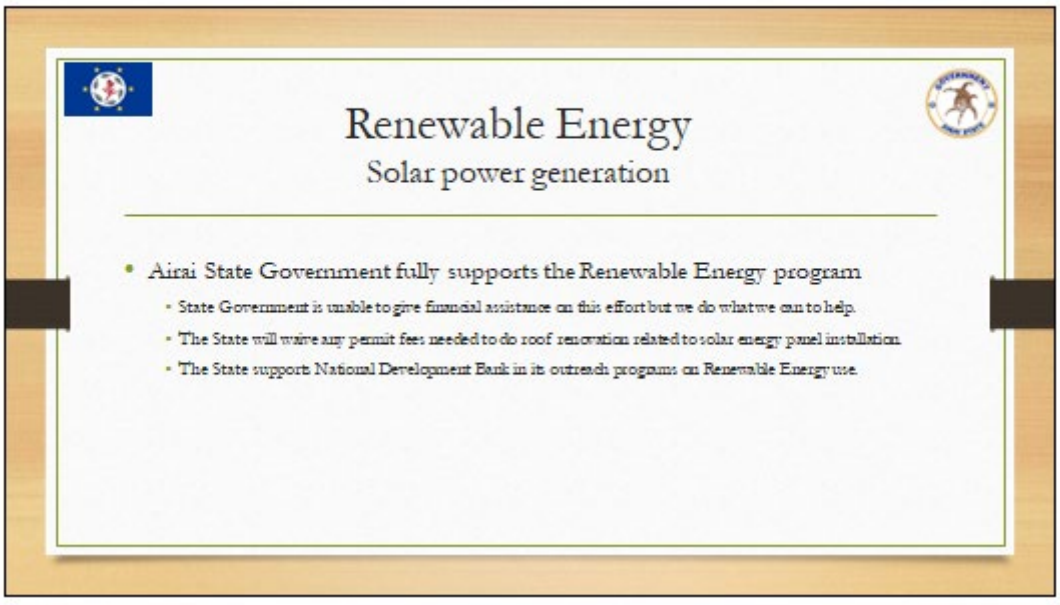


1

2


Waste Management/Treatment
Planned centralized sewer system in Airai State
Currently, there is an existing plan to have a centralized sewer system in a housing project consisting of 12 houses.

3


Renewable Energy
Solar power generation
Airai State Government fully supports the Renewable Energy program
State Government is unable to give financial assistance on this effort but we do what we can to help.
The State will waive any permit fees needed to do roof renovation related to solar energy panel installation.
The State support National Development Bank in its outreach programs on Renewable Energy use.

Status of Solar Power Generation Installation

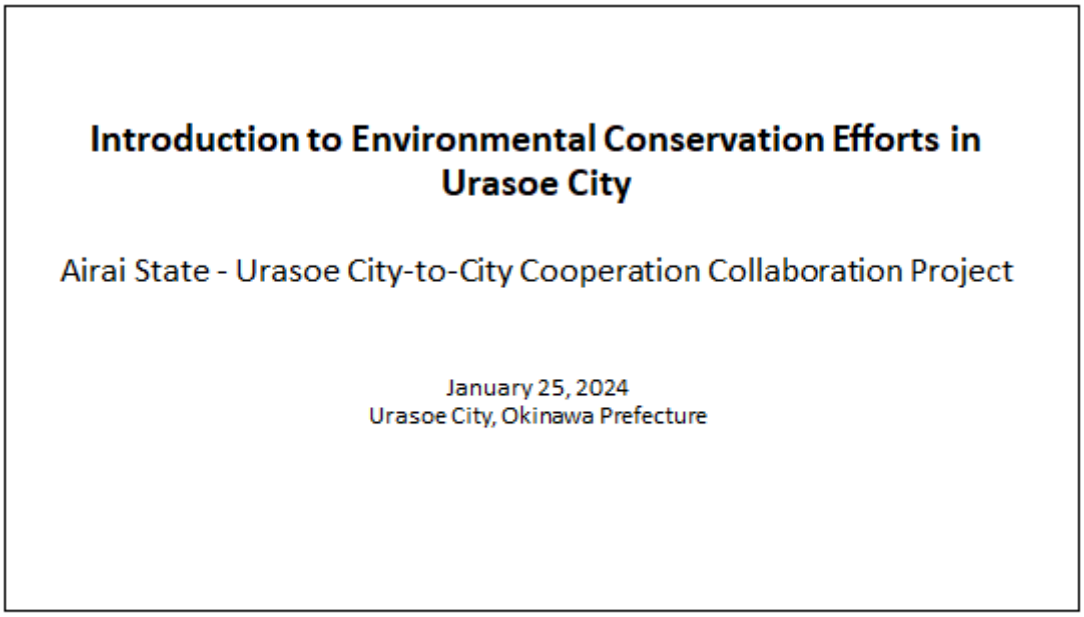
- Estimated number of homes in Airai State: 1,100 houses
  - Number of buildings in Airai State with Solar Power system:
    - ✓ 79 residential houses,
    - ✓ 9 commercial buildings, and
    - ✓ 4 government establishments.

5

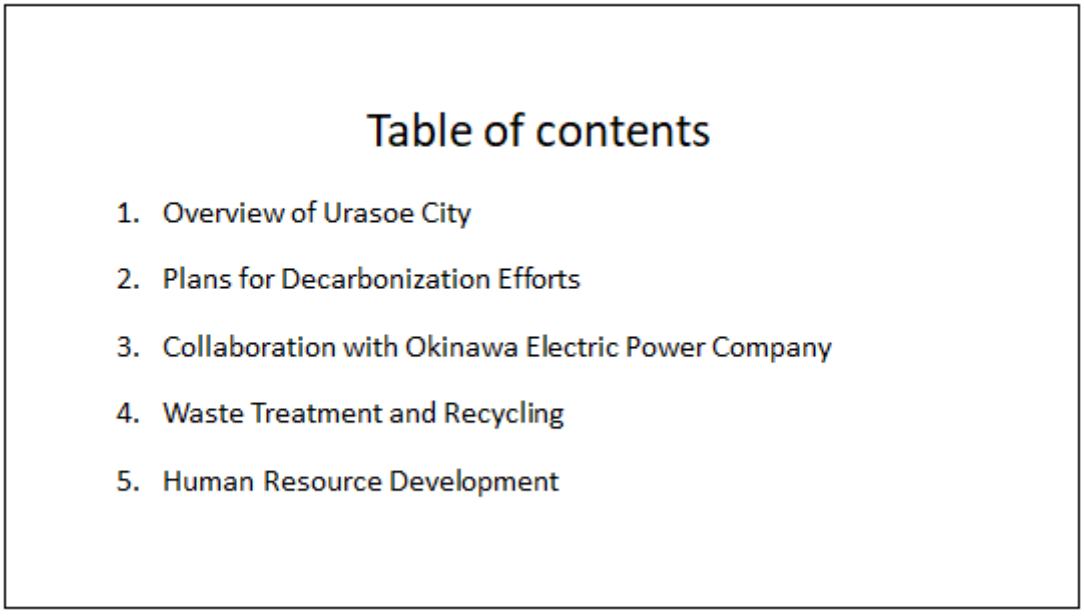
Environmental Measures in Airai State

Q & A

Reference 3 Material for a seminar for the workshop of the intercity cooperation project (Material of Urasoe City)



1



2

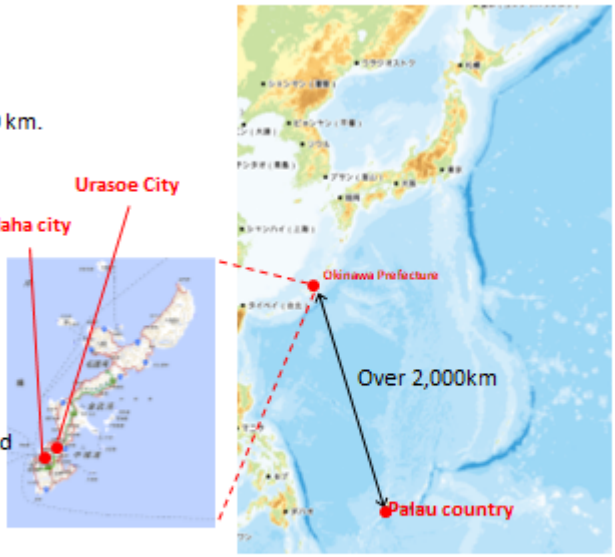
1. Overview of Urasoe City

Okinawa Prefecture

- A prefecture consisting of more than 150 islands within a radius of more than 500 km.
- 41 municipalities
- Population : 1.47 million people
- Distance from Palau: 2,000km

Urasoe City

- One of 11 cities in Okinawa Prefecture
- Population: 115,000 people
- Area :19.44㎢
- Most of the city area is residential land, and most of the west coast is the U.S. military Makiminato Harbor supply area



3

2. Plans for Decarbonization Efforts

- Japan's global warming prevention and decarbonization efforts are in line with multiple plans.
- Urasoe City has also formulated the "Urasoe City Environmental Basic Plan" and the "Urasoe City Comprehensive Plan."

Urasoe City Environmental Basic Plan
To promote : a desirable environmental image and clarify specific measures and action guidelines for citizens, citizen groups, businesses, visitors, and the city (administration) to work together.

Urasoe City Comprehensive Plan
- Environmental improvements such as disaster prevention, fire and emergency systems, crime prevention and traffic safety
- Related to landscape and greenery (tree planting and parks)
- Related to environmental conservation and a recycling-oriented society

Urasoe City Environmental Basic Plan


Urasoe City Comprehensive Plan

4

2. Plans for Decarbonization Efforts

Urasoe City Environmental Basic Plan

Urasoe City Comprehensive Plan

Urasoe City Global Warming Countermeasures Implementation Plan

Law Concerning the Promotion of Measures to Cope with Global Warming (Responsibilities of local governments)

- **Administrative Business Edition (started in 2009, 2018 edition)**
  Target: City Hall
  -To promote the reduction of greenhouse gas emissions by introducing high-efficiency equipment into city facilities and promote energy-saving actions.

- **Area policy edition (2017)**
  Target: Entire Urasoe city area (residents, businesses, etc.)
  - Implement measures to understand and disclose progress regarding greenhouse gas emissions.

5

3. Collaboration with Okinawa Electric Power Company

In 2021, Urasoe City and Okinawa Electric Power Company has signed the "Comprehensive Partnership Agreement" , which aims to solve regional issues and create a sustainable town.

<u>Cooperation matters</u>

1. Stable and appropriate supply of energy
2. Introduction and conversion of energy with consideration to reduce environmental impact
3. Creating a city resilient to disasters
4. Education of the next generation

◆Example of initiatives based on the agreement (PV-TPO)
Okinawa Electric Power introduced "free installation service of third-party owned solar panels and storage batteries(PV-TPO) " to municipal junior high schools .

4. Waste Treatment and Recycling

Urasoe City Clean Center

- In Japan, many local governments : separate garbage, separate recyclable items as much as possible, and burn the minimum amount of garbage.

- As an island nation : The difficulty in securing final disposal sites due to limited land availability and concerns about pollution at landfill sites.
  Adopted a policy to reduce the amount of waste to be sent to the landfills as much as possible by burning it.

7

4. Waste Treatment and Recycling

Collected by packer vehicles.

↓

●Burnable garbage
Stir once in the combustible pit.
Incinerated at a high temperature of 800℃ in an incinerator

●Non-burnable garbage/oversized garbage
Collect and recycle metals by hand or using a crusher.

●Containers, etc.
Separated and recycled at Recycle Plaza

Scale

Crane dumping garbage into the incinerator

Combustible pit
(Crane stirs and equalizes the garbage)

8

5. Human Resource Development

- **Environmental learning course**

We have been holding courses for elementary school students for over 20 years in order to develop the next generation of human resources involved in environmental conservation.

Facility tour
(Urasoe City Clean Center Recycle Plaza)

Nature observation in city parks

Summary of results after natural observation

- **Environmental education planner training course**

Established a course to train instructors and planners : To practice environmental education themselves in each region and organization.

9

10

Reference 4 Material for a seminar for the workshop of the intercity cooperation project (Material of SeED Okinawa)

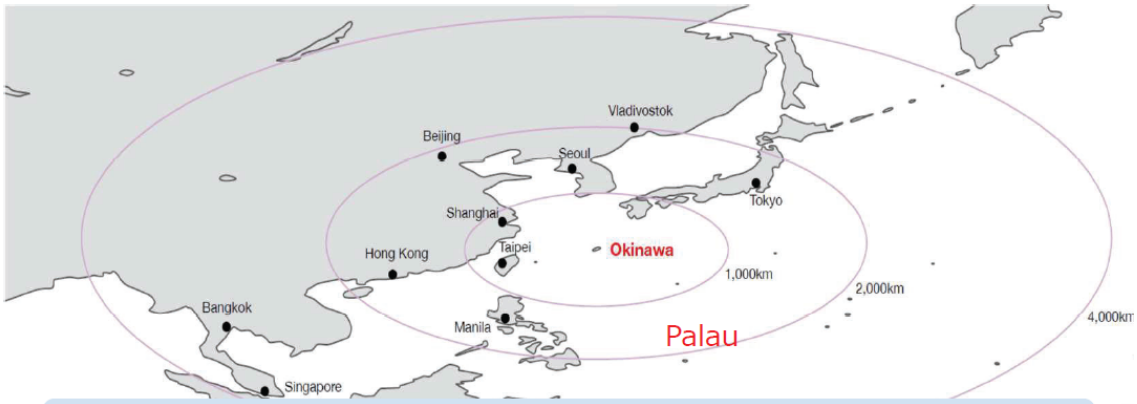
The Okinawa Electric Power Company, Incorporated

TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

SeED Okinawa

About Okinawa Electric Power Company (OEPC)

1



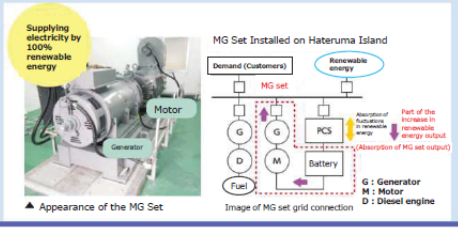
- Supplies electricity to 38 inhabited islands of Okinawa Prefecture situated at the southern tip of Japan, over a distance of 1,000 km from east to west and 400 km from north to south
- Engaged in research, development and operation of hybrid power generation using renewable energy and diesel power for over 30 years given a topography that makes hydropower development difficult
- First electric power company to declare "Zero Emission by 2050" in line with the Government of Japan policy (2020)

Renewable Energy Development and Operation

2

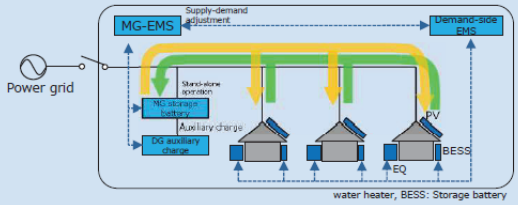
■ **Deployment of Tiltable Wind Turbines: First in Japan**
Tilting prevents damage during typhoons
OEPC Group installed 5 units in Tonga in 2019 through ODA
*First Japanese ODA for wind power deployment

■ **Establishment of Grid Stabilization Technology (MG Set)**
Supplies electricity derived from renewable energy to the grid via storage batteries
Achieved 100% renewable energy operation on Hateruma Island for approx. 10 days

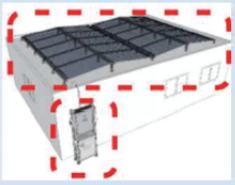


■ **Small Scale Microgrid System (ex. Kurima Island)**
Leading example of regional energy-sharing using renewable energy and storage batteries
Capable of supplying electricity to the area independently in the event of a grid failure

Microgrid



■ **Free Solar Panel and Storage Battery Installation Service**
Installation of solar panels and storage batteries with zero initial cost to the customer
Electricity from solar panels and storage batteries can be used even in times of disaster



Residences: 384 (2.1 MW)
Businesses: 22 (1.8 MW)

Total installed: 406
Total output: 3.9MW

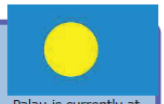
As of June 30, 2023

(deployed in the main island and major remote islands.)

Phased Renewable Energy Deployment in the Republic of Palau

3

STEP 1 Renewable Energy Source Deployment Phase	Selection of renewable energy sources suited for the site considering land use, natural environment, and other factors (Solar (Palau: 13 MW mega solar), Wind turbine, etc.)
STEP 2 Renewable Energy Utilization Improvement Phase (1)	Initiatives to increase the utilization rate of renewable energy sources deployed by power producers (MG sets, grid storage batteries, and technical studies using analytical tools)
STEP 3 Renewable Energy Utilization Improvement Phase (2)	Expanded use of distributed renewable energy on the demand side as an initiative to deploy and increase the use of renewable energy while reducing impacts on the grid (DR using controllable load, consumer-side storage batteries, etc.)
STEP 4 Full-Utilization Phase	Efficient grid operation integrating diesel power generation, renewable energy power sources, and demand-side facilities (Area Aggregation)


Palau is currently at this phase

Seek to achieve renewable energy deployment targets through phased implementation of measures tailored to the local conditions in the Republic of Palau, along with steady capacity building of engineers in each country for enhanced sustainability.

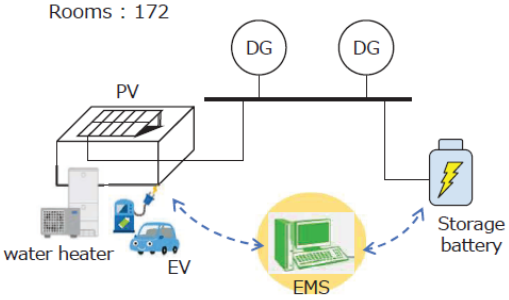
Palau-style Decarbonization Model (Palau Pacific Resort)

4

Establish a model case of carbon neutrality (STEPS 1-4) and spread it throughout the Republic of Palau.

Deploy throughout the Republic of Palau to promote decarbonization

Overview of Palau Pacific Resort
Establishment : December 1984
Rooms : 172



Initiatives at Palau Pacific Resort (PPR)

The following initiatives are being studied and implemented for PPR, which is an independent grid that supports its load by small-scale diesel generation.

- Deployment of renewable energy (solar) and grid stabilization using storage batteries
- Establishment of a hybrid power generation system consisting of diesel and renewable energy
- Exhaust heat recovery to use for air conditioning, and control by controllable load