Memorandum
between
Palau Public Utilities Corporation (PPUC)
and
The JICA Study Team
for
The Project for Study on Upgrading and Maintenance Improvement
of
National Power Grid in the Republic of Palau
(2nd Field Survey)

The JICA Study Team (hereinafter referred to as "the Team") consists of Yachiyo Engineering Co., Ltd. Tokyo, Japan (hereinafter referred to as "YEC") and Kansai Electric Power Co., INC. Osaka, Japan (hereinafter referred to as "KEPCO") visited the Republic of Palau (hereinafter referred to as "Palau") from 12th September, to 1st October, 2017 for **the Project for Study on Upgrading and Maintenance Improvement of National Power Grid in the Republic of Palau** (hereinafter referred to as "the Project") as 2nd field survey.

During its stay in Palau, the Team had a series of discussions and exchanged mutual opinions with Palau Public Utilities Corporation (hereinafter referred to as "PPUC") and other concerned authorities of the Government of Palau (hereinafter referred to as "the Palauan side") through the explanation of the Planned Activities during the 2nd field survey, conducting the field survey and the collection of necessary data and information for the successful implementation of the Project, and this survey will continue up to 25th October,2017.

As a result of discussions, both sides recognized the matters referred to in the document attached hereto.

Koror, Palau, 29th September, 2017

Mr. Mitsuhisa NISHIKAWA Team Leader JICA Project Team, Japan International Cooperation Agency (JICA)	Mr. Kione J. Isechal, P.E. Chief Executive Officer Palau Public Utilities Corporation (PPUC) The Republic of Palau

ATTACHMENT

1 Explanation of the planned activities during 2nd field survey.

The Team distributed the explanation sheets to the Palauan side, and explained their contents. Main contents of explanations are as follows:

(1) Power Demand forecast (Explain to and discuss with PPUC counterparts)
1) Main preconditions for model building
2) Results of PPUC Power Demand
3) Results of State Power Demand
4) Comparison of Power Demands
5) Schedule of Power Demand Evaluation

(2) Power Flow Analysis (Explain to and discuss with PPUC counterparts)
1) Power Flow Analysis under the present conditions (year 2016-2017)
2) Collection of data necessary for Power Flow Analysis (continued)
3) Building of main preconditions for Power Flow Analysis
4) Stability analysis under the present conditions (Preliminary)

(3) Power Transmission and Distribution (T/D) System
1) Conducting detailed site survey with PPUC counterparts and Grasping the present situations
2) Collecting Transmission and Distribution drawings & specifications
3) Confirmation of present operation & maintenance system of PPUC
4) Preparation of alternatives for Pre-F/S Projects (Preliminaries)
5) Explain to and discuss with PPUC counterparts regarding Pre-F/S Projects
6) Meeting with IS Systems Pty Limited (Austria Electric Engineering Company) for the causes of power outage of Nekken transmission lines, in case they come to Palau by PPUC request. If they did not come to Palau, the Team would contact them by e-mail as necessary.

(4) Substation system
1) Confirmation of present operation & maintenance system of PPUC(continued)
2) Conducting detailed site survey with PPUC counterparts and Grasping the present situations of substations (Continued)
3) Collection of specifications & drawings of substation's equipment and systems (continued).
4) Preparation of alternatives for Pre-F/S Projects (Preliminaries)
5) Explain to and discuss with PPUC counterparts regarding Pre-F/S Projects

(5) Economic and Financial Analysis
1) Collection of basic data with PPUC counterparts for Economic & financial analysis
2) Building of main preconditions for Economic analysis, and explain to PPUC counterparts about economic valuation criteria and models.

(6) Environment and Social Consideration
1) Collection of data and information necessary for Environment and Social consideration and SEA (Strategic Environment Assessment) (continued)
2) Confirmation of Pre-F/S Project sites for T/D and Substation
3) Conducting 1st stakeholder meeting, as EQPB (Environment Quality Protection Board) accepted during 1st field survey.

2 Technology transfer commenced.

The Team has conducted the lecture for "the Evaluation of Renewable Energy Integration capacity" 25th to 26th September, 2017 and "Smart Meter System" 27th September, 2017 at PPUC meeting room at Malakal Power Plant.

(1) Lecture of "the Evaluation of Renewable Energy Integration capacity"
Two(2) days Lecture were conducted with view point that the System stabilization measures when introducing renewable energy in large quantities mainly comprise the following three items:
1) Evaluation methodology of Renewable Energy Integration Capacity.
2) Reduction of the renewable energy fluctuation rate with batteries
3) Curtailment of renewable energy output
Since the Study targets the transmission and distribution system, feasibility will be assessed concerning 2) and 3). Concerning 3), it is common to control renewable energy output through control of the power conditioners (PCS) composing PV systems.

(2) Lecture of "Smart Meter System"
This Lecture was conducted with view point that Introduction of Current situation of Smart Meter System in KANSAI. After this lecture, the team and students had discussion about installation possibility of Smart Meter in Palau.

(3) Occasional students of the Lecture were persons from Energy Administration and the young technicians from PPUC. Total numbers of attendance were around 10 persons.

3 Target of introduction of renewable energy capacity against total generating capacity by year 2025

(1) The Team confirmed that Palau's NDC put the nation on a trajectory to generating 45% of its energy from renewable sources by 2025.

(2) PPUC strongly hope that one (1) 5MW diesel generator out of three (3) 5MW diesel generators which are operating at present, replace to renewable energy (RE) source.

(3) The Team will make the following study and show the results in the Master Plan report.
1) Influences and issues in the case that the 45% power demand covered by renewable resources, including compositions of auxiliaries, rough cost estimation and O & M cost.
2) A proposal that most reasonable compositions (ratio of renewable energy against total generation capacity), with viewpoints of equipment, O & M cost, cost estimation, etc.

(4) The Team submitted and explained to PPUC an attached report (Appendix-1) of "Influence and Issues Brought by High Penetration of PV or Wind" and PPUC side basically understood it.

(5) Energy Administration shows the Team the expected locations (candidate sites) for the high penetration of PV system as preliminary (not fix yet) as Appendix-2.

4 Meeting with IS Systems Pty Limited (Austria Electric Engineering Company)

For the causes of power outage of Nekken transmission lines, the Team requested to arrange a meeting with IS systems. However, the contract between IS systems and PPUC was completed, and IS system has no idea to visit Palau in near future. Therefore, the Team will contact IS system by e-mail if the Team find questions in their final report.

candidate projects were discussed.

(1) Expanding 34.5kV transmission lines from Kokusai S/S～Melekeok～Airai or New Koror S/S～Malakal S/S. (Airai or New Koror S/S should be constructed by year 2023)
This Project plans to improve power supply reliability by double circuits between Malakal～Melekeok～Aimeliik～Malakal.

(2) Re-location of Nekken 34.5kV transmission and 13.8kV distribution lines which are presently installed far from Compact road and difficult to accesses for maintenance, to alongside of Compact road (target year; as early as possible).

(3) Rehabilitation of Malakal S/S and Aimeliik S/S by year 2030.

(4) Rehabilitation of small substations, specially switching system, metering system, communication system as necessary.(At least, the key lock system shall immediately be installed)

6 Next field survey

The Team will visit Palau from 18th November to 17th December, 2017 as third field survey. (See Appendix – 3)

Appendix List

Appendix 1: Influence and Issues Brought by High Penetration of PV or Wind
Appendix 2: Expected PV installation Location
Appendix 3: Dispatching schedule of the team members (preliminary)
Appendix4: Preliminary Location Map of Transmission lines, Distribution lines and Substations (After year 2030)

Japan International Cooperation Agency

YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

Kansai Electric Power

Influence and Issues Brought by High Penetration of PV or Wind

September, 2017

Influence and Issues Brought by High Penetration of PV and Wind

	Influence and Issues	Countermeasures
1	Frequency Fluctuation (Short-term)	• LFC/AFC function improvement • Batteries
2	Surplus Electricity (Long-term)	• Demand creation at peak time • Generator Improvement • RE output curtailment • RE output forecast • Batteries
3	Voltage Rise in Distribution System	• Demand creation in the distribution line. • Voltage control equipment
4	Lack of Transmission/Distribution Facilities	• New transmission/distribution facilities

Underlined Items need lots of cost

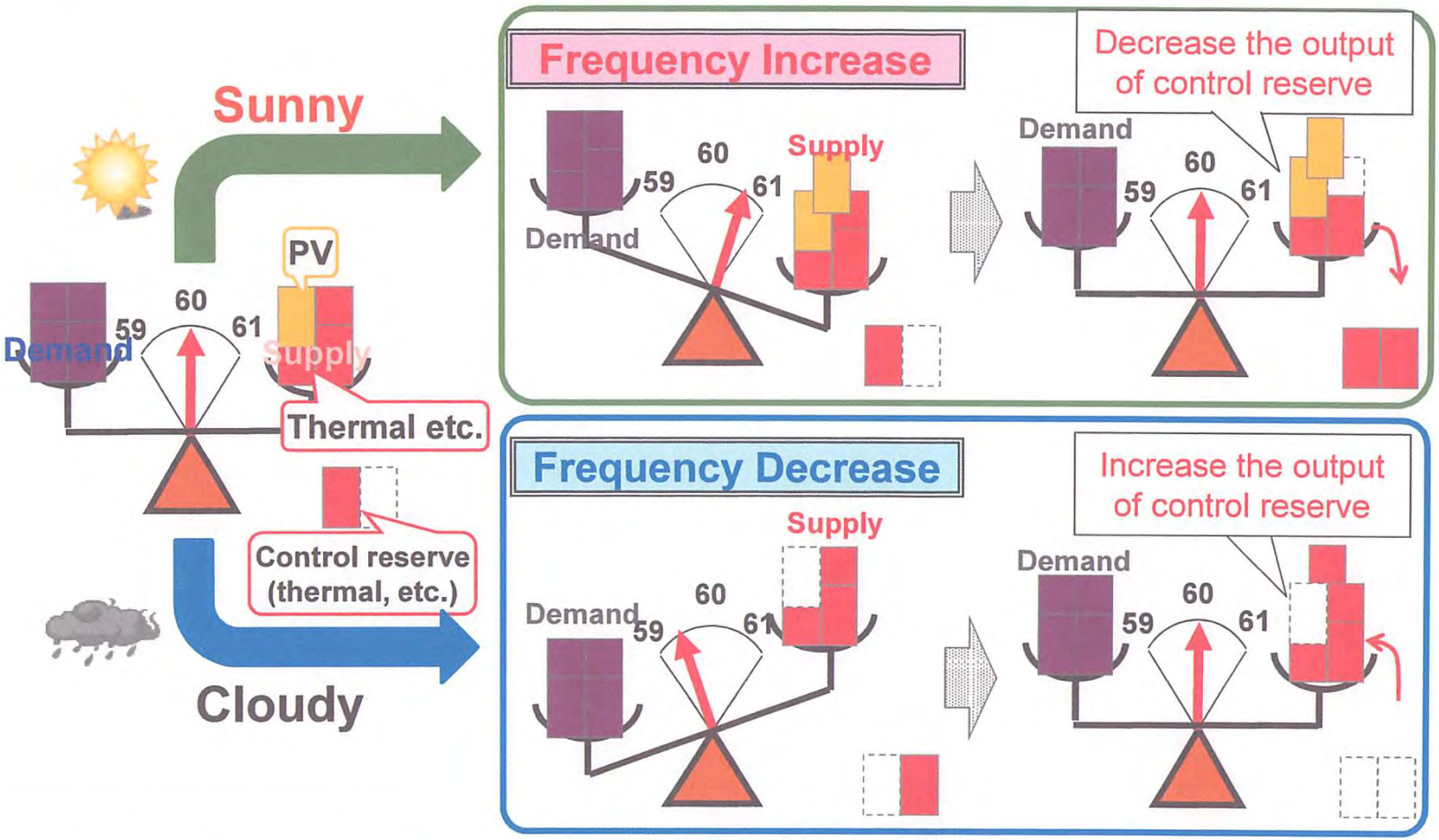
Influence and Issues Brought by High Penetration of PV

	Influence and Issues	Measures
1	Frequency Fluctuation (Short-term)	• LFC/AFC function improvement • Batteries
2	Surplus Electricity (Long-term)	• Demand creation at peak time • Gene • RE ou • RE ou • Batte
3	Voltage Rise in Distribution System	• Demand creation i… the distribution line.
4	Lack of Transmission/Distribution Facilities	

These issues may cause fluctuation of …
- Frequency
- Voltage

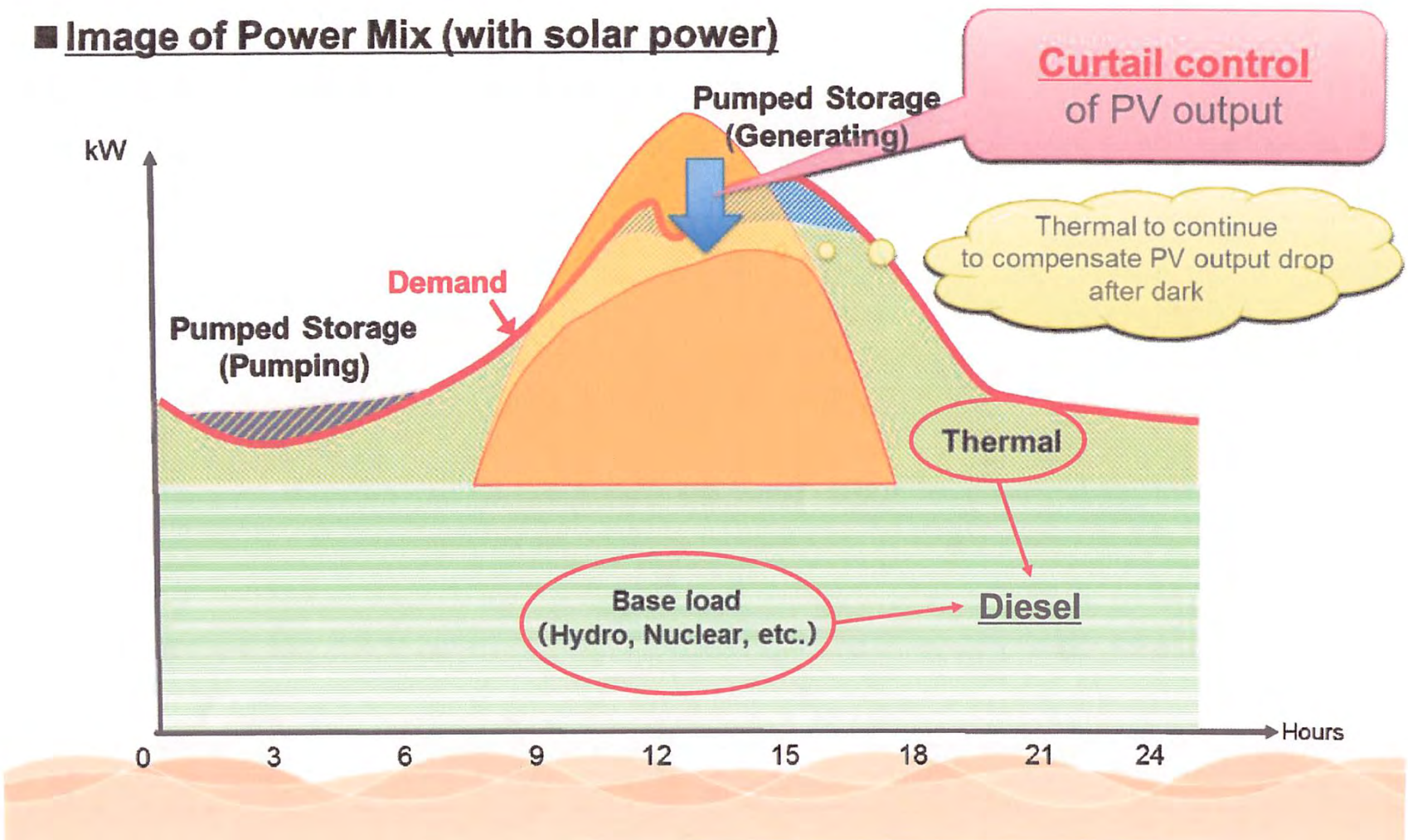
- ✓ Blackout
- ✓ Appliance breakdown

One of issues of Short term Fluctuation



As output fluctuation of PV power generation, in addition to demand change, is covered by increasing or decreasing the output of control reserve, required capacity for frequency control (thermal or pumped storage) increases.

One of issues of long term Fluctuation

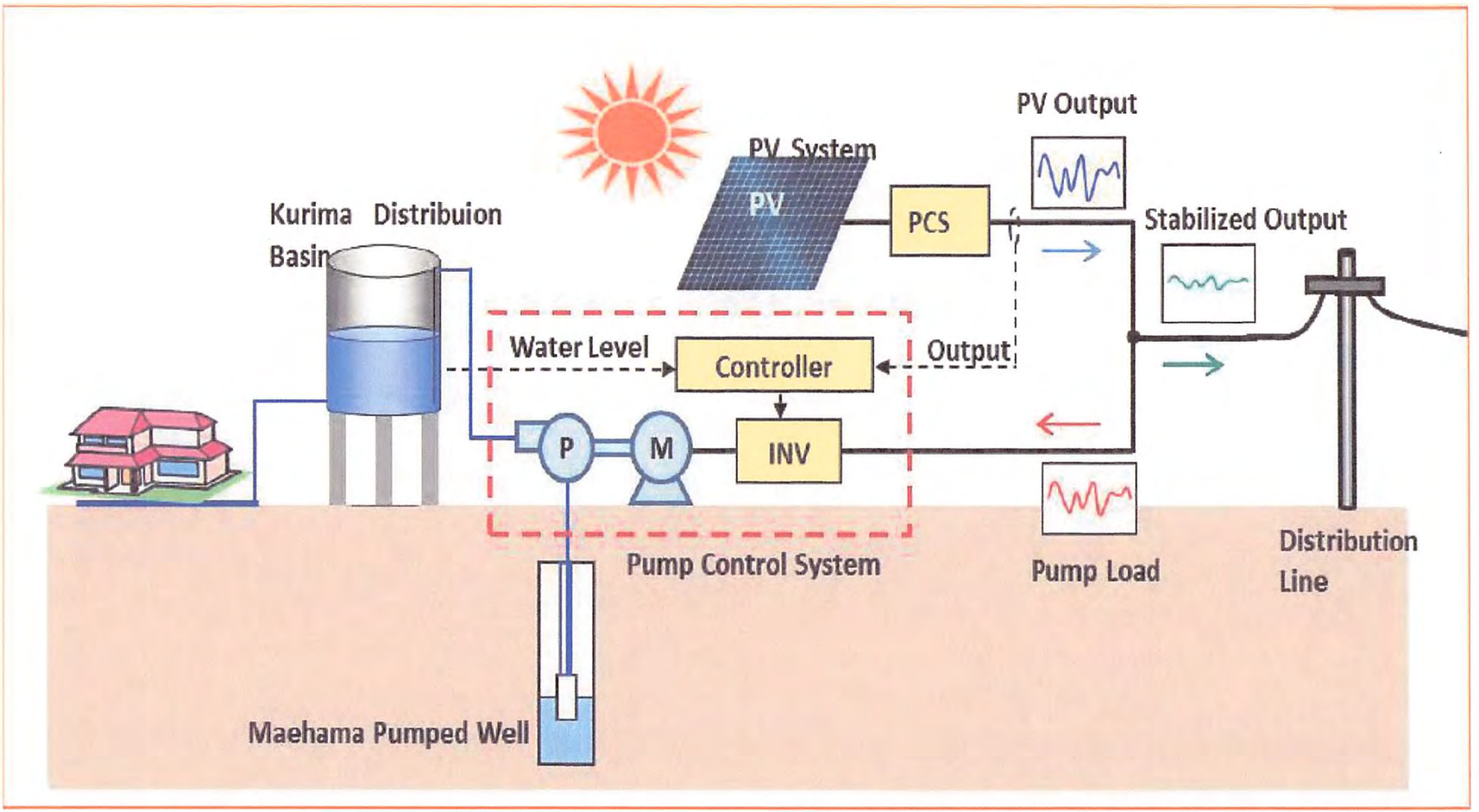


Influence and Issues Brought by High Penetration of PV

	Technical Challenges	Measures
1	Frequency Fluctuation (Short-term)	• LFC/AFC funct • Batteries
2	Surplus Electricity (Long-term)	• Demand creation at peak time • Generator Improvement • RE output curtailment • RE output forecast • Batteries
3	Voltage Rise in Distribution System	• Demand creation in the distribution line. • Voltage control equipment
4	Lack of Transmission/Distribution Facilities	• New transmission/distribution facilities

Pumping for Water Tank?
Ice making machine?

Expanding PV integration by utilizing the water supply facilities



Ref: JICA report by Okinawa Enetec

Long term fluctuation

POWERHOUSE

New powerhouse built by STELCO for its existing diesel generators and the new PV system equipment.

HYBRID SYSTEM

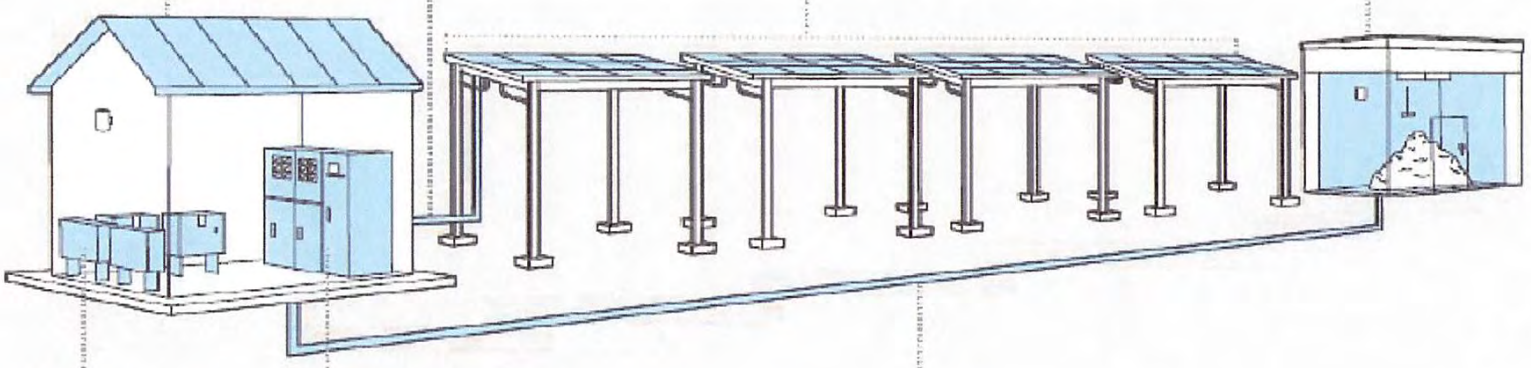
40 kW PV system is connected to Dhiffushi's power grid and works in conjunction with the existing diesel generators.

MULTI-FUNCTIONAL FRAME STRUCTURE

3 metre high frame structure holds four separate 10 kW PV panel arrays inclined at 5 degrees, limiting the extent of damage in case of a tsunami and providing good shade for residents.

ICE HOUSE

Industrial ice machine installed in new ice house on the pier effectively functions as the supply-demand controller for the grid-connected PV system.



POWER CONDITIONERS

Four power conditioners and a system controller are installed inside the powerhouse.

FLEXIBLE CONTROL SYSTEM

The control system is operated in both automatic and manual mode. This flexibility helps maximize PV power generation and improve its stability, making maintenance and troubleshooting easier.

CABLING

The PV system and ice making machine are connected to the powerhouse through underground cables.

Appendix-2

Expected PV System Installation Location

As of 24th September

No.	Location	Capacity	Owner/Present situation
1	**Aimeliik (Next to power plant)**	**5 MW**	**PPUC** This is already planned by PPUC but Energy administration do not have the details. Please ask Ken Sugiyama for confirmation
2	**Ngatpang (Kokusai)**	**2-3 MW**	Owners of both sites are not confirmed yet for both #2 Ngatpang and #3 Ngardmau. The capacity are also not confirmed yet,
3	**Ngardmau (Terraces of Hill)**	**2-3 MW**	
4	**Koror & Airai (Roof top)**	**2-5 kw / roof**	**House owner** Energy Administration will send the detail number of systems and capacity to PPUC
5	**Commercial roof top by Joint Crediting Mechanism**	**Total 5 MW**	Surangle, WCTC PIDC & PMA
6.	**Airai airport (side by road)**	**3 MW**	**PPUC**
7.	**Ocean Thermal Energy Conversion in 15 – 20 years later**	**3 MW**	**PPUC**
Total		**18 ～23 MW**	

Notes

(1) Above data received from Energy Administration, but not authorized yet (as of the end of September, 2017)

(2) Capacity of No. 6 & 7 are only expectation, but we, Energy Administration will make more details after our plans become more detailed.

The Project for Upgrading and Maintenance of the National Electrical Power Grid in the Republic of Palau

Tentative Team Members Dispatching Schedule to Palau

Assignment	Name	Belong to	Fisical Year 2017											Fisical Year 2018								
			6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
Team Leader/Power System Planning	Mitsuhisa NISHIKAWA	YEC		(16) 8 23		(16) 16 1		(16) 18 3			(16)									(12)		
Depty Team Leader / Renewable Energy / System Stabilization Method	Masaki KOBAYASHI	KEPCO		(21) 9 29			(16) 12 27				(21)			(14)			(14)			(14)		
Power Demand Forecast	Tomoyuki INOUE	YEC		(16) 8 23		(16) 16 1					(16)											
Power System Analysis (1)	Nobuyuki KINOSHITA	YEC		(23) 8 30		(23) 16 8		(23) 18 10			(16)											
Power System Analysis (2)	Kazuaki KONDO	YEC		(23) 18 9		(23) 16 8		(23) 18 10			(23)											
Power Transmission & Distribution System	Tatsuhiro TAMURA	KEPCO					(18) 11 28	(21) 19 9			(21)			(14)	(16)		(14)			(14)		
Operation & Maintenance of Power Transmission & distribution System	Takashi GENJI	KEPCO					(18) 11 28	(23) 18 10			(21)			(14)			(14)			(14)		
Substation System	Makoto ABE	YEC		(16) 8 23		(30) 16 15		(23) 25 17			(23)				(16)			(12)		(12)		
Operation & Maintenance of Substation System	Takaya FUYUKI	KEPCO					(18) 11 28	(21) 28 16			(21)				(14)			(12)		(14)		
Economic & Financial Analysis	Yoshiyuki CYOSO	YEC				(19) 16 4		(19) 29 17			(23)											
Evironment & Social Consideration	Masaya SUGITA	YEC		(16) 18 2			(16) 3 18	(16) 25 10			(16)											
Project Coordinator/Assistant of Power System Planning	Naoya KISHI	YEC		(23) 8 30		(30) 16 15		(30) 18 17			(30)			(16)				(12)		(12)		
YEC: Yachiyo Engineering Co., LTD. KEPCO: The Kansai Electrlic Power Co., Inc.				▲ Inception Report				▲ Progress Report (1)			▲ Progress Report (2)									▲ Draft Final Report	▲ Final Report	

(As of 12 June 2017)

Appendix-4: Preliminary Location Map of Transmission Lines, Distribution Lines and Substations (After Year 2030)

Minutes of Discussion
for
The Project for Study on Upgrading and Maintenance Improvement
of
National Power Grid in the Republic of Palau
between
Palau Public Utilities Corporation (PPUC)
and
Japan International Cooperation Agency (JICA)

In the middle of the implementation of the Project for Study on Upgrading and Maintenance Improvement of National Power Grid in the Republic of Palau (hereinafter referred to as "the Project"), Japan International Cooperation Agency (hereinafter referred to as "JICA") with JICA Expert team (hereinafter referred to as "the JICA side") exchanged their opinions and had a series of discussions with Palau Public Utilities Corporation (hereinafter referred to as "PPUC") for pursuing consensus on direction of the Project especially for updating renewable energy roadmap as well as transmission and distribution system expansion plan.

As a result of the discussions, the JICA side and PPUC agreed to the matters referred to in the document attached hereto as a supplement to the original Record of Discussions (hereinafter referred to as "R/D") signed on 21 March, 2017.

Koror, Palau, 1st December, 2017

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Team 1
Energy and Mining Group
Industrial Development and Public Policy Dept.
Japan International Cooperation Agency (JICA)

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Mr. Mitsuhisa NISHIKAWA
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Mr. Sam Yoyo Masang
Chairman of Board of Directors
Palau Public Utilities Corporation (PPUC)
The Republic of Palau

Mr. Nobuaki MIYATA
Resident Representative
JICA Palau Office
Japan International Cooperation Agency (JICA)

Mr. Charles I. Obichang
Minister of Public Infrastructure, Industries & Commerce (MPIIC)
The Republic of Palau

ATTACHMENT

I. Scenario Setting of Renewable Energy Road Map and Master Plan

Under the Palau's Nationally Determined Contribution (hereinafter referred to as "NDC") which put the nation on a trajectory to generating 45% of its energy from renewable sources by 2025, both sides confirmed that base scenario of master plan for upgrading and enhancement of power transmission and distribution facilities in consideration of the introduction of further renewable energy (hereinafter referred to as "RE") will be formulated in line with it. In other word, 45% RE scenario (hereinafter referred to as "45% Scenario") will be prepared in the master plan (hereinafter referred to as "MP").

On the other hand, JICA Expert team explained expected challenges to achieve 45% Scenario including high capital and O&M costs, land issues as well as technical side such as RE output forecasting, control and battery management. Then, in order to compare several scenarios from financial and technical view point, the JICA side proposed to prepare alternative scenario with lower RE generation rate through analyzing levelized cost of electricity (hereinafter referred to as "LCOE"). In response, PPUC explained that 45% Scenario is the national target so they requested the JICA side to analyze detailed phasing and sequence of RE road map by 2025, instead of preparation of alternative plan. The JICA side agreed to analyze it, even though they showed concern of realization of 45% Scenario up to 2025.

Then, preliminary analysis by JICA Expert team revealed that introduction of RE which can generate 45% of power would require large amount of energy storage system both for short and long term. To avoid potentially excessive cost that PPUC might incur through the introduction of energy storage system, optimizing operation of the existing power system with battery storage system be examined and studied closely to find out the most reasonable scenario economically and environmentally.

In this way, both sides confirmed that necessary steps for the analysis of updating RE road map are as follows.

Step 1: Improvement of operational practice of Diesel Engine Generators

In order to integrate larger capacity of RE into PPUC grid, the existing operation practice of Diesel Engine Generators (hereinafter referred to as "DEG") should be examined and improved. For example, following items need to be considered:

(1) Low Load Operation of DEG
The allowable minimum power output from each unit is generally different depending on manufacturers and type of engines. Some manufacturers will allow 30% minimum output in one hour, if the output return close to 100% rated capacity after that period. Therefore, specification and actual operational conditions for each unit should be taken into consideration.

(2) Number of DEG in operation
Allowable RE connection capacity from the viewpoint of the long-term restriction is decided by DEG output under the low load operation. However, it will be determined not only by DEG output, but also the number of units of the DEGs in operation. Therefore, in order to make the wide range of analysis, JICA Expert team will add a study case that one (1) unit of DEG shall be deleted from normal operation conditions in day time (when PV system is operational).

(3) Operation with high-speed engines
As the share of variable RE are increasing, introduction of high-speed DEG should be examined, as they are usually more flexible in terms of start-up time and changing rate of power output (kW/second).

(4) Improvement of governor control
Improvement of governor response can be expected by replacing the existing mechanical governor into electronics governor. Also, the possibility of introducing isochronous control should be studied with cost-benefit analysis.

(5) Sequence of RE development
Analyze and discuss in detail the practical phasing sequence up to the year 2025 that will take advantage of the swiftly decreasing costs of PV and battery storage system.

Step 2: Output restriction of RE generation systems

In order to reduce the output/capacity of energy storage, the optimum capacity and duration of restriction mechanism should be proposed. The energy amount (kWh) that need to be restricted can be calculated by reviewing the record of existing PV system and demand forecast.

Step 3: Finalize the output and capacity of energy storage

As a result of the above examination, the required output/capacity of energy storage can be calculated for short- and long-term energy storage, respectively for efficient and safe utilization of existing base load DEG.

The result of above careful analysis for 45% Scenario will be reflected to power system analysis and transmission/distribution system planning.

II. Important Factors of 45% Scenario

Based on the Annex-1, both sides discussed on the important factors for the study of 45% Scenario:

1. Minimum Power Output of DEG

Based on the Annex-1, JICA Expert Team explained possible impact by setting of DEG minimum output and number of DEG for further penetration of RE. In order to realize 45% Scenario, PPUC is expected to set minimum output of DEG as 40% or 50%. However, PPUC explained that 40% operation in a longer period cause to harmful influences on engines such as black smoke generation by abnormal combustion, low fuel consumption rate, etc. Finally, both sides agreed to use 50% of minimum output of DEG on the condition that one (1) DEG will be stopped to accept further RE as well as to keep output level of DEG more than 50%.

2. RE Power Resource

Besides, through the explanation of Annex-1, in order to consider optimal combination of photovoltaic (hereinafter referred to as "PV") and Wind Turbine (hereinafter referred to as "WT"), the JICA Expert Team pointed out negative aspect of WT especially for low capacity factor in other island countries and difficulty of timely supply of spare parts. PPUC agreed to conduct sensibility analysis with lower capacity factor of WT.

3. Power System Analysis and Planning.

In consideration of negative aspect of WT mentioned above, both sides confirmed that

45% Scenario with 100% of PV will be utilized for the core case of transmission/distribution system planning. Then, 45% Scenario with PV and WT could be the reference case of MP.

4. Potential Sites of Renewable Energy

Current potential sites for RE is as shown in Annex-II. However, JICA side explained that additional potential sites for PV with around 20MW including Solar Home System (hereinafter referred to as "SHS") are necessary to achieve 45% Scenario. Then, both sides confirmed that around 10% of additional PV potential site will be calculated as SHS.
JICA side requested PPUC to propose rough location of potential sites for additional PV before 8th December, 2017.

5. Implementation Structure of 45% Scenario

In order for Palau side to realize 45% Scenario by the target year, PPUC request the JICA side to analyze possible measures and necessary implementation structures how to finance or invest RE related projects including inviting Independent Power Producer (hereinafter referred to as "IPP"). The JICA side agreed to consider it.

III. Project Implementation Schedule

1. Approval Process of MP

PPUC explained that MP prepared by the Project will be approved by the board members of PPUC as well as Minister of Public Infrastructure, Industries & Commerce.

2. After 3rd Field Survey
   (1) JICA Expert team explained the tentative project implementation schedule (refer to Annex-3). PPUC agreed with the schedule as a baseline schedule to formulate MP including pre-feasibility study for high-prioritized-projects.
   (2) As a part of the Strategic Environmental Assessment (SEA), comments/opinions from stakeholders on the progress report-2 must be collected prior to the 4th field survey, scheduled in March-April 2018. Therefore, PPUC and the JICA Expert team will collect the comments/opinions from the stakeholders by the end of February 2018 by means not limited to physical conference under the attendance of all stakeholders.

Annex List

Annex-1: Explanation sheets for "Target of introduction of renewable energy capacity against total generating capacity by year 2025"
Annex-2: Expected PV installation Location
Annex-3: Tentative Project Implementation Schedule

Japan International Cooperation Agency

YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

Kansai Electric Power

Current Report of Renewable Energy Roadmap Study - Draft for Discussion -

1 December, 2017

Agenda

1. Study Process in this Project
2. RE Roadmap Study Steps
3. Further Study Policy

Study Process in this project

RE Roadmap Study Steps

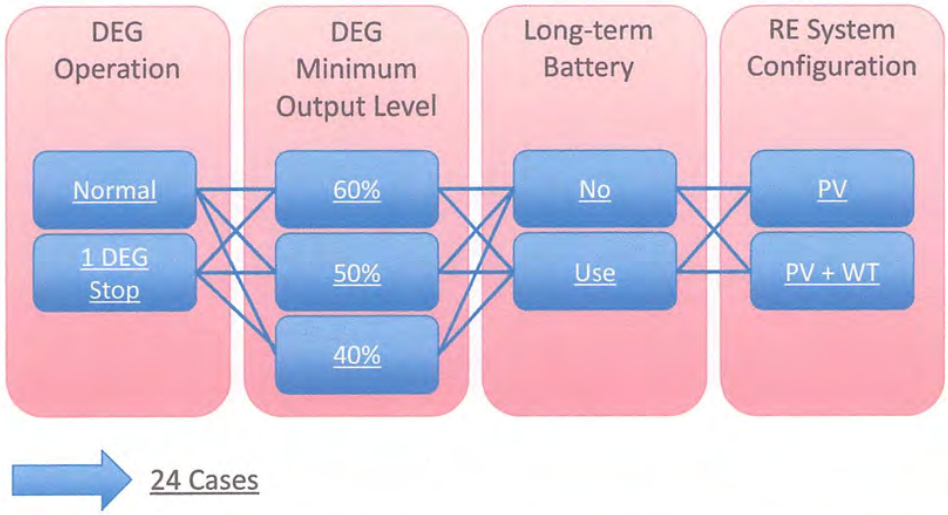
Step1: DEG improvement
- ✓ Operation of DEG
  - Minimum output level
  - No. of unit connected to the grid
  - High speed DEG

Step2: RE output curtailment
- ✓ RE system configuration
  - PV only or PV + WT
- ✓ Location of PV and WT

Step3: Long-term battery Introduction

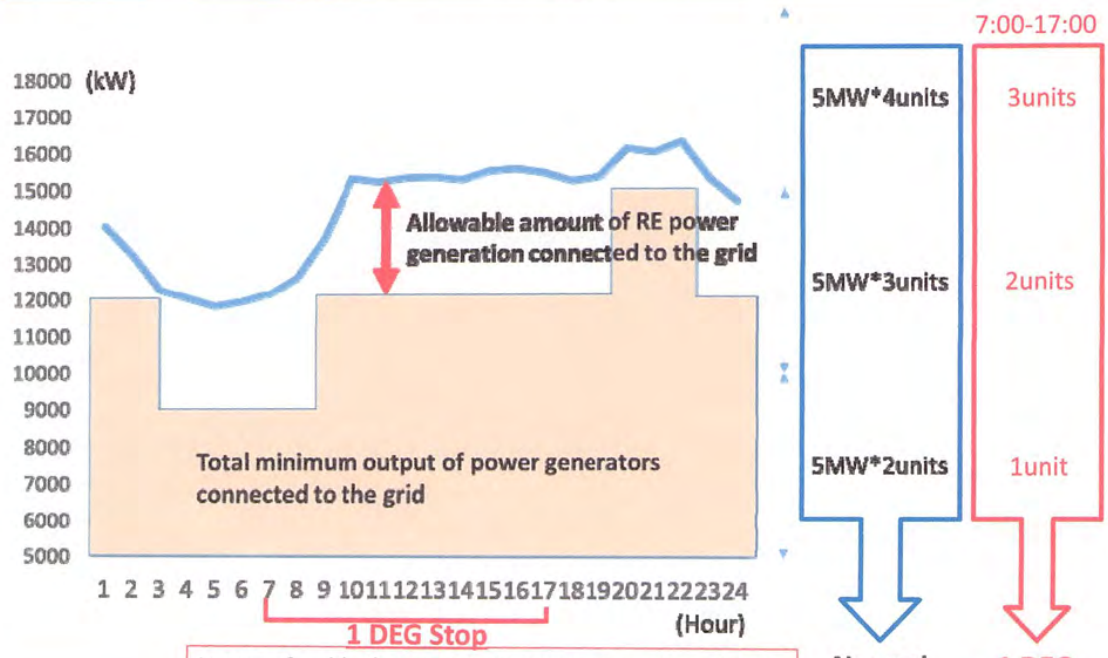
Study Condition: Summary

Demand Data: 2025 Weekday and Weekend



24 Cases

Study Condition: <Step1> DEG Operation



In case of suddenly stopping RE power generation, electric power will be supplied from batteries for a short time until additional DEG starts electric power generation.

Study Condition: <Step1> DEG Load Operation

6

Generator use	Make	Model	Name	Year installed	Capacity (kW)
Active generation	Nigata	16V28HLX	Unit 14	2011	5,000
	Nigata	16V28HLX	Unit 15	2011	5,000
	Mitsubishi	18KU30A	Unit 6	2013	5,000
	Mitsubishi	18KU30A	Unit 7	2013	5,000
Total active generation capacity					20,000

Minimum Output : 40%, 50% and 60%

Additional maintenance will be required

Generator use	Make	Model	Name	Year installed	Capacity (kW)
Back up	Caterpillar	3516B	Unit 1	2007	2,000
	Caterpillar	3516B	Unit 2	2007	2,000
	Wartsila	SACM 12V200	Wartsila 1	1996	1,200
	Mitsubishi	S6R - PTA	Unit 1	2013	500
	Mitsubishi	S6R - PTA	Unit 2	2013	500
	Mitsubishi	S6R - PTA	Unit 3	2013	500
	Mitsubishi	S6R - PTA	Unit 4	2013	500
Total backup capacity					7,200

Study Condition: <Step2> RE System Configuration

7

RE power source

PV or WT Location is necessary for Power system analysis.

Study Condition: <Step2> RE System Configuration

No	Location	Capacity	Owner
1	Aimeliik (Next to power plant) This is already planned with PPUC.	5 MW	PPUC
2	Ngatpang (Kokusai)	2-3 MW the capacity is not confirmed for #2 Ngatpang and #3 Ngardmau	PPUC
3	Ngardmau (Terraces of Hill)	2-3 MW	PPUC
4	Commercial roof top by Joint Crediting Mechanism	Total 5 MW	Surangle, WCTC PIDC & PMA
5	Airai airport side by road	3 MW	PPUC
	Koror & Airai (Roof top)	2-5 kw / roof	House owner
Total		19 MW	

More PV installation plans are needed to achieve 45% goal

Study Condition: <Step2> RE System Configuration

- Basically maintenance-free

There are big challenges for deployment of WTs

- Regular maintenance is required
- 30% of output curtailment
  → 1.5 times capacity is required
- Low capacity factor in other Island country
- Bad supply of spare parts
- Output forecast is difficult

Study Condition: <Step2> RE System Configuration

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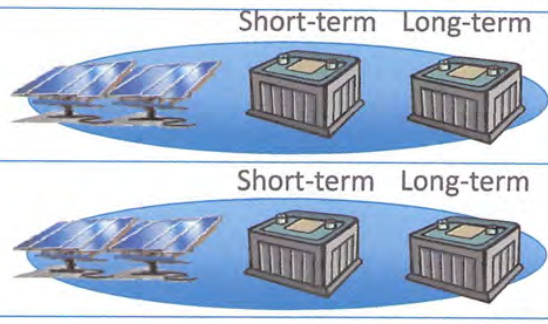
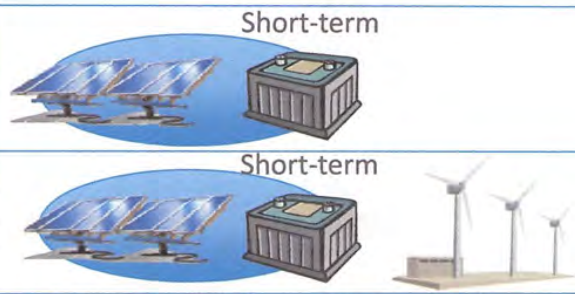
Long-term Battery Use



45% Scenario

No Long-term Battery

Surplus Power will be curtailed



Another Scenario

Draft of Study :<Step3> Long-Term Battery Use

11

<Common condition for all cases> A little of RE output curtailment is accepted.
No. of 275kW WT unit is maximum capacity for short-term fluctuation.
PV is installed at maximum capacity in daytime.

System configuration :

Annual Gross Generation at 2025 115,110 MWh
RE deployment goals at 2025 51,800 MWh

	DEG		Maximum Capacity of RE Connected to Electricity Grid (MWh)		RE share (%)	PV (MW)	WT		Batt					
	Minimum output ratio	Operation	Gross	Net			275kW WT No. of unit	Capacity (MW)	Long-Term			Short-Term		
									MW	MWh	Inv.	MW	MWh	Inv.
1-1.PV	60%	Normal	33,241	31,991	28	24	0	0	24	55	11	19.9	8.0	19.9
1-1.PV+WT				31,725	28	13	27	7	13	17	9	11.2	4.5	11.2
1-2.PV		1DEG Stop	44,041	42,607	37	32	0	0	32	57	13	29.1	11.6	29.1
1-2.PV+WT				43,522	38	25	19	5	25	50	11	23.7	9.5	23.7
2-1.PV	50%	Normal	46,931	46,687	41	35	0	0	35	79	16	30.9	12.4	30.9
2-1.PV+WT				46,418	40	24	27	7	24	66	13	22.2	8.9	22.2
2-2.PV		1DEG Stop	55,931	52,107	45	39	0	0	39	72	16	36.1	14.4	36.1
2-2.PV+WT				51,539	41	31	19	5	31	62	14	29.7	11.9	29.7
3-1.PV	40%	Normal	60,621	52,080	45	39	0	0	39	79	17	34.9	14.0	34.9
3-1.PV+WT				51,705	45	27	27	7	27	66	14	25.2	10.1	25.2
3-2.PV		1DEG Stop	67,821	52,166	45	39	0	0	39	64	15	36.1	14.4	36.1
3-2.PV+WT				51,718	45	31	19	5	31	54	13	29.7	11.9	29.7

Draft of Study :<Step3> Long-Term Battery Use

Capital Cost @ 2025

Unit: USD

	PV	WT	Batt				DEG Maintenace	Total
			Long-Term		Short-Term			
			Li-ion	Inverter	Li-ion	Inverter		
1-1.PV	33,000,000	0	19,250,000	1,650,000	2,786,000	2,985,000	0	59,671,000
1-1.PV+WT	16,500,000	20,250,000	5,950,000	1,350,000	1,568,000	1,680,000	0	47,298,000
1-2.PV	45,000,000	0	19,950,000	1,950,000	4,074,000	4,365,000	0	75,339,000
1-2.PV+WT	34,500,000	14,250,000	17,500,000	1,650,000	3,318,000	3,555,000	0	74,773,000
2-1.PV	49,500,000	0	27,650,000	2,400,000	4,326,000	4,635,000	0	88,511,000
2-1.PV+WT	33,000,000	20,250,000	23,100,000	1,950,000	3,108,000	3,330,000	0	84,738,000
2-2.PV	55,500,000	0	25,200,000	2,400,000	5,054,000	5,415,000	0	93,569,000
2-2.PV+WT	43,500,000	14,250,000	21,700,000	2,100,000	4,158,000	4,455,000	0	90,163,000
3-1.PV	55,500,000	0	27,650,000	2,550,000	4,886,000	5,235,000	1,000,000	96,821,000
3-1.PV+WT	37,500,000	20,250,000	23,100,000	2,100,000	3,528,000	3,780,000	1,000,000	91,258,000
3-2.PV	55,500,000	0	22,400,000	2,250,000	5,054,000	5,415,000	1,000,000	91,619,000
3-2.PV+WT	43,500,000	14,250,000	18,900,000	1,950,000	4,158,000	4,455,000	1,000,000	88,213,000

PV = 1,500USD/KW
275kW WT = 750,000USD/Unit
Li-ion Battery = 350USD/KWh
Battery Inverter = 150USD/KW
Same as IRENA Roadmap

DEG Maintenace = 1,000,000USD (For All Generator)

Tentative

Draft of Study :<Step3> Long-Term Battery Use

Capital Cost @ 2025

→ 60% actual capacity factor of WT in other Island country is reflected to costs.

	PV	WT	Batt				DEG Maintenace	Total
			Long-Term		Short-Term			
			Li-ion	Inverter	Li-ion	Inverter		
1-1.PV	33,000,000	0	19,250,000	1,650,000	2,786,000	2,985,000	0	59,671,000
1-1.PV+WT	16,500,000	33,750,000	5,950,000	1,350,000	1,568,000	1,680,000	0	60,798,000
1-2.PV	45,000,000	0	19,950,000	1,950,000	4,074,000	4,365,000	0	75,339,000
1-2.PV+WT	34,500,000	23,750,000	17,500,000	1,650,000	3,318,000	3,555,000	0	84,273,000
2-1.PV	49,500,000	0	27,650,000	2,400,000	4,326,000	4,635,000	0	88,511,000
2-1.PV+WT	33,000,000	33,750,000	23,100,000	1,950,000	3,108,000	3,330,000	0	98,238,000
2-2.PV	55,500,000	0	25,200,000	2,400,000	5,054,000	5,415,000	0	93,569,000
2-2.PV+WT	43,500,000	23,750,000	21,700,000	2,100,000	4,158,000	4,455,000	0	99,663,000
3-1.PV	55,500,000	0	27,650,000	2,550,000	4,886,000	5,235,000	1,000,000	96,821,000
3-1.PV+WT	37,500,000	33,750,000	23,100,000	2,100,000	3,528,000	3,780,000	1,000,000	104,758,000
3-2.PV	55,500,000	0	22,400,000	2,250,000	5,054,000	5,415,000	1,000,000	91,619,000
3-2.PV+WT	43,500,000	23,750,000	18,900,000	1,950,000	4,158,000	4,455,000	1,000,000	97,713,000

Big Challenges for Achievement 45% Goal

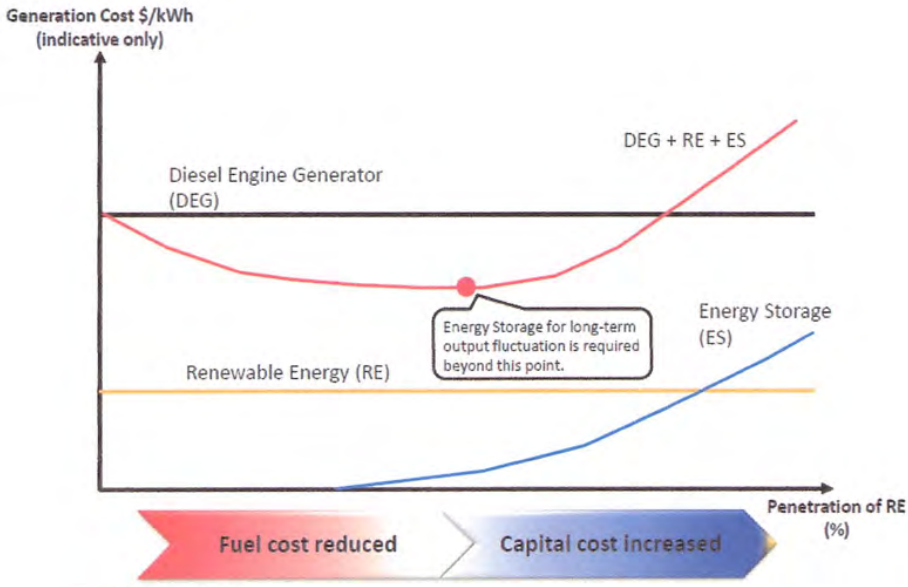
<Finance>

- High Capital Costs
- High O&M Costs
- High Tariff
- Land Space
- ...

<Technology>

- DEG and RE operation
  - RE output forecasting and control
  - Battery Management
- Maintenance
- ...

Further Study Policy



Source : JICA

PV generation system installation plan (As of Oct. 2017)

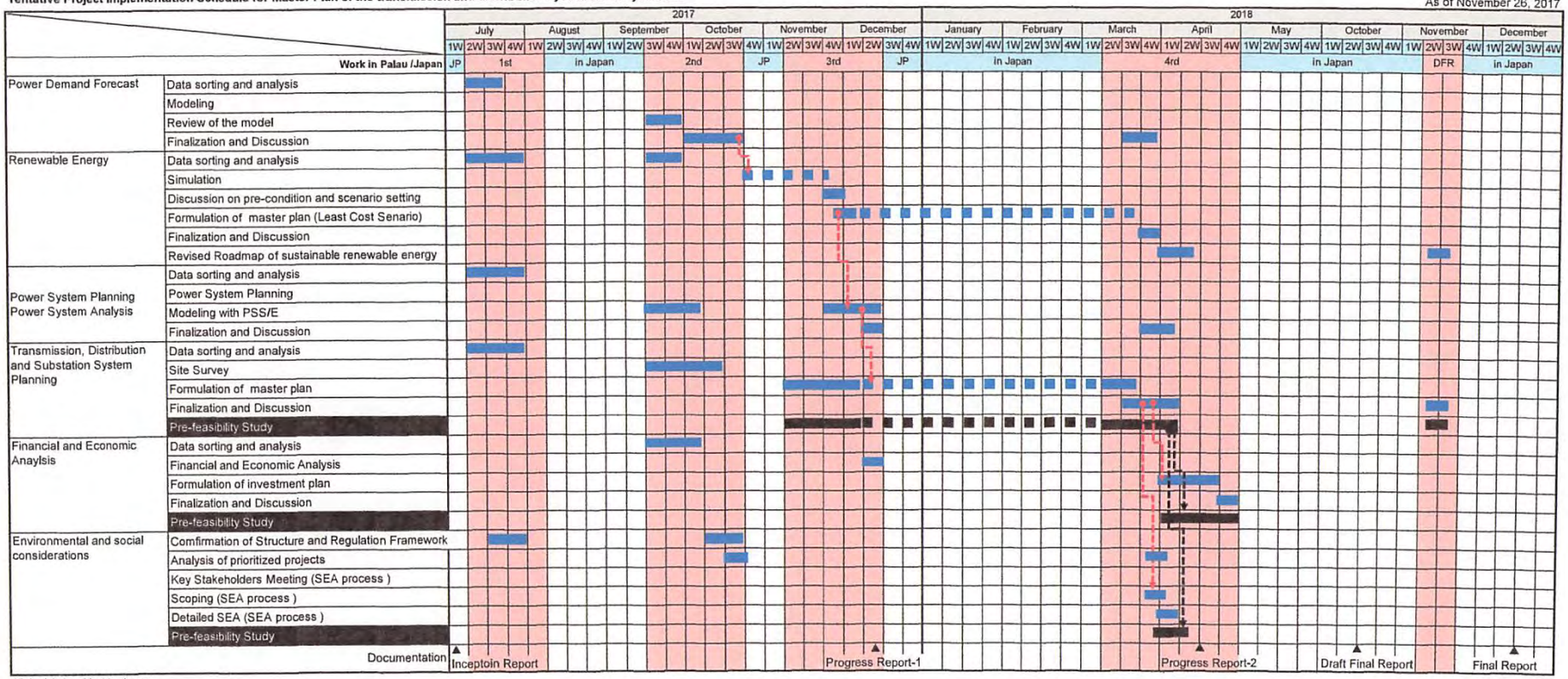
In the Republic of Palau

No	Location	Capacity	Owner
1	Aimeliik (Next to power plant) This is already planned with PPUC.	5 MWp	PPUC
2	Ngatpang (Kokusai)	2-3 MWp the capacity is not confirmed for #2 Ngatpang and #3 Ngardmau.	PPUC
3	Ngardmau (Terraces of Hill)	2-3 MWp	PPUC
4	Commercial roof top by Joint Crediting Mechanism(JCM)	Total 5 MWp	Surangle, WCTC PIDC & PMA
5	Airai airport side by road	3 MWp	PPUC
6	Koror & Airai (Roof top)	2-5 kWp / roof	House owners
	Total	19 MWp	

Source: Energy Administration office

Tentative Project Implementation Schedule for Master Plan of the transmission and distribution system for the year 2030

As of November 26, 2017



*Schedule is subject to change

Minutes of Discussion
for
The Project for Study on Upgrading and Maintenance Improvement
of

National Power Grid in the Republic of Palau
between
Palau Public Utilities Corporation (PPUC)
and
Japan International Cooperation Agency (JICA)

The 1st Joint Coordination Committee (hereinafter referred to as "JCC") Meeting on Japan Technical Cooperation Project for Study on Upgrading and Maintenance Improvement of National Power Grid in the Republic of Palau (hereinafter referred to as "the Project"), was held on 13th April, 2018. Japan International Cooperation Agency (hereinafter referred to as "JICA") with JICA Expert team (hereinafter referred to as "the JICA side") presented the progress of the Project and had a series of discussions with Palau Public Utilities Corporation (hereinafter referred to as "PPUC") for pursuing consensus on the progress report-2 for the master plan and pre-feasibility study.

As a result of the discussions prior to JCC meeting, the JICA side and PPUC have confirmed the main items described in the attachment.

Koror, 13th April, 2018

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ATTACHMENT

I. Scenario of Renewable Energy Road Map and Master Plan

Under the Palau's Nationally Determined Contribution (hereinafter referred to as "NDC") which put the nation on a trajectory to generating 45% of its energy from renewable sources by 2025, both sides confirmed that the target year of the master plan (hereinafter referred to as "MP") for updating roadmap of 45% of renewable energy (hereinafter referred to as "RE") and for enhancement of power transmission and distribution facilities in consideration of the introduction of further RE would be 2025. However, the said MP was formulated for the target year of 2030 in the progress report-2, and therefore the both sides agreed to revise it in the updated progress report-2. Moreover, replacement of substation facilities, such as existing Malakal and Aimeliik substations and decommissioning of Airai substation by 2030 might be replaced as a recommendation in the updated progress report-2.

On the other hand, PPUC requested the JICA side to delete the scenario of MP in 2030 for only operation of diesel power plant (hereinafter referred to as "DG) in the updated progress report-2.

II. Important Factors of 45% Scenario

Both sides discussed the important factors for the study of 45% Scenario:

1. Change of precondition for the worst condition of power flow analysis during peak time in 2025
   In case batteries discharge continuously for 365 days at peak periods and no renewable energy, PPUC requested that power flow analysis during that time as the peak time condition. JICA side agreed it.

2. Confirmation of battery allocation sites
   PPUC requested that the sites for batteries would be distributed in each PV power stations, and power flow analysis was executed accordingly. However, JICA side explained the advantage and disadvantage of distributed allocation as below. PPUC confirmed the advantages and disadvantages and PPUC would consider the detailed study whether it is profitable or not technically and financially in the future feasibility study.

   Advantages:
   - Reduction of land space by each site
   - Reduction of transmission loss
   - High flexibility operation of power generation

   Disadvantages:
   - Cost impact

3. Power flow analysis of the intermediate section
   PPUC requested JICA side to conduct power flow analysis at each step up to the final step in 2025 in order to anticipate impacts due to delay.

4. Power flow analysis for Wind Turbine
   JICA side implemented load flow analysis for wind turbine as a reference case in progress report-2. PPUC accepted it.

III. Implementation Structure of 45% Scenario

In order for Palau side to realize 45% Scenario by the target year, PPUC requests the JICA side to analyze possible measures and necessary implementation structures how to finance or invest RE related projects including inviting independent power producer (hereinafter referred to as "IPP"). JICA side will recommend it in the updated progress report-2 in order to enhance private investment for IPP. Furthermore, PPUC requested that a sentence, "PPUC should employ technical and financial consultants for IPP introduction" would be added in the updated progress report-2. JICA side confirmed to give recommendations on each step for the analysis of updating RE road map in the view point as below.

- Benefit and disadvantage of introducing IPP
- Regulation of IPP introduction
- Finance of IPP introduction
- IPP contract
- Scope of work of IPP

IV. Additional Activities

JICA side has decided to extend the Project from January 2019 to May 2019 depending on the progress of activities. Accordingly, the JICA Expert team presented the completed and on-going technical transfer items based on the Annex 4.

PPUC requested the JICA side to add technical transfer of "Fault Calculation" so that PPUC can identify the cause of faults, such as fault current and fault voltage against customers and among the related department of PPUC. JICA Expert team, however explained even though the utility company in Japan implements the fault calculation, there are some cases that cause of faults cannot be identified. Therefore, JICA Expert team suggested implementing technical transfer from the point of view of the knowledge and experiences in Japan and PPUC agreed it as a part of technical transfer.

On the other hand, PPUC is concerned some items in connection with the calculation of allowable amount of renewable energy and maintenance of transmission and distribution lines as below. Those 3 items are on-going training in the Project. Therefore, PPUC and JICA Expert team confirmed not to include the following three items PPUC requested.

- Algebraic method of short-term constraint
- Demand-supply balance simulation including how to use HOMER-Pro
- Facility maintenance and management technology

V. Project Implementation Schedule

After 4th Field Survey, JICA side explained the tentative project implementation schedule as of Annex-3. PPUC agreed with the schedule as an extended schedule to implement the project activity.

Both sides agreed that JICA side would revise the report based on the above discussions with PPUC and would submit the updated progress report-2 in the beginning of August, 2018.

Draft final report will be submitted in the middle of February, 2019 and final report will be submitted in May, 2019.

VI. Other relevant information

In the JCC meeting, Mr. Ken Uyehara, governor of Angaur stated that MP should consider to install underground transmission lines, submarine cable and gas turbine instead of battery for renewable energy. JICA Expert team explained why they are not feasible for PPUC to apply such technology, and will include the reasons in the updated progress report-2.

Annex List

Annex-1: Presentation Papers for JCC

Annex-2: List of the JCC Meeting Participants

Annex-3: Tentative Project Implementation Schedule

Annex-4: Technical Transfer Items