Environmental and social considerations
Presentation material for the JCC (13th March, 2019)

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Outline of the Strategic Environmental Assessment (SEA)

1 (1) Outline and objective of the SEA

What is the Strategic Environmental Assessment (SEA)?

" Analytical and participatory approach that aims to integrate environmental considerations into policies, plans and programs and evaluate inter linkages with economic and social considerations. " (OECD/DAC (2006))

Objective

To elaborate master plan (MP) ensuring a full integration of relevant biophysical, economic, and social aspects considering stakeholders' opinions and concerns by involving the stakeholders at the early stage of MP examination.

1 (2) Major targets of the SEA

Phase	Targets to be examined
1. Policy	-Setting the goal of the National Power Grid MP -Long-term energy balance and composition of power generation system including renewable energy -Alternatives to achieve the goal etc.
2. Plan	-Long-term development plan (up to 2030) on T&D lines, substations and related facilities -Alternatives of the development plan etc.
3. Program and Project	-Alternatives of priority project to be proposed in the National Power Grid MP etc.

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1 (3) Major tasks to be executed in the SEA

(1) Examination of development alternatives

- Comparative analysis of development alternatives for the assessment of possible environmental and social impacts

(2) Consultation with stakeholders

- Collecting the opinions of public and private stakeholders

(3) Reflecting stakeholders' opinions to the MP

- Elaborating the MP considering stakeholders' opinions and concerns addressed in stakeholder's meetings.

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Report of the result of the SEA

1. Project outline, scoping and evaluation of alternatives
(1) Roadmap for renewable energy 1) Outline

Site	Output	Area
Aimeliik (Next to power plant)	5 MWp+1MWp	15 acres+α
Ngatpang (Kokusai)	2-3 MWp+1MWp	8 acres+α
Ngardmau (Terrace of Hill)	2-3 MWp+1MWp	7 acres+α
Airai Airport side by road	3 MWp+3MWp	8 acres+α
Ngchesar	3 MWp+1MWp	8 acres+α
Ngiwal	3 MWp+1MWp	9 acres+α
Ngardmau	5 MWp+1MWp	15 acres+α
Melekeok	3 MWp+1MWp	9 acres+α
Ngaremlengui	5 MWp+1MWp	18 acres+α
Total	33MWp+11MWp	

Candidate site for
PV installation proposed by PPUC

<Note> Other technical details are mentioned in the Progress Report 2.

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1 (1) 2) Scoping (renewable energy)

	Scoping items	Construction phase			Operation phase		
		PV Panel	Wind Turbine	Battery	PV Panel	Wind Turbine	Battery
Environmental	Air pollution	B-	B-	B-	D	D	D
	Soil pollution	B-	B-	B-	D	D	D
	Water pollution	C-	C-	C-	D	D	D
	Noise and vibration	B-	B-	B-	D	B-	C-
	Flora and fauna	A-	B-	B-	C-	C-	C-
	Preserved area	C-	C-	C-	C-	C-	C-
	Biodiversity	C-	C-	C-	C-	C-	C-
Social	Land acquisition/ involuntary resettlement	A-	B-	B-	D	D	D
	Influence on local economy	C-	C-	C-	Positive	Positive	Positive
	Human health hazard	B-	B-	B-	C-	C-	C-
	Risk of accident	B-	B-	B-	C-	B-	C-

A-: Significant negative impact is expected. B-: Negative impact is expected.
C-: Extent of negative impact is unknown. D: No impact is expected.

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1 (1) 3) Comparative evaluation of environmental and social aspects (renewable energy)

	Case 1	Case 2	Case 3	Case 4
Outline	-PV panel -Short-term battery -Long-term battery	-PV panel -Short-term battery -Long-term battery -Wind turbine	-PV panel -Short-term battery	-PV panel -Short-term battery -Wind turbine
Environmental aspect	Negative impact on flora and fauna	Negative impact on flora and fauna, negative impact due to construction of access road of wind turbine and new transmission line, noise during operation	Negative impact on flora and fauna	Negative impact on flora and fauna, negative impact due to construction of access road of wind turbine and new transmission line, noise during operation
Social aspect	Larger site required	Accident risk during wind turbine maintenance	Larger site required	Accident risk during wind turbine maintenance
Evaluation	++	+	++	+

Considering the negative impacts derived from the installation wind turbines, the first and third cases are relatively advantageous from the environmental and social viewpoint.

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1 (1) 4) Distribution of protected areas and historic sites in candidate sites for solar power generation

Site	Output	Area	Location	
			Preservation area	Historic site
Aimeliik (Next to power plant)	5 MWp+1MWp	15 acres+α	-	Near
Ngatpang (Kokusai)	2-3 MWp+1MWp	8 acres+α	-	-
Ngardmau (Terrace of Hill)	2-3 MWp+1MWp	7 acres+α	-	Included
Airai Airport side by road	3 MWp+3MWp	8 acres+α	-	-
Ngchesar	3 MWp+1MWp	8 acres+α	-	-
Ngiwal	3 MWp+1MWp	9 acres+α	-	Near
Ngardmau	5 MWp+1MWp	15 acres+α	Near	Near
Melekeok	3 MWp+1MWp	9 acres+α	Included	-
Ngaremlengui	5 MWp+1MWp	18 acres+α	-	-
Total	33MWp+11MWp			

Protected areas and historic sites are included or are in proximity in some candidate sites. It is necessary to give due consideration to the impact on the protected areas and historic sites at the phase of feasibility study and basic design in the future.

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1. Project outline, scoping and evaluation of alternatives (2) T&D network and substation 1) Outline

Year	Item	Outline
2020	Improvement of 34.5kV Nekken feeder	Relocation of 34.5kV Transmission Line (Aimeliik – Ngaraard 2)
	Relocation of the Existing Substation facilities	Asahi substation Ngardmau substation Ngaraard 1substation Ngaraard 2substation
	Construction of Koror substation	34.5/13.8kV 1bank 10MVA
2023	Construction of 34.5kV Transmission Line	34.5kV Transmission Line (Malakal substation – Melekeok PV site) Expansion of 34.5kV outgoing bay at Malakal substation
2025	Construction of 34.5kV Transmission Line	34.5kV Transmission Line (Melekeok PV site – Ngaraard 1) Expansion of 34.5kV outgoing bay at Ngaraard 1 substation
2026	Replacement of the existing Substation equipment	Aimeliik substation Aimeliik 1 substation Nekkeng substation Aimeliik 2 substation

<Note> Other technical details are mentioned in the Progress Report 2.

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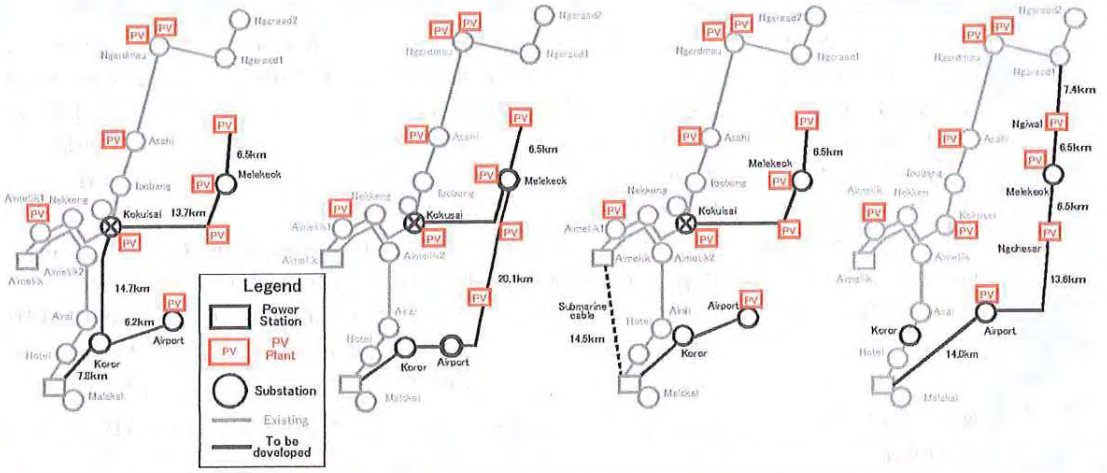
1 (2) 2) Alternatives of T&D network development



	Case 1	Case 2	Case 3	Case 4
	New transmission line along existing transmission line (Malakal power plant – Kokusai substation)	Construction of a network that half-rounds the southern part of Babeldaob Island	Linkage by submarine cable (Malakal power plant - Aimelik power station)	Construction of a network that circles Babeldaob Island

<Note> Other technical details are mentioned in the Progress Report 2.

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1 (2) 3) Scoping (T&D network)

	Scoping items	Construction phase			Operation phase		
		Expansion	Relocation	Rehabili-tation	Expansion	Relocation	Rehabili-tation
Environmental	Air pollution	B-	B-	B-	D	D	D
	Soil pollution	B-	B-	B-	D	D	D
	Water pollution	C-	C-	C-	D	D	D
	Noise and vibration	B-	B-	B-	D	D	D
	Flora and fauna	B-	B-	C-	C-	C-	C-
	Preserved area	C-	B-	D	D	D	D
	Biodiversity	C-	B-	D	C-	C-	C-
Social	Land acquisition/ involuntary resettlement	C-	B-	D	D	D	D
	Influence on local economy	C-	C-	C-	Positive	Positive	Positive
	Human health hazard	B-	B-	B-	C-	C-	C-
	Risk of accident	B-	B-	B-	C-	C-	C-

A-: Significant negative impact is expected. B-: Negative impact is expected.
C-: Extent of negative impact is unknown. D: No impact is expected.

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1 (2) 4) Comparative evaluation of environmental and social aspects (T&D network)

	Case 1	Case 2	Case 3	Case 4
Outline	New transmission line along existing transmission line (Malakal power plant – Kokusai substation)	Construction of a network that half-rounds the southern part of Babeldaob Island	Linkage by submarine cable (Malakal power plant - Aimelik power station)	Construction of a network that circles Babeldaob Island
Environmental aspect	Temporary negative impact at the construction phase	Temporary negative impact at the construction phase	Temporary negative impact at the construction phase, irreversible negative impact on coral reefs at the seafloor	Temporary negative impact at the construction phase
Social aspect	Noticeable negative impact is not assumed because the construction will be basically on public land.			
Evaluation	++	++	+	++

The newly installed power distribution lines are supposed to be constructed at public places along the compact road; land acquisition and involuntary resettlement are not assumed. In the third case, irreversible negative impact on coral reefs is assumed.

1 (2) 5) Scoping (substation)

	Scoping items	Construction phase		Operation phase
		Relocation/ New construction	Rehabilitation/ Replacement	All
Environmental	Air pollution	B-	B-	D
	Soil pollution	B-	B-	D
	Water pollution	C-	C-	D
	Noise and vibration	B-	B-	C-
	Flora and fauna	B-	C-	C-
	Preserved area	B-	D	D
	Biodiversity	B-	D	C-
Social	Land acquisition/ involuntary resettlement	B-	D	D
	Influence on local economy	C-	C-	Positive
	Human health hazard	B-	B-	C-
	Risk of accident	B-	B-	C-

A-: Significant negative impact is expected. B-: Negative impact is expected.
C-: Extent of negative impact is unknown. D: No impact is expected.

1 (2) 6) Comparative evaluation of environmental and social aspects (substation)

Target of the evaluation is the examination of the new construction of Koror substation which is urgently needed by 2020.

	Case 1	Case 2	Case 3
Outline	Rehabilitation of Airai substation (same location)	Renewal of Airai substation (different location)	New construction of Koror substation
Environ-mental aspect	Historic site is adjacent to the slope to be constructed at the site. Protected areas are not adjacent.	Necessary to find the location that do not affect the historic sites in Airai.	No historic sites and protected areas are around the site.
Social aspect	No dwellings and buildings in the target area; involuntary resettlement is not expected.	Since the site is uncertain, it is necessary to acquire a site that does not require as much as possible involuntary resettlement.	No dwellings and buildings in the target site; involuntary resettlement is not expected.
Evaluation	++	+	++

Compared to the second case where the site is not fixed, the first and third plans are evaluated relatively high because the location has already been identified and the uncertain factors are also limited.

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2. Proposed mitigation measures

Item	Mitigation Measures
Air pollution Soil pollution Noise and vibration	- Appropriate operation and management of construction activity - Installation of countermeasures against noise and vibration at construction site (e.g. soundproof sheet, etc.)
Flora and fauna Preserved area Biodiversity Involuntary resettlement and land acquisition	- Careful consideration on the location of development site and basic designs to avoid/mitigate environmental and social impacts as far as possible - Examination of optimal plan considering opinion of stakeholders to minimize environmental and social impacts that cannot be avoided - Recovery of natural environment by backfilling, afforestation, etc.
Human health hazard	- Careful consideration on health condition of workers at construction site
Risk of accident	- Implementation of safety control measures, preparation and training for accident (e.g. evacuation, firefighting, etc.)

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3. Proposed monitoring structure

Proposed responsible organization for monitoring

[Planning phase]

Project Planning & Implementation Department, PPUC

[Implementation phase]

During construction: Contractor

During operation: Operator (PPUC)

- EQPB shall supervise the above-mentioned organizations in both planning and implementation phase.
- PPUC as a project proponent shall report the status of the monitoring to EQPB and shall share the status among stakeholders as necessary.

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4. Major comments and opinions from stakeholders

(comments collected by 11th April 2018)

<EQPB>

- It is **necessary to carefully consider environmental negative impacts in and around environmentally vulnerable area** such as water source and area along the coast.
- It is **better to consult with relevant State Government at an early stage** to obtain State Authorization and to proceed the examination of environmental permit smoothly.
- It is **recommended to hold quarterly meetings with stakeholders during construction phase,** which is the same as water supply project.

Comments from other stakeholders (Historic Preservation Office, Palau Conservation Society, etc.) are under collection.

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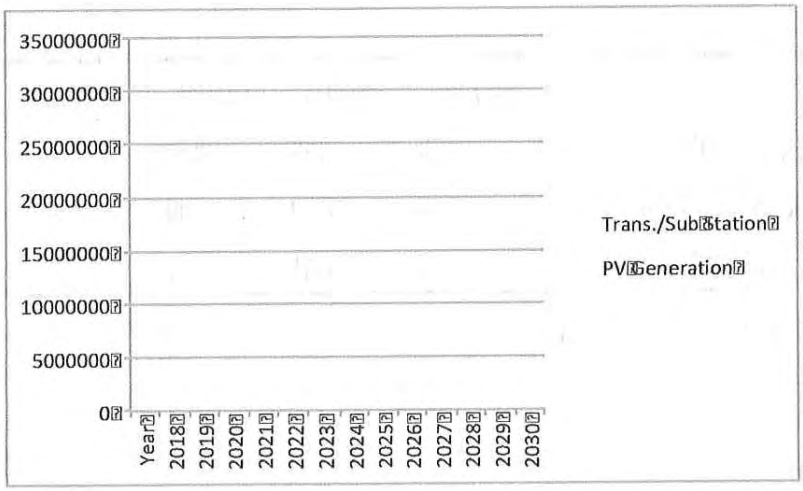
ECONOMIC ANALYSIS OF MASTER PLAN

March 13, 2019

By Yoshiyuki Choso (JICA Study Team)

The Required Money for Master Plan (1)

- US$112.3 million Investment for PV Generation
- US$35 million for Transmission and Sub Station
- Total US$ 147 million



The Required Money for Master Plan (2)

Capital Expenditure			
Year	PV Generation	Trans./Sub Station	Annual Capital Expenditure
2018	9,332,879	1,810,000	11,142,879
2019	8,315,098	10,498,000	18,813,098
2020	10,646,428	5,792,000	16,438,428
2021	285,000	1,140,000	1,425,000
2022	10,445,701	6,612,000	17,057,701
2023	27,233,399	3,648,000	30,881,399
2024	25,941,098	1,705,000	27,646,098
2025	20,105,397	3,795,000	23,900,397
Sub Total	112,305,000	35,000,000	
	Total Capital Cost		147,305,000

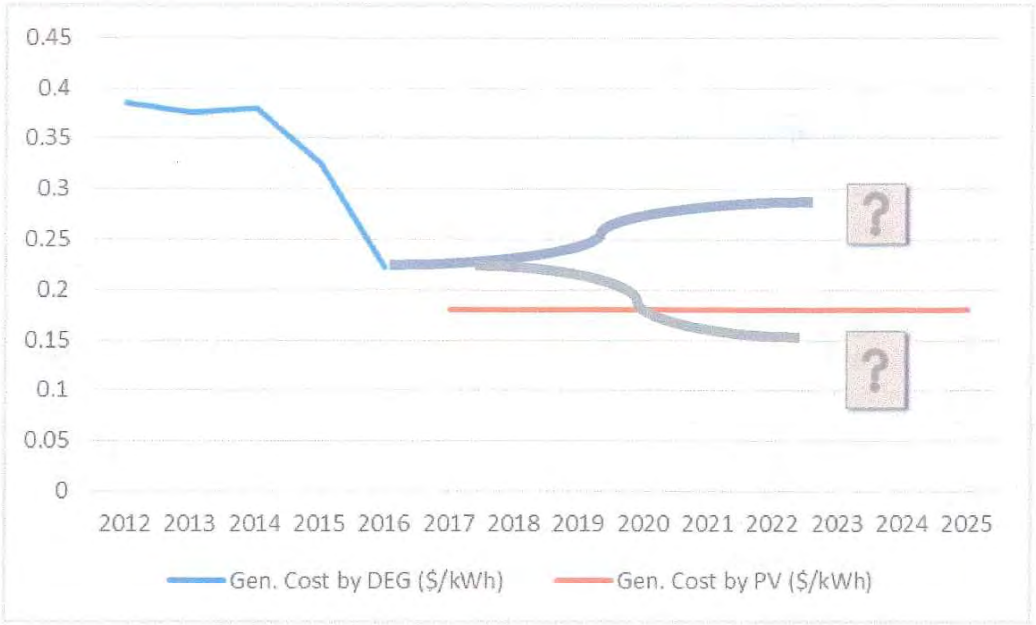
Cost of Generation

- US$0.19 /kWh by PV based on the PV expenditure cost
- US$0.38～0.22/kWh by DEG(Table below)

	FY2012	*FY2013*	*FY2014*	*FY2015*	*FY2016*
Cost of Generation (kWh)	0.38	0.38	0.38	0.33	0.22
Cost of Electricity (kWh)	0.41	0.40	0.40	0.35	0.26
Average revenue of Electricity (kWh)	0.40	0.41	0.41	0.32	0.29

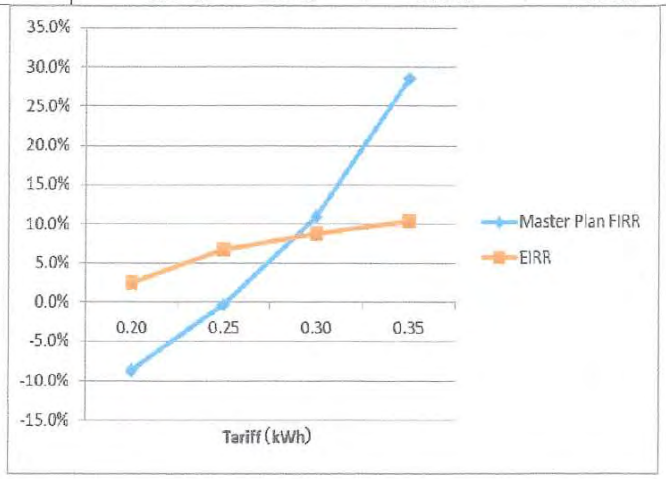
Source: Study Team based of PPUC data

Stable Generation Cost by PV
Uncertain Generation Cost by DEG



Investment Return for Master Plan
Financial IRR & Economic IRR

Tariff	Tariff ($/kWh)			
	0.20	0.25	0.30	0.35
Master Plan FIRR	-8.7%	-0.3%	11.0%	28.6%
EIRR	2.5%	6.7%	8.8%	10.4%



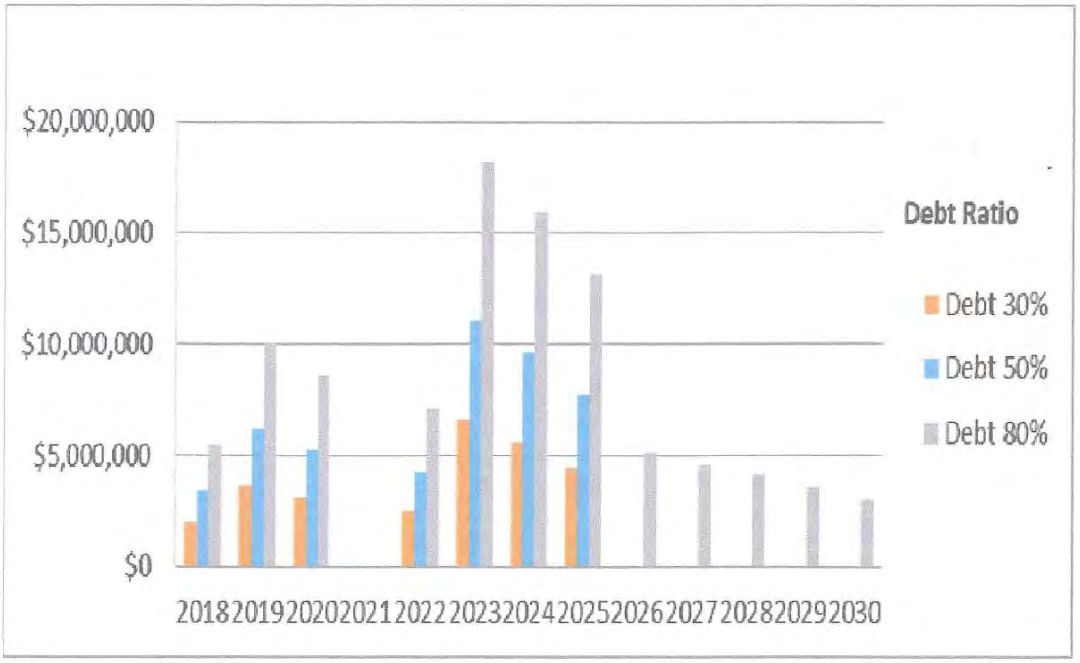
Financing Plan for Mastster Plan (1)

Tariff $0.30kwh, Debt Ratio 30%, Interest 3.0%

Financing Projection for Master Plan											
Year		Out Flow (US$, million)				In Flow (US$, million)					Net Cash (USD, million)
		Expenditure and O&M Cost	Loan		Total Out Flow	Electric Power Revenue	Finance			Total Inflow	
			Repayment	Interest			Equity	Debt	Total		
1	2018	28,966,529	0	60,722	29,027,251	22,280,371	4,722,816	2,024,064	6,746,881	29,027,251	0
2	2019	36,785,753	0	185,506	36,971,259	23,106,344	9,705,440	4,159,474	13,864,915	36,971,259	0
3	2020	34,568,983	0	278,445	34,847,428	24,520,893	7,228,575	3,097,961	10,326,535	34,847,428	0
4	2021	19,928,830	0	278,445	20,207,275	25,364,107	0	0	0	25,364,107	5,156,832
5	2022	35,256,700	0	364,588	35,621,288	26,049,842	6,700,012	2,871,434	9,571,446	35,621,288	0
6	2023	48,908,979	0	566,301	49,475,280	27,062,727	15,688,787	6,723,766	22,412,553	49,475,280	0
7	2024	45,298,805	0	729,893	46,028,698	27,851,824	12,723,812	5,453,062	18,176,874	46,028,698	0
8	2025	41,960,017	0	852,993	42,813,010	29,135,238	9,574,441	4,103,332	13,677,773	42,813,010	0
9	2026	18,247,869	5,686,619	682,394	24,616,882	29,576,856	0	0	0	29,576,856	4,959,973
10	2027	18,495,361	5,686,619	511,796	24,693,775	30,157,454	0	0	0	30,157,454	5,463,679
11	2028	18,725,179	5,686,619	341,197	24,752,995	30,696,591	0	0	0	30,696,591	5,943,597
12	2029	18,936,086	5,686,619	170,599	24,793,303	31,191,365	0	0	0	31,191,365	6,398,061
13	2030	19,122,643	5,686,619	-0	24,809,262	31,629,015	0	0	0	31,629,015	6,819,753

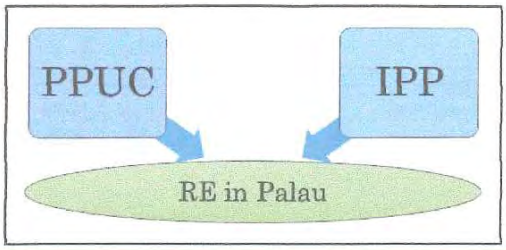
Financing Plan for Master Plan (2)

Debt Balance at each Debt Ratio ($0.30kWh, Interest 3.0%)



If IPPs enter in PV (1)

- RE Development will be shared between PPUC and IPP.
- IPP will wholesale PV power to PPUC



RE Power Generation
•PPUC
•IPP

Transmission
•PPUC

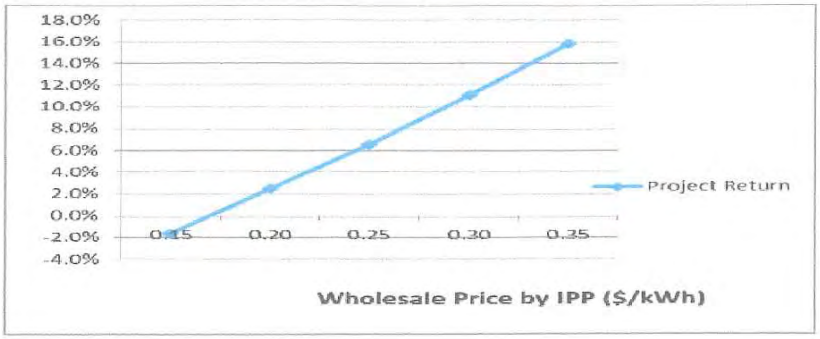
Distribution
•PPUC

Services to Consumer
•PPUC

If IPPs enter in PV (2)

- Wholesale price will depend on target return of IPPs and PV Expenditure Cost.

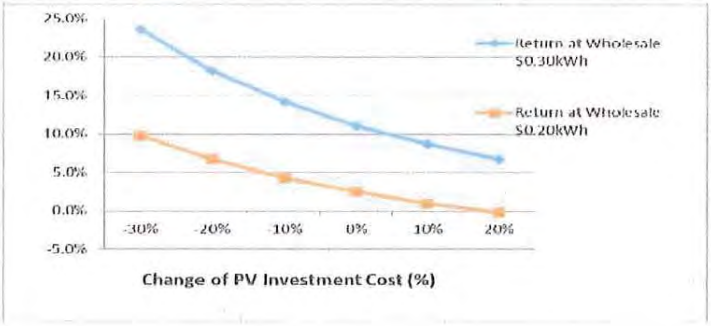
IPP Return based on the Expenditure cost of JICA Study Team (Indication only)



If IPPs enter in PV (3)

- IPP Return analysis based on Change of Investment Cost (-30% ~ + 20%) from the Original Cost.

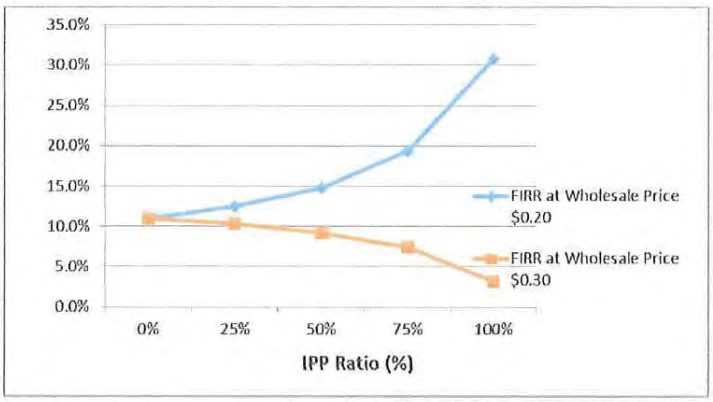
Change of PV Investment Cost	-30%	-20%	-10%	0%	10%	20%
Project Return at Wholesale $0.30kWh	23.6%	18.2%	14.2%	11.1%	8.7%	6.7%
Project Return at Wholesale $0.20kWh	9.8%	6.7%	4.3%	2.5%	1.0%	-0.2%



If IPPs enter in PV (4)

- IPP Return analysis based on Change of Investment Cost (-30% ~ + 20%) from the Original Cost.

IPP Ratio	0%	25%	50%	75%	100%
FIRR at IPP Price $0.20	11.0%	12.5%	14.8%	19.3%	30.8%
FIRR at IPP Price $0.30	11.0%	10.3%	9.2%	7.4%	3.2%



If IPPs enter in PV (5)

- National Plan of RE 45% by 2025 is feasible
- Fair Energy Market and Rules for both PPUC and IPP

Feasibility increases for RE45% Target	Decrease of Public Spending for RE Investment	Effective Operation through Competition
Possibility of lowering the Tariff	New Regulatory System for Power Market	Prevening Market Power Obtained by IPP

THE PROJECT FOR STUDY ON UPGRADING AND MAINTENANCE IMPROVEMENT OF NATIONAL POWER GRID IN THE REPUBLIC OF PALAU

JOINT COORDINATION COMMITTEE (JCC)

TARGET OF PRE-FEASIBILITY STUDY AND PROJECT PACKAGE

MARCH 13TH, 2019
JICA STUDY TEAM

Contents

1. Methodology to select the prioritized project (Step)

Step-1 Nomination of project components from Master Plan

↓

Step-2 Grouping the components by category

↓

Step-3 Selection of target project for Pre-feasibility study

↓

Step-4 Set up Criteria for Evaluation

↓

Step-5 Evaluation for Prioritization

↓

Step-6 Selection of prioritized project

2. Nomination of components for projects

List of Components from Master Plan

Step	Target Year	RE roadmap	ID	Year	Facility	Outline
1	2020	Phase1	1-1	2020	T&D	■ Relocation of existing 34.5kV Transmission Line ・ Airai – Ngaraard 2
			1-2	2020	SS	■ Relocation of existing substations ・ Ngardmau ・ Ngaraard 1 ・ Ngaraard 2
			1-3	2020	SS	■ Construction of Koror substation ・ 34.5/13.8kV 1 bank x 10MVA
			1-4	2020	D	■ Construction of 13.8kV distribution line ・ 1 feeder x 13.8kV distribution line
			1-5	Within the period	SS	■ Installation of circuit breaker panel ・ Grid connected PV system (Aimeliik) ・ Grid connected PV system (Ngatpang (Kokusai)) ・ Grid connected PV system (Ngaremlengui)
2	2021 – 2023	Phase2	2-1	2023	T	■ Construction of 34.5kV transmission line ・ Malakal – Melekeok PV site
			2-2	2023	SS	■ Expansion of Malakal substation ・ Expansion of Malakal outgoing feeder bay ・ 34.5/13.8kV 1 bank x 10MVA(Option)
			2-3	Within the period	SS	■ Installation of circuit breaker panel ・ Grid connected PV system (Airai Airport) ・ Grid connected PV system (Ngchesar) ・ Grid connected PV system (Melekeok)
3	2024 – 2025	Phase3	3-1	2025	T&D	■ Construction of 34.5kV transmission line ・ Melekeok PV site - Ngaraard 1 ・ Expansion of outgoing feeder at Ngaraard 1
			3-2	Within the period	SS	■ Installation of circuit breaker panel ・ Grid connected PV system (Ngiwal) ・ Grid connected PV system (Ngardmau (Terraces of Hill)) ・ Grid connected PV system (Ngardmau)
Option	after 2025	-	4-1	2026	SS	■ Simple replacement work for existing substations ・ Aimeliik ・ Aimeliik 1 ・ Nekkeng ・ Aimeliik 2
			4-2	2026	SS	■ Expansion of Koror substation ・ 34.5/13.8kV 1 bank x 10MVA

Project package

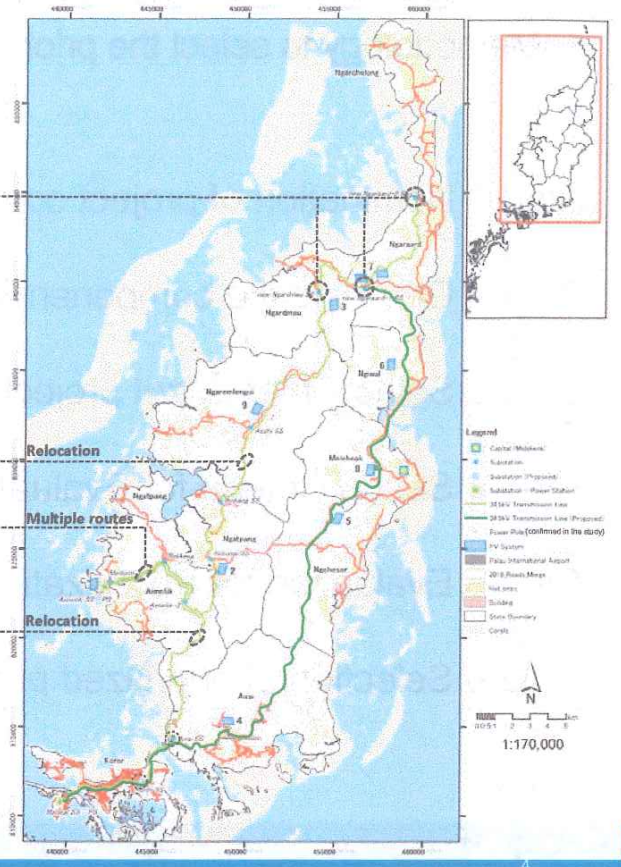
Project package	ID	Component
1	-	**Improvement of Maintenance Manageability** **Improvement of 34.5kV Existing Transmission Line**
	1-1	Relocation of existing 34.5kV Transmission Line Transmission line (41.8km) Airai – Aimeliik - Ngaraard 2 Distribution line (4.6km) Ngaraard 1 Countermeasure against power outage
	1-2	Relocation of existing substations Ngardmau Ngaraard 1 Ngaraard 2
2	-	**Improvement of Power Supply Reliability** **Construction of Koror Substation** **Construction of 34.5kV Transmission Line**
	1-3	Construction of Koror substation 34.5/13.8kV 1 bank x 10MVA
	1-4	Construction of 13.8kV distribution line 1 feeder (2km) x 13.8kV distribution line
	2-1	Construction of 34.5kV transmission line Transmission line (33.5km) Malakal – Melekeok PV site Cabling (0.6km at KB bridge)
	2-2	Expansion of Malakal substation Expansion of Malakal outgoing feeder bay
	3-1	Construction of 34.5kV transmission line Transmission line (13.9km) Melekeok PVsite - Ngaraard 1 Expansion of outgoing feeder at Ngaraard 1

3. Project package-1

Improvement of Maintenance Manageability

ID1-2: Relocation of existing 3 substations
-Ngardmau
-Ngaraard 1
-Ngaraard 2

ID1-1: Improvement of 34.5kV Existing Transmission Line (Airai – Aimeliik - Ngaraard 2)----Approx.61.2km



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4. Project package-2

Improvement of Power Supply Reliability

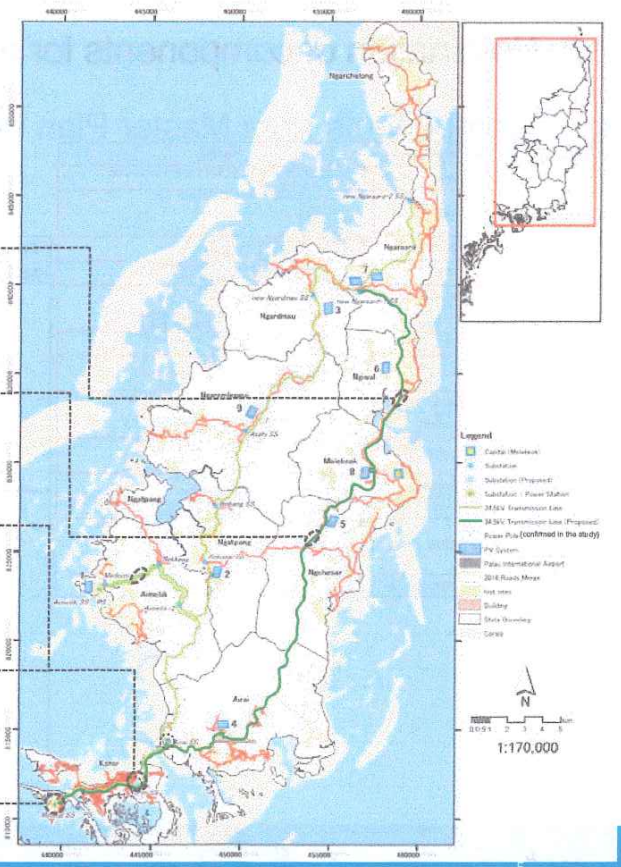
ID3-1: Construction of 34.5kV transmission line
Transmission line (13.9km) Melekeok PVsite-Ngaraard 1
Expansion of outgoing feeder at Ngaraard 1

ID2-1: Construction of 34.5kV transmission line
Transmission line (33.5km) Malakal – Melekeok PV site
Cabling (0.6km at KB bridge)

ID1-4: Construction of 13.8kV distribution line
1 feeder (2km) x 13.8kV distribution line

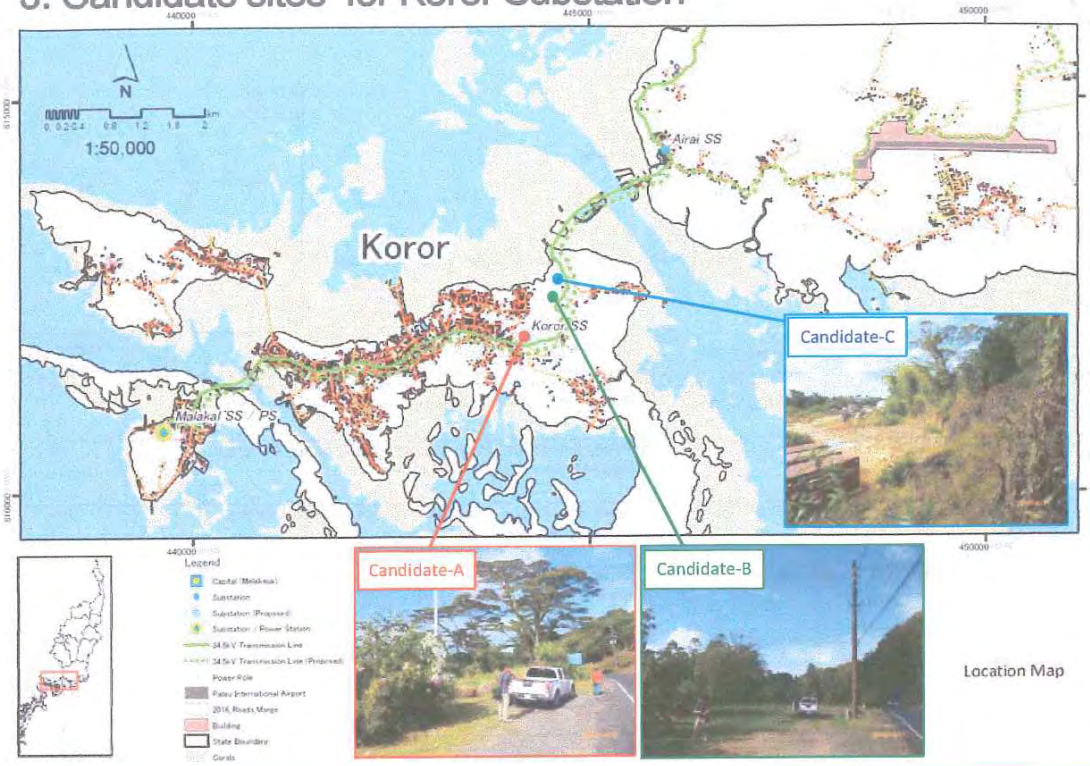
ID1-3: Construction of Koror substation
34.5/13.8kV 1 bank x 10MVA

ID2-2: Expansion of Malakal substation
Expansion of Malakal outgoing feeder bay



5

5. Candidate sites for Koror Substation



6

6. Set up Criteria for Evaluation

- Evaluation

Qualitative Impact ⇒ Pre-Feasibility Study

Quantitative Impact ⇒ Feasibility Study

- Criteria

1. Technical
2. Economic Efficiency
3. Urgency
4. Environmental Impact
5. Social Impact

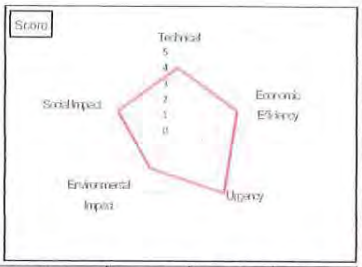
7

7. Evaluation for Project package - 1

Project No.: 1
Target Year: 2020-2023
Project: Improvement of existing 34.5kV Transmission Line
Component: ID 1-1: Relocation of 34.5kV Transmission Line (Airai – Aimeliik - Ngaraard 2)
ID 1-2: Replacement of Ngardmau, Ngaraard 1, Ngaraard 2 Substation facilities

Main Objective: Adequate maintenance and improvement of power supply reliability

Remarks: Three substation facilities should be replaced in parallel with the relocation of the existing 34.5kV transmission line facilities



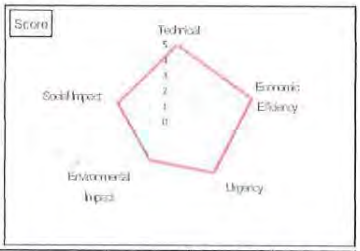
No.	Criteria	Contributing Factor	Specific Information	Score	Weight of Criteria	Evaluation Score
1	Technical	Power Supply Reliability and Maintenance Managebility	Power supply reliability and Maintenance managebility shall be improved by relocating the Nekkeng Feeder along the line with the compact road.	4	25%	1.00
2	Economic Efficiency	Cost and Economic benefit	Profitability could be better by reducing power interruption and saving tree-cutting cost though need to secure construction cost .	4	20%	0.80
3	Urgency	Reduction of Power Interruption	Number and Time of power interruption should be reduced by relocating the Nekkeng Feeder from jungle/bush.	5	25%	1.25
4	Environmental Impact	Environmental protection	Environmental impact should be minimized by choosing adequate line route and locatoin of substation facilities.	3	15%	0.45
5	Social Impact	Involuntary resettlement	Involuntary resettlement could be avoidable by choosing adaquate line route and locatoin of substation facilities.	4	15%	0.60
			Total	20	100%	4.10

[Remark]Evaluation Score: Low1<Average3<High5

8

8. Evaluation for Project package - 2

Project No.: 2
Target Year: 2020
Project: Construction of Koror Substation and 34.5kV Transmission Line
Component: ID 1-3: Construction of Koror Substation 34.5/13.8kV 1 bank 10MVA
ID 1-4: Construction of 13.8kV distribution line (1 feeder)
ID 2-1: Construction of 34.5kV Transmission Line (Malakal – Melekeok)
ID 2-2: Expansion of 34.5kV outgoing bay at Malakal Substation
ID 3-1: Construction of 34.5kV Transmission Line(Malakal – Ngaraard 1), Expansion of 34.5kV outgoing bay at Ngaraard 1
Main Objective: Improvement of Power Supply Reliability
Remarks: Recommended to consider space for the second bank at Koror substation in order to improve the power supply reliability and to satisfy N-1 criterion
Cost related to RE roadmap is not included in the estimation



No.	Criteria	Contributing Factor	Specific Information	Score	Weight of Criteria	Evaluation Score
1	Technical	N-1 criterion	By satisfying N-1 criterion, power supply from either Malakal or Aimeliik power plant shall be available in case of fault on the 34.5kV transmission line.	5	25%	1.25
2	Economic Efficiency	Cost	Impact to the Profitability cant expect to become high after complation of the project even though the Profitability at the initial stage might be limited because of high initial construction cost.	5	20%	1.00
3	Urgency	Power supply reliability	Power supply reliability for the load center (Koror and Airai) shall be improved by satisfying N-1 criterion and re-configuration of 13.8kV network.	4	25%	1.00
4	Environmental Impact	Environmental protection	Environmental impact should be minimized by choosing adequate locatoin of substation facilities.	3	15%	0.45
5	Social Impact	Land acquisition and involuntary resettlement	Involuntary resettlement could be avoidable by choosing adequate line route and locatoin of substation facilities.	4	15%	0.60
			Total	21	100%	4.30

[Remark]Evaluation Score: Low1<Average3<High5

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9. Summary of the Project package

Project	Priority	Achievement	Com. ID	Project	Evaluation Score	Remarks
1	2	Improvement of Maintenance Manageability		**Improvement of 34.5kV Existing Transmission Line**	4.10	Rough cost estimation is approx. 13.8 million USD
			1-1	Relocation of 34.5kV Transmission Line (Airai – Aimeliik - Ngaraard 2)		
			1-2	Replacement of Ngardmau Substation facilities		
			1-2	Replacement of Ngaraard 1 Substation facilities		
			1-2	Replacement of Ngaraard 2 Substation facilities		
2	1	Improvement of Power Supply Reliability		**Construction of Koror Substation**	4.30	Rough cost estimation is approx. 14.4 million USD
			1-3	Construction of Koror Substation 34.5/13.8kV 1 bank 10MVA		
			1-4	Construction of 13.8kV distribution line (1 feeder)		
				Construction of 34.5kV Transmission Line		
			2-1	Construction of 34.5kV Transmission Line (Malakal – Melekeok)		
			2-2	Expansion of 34.5kV outgoing bay at Malakal Substation		
			3-1	Construction of 34.5kV Transmission Line (Melekeok – Ngaraard 1)		
			3-1	Expansion of 34.5kV feeders at Ngaraard 1 Substation		

[Remark] Evaluation Score: Low1<Average3<High5
Concerning the Priority 1, cost related to RE roadmap is not included in the estimation

Thank you for your attention

Japan International Cooperation Agency

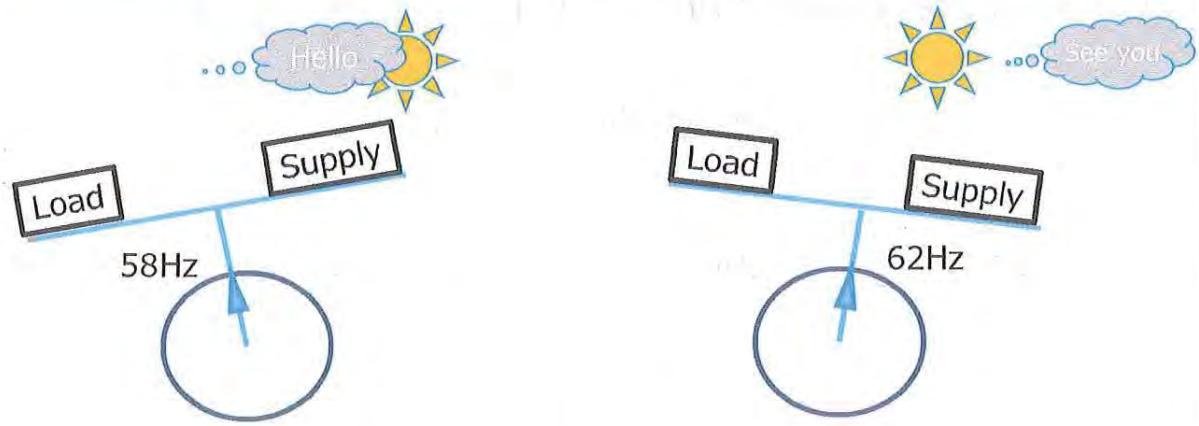
YACHIYO ENGINEERING CO.,LTD.
Consulting Engineers & Architects

Kansai Electric Power

Calculation method for Capacity of Battery using for short –term Fluctuation Absorption

13 March 2019

Influence of a Short-Term Fluctuation



- ✓ A change of weather causes a fluctuation of PV output.
- ✓ When the PV penetration is small amount, a grid can absorb the fluctuation and keep a frequency in permissible range.
- ✓ However, PV penetration will be progressed in future, the frequency may deviate from the appropriate value.
- ✓ Therefore, a battery system for absorbing the fluctuation of PV output is required.

Algebraic Method

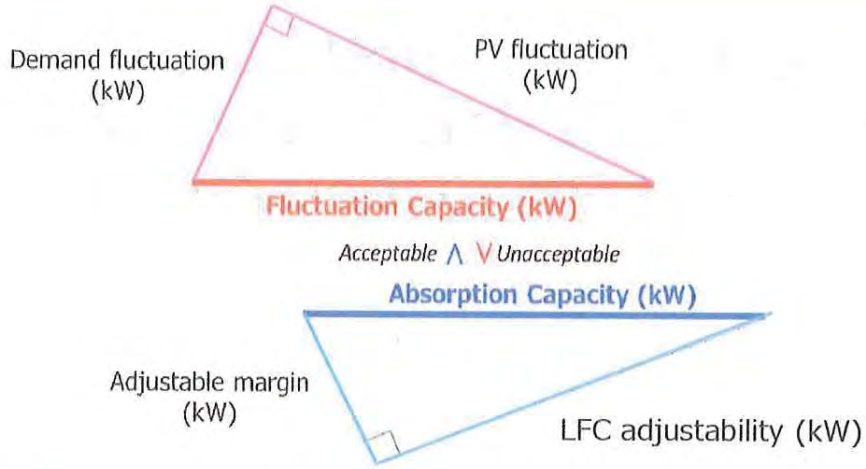
3

Fluctuation Sources

- Demand
- RE output

Absorption Sources

- LFC adjustability
- Adjustable margin



When the elements are independent with each other, total magnitude is evaluated by Algebraic Method.

Absorption Sources

4

LFC (Load Frequency Control) is not adopted in Palau.

LFC adjustability = 0 KW

Adjustable Margin is shown by below formula.

$$P \times K \times f$$

P: Demand (kW)
K: System constant (%kW/Hz)
f: Permissive deviation range of frequency (Hz)

- In this study, "K" is 10 as an ordinary value for a grid in islands.
  JICA study team recommends PPUC to take the measurement of "K" in the grid.
- And "f" is 2 informed by PPUC.

Algebraic Method

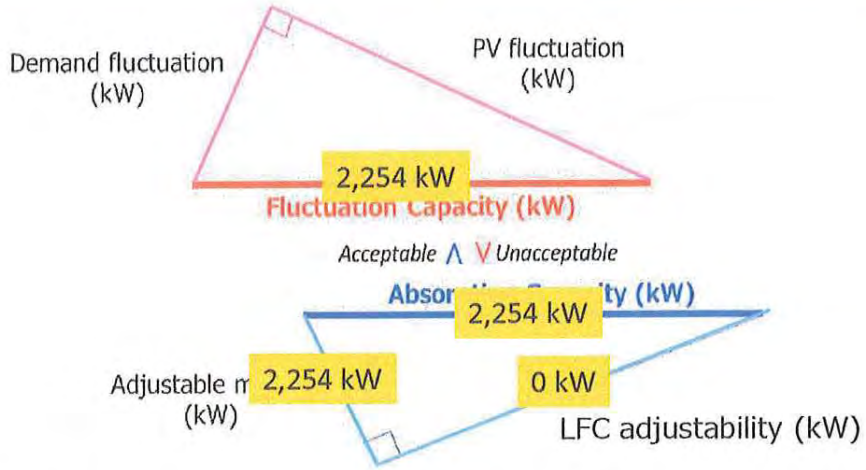
5

Fluctuation Sources

- Demand
- RE output

Absorption Sources

- LFC adjustability
- Adjustable margin



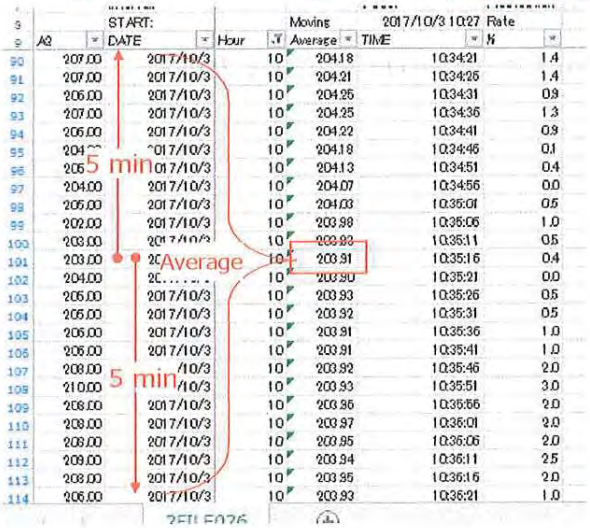
Affordable fluctuation capacity is estimated to be up to 2,254 kW by Algebraic Method.

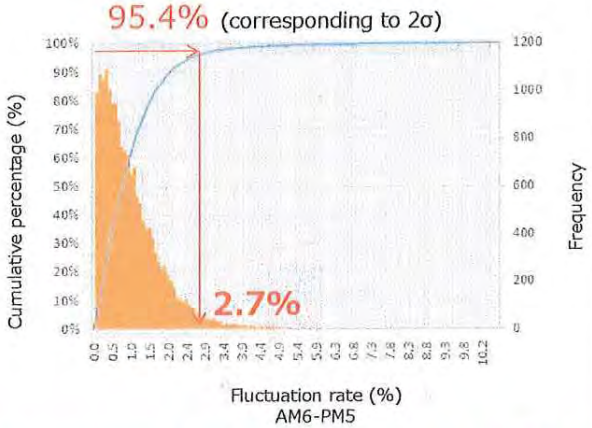
Demand Fluctuation

6

This analysis is based on the demand data measured for 3 days in October 2017.

A B |A-B|/B x 100





Fluctuation rate of demand is 2.7%

	2019	2020	2021	2022	2023	2024	2025
(a) Demand (kW)	8,938	9,485	9,811	10,076	10,468	10,774	11,270
(b) Demand fluctuation (kW)	241	256	265	272	283	291	304

Permissive PV Fluctuation

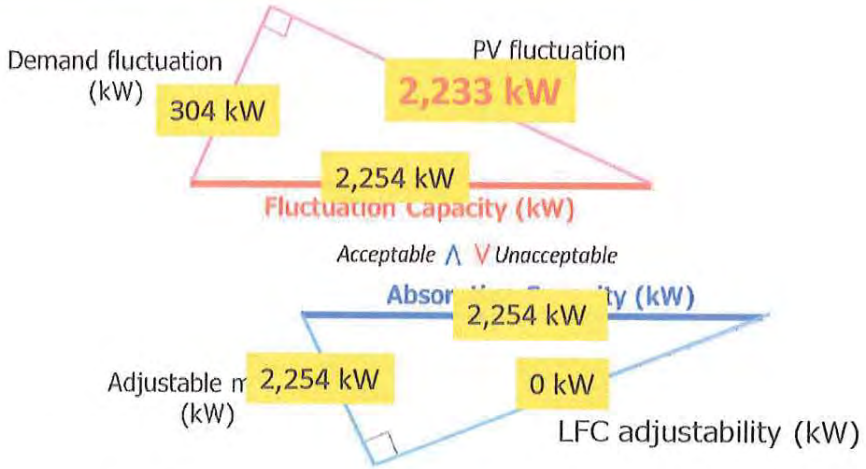
7

Fluctuation Sources

- Demand
- RE output

Absorption Sources

- LFC adjustability
- Adjustable margin

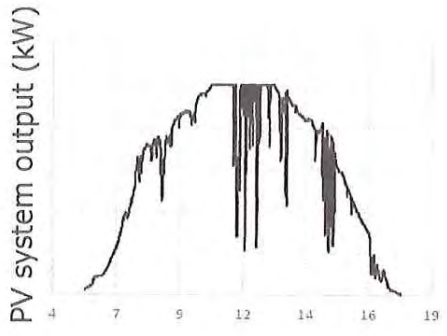


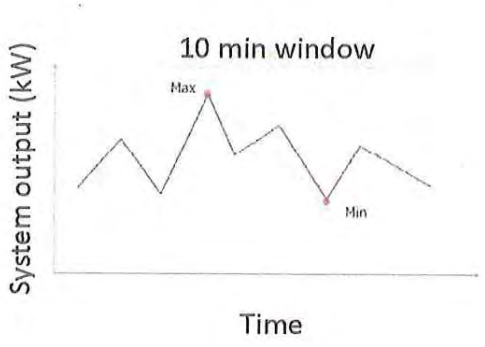
The permissive fluctuation caused by PV is estimated to be 2,233 kW.

Fluctuation

8

- The solar radiation data measured with several seconds pitch is required to evaluate a PV fluctuation rate.
- The data necessary for this study has been provided by JAMSTEC.

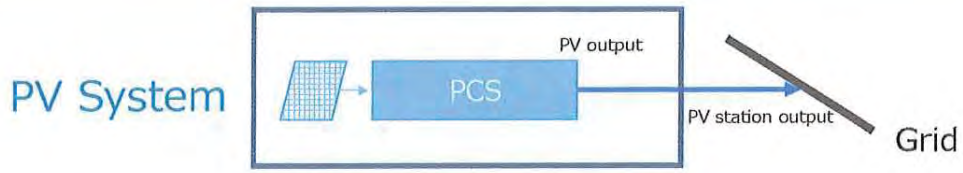


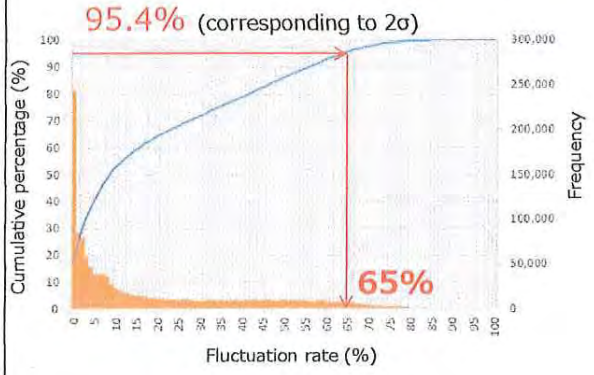


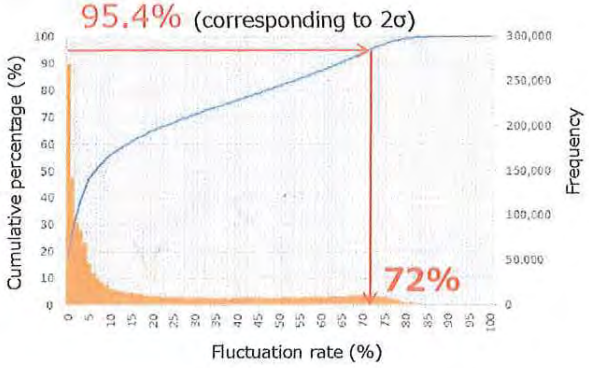
$$\text{Fluctuation rate of PV} = \frac{\text{Max - Min}}{\text{PCS capacity}} \times 100\%$$

PV Fluctuation Ratio without battery system

9







PV power station

$$\frac{\text{Panel 2 MW}}{\text{PCS 1 MW}} = 2$$

Rooftop

$$\frac{\text{Panel 3 kW}}{\text{PCS 2.5 kW}} = 1.2$$

Fluctuation rate of PV power statin and Rooftop are 65% and 72%, respectively.

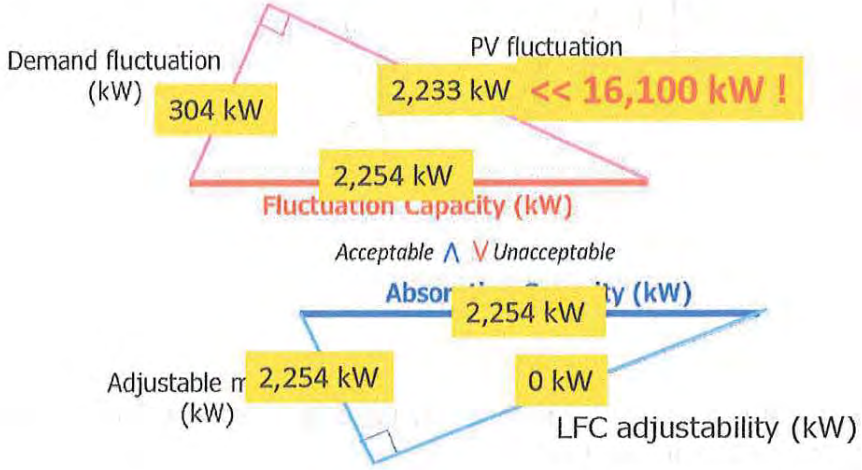
PV Fluctuation without Battery System

10

Conditions

- The capacity of PCS for PV power station is 22 MW in total. (= 44 MW of PV panel)
- The capacity of PCS Rooftop is 2.5 MW in total. (= 3 MW of PV panel)

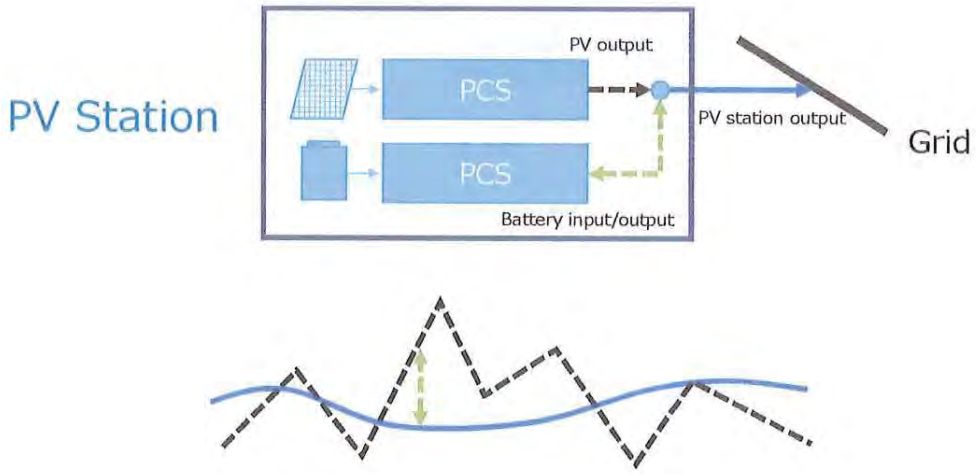
PV fluctuation without battery system is 16,100 kW.
(22 MW x 65% + 2.5 MW x 72%)



This result suggests that the battery system for absorbing the fluctuation must be installed, when the large amount of PV is penetrated.

Concept of Output Control by Battery System

11



- A battery system can smooth an output of a PV station by absorbing its fluctuation.
- In this study, a tentative algorism in which the PV station output is controlled to the average value of PV output in last "T" minutes is applied.

PV station output controlled by the system

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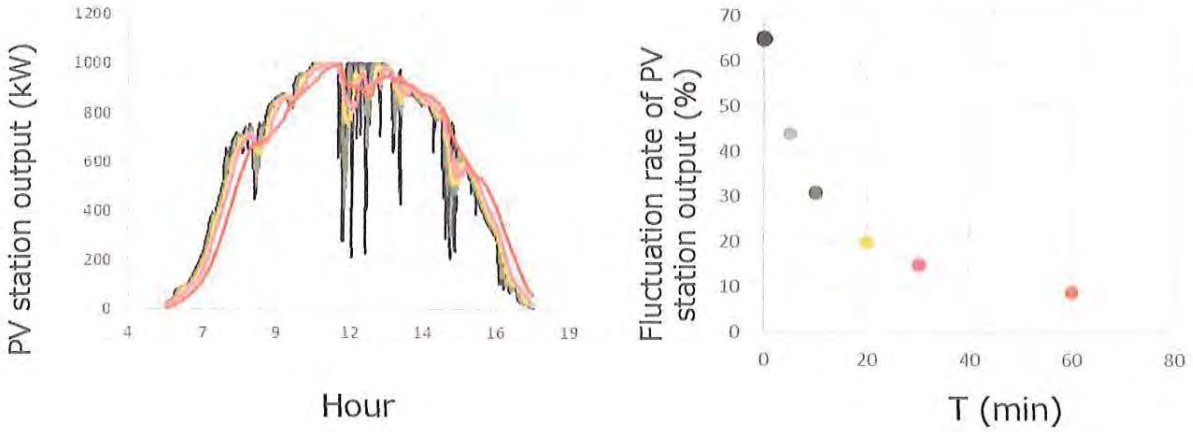
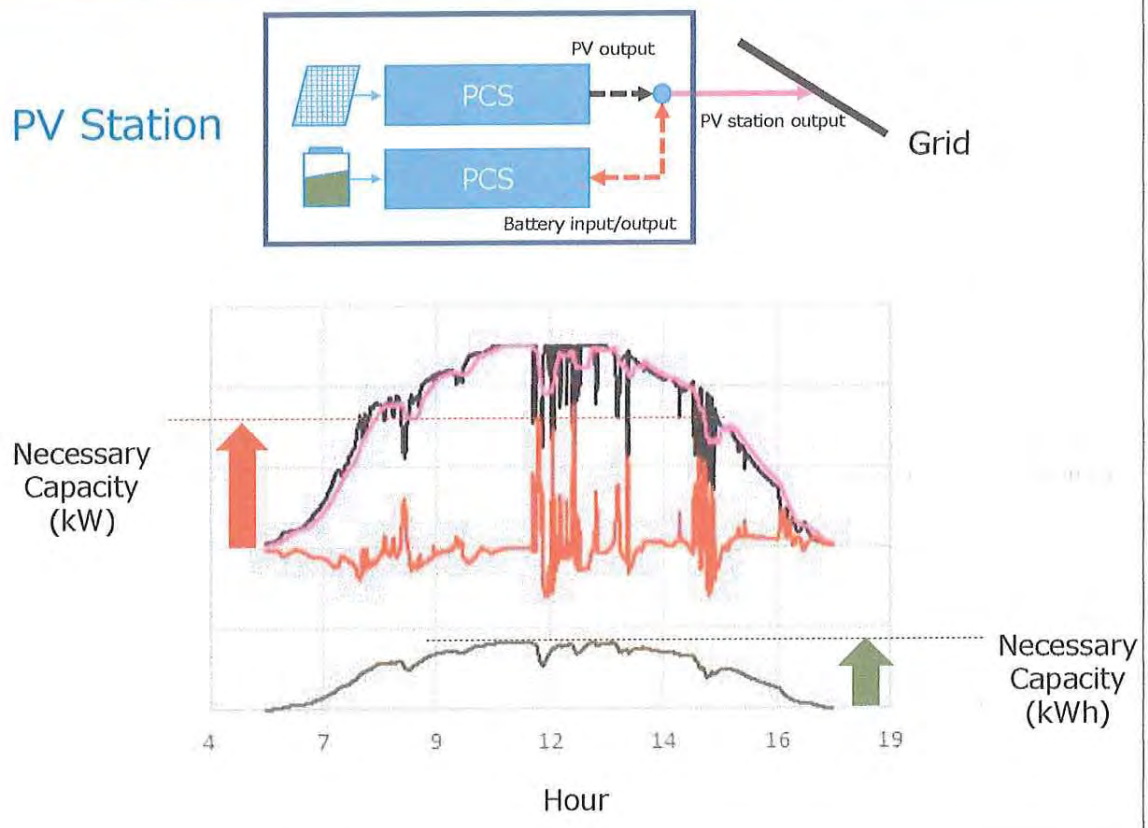


The PV station output becomes smoothly and the fluctuation rate decreases with increasing of "T".

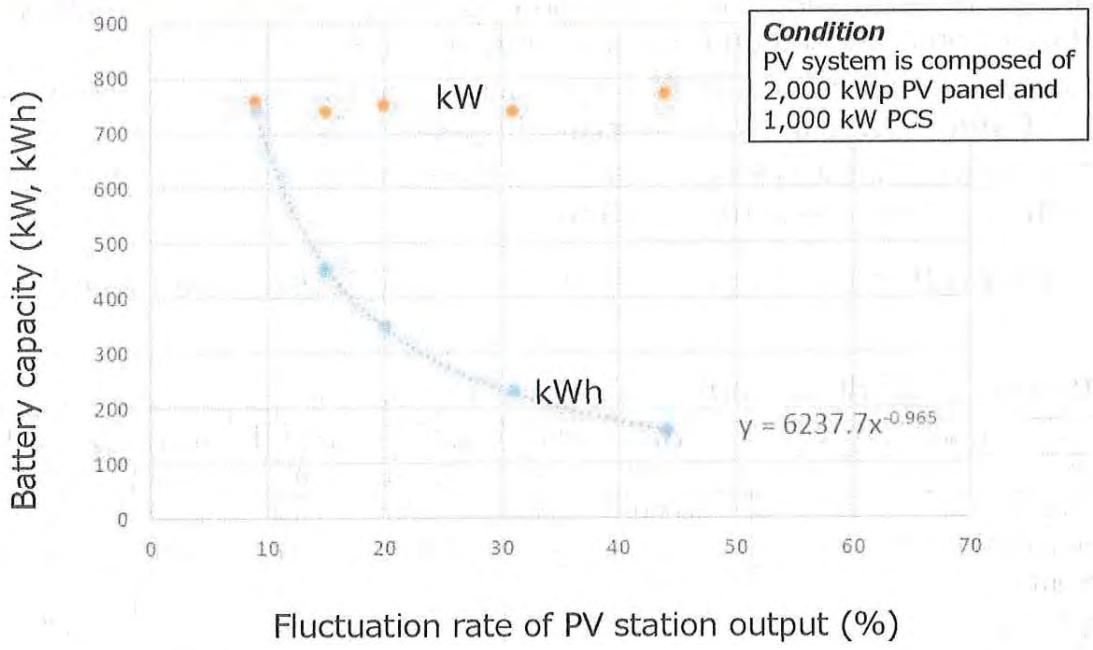
Battery

13



Battery Capacity and Fluctuation Rate

14

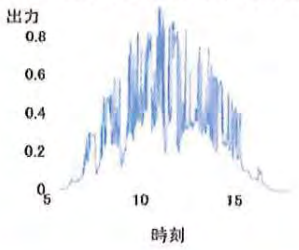


- The fluctuation decreases with increasing the battery capacity (kWh).
- The necessary capacity is estimated from the permissive fluctuation rate.

Smoothing Effect

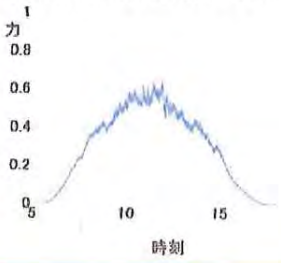
15

Total output of rooftop PV which are concentrated around Koror



Smoothing Effect

Total output of rooftop PV which are distributed around Palau



Permissive fluctuation rate

16

- When a fluctuation of PV station is independently each other, total fluctuation of PV station is estimated by Algebraic method.
- Composited fluctuation of PV output is referred by the formula shown as **$\sqrt{\Sigma}$(Rated power of PCS x fluctuation rate / 100)^2}**
- Rooftops are located in Koror area. So they are regarded to be a PV power station without the battery system.

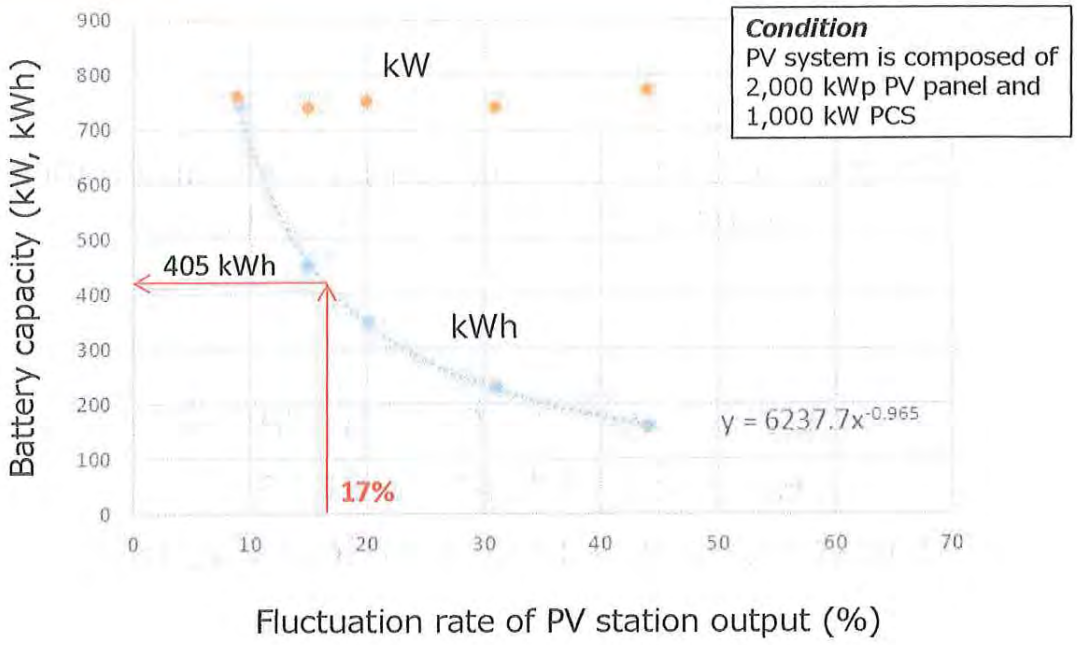
In result, permissive PV fluctuation rate is estimated to be 17%.

(Reference: RE Roadmap)

Values in table crrespond to PCS capacity (kW)

PV Installation Plan	2019	2020	2021	2022	2023	2024	2025
Rooftop	810	1,000	1,170	1,420	1,670	2,000	2,500
Aimeliik	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Ngaramiengui		3,000	3,000	3,000	3,000	3,000	3,000
Ngargmau*						2,000	2,000
Ngargmau**						3,000	3,000
Ngiwal							2,000
Meiekeok					2,000	2,000	2,000
Ngchesar					2,000	2,000	2,000
Ngatpang	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Airport				3,000	3,000	3,000	3,000

Required Capacity for Battery



Condition
PV system is composed of 2,000 kWp PV panel and 1,000 kW PCS

- The necessary battery capacity is estimated to be 425 kWh and 800 kW including margin, for the PV power station consisted with 2MW panel and 1 MW PCS.
- In the result, total capacity is about **9,400 kWh and 17,600 kW in 2025**.

Thank you for your attention.

March 13, 2019
JICA Project Team

Project for Study on Upgrading and Maintenance Improvement of the Grid in Palau

Activities on technical transfer regarding Maintenance of Transmission & Distribution Facilities

Table of contents

3

1. Background

Estimated situation of T&D Facilities	Candidate idea of Pilot Project
Occurrence of many unknown faults → Tree contact to T and D line conductor in Nekken line	(1) Conducting **Tree Management** (in Nekken Line) — Selected (Project 1)
Occurrence of many unknown faults → Inappropriate protection coordination in Nekken line	(2) → protection coordination study had already been done — Not Selected
Occurrence of many unknown faults → insufficient maintenance and inspection of equipment	(3)Conducting **preventive maintenance** (in urban area) — Selected (Project 3)

Two pilot projects were selected for the implementation of Technical transfer

March 13, 2019
JICA Project Team

4

2. Setting up the Pilot Projects

Pilot Project 1

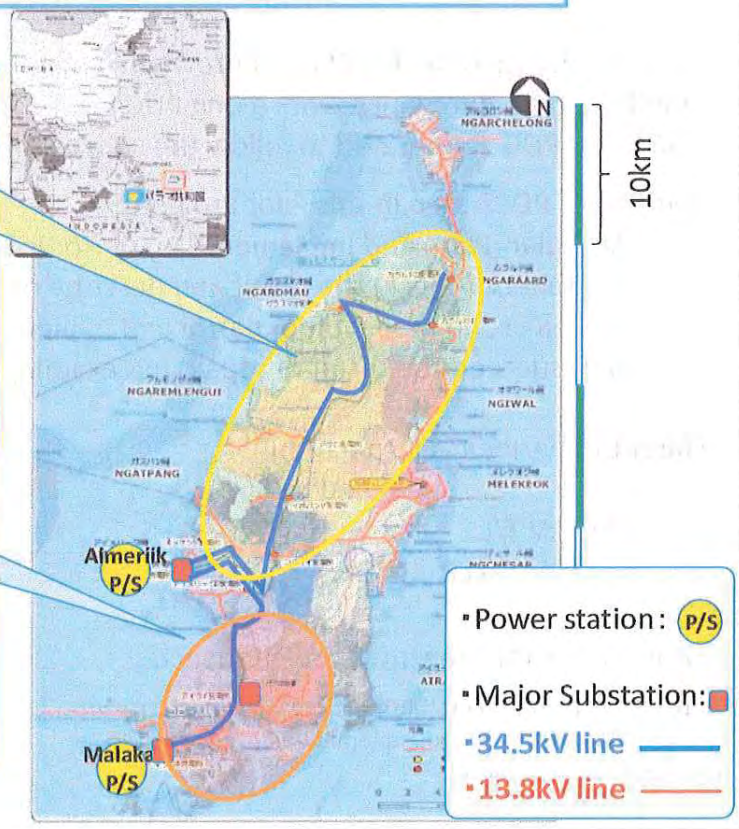
Conducting **Tree management** in Nekken line

✓Installation of **vine-guard**
✓Installation of **OCI** (Over Current Indicator) for detecting frequent fault section

Pilot Project 3

Conducting **preventive maintenance** in urban areas

✓Preparation of manuals for patrol
✓Implementation of maintenance in PDCA steps



3. Activities for Pilot Project 1 / **Tree management** in Nekken line

1. Planned **trimming**

For the 34.5 kV line, PPUC has already implemented planned trimming at a cycle of once / year since 2015.

Time	Status of measures implementation
1. 2015 / 5	Start tree trimming in Babeldaob
2. 2016 / 4	Completion of trimming of the entire Nekken transmission line
3. 2016 / 5	Start of trimming between Aimeriik Power Station - Airai Substation
4. 2017 / 9	JICA project started
5. 2017 / 11	Installation of Vine guard

2. Installation of **vine-guard** (Nov.2017)

Vine guards are installed with the aim of reducing the frequency of trimming due to fast growing.

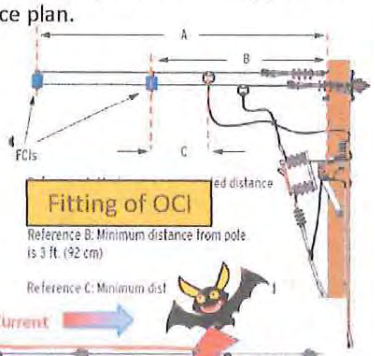
Vine Guard for Pole

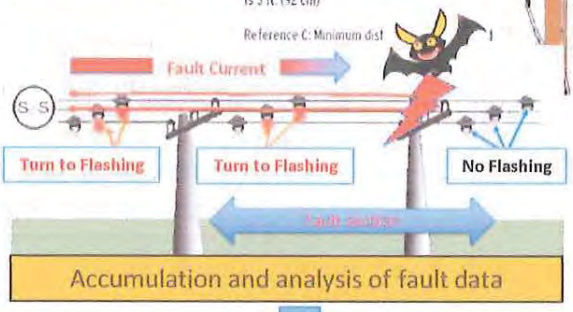
Vine Guard for Guy Wire

3. Installation of **OCI** for detection of frequent fault section (Sep.2018)

Clarifying the frequent fault section and causes contribute reviewing the priority of the trimming plan and optimizing maintenance plan.

Over current indicator





Accumulation and analysis of fault data

✓Detection of problem section
✓Clarification of the true cause

4. Activities for Pilot Project 3 / Conducting **preventive maintenance**

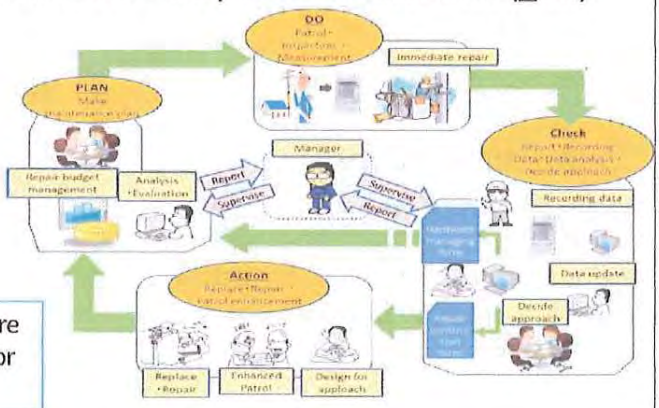
- For the instruction of outline of preventive maintenance, JICA team proposed PPUC to implement maintenance work along PDCA cycle step.
- SCD and PDD cooperated to follow the step as follows;

[Outline of PDCA step in this Pilot Project]

- SCD plan(Plan) and implement(Do) **periodic inspection**.
- SCD check (Check) the result and describe recommendation for maintenance.
- PDD succeed the result of patrol and implement **repair work** (Action).
- SCD succeed the result of repair and examine the next plan of maintenance (Plan).

[Target of periodical inspection]
(planned by SCD)

- 34.5kV T/L
- 13.8kV D/L(Trunk line)



[PDCA cycle for preventive maintenance]

Note : It is required to establish the organizational structure and work operation rule to implement a firm work cycle for preventive maintenance.

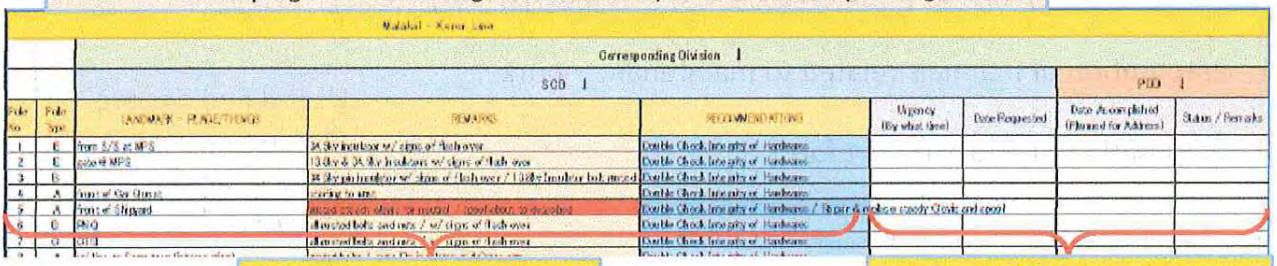
4. Activities for Pilot Project 3 / Conducting **preventive maintenance**

1. Preparation of standards for maintenance work

- ✓Maintenance Guideline of T & D Facilities
- ✓Patrol Check Point Manual

2. Preparation of management form corresponding to PDCA cycle

- ✓ Preparation of Patrol results report and Status management table of Repair work
  → The progress of each stage of the PDCA cycle is consistently managed .



Section for reporting patrol results (SCD)

Section for updating status of Repair work (PDD)

3. Periodic Inspection (Feb. to Mar. 2018 by SCD)

- ✓Finding defective equipment
- ✓Accumulation of data for deterioration judgment and focused inspection

Example of equipment defect

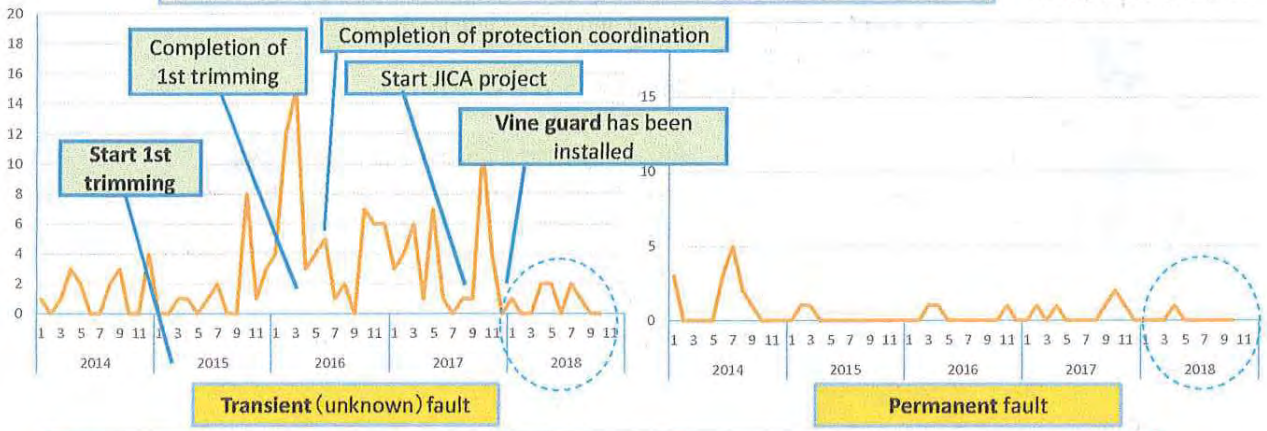
Corrosion rupture of clevis

Rust of arm & U-bolt

5. Summary of achievement (Quantitative effect)

Transition of fault in **Nekken** transmission line

The number of Feeder CB trip is counted here



Transient (unknown) fault

Permanent fault

- ✓The percentage of transient fault accounts for over 90% within two fault conditions.
- ✓Trimming began in May 2015 and finished in Babeldaob by April 2016. (The first round)
- ✓**Transient faults** did not immediately decrease after the countermeasure, but effects appeared with time lag of one year.
  It has **decreased remarkably since December 2017.**
- ✓In 2018,The permanent fault is also decreasing in terms of the year.

It is considered that the main cause of the transient fault was tree contact, and it can be evaluated that **tree trimming and vine guard are effective countermeasures**

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5. Summary of achievement (Qualitative effect)

Pilot project 1 (Tree management)

1) Implementation of **vine-guard** and Establishment of management system

2) Construction of detection system for trees frequent contact section by **overcurrent indicator**
   ① Segmentation of detection section by adding overcurrent indicator
   ② Improvement of fault cause exploration process
   ③ Preparation of a form for detection of frequent fault sections

Pilot project 3 (Preventive maintenance)

1) Preparation of manuals related to maintenance work

2) Preparation of patrol report form

3) Implementation of periodic patrol

Useful findings are obtained from patrol results and fault data analysis. (next page)

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5. Summary of achievement (Qualitative effect)

Breakage of clevis found by patrol

- ✓Neutral clevises are prone to break due to corrosion.
- ✓Such deteriorations are easy to occur on many poles.
- ✓Contact between neutral and power line leads to serious fault.
- ✓This defect seems difficult to find in fault patrol.

Difficult to find the condition in fault patrol

Zoomed picture from when you're at the compact road. Arrow points to the fallen power line. From afar it looks normal.

An example case which broken clevis caused a long time outage

Date: 11/19/18
Time: 5:00am-1:20pm
Feeder affected: Nekken Line/Asahi Substation
Cutout: Line A & B/Ngardmau cutouts
Affected Areas: Entire Babeldaob/Ngardmau to Ngarchelong

Damaged clevis on the power pole supposed to be holding insulator & neutral line. Insulator fell off and neutral line fell too.

The green wire is holding the neutral line from touching the primary lines and placing it right next to the center line that when seen from afar you cannot tell it has fallen.

6. Recommendations

For more stable Implementation of T&D equipment maintenance, points as follows could be taken into consideration.

1) Reinforce of organization and human resources and clarify of business operations

2) Multi-Skilling of Line worker

3) Establishment of standards and thorough informing

4) Completion of facility management data and drawings

Thank you for your attention