9-2 Maintenance of Substation Equipment

9-2-1 Organization and role division for substation equipment maintenance

The System Control Division (SCD) is responsible for considering technical matters such as facility capacity calculations when the substation equipment, 34.5kV transmission lines, 13.8kV distribution lines, and meters are constructed, extended, replaced, and repaired. The management organization is shown in Figure 9-2-1.1. There are 14 staff persons, including the division manager.

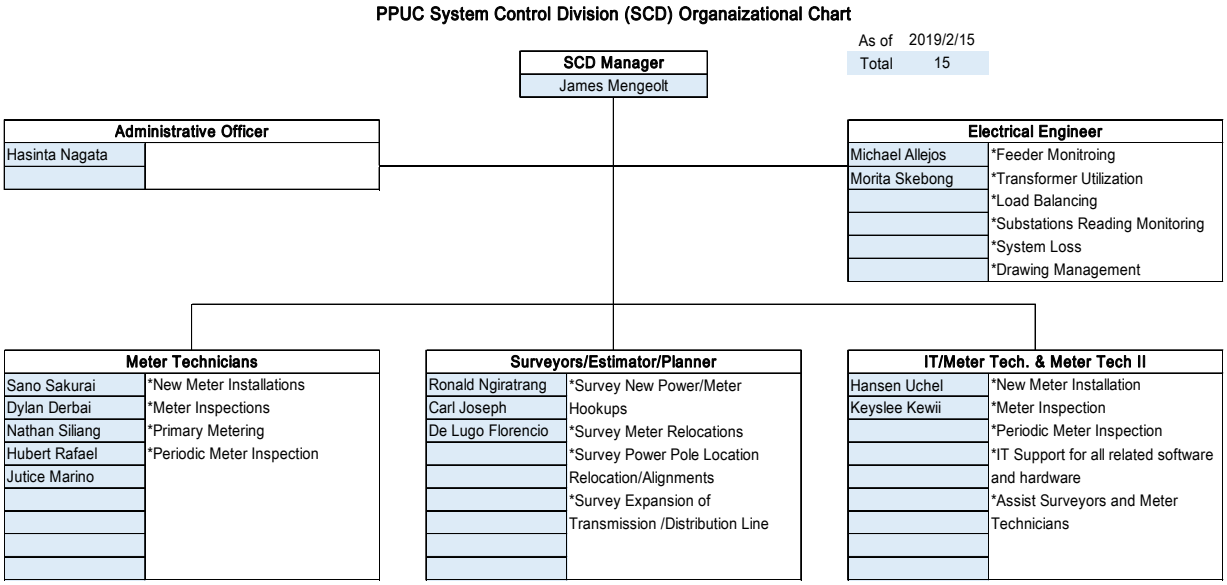


Figure 9-2-1.1 The management organization of SCD

Though SCD and the Power Distribution Division (PDD) are in charge of the substation equipment and transmission/distribution lines in PPUC, respectively, the maintenance work on the substation equipment is shared by SCD and PDD. Specifically, periodic patrols are carried out by SCD. When an accident or equipment failure occurs, the initial response is carried out by PDD regardless of the equipment. In the case of a failure of transformer equipment, on the other hand, a detailed survey is carried out by SCD.

Regarding the replacement and repair work for transformer equipment, on the other hand, the planning and budget requests are carried out by SCD and the work itself is carried out by PDD or a contractor. The work-sharing arrangement for transformer equipment maintenance is shown in Table 9-2-1.1

Table 9-2-1.1 Work-sharing arrangement in substation equipment maintenance

	patrol	Failure		Replace and repair		
		Initial response	Survey of details	Plan	Request budget	Work done by
Transformer equipment	SCD	PDD	SCD	SCD	SCD	PDD or Contractor
(reference) Transmission Line Distribution Line	SCD	PDD	PDD	SCD	PDD	PDD

In order to maintain and operate substation equipment, it will be necessary to practice a PDCA cycle for maintenance. Necessary steps would include, for example, clarifying the roles based on the office organization, formulating and implementing maintenance plans, and taking necessary measures.

The roles of the manager are to consider the balance between quality and cost and to carry out the maintenance work smoothly and safely. The manager should also provide guidance to the staff members to encourage them to feel commitment to the facilities, to help them improve their skills, and to respond appropriately to substation equipment accidents.

The objectives, therefore, are to implement the maintenance work surely, contribute to the customer and society as a whole by ensuring the safety of the staff, and prevent electrical accidents in advance.

The roles of the staff are to recognize the importance of the maintenance work for ensuring safety and the supply of stable electric power and to carry out the maintenance work on the electric equipment based on the applicable laws and working procedures.

9-2-2 PDCA cycle for maintenance work

PPUC does not implement equipment inspections, so we will have them carry out the maintenance PDCA cycle based on the patrol.

① The patrol is carried out to maintain stable facility operation while keeping close track of the degree of facility deterioration, patrol records, histories of accidents and obstacles, and so on.

② The staff formulates a patrol plan for substation equipment through discussion within SCD focused on the patrol records, records of accidents and obstacles, the equipment repair plan, and budget. For the transformers in particular, it is desirable to manage their temperature trends.

The flow of patrol plan formulation is shown in Figure 9-2-2.1.

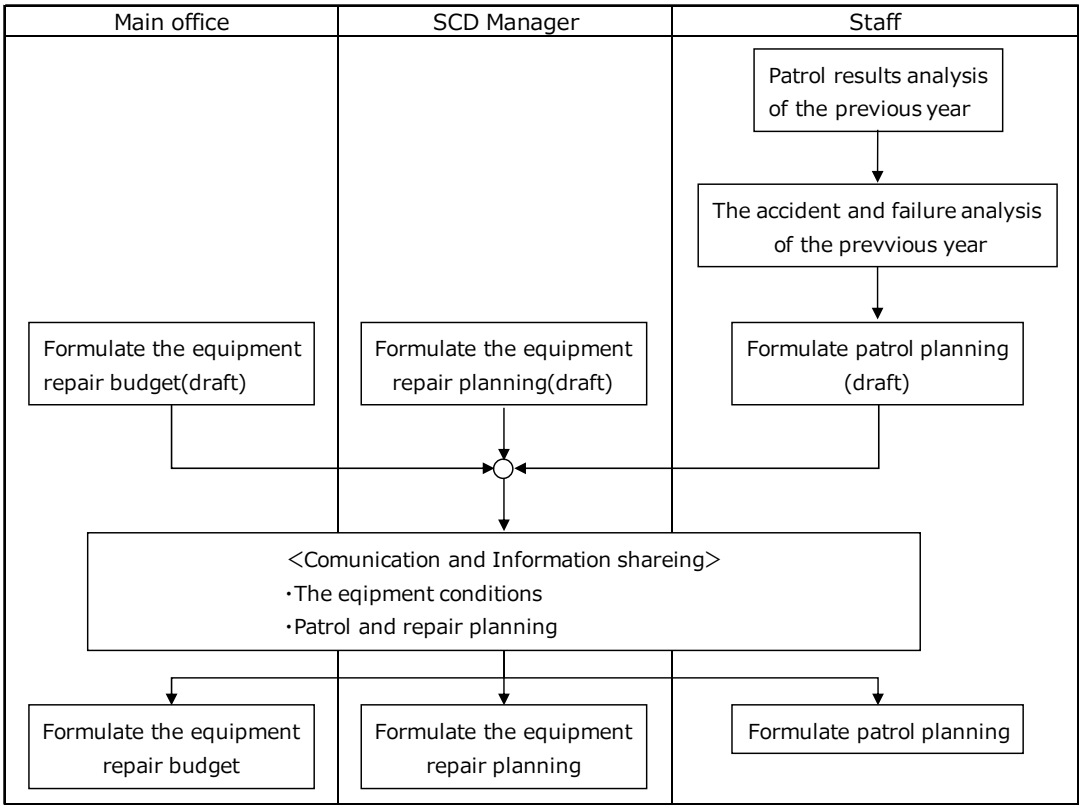


Figure 9-2-2.1 The flow of patrol plan formulation

③ The staff carries out the patrol based on "Appendix-6 Patrol Checklist and Recording Form" and records and keeps the results. During the patrol they listen for abnormal noise from the equipment. Upon discovering a malfunction in the equipment on a patrol, they fill out a "Appendix-7 Accident Injury Criteria Report," share the information and discuss the restoration policy within SCD, and restore the equipment. The patrol working flow is shown in Figure 9-2-2.2.

④ Based on the patrol record and records of accidents and obstacles, SCD formulates an annual repair plan through discussion within SCD and restores the equipment. The flow for formulating a repair plan is shown in Figure 9-2-2.3.

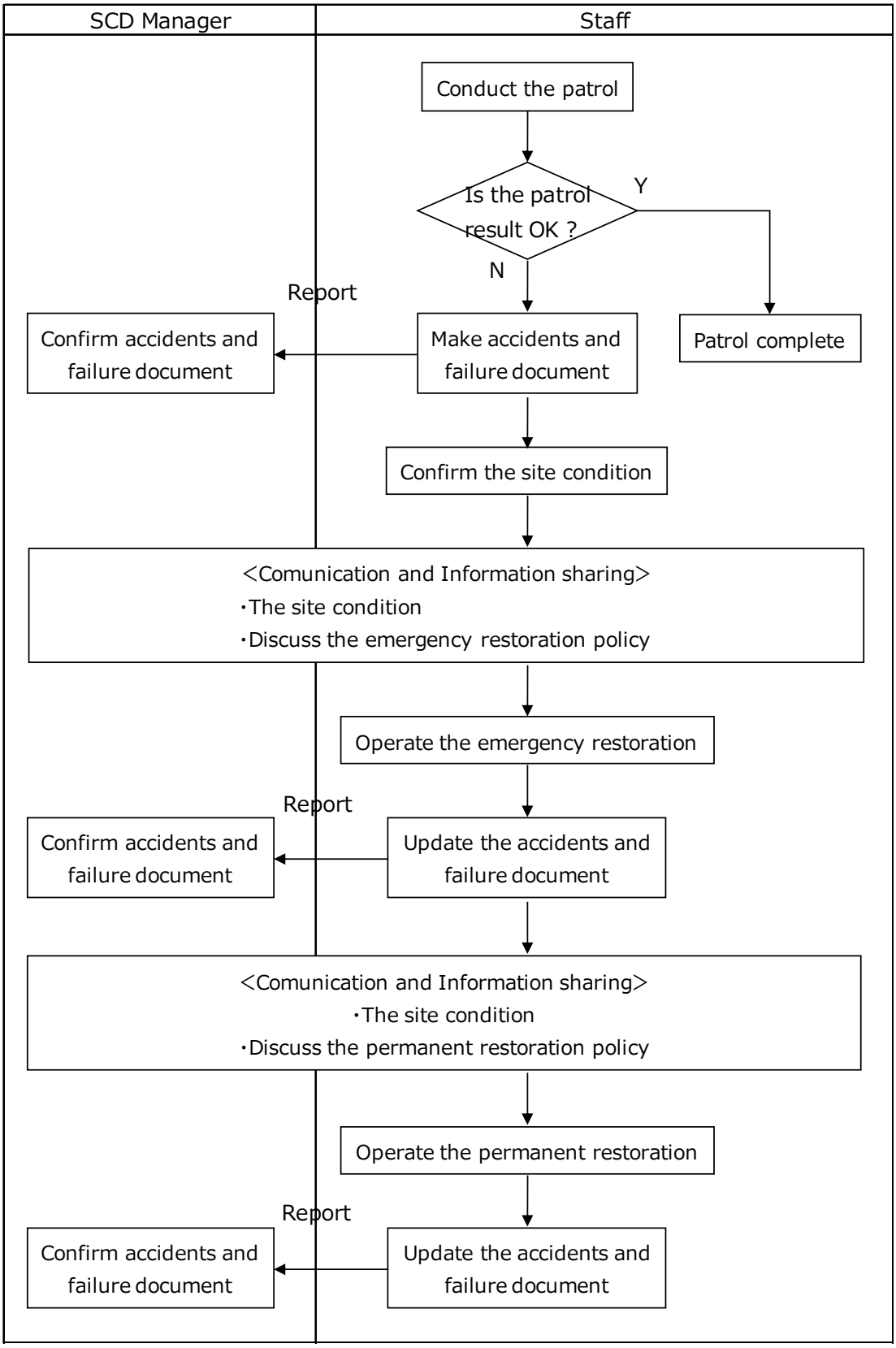


Figure 9-2-2.2 The patrol working flow

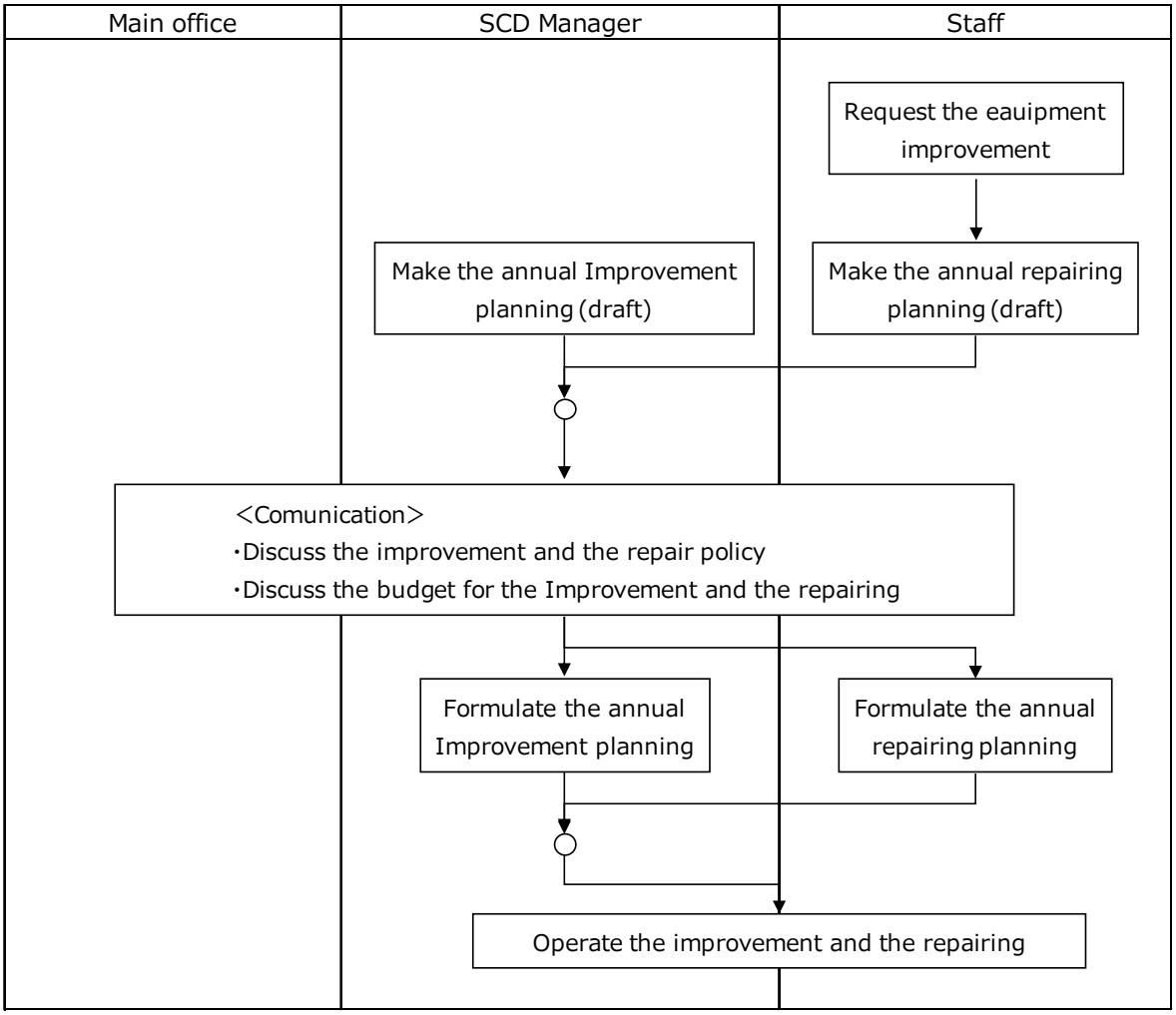


Figure 9-2-2.3 The flow for formulating a repair plan

9-2-3 Methodology for Making Repair Plan Decisions

Regarding transformers, circuit breakers, and disconnections, the main circuit facilities, we will set the replacement interval at about 40 years as a guideline. In setting the budget, we will look to the repair criteria shown in Appendix-8 for guidance while considering the condition of the obstacles.

The oil leaks and temperature rises in the transformers, abnormal smells and noise in the circuit breakers, and overheating in disconnecting switches all require attention. Soot will accumulate inside an oil circuit breaker in the course or repeated current breaking failures. Hence, the oil circuit breakers should ideally be replaced with vacuum circuit breakers, an easier type of equipment to maintain, in the equipment renewal.

9-2-4 The Maintenance Data Control

The equipment specifications (rated current and voltage, manufacturer, etc.) of each substation are not managed in Palau. Moreover, the single line diagram remains unchanged from the original version at completion, with no updates. To grasp the equipment condition, it will be necessary to keep the equipment specification data up to date at all times. We propose that PPUC modify the single line diagram (Appendix-4) we have prepared, every time a piece of equipment is updated.

From the viewpoint of managing the equipment individually, we also propose that the manager advise the staff to organize and keep historical records on the maintenance, patrols, repairs, accidents, and obstacles.

9-2-5 The Maintenance Analysis Evaluation

To improve the maintenance work on a continuous basis, the manager analyzes and evaluates the maintenance work results.

The staff members on patrol, meanwhile, confirm the difference between the plan and actual result, and analyze the factors responsible for the difference. Then they improve the patrol plan and operation rules by evaluating the countermeasures.

Regarding accidents and obstacles, the staff members analyze the number of occurrences and causal factors from the accident and obstacle report. They then evaluate the adequacy of the measures and incorporate the measures into the patrol plan and repair plan. Lastly, they improve the operation rules such as the patrol time and replacement time.

9-2-6 The Maintenance Analysis Evaluation

(1) In the current organization, SCD asks PDD to take countermeasure against equipment failures when SCD discovers issues with the transmission line and distribution line facilities. SCD, however, cannot recognize whether an issue has been fully addressed, and thus is forced to repeatedly make the same countermeasure request. PDD, therefore, should carry out the patrol as the department with expert experience. SCD, meanwhile, does not carry out patrols on the substation equipment. To prevent serious failures in advance, SCD should carry out the patrol for the substation equipment and record the information useful for making replacement and repair plans. The same information should also be made available for making budget requests.

(2) When we inspected the oil replacement work at the existing transformer at Aimeliik substation, we confirmed that no electroscopes or ground wires were used. We therefore propose the use of voltage checkers (we will provide them) and ground wires to ensure their safety, given that inspections of the facility are expected to increase in the future.

9-2-7 Attack and Achievement for the Establishment of Equipment Maintenance

(1) Establishment of the patrol

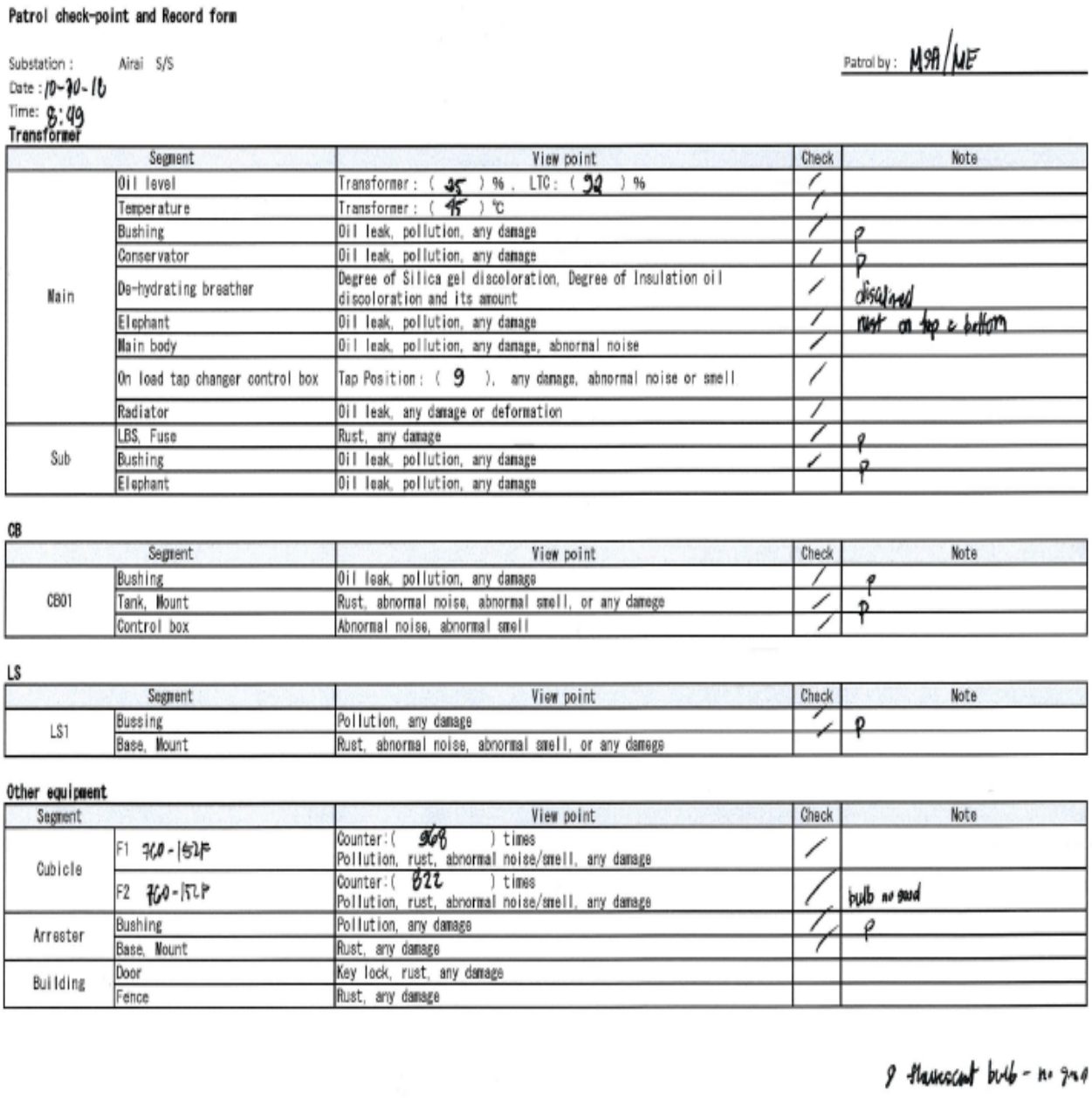
- **<u>Tackle</u>**

SCD does not carry out patrols for the substation equipment and thus is unable to grasp the equipment condition. Further, it lacks the structure to prevent serious failures in advance. To respond, we prepared a Patrol Checklist and Recording Sheet enumerating the items to be confirmed for each piece of equipment on a patrol (see Appendix-1). In addition to providing the Patrol Checklist and Recording Sheet to PPUC, we visited sites together with PPUC personnel to provide training on the checkpoints for the patrols. We also established fixed patrol procedures by providing advice as necessary. Then we recommended that PPUC manage the checklist and regularly confirm the equipment condition trend in

order to preempt serious failures and gather supporting material for budget requests.

- **Achievement**

Through the teaching and advice it received, PPUC gained the capacity to independently carry out safe patrols adequate for each type of equipment. And by recording the patrol data and managing the checklist, PPUC was able to grasp the condition of each type of equipment and attained a structure to prevent serious failures in advance. PPUC also made the patrol schedule by itself and thus was able to carry out the patrols of each substation steadily once a month. The patrols, therefore, were established.



Patrol check-point and Record form

Substation : Airai S/S
Patrol by : MSA/ME
Date : 10-30-16
Time: 8:49

Transformer

Segment		View point	Check	Note
Main	Oil level	Transformer : (85) % , LTC : (92) %	✓	
	Temperature	Transformer : (45) ℃	✓	
	Bushing	Oil leak, pollution, any damage	✓	P
	Conservator	Oil leak, pollution, any damage	✓	P
	De-hydrating breather	Degree of Silica gel discoloration, Degree of Insulation oil discoloration and its amount	✓	discolored
	Elephant	Oil leak, pollution, any damage	✓	rust on top & bottom
	Main body	Oil leak, pollution, any damage, abnormal noise	✓	
	On load tap changer control box	Tap Position : (9), any damage, abnormal noise or smell	✓	
	Radiator	Oil leak, any damage or deformation	✓	
Sub	LBS, Fuse	Rust, any damage	✓	P
	Bushing	Oil leak, pollution, any damage	✓	P
	Elephant	Oil leak, pollution, any damage		

CB

Segment		View point	Check	Note
CB01	Bushing	Oil leak, pollution, any damage	✓	P
	Tank, Mount	Rust, abnormal noise, abnormal smell, or any damage	✓	P
	Control box	Abnormal noise, abnormal smell	✓	

LS

Segment		View point	Check	Note
LS1	Bussing	Pollution, any damage	✓	P
	Base, Mount	Rust, abnormal noise, abnormal smell, or any damage		

Other equipment

Segment		View point	Check	Note
Cubicle	F1 760-1627	Counter:(968) times Pollution, rust, abnormal noise/smell, any damage	✓	
	F2 760-1572	Counter:(822) times Pollution, rust, abnormal noise/smell, any damage	✓	bulb no good
Arrester	Bushing	Pollution, any damage	✓	P
	Base, Mount	Rust, any damage	✓	
Building	Door	Key lock, rust, any damage		
	Fence	Rust, any damage		

P fluorescent bulb - no good

Figure 9-2-8.1 Example of a patrol checklist（filled out by PPUC）

Figure 9-2-8.2 Technical transfer of patrol procedures

(2) Suggestions for substation equipment maintenance

- **Tackle**

PPUC has not replaced the silica gel in their transformers since they were installed. This condition could compromise the transformer insulation, which in turn could pose an obstacle to equipment maintenance. In addition to mentioning the need for silica gel replacement, we supplied silica gel to PPUC and oversaw its replacement. We also reminded PPUC of the need to replace the silica gel regularly to ensure transformer insulation.

Other transformer types of equipment such as the LSs (Line Switches) are heavily rusted. PPUC has been unable to perform maintenance on the LSs since they were installed. Poor conductivity, therefore, might pose an obstacle to steady supply. We responded by providing grease for transformer equipment maintenance and proposed that regular maintenance be performed using grease.

- **Achievement**

By carrying out the silica gel replacement and transformer equipment maintenance using grease, PPUC came to better understand the need for regular equipment maintenance.

Figure 9-2-8.3 Silica gel replacement

Before After

Figure 9-2-8.4 Before and after of replacement

(3) Development of a safety-minded culture

- Tackle

  PPUC had not been carrying our voltage checks, so we provided them with voltage checkers. In addition to explaining the purpose of the voltage checkers and how to use them, we proposed that PPUC personnel carry them while working on patrols and the like.

- Achievement

  PPUC personnel always carry voltage checkers while working, including on the patrols, and their awareness of safety has improved. SCD also provided feedback to PDD to develop a safety-minded culture in all of PPUC.

Figure 9-2-8.5 Voltage checker

(4) Lecture on fault calculation

- Tackle

  We presented lectures to SCD and PDD on: “Outline of the %Z method,” “How to calculate fault currents using the %Z method,” and “How to calculate the distance to a fault point.” Each lecture was followed by exercises on the basic contents for setting protection relays, deciding the rated breaking current of a CB (Circuit Breaker), and fault analysis.

- Achievement

  By presenting lectures with exercises on the basic details of fault calculation, we were able to improve both the technical calculation skills and knowledge in PPUC. We also recommended that they provide feedback on the skills and knowledge learned from the lectures in PPUC.

Figure 9-2-8.6 The lecture on fault calculation

Figure 9-2-8.7 Exercise

CHAPTER 10 Pre–Feasibility Study

Chapter 10 Pre–Feasibility Study

10-1 Basic Concept

Based on the transmission and distribution master plan, a pre-feasibility study for the project will be carried out after a comparative examination.

10-2 Methodology to select the priority project

STEP 1：Extraction components based on the results of the transmission and distribution master plan in order to determine a project package.

As shown in the following Table 10-2.1, the necessary reinforcements for the distribution and substation facilities that are not influenced by the introduction of grid-connected PV system are extracted from the components of the transmission and distribution master plan.

Table 10-2.1 Transmission, distribution, and substation facility plan

Step	Period	RE roadmap	ID	Year	Facility	Main Objective	Outline
1	by 2020	Phase1	1-1	2020	T&D	Improved manageability of maintenance	■ Relocation of the existing 34.5 kV Transmission Line ・ Transmission line (41.8 km) Airai – Aimeliik - Ngaraard 2 ・ Distribution line (4.6 km) Ngaraard 1 ・ Countermeasure against power outage
			1-2	2020	SS	Improved manageability of maintenance	■ Relocation of existing substations ・ Ngardmau ・ Ngaraard 1 ・ Ngaraard 2
			1-3	2020	SS	Improved power supply reliability	■ Construction of Koror substation ・ 34.5/13.8 kV 1 bank x 10MVA
			1-4	2020	D	Improved power supply reliability	■ Construction of 13.8 kV distribution line ・ 1 feeder (2 km) x 13.8 kV distribution line
			1-5	Within the period	SS	For grid protection and maintenance	■ Installation of circuit breaker panel ・ Grid-connected PV system (Aimeliik)
			1-6	Within the period	SS	For grid protection and maintenance	■ Installation of pole-mounted switches ・ Grid-connected PV system（Ngatpang (Kokusai)） ・ Grid-connected PV system（Ngaremlengui）
2	2021 - 2023	Phase2	2-1	2023	T	For grid-connected PV system and improved power supply reliability	■ Construction of 34.5 kV transmission line ・ Transmission line (33.5 km) Malakal – Melekeok PV site ・ Cabling (0.6 km at KB bridge)
			2-2	2023	SS	Improved manageability of maintenance	■ Expansion of Malakal substation ・ Expansion of Malakal outgoing feeder bay
			2-3	Within the period	SS	For grid protection and maintenance	■ Installation of pole-mounted switches ・ Grid-connected PV system（Airai Airport） ・ Grid-connected PV system（Ngchesar） ・ Grid-connected PV system（Mlelekeok）
3	2024 - 2025	Phase3	3-1	2025	T&D	For grid-connected PV system and improved power supply reliability	■ Construction of 34.5 kV transmission line ・ Transmission line (13.9 km) Melekeok PV site - Ngaraard 1 ・ Expansion of outgoing feeder at Ngaraard 1
			3-2	Within the period	SS	For grid protection and maintenance	■ Installation of pole-mounted switches ・ Grid-connected PV system（Ngiwal） ・ Grid-connected PV system（Ngardmau（Terraces of Hill）） ・ Grid-connected PV system（Ngardmau）

[Remarks] T&D, Transmission and Distribution facilities; T, Transmission facilities; D, Distribution facilities; SS, Substation facilities
Candidate components for the feasibility study are framed in bold borders.
[Source] JICA Study Team

As shown in Table 10-2.2, the necessary reinforcements for transmission, distribution, and substation

facilities that are not influenced by grid-connected PV system are extracted after the project package is determined.

Table 10-2.2 Candidate projects

Project	ID	Outline
1	1-1	■ Relocation of the existing 34.5 kV transmission line ・ Transmission line (41.8 km) Airai – Aimeliik - Ngaraard 2 ・ Distribution line (4.6 km) Ngaraard 1 ・ Countermeasures against power outages
	1-2	■ Relocation of existing substations ・ Ngardmau ・ Ngaraard 1 ・ Ngaraard 2
2	1-3	■ Construction of Koror substation ・ 34.5/13.8 kV 1 bank x 10MVA
	1-4	■ Construction of 13.8 kV distribution line ・ 1 feeder (2 km) x a 13.8 kV distribution line
	2-1	■ Construction of 34.5 kV transmission line ・ Transmission line (33.5 km) Malakal – Melekeok PV site ・ Cabling (0.6 km at KB bridge)
	2-2	■ Expansion of Malakal substation ・ Expansion of Malakal outgoing feeder bay
	3-1	■ Construction of 34.5 kV transmission line ・ Transmission line (13.9 km) Melekeok PV site - Ngaraard 1 ・ Expansion of outgoing feeder at Ngaraard 1

[Source] JICA Study Team

STEP 2：Set up the criteria for the priority evaluation

Five evaluation criteria are adopted for the priority evaluation

The weights for the criteria are assigned based on the background of the project and the challenges that PPUC has been facing, as confirmed through the field survey. The most important criteria are Reliability (stable power supply) and Urgency (reduction of power outages), and followed by Economic Efficiency, Environemental and Social Impacts.

Table 10-2.3 Criteria for the evaluation to select the priority project

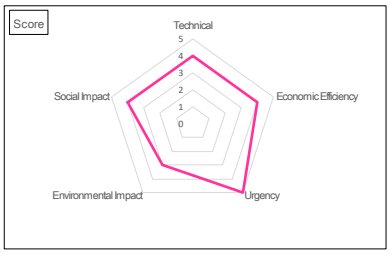
No.	Criteria	Weight
1	Reliability (stable power supply)	25%
2	Economic Efficiency	20%
3	Urgency (reduction of power outages)	25%
4	Environmental	15%
5	Social Impact	15%

STEP 3：Grading for the priority evaluation

The evaluation points were computed by taking advantage of the grading in the five-step evaluation of the criteria prepared in STEP 2 and the weights assigned thereto. Neverthless, the qualitative impact is adopted as an evaluation point in this pre-feasibility study stage.

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 (Aimeliik – Ngaraard 2)
ID 1-2: Replacement of Ngardmau, Ngaraard 1, Ngaraard 2 Substation facilities

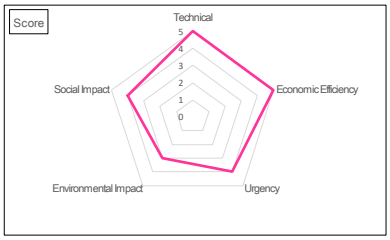
Main Objective: Adequate maintenance and improvement of power supply reliability
Remarks: Three substation facilities should be replaced in parallel with the relocation of the existing 34.5kV transmission line facilities



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 adequate line route and locatoin of substation facilities.	4	15%	0.60
			Total	**20**	**100%**	**4.10**

[Remark]Evaluation Score: Low1<Average3<High5

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 completion 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

STEP 4 : Select the target projects for the pre-feasibility study

The evaluation results are shown in Table 10-2.4. Although Project 2 was evaluated to have higher priority, both projects will be targets for the pre-feasibility study.

Table 10-2.4 Results of the evaluation of the projects for the pre-feasibility study

Priority	Project	Achievement	Com. ID	Project	Evaluation Score	Pre-FS Study	Remarks
1	2	Improvement of Power Supply Reliability		**Construction of Koror Substation**	4.30	Yes	Tentative rough cost estimation is approx. 16.9 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			
2	1	Improvement of Maintenance Manageability		**Improvement of 34.5kV Existing Transmission Line**	4.10	Yes	Tentative rough cost estimation is approx. 13.0 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			

[Remarks] Evaluation Score: Low1<Average3<High5,
Concerning Priority 1, the cost related to the RE roadmap is not included in the estimation.
[Source] JICA Study Team

10-3 Concept Planning for the Priority Projects

10-3-1 Improvement of the Existing Transmission Lines (Project 1)

10-3-1-1 Improvement of the existing transmission and distribution line

The preliminary design work for the improvement of the existing transmission lines has been conducted to secure adequate maintenance and power supply reliability of the power system.

(1) Planned construction work on the transmission and distribution lines

The following construction works for transmission and distribution lines are planned.

· 34.5 kV transmission lines
(Nekken transmission line and Aimeriik - Malakal transmission line)
· Relocation of the transmission line (sections along Compact Road)
· Separation of the double-circuit of the transmission line (section from Aimeriik power station and Nekken substation)
· 13.8 kV distribution
· Construction of distribution lines (Ngaraard 1 and Ngaraard 2 substation area)
· Diversion of the existing 34.5 kV line to a 13.8 kV line (Ngardmau substation area)

(2) Outline of the design

The design of the construction has been outlined based on the policy and method used for the new construction of transmission and distribution lines to be described later.

(3) Summary of main construction materials

Table 10-3-1-1.1 summarizes of main construction materials to be used, as calculated through the preliminary design work.

Table 10-3-1-1.1 Summary of construction materials (transmission and distribution lines)

	Material	Type	Number
34.5 kV transmission line (54 km)			
	Support	Concrete pole	794 poles
	Conductor （34.5 kV line）	34 kV　aluminum insulated wire 150 mm2	161 km
	Conductor （ground line）	HDCC　34 mm2	54 km
13.8 kV Distribution line (6 km)			
	Support	Concrete pole	114 poles
	Conductor （34.5 kV line）	AAC　150 mm2	18 km
	Conductor （ground line）	HDCC　34 mm2	6 km

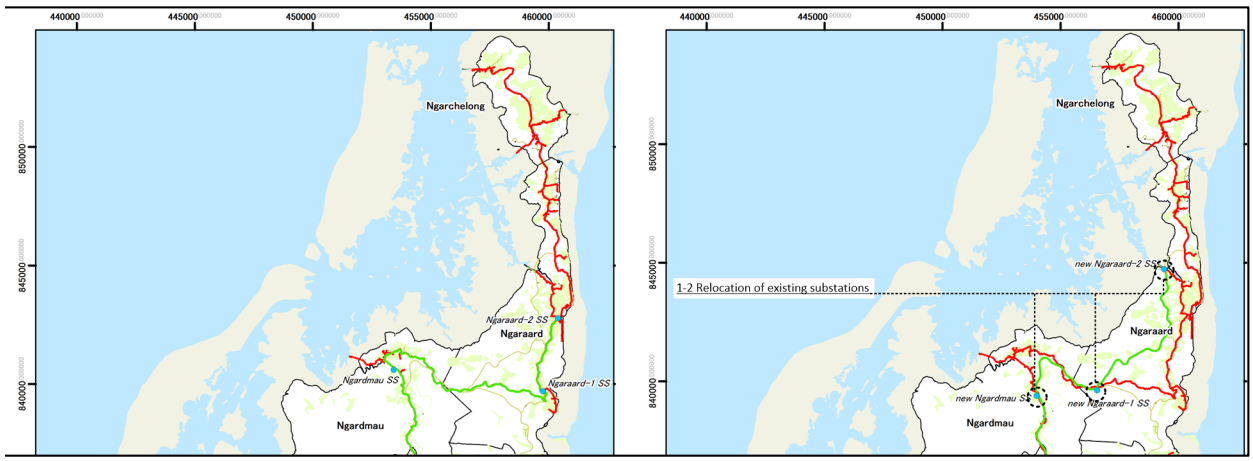
10-3-1-2　Replacement of substation facilities

(1)　Basic concept

The following substation facilities will be relocated along the relocated transmission and distribution lines.

■ Targets for substation facility replacement
- Ngardmau
- Ngaraard 1
- Ngaraard 2

(2)　Relocation



Before　　After

Figure 10-3-1-2.1 Relocation of substation facilities

(3)　Substation Facilities

The target substation facilies are shown in Table 10-3-1-2.1

Table 10-3-1-2.1 Substation facilities and specifications

Equipment	Specifications	Quantity
Ngardmau substation		
34.5 kV/13.8 kV TrB	75 kVA (1-phase)	3
34.5 kV LBS	200A, 10kA/s	1
34.5 kV LAr	10kA (3-phase)	1
34.5 kV Open Fuse Cutout	8kA	3
13.8 kV Open Fuse Cutout	8kA	3
13.8 kV LAr	5kA (3-phase)	1
Removal of old equipment		1
Ngaraard 1 substation		
34.5 kV/13.8 kV TrB	75 kVA (1-phase)	3
34.5 kV LBS	200A, 10kA/s	1
34.5 kV LAr	10kA (3-phase)	1
34.5 kV Open Fuse Cutout	8kA	3
13.8 kV Open Fuse Cutout	8kA	3
13.8 kV LAr	5kA (3-phase)	1
Removal of old equipment		1
Ngaraard 2 substation		
34.5 kV/13.8 kV TrB	750 kVA (3-phase)	1
34.5 kV LBS	200A, 10kA/s	1
34.5 kV LAr	10kA (3-phase)	1
34.5 kV Open Fuse Cutout	8kA	3
13.8 kV Open Fuse Cutout	8kA	3
13.8 kV LAr	5kA (3-phase)	1
Removal of old equipment		1

10-3-2 Construction of New Transmission Lines (Project 2)

10-3-2-1 Construction of new transmission and distribution lines

The preliminary design work has been conducted for the construction of the transmission, distribution, and substation equipment necessary for building the power system based on the master plan.

(1) Plans for the new construction of transmission and distribution lines

The plans for the new construction of transmission and distribution lines are as follows.

- 34.5 kV transmission line (from Malakal power station to Ngaraard1 substation)
- 13.8 kV distribution line (Koror substation feeder)

1) Selection of the transmission and distribution line route

The line routes for the transmission and distribution lines have been selected in consideration of the following requirements.

1. The safety and efficiency of the work for construction and maintenance of the lines will be secured. (It will be easy to use trucks, for example, near the equipment.)
2. The lines can be easily patrolled and inspected.
3. Routes subject to any of the following conditions should be avoided, insofar as possible.
   - Roads not sufficiently maintained, as poorly maintained road conditions would

imperil any trucks and linesmen that entered them.
- Roads in mountainous or damp terrain that is difficult to pass through.
- Places foreseen to be susceptible to high risk of equipment damage from landslides and floods.

2) Selection of the system type (overhead or underground)

As the comparison of the merits of the various system types shows (see Table **10-3-2-1.1**), the underground system has the advantages of low visual intrusiveness and freedom from disruption by contact with trees and wildlife. On the other hand, the cost of constructing an underground system far exceeds the cost of constructing an overhead system. The construction of an underground system would also require PPUC to secure additional tools and skilled personnel for maintenance. In view of these burdens, the overhead system will be selected as the standard type in this study and the underground system will be applied only for limited sections where it is essentially needed.

Table 10-3-2-1.1 Merits and demerits of using an underground system in PPUC (Comparison with an overhead system)

Aspect	Merit	Demerit
Construction cost		Much higher construction cost versus an overhead system
Environment	Low visual intrusiveness	
Maintenance		The maintenance of the underground system would require PPUC to secure additional maintenance tools and skilled personnel.
Network reliability	Effective for avoiding disruptions from contact with trees and wildlife	Cable damage could result in long blackouts because of the extra time required for underground restoration work.

3) Finalization of the transmission and distribution line route

The following routes for the transmission and distribution lines have been selected in consideration of the above-mentioned policy.

a) Line route on Babeldaob Island

The route for the new overhead transmission line will be constructed along trunk roads such as Compact Road.

For sections with the existing 13.8 kV distribution line, a new route will be constructed on the opposite side of the road.

At points where an existing distribution line is partially installed across the road, the partial stretch of line on the opposite side of the road will be replaced with new line so that the line does not cross the road (see Figure 10-3-2-1.1).

If there is no space to install a new pole, a multi-circuit will be installed on the pole by remodeling or replacing the existing pole into/with a longer one.

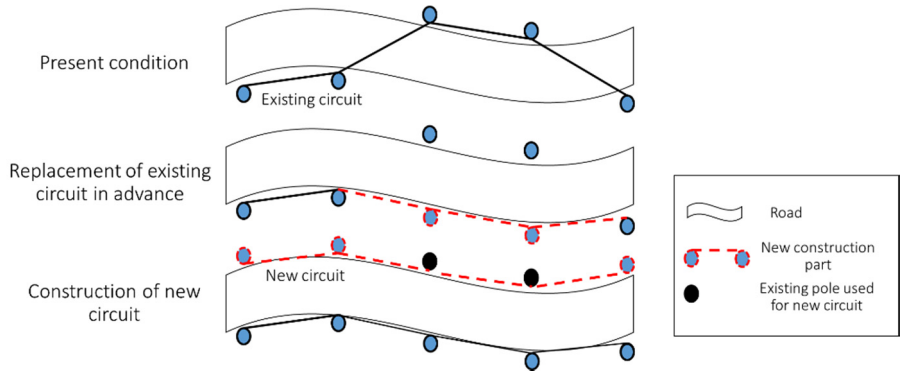


Figure 10-3-2-1.1 Procedure for the construction of new line (Where existing lines are partially installed across the road)

b) Line route around KB bridge

The new power cable will be laid in the space already secured inside the KB Bridge structure. The underground conduit will be constructed between the handhole adjacent to KB Bridge and the pole for the overhead line connection.

Figure 10-3-2-1.2 Situation around the hand hole adjacent to KB bridge

c) Line route in Koror Island

A new overhead line will be constructed along the "main road," a trunk road on the island. In places where power transmission lines already exist, the new transmission line is to be installed by the same procedure shown Figure 10-3-2-1.1.

In places where it is difficult to secure the space to install a new pole (as shown in the example in Figure 10-3-2-1.3), a multi-circuit will be installed on the pole by remodeling or replacing the existing pole into/with a longer one. In the section from new Koror substation to the entrance of Koror downtown, a total of two transmission lines and two distribution lines are planned as the final form. The surveying, examination of the pole arrangement, and strengthening of design will therefore be conducted in greater detail. If proper clearance is difficult to secure, the use of cable can also be considered as a design option.

Figure 10-3-2-1.3 A place where it will be difficult to secure the space necessary for new pole installation (example)
(Near the entrance of Koror downtown)

4) Measures to avoid long-term power outages for construction work

The power supply through the existing lines will have to be interrupted during the construction work for relocation and remodeling of the existing transmission and distribution lines. The following points are to be considered in the construction work planning in order to avoid prolonged power outage periods.

- The erection of new poles and installation of wiring in the newly construction sections should be carried out beforehand, leaving only the conductor connection work to be handled during the power outage period (in order to minimize the period without power for customers).
- If there are important areas where no outages are permissible, temporary power supply using bypass cables and emergency generators will be considered.

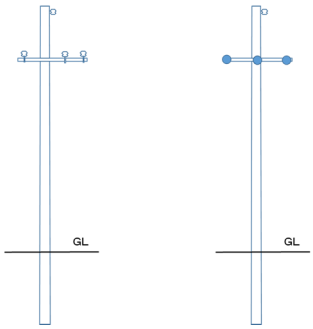
5) Outline of the preliminary design

a) Supports

The supports will be concrete poles with high corrosion resistance, as has been arranged with the existing transmission lines. The new support poles will have the same specifications as the existing poles, as outlined in Table 1. To reduce the risk of power outages due to contact with trees, longer type poles (16 m) will basically be applied for the transmission lines. Two examples of typical pole fitting styles are shown in Figure 10-3-2-1.4.

Table 10-3-2-1.2 Outline of supports

length	Load design	Application style
16 m	700 kg	・Single 34.5 kV circuit ・Double 34.5 kV circuit（where PV interconnection lines are to be installed） ・Single 34.5 kV circuit + Single 13.8 kV circuit
13 m	700 kg	・Single 13.8 kV circuit



Straight pull pole　　Angle pole

Figure 10-3-2-1.4　Typical pole arrangements

b) Conductor

As the conductor for the transmission line, insulated wire will be applied in order to reduce the influence of power outages due to contact with and trees and wildlife. The conductors for the distribution line and ground line will be the same types used for the existing lines.

Table 10-3-2-1.3 Outline of conductor types

Category	Types of conductor	Size
34.5 kV line	Aluminum conductor cross-linked polyethylene insulated wire	150 mm^2
13.8 kV line	AAC (all aluminum conductor)	150 mm^2
Ground line	HDCC (hard-drawn copper stranded conductor)	34 mm^2

c) Power cable

The power cable to be installed in KB bridge will be the same type installed in the existing line: CV (cross-linked polyethylene insulated vinyl sheath) cable consisting of four conductors, each with a cross-section area of 250 mm2. Three of the four conductors are to be used for regular power transmission and the fourth will serve as a spare.

6) Summary of main construction materials

Table 10-3-2-1.4 summarizes the main construction materials determined to be necessary through the preliminary design work.

Table 10-3-2-1.4　Summary of construction materials (transmission and distribution line)

Material		type	Number
34.5 kV Transmission line (48 km)			
	Support	Concrete pole	901 pieces
	Conductor（34.5 kV line）	34 kV　Aluminum insulated wire　150 mm2	142 km
	Conductor（Ground line）	HDCC　34 mm2	47 km
	Cable	34 kV CVQ（4 conductors） 250 mm2	0.6 km
13.8 kV Distribution line (2 km)			
	Support	Concrete pole	38 pieces
	Conductor （34.5 kV line）	AAC　150 mm2	6 km
	Conductor （Ground line）	HDCC　34 Imm2	2 km

7) Calculation of the construction cost

The following points will be considered when calculating the construction costs for the transmission and distribution lines.

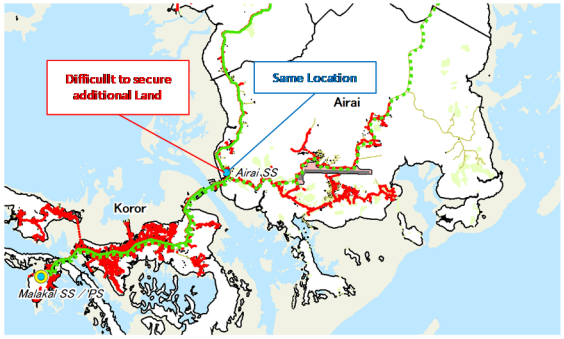
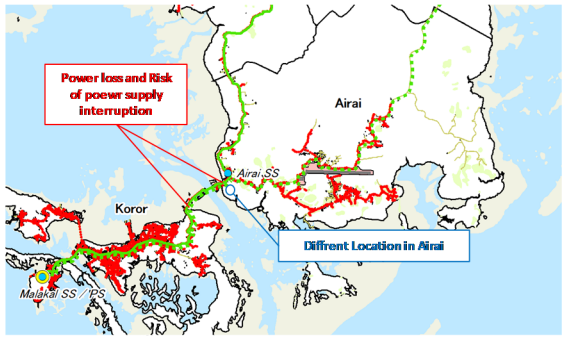
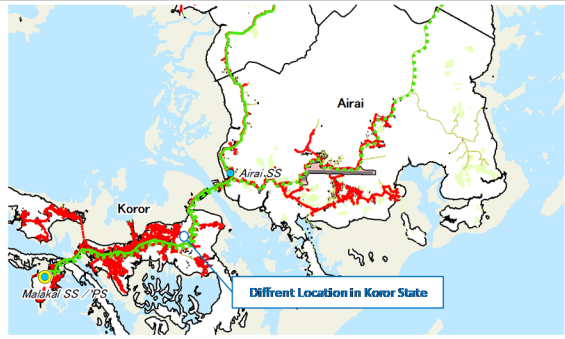
- The construction work for the overhead lines is to be carried out by local workers. Because the local workers lack sufficient experience for the construction of insulated conductors, skilled workers from Japan will be dispatched for technical guidance.
- Technical skill with power cables will be necessary for the construction/installation of the cable through KB bridge. Therefore, materials and technical personnel will be procured and dispatched from Japan.
- The power cable will be installed in the following steps.
    - · Construct a conduit between the pole and adjacent hand hole on KB bridge.
    - · Split the cables into pieces, draw them onto KB bridge from the poles on both sides, and connect them inside the bridge.

10-3-2-2 Construction of a new substation

(1) Alternatives to Airai substation

Back in Chapter 6, the examination of alternatives to Airai substation singled out Koror substation as a major candidate. This chapter provides the examination results in more detail (see Tables 10-3-2-2.1 below).

Table 10-3-2-2.1 Alternatives to Airai substation (Detailed)

Item		Plan-A		Score	Plan-B		Score	Plan-C		Score
Map										
		Improvement of the existing Airai substation		2.7	Renewal of the Airai substation		3.3	Construction of New Koror substation		4.2
1	Location	Locatoin	Same Location	3.0	Locatoin	Different Location	3.0	Locatoin	New Location	4.0
		Site	Need to expand(0.14acre→ approx.0.21acre)		Site	Need to secure approx. 0.12 acre		Site	Need to secure approx. 0.12 acre	
		Challenge	Due to expansion of the site, it is necessary for additional site preparation on the slope		Challenge	It seems like that it is very limited and difficult to secure the land on the existing transmission line route close to Koror island in the Airai state.		Challenge	It might be difficult to secure land in Koror state compare to Airai state.	
2	Technical Aspect (Facility, Reliability)	Composition	Current T-branch should be changed to in and out connection with necessary switching devices and to secure enough capacity for future load.	3.0	Composition	To make in and out connection from the existing transmission line with necessary switching devices and to secure enough capacity for future load.	3.0	Composition	To make in and out connection from the existing transmission line with necessary switching devices and to secure enough capacity for future load.	5.0
		Facility	2 x Transmission line bay 2 x Transformer bay (1 is for future extension) 1 unit x other substation equipment		Facility	2 x Transmission line bay 2 x Transformer bay (1 is for future extension) 1 unit x other substation equipment		Facility	2 x Transmission line bay 2 x Transformer bay (1 is for future extension) 1 unit x other substation equipment	
		Reliability	Due to long distance distribution supply system for Koror island, power supply would not be improved dramatically, and would cost for future network expansion because of cabling at the KB bridge.		Reliability	Due to long distance distribution supply system for Koror island, power supply would not be improved dramatically, and would cost for future network expansion because of cabling at the KB bridge.		Reliability	Power supply reliability would be widely improved because of adequate load allocation and possibility to relief Airai load after decommissioning of Airai substation	
3	Construciton Aspect (Difficulty, Period)	Construction	Need to expand the site without power outage. Due to the limited space for construcitn and machineries, construction work would be more difficult.	1.0	Construction	Construciton constraint such as method or procedure would be mitigated and make the construction easier.	4.0	Construction	Construciton constraint such as method or procedure would be mitigated and make the construction easier.	4.0
		Power outage	All the substation load, in the most of the construction period, would power outage, and necessary for power supply relief from other distribution network.		Power outage	Power outage would be needed when changeover from the existing transmission line.		Power outage	Power outage would be needed when changeover from the existing transmission line.	
		Implementation	Because of the above construction aspects, construction period would be much longer.		Implementation	Because of the above construction aspects, construction period would be shorter.		Implementation	Because of the above construction aspects, construction period would be shorter.	
4	Cost Impact	Cost	Construction cost such as expansion of site and retaining wall, expansion of bays and to improve the reliability make cost much higher. Expected additional cost for the additional construction is approximately USD 195,000.	2.0	Cost	By selecting the suitable place and because of the shorter construction period, construction cost could be minimized.	4.0	Cost	By selecting the suitable place and because of the shorter construction period, construction cost could be minimized.	4.0
5	Environmental Impact	Protectoin	Necessary to consider protection of historic sites and landscape from the Compact Road. This area is not categoriaed as a protected area.	3.0	Protectoin	Necessary to select the location not to affect existing historic sites though there are no protected area.	3.0	Protectoin	Proposed location and the surrounding area are not categorized neither protected area nor historic sites.	4.0
6	Social Considerations	Resettlement	There are no household or buildings in the area for the extension. Therefore involuntary resettlement is not expected.	4.0	Resettlement	Necessary to consider location without involuntary resettlement.	3.0	Resettlement	There are no household or buildings in the target area. Therefore involuntary resettlement is not expected.	4.0

[Remark]Evaluation Score: Low1<Average3<High5

(2) Candidate sites for Koror substation

Although the possibility of private land use is clearly shown to be high in the examination of the three proposed sites (as shown on Figure 10-3-2-2.1) for construction of the substation in Koror, the 2nd candidate (Candidate-B) is recommendable in terms of location, with advantages such as the space of an environmental side and a lot, and connection established power line.

Figure 10-3-2-2.1 Candidate sites for Koro substation (Koror state)

(3) Substation facilities

Table 10-3-2-2.2 shows the target substation facilities and Figure 10-3-2-2.2 shows a single line diagram for Koror substation.

Table 10-3-2-2.2 Target equipment and specifications

Item	specification	Amount
34.5 kV/13.8 kV TrB	10MVA (3-phase)	1
34.5 kV Cub (Feeder)	34.5 kV CB 600A, 12.5kA	2
	34.5 kV Earthing Switch	2
	34.5 kV Line PT	2
	34.5 kV Ar	2
34.5 kV Cub (A)	34.5 kV Bus PT	1
	34.5 kV DS	1
34.5 kV Cub (S)	34.5 kV DS	1
13.8 kV CUB(Feeder)	13.8 kV CB	3
	13.8 kV Line PT	3
	13.8 kV Ar	3
13.8 kV Cub (M)	13.8 kV CB	1

Item	specification	Amount
	13.8 kV Bus PT	1
13.8 kV Cub (H)	Station TrB	1
Control Panel	-	1
Protection Relay	34.5 kV Bus	1
	TrB	1
	34.5 kV Feeder	2
	13.8 kV Feeder	3
SCADA Panel	-	1
DC Panel	-	1
Battery	-	1
Housing	-	1
Fence	-	1

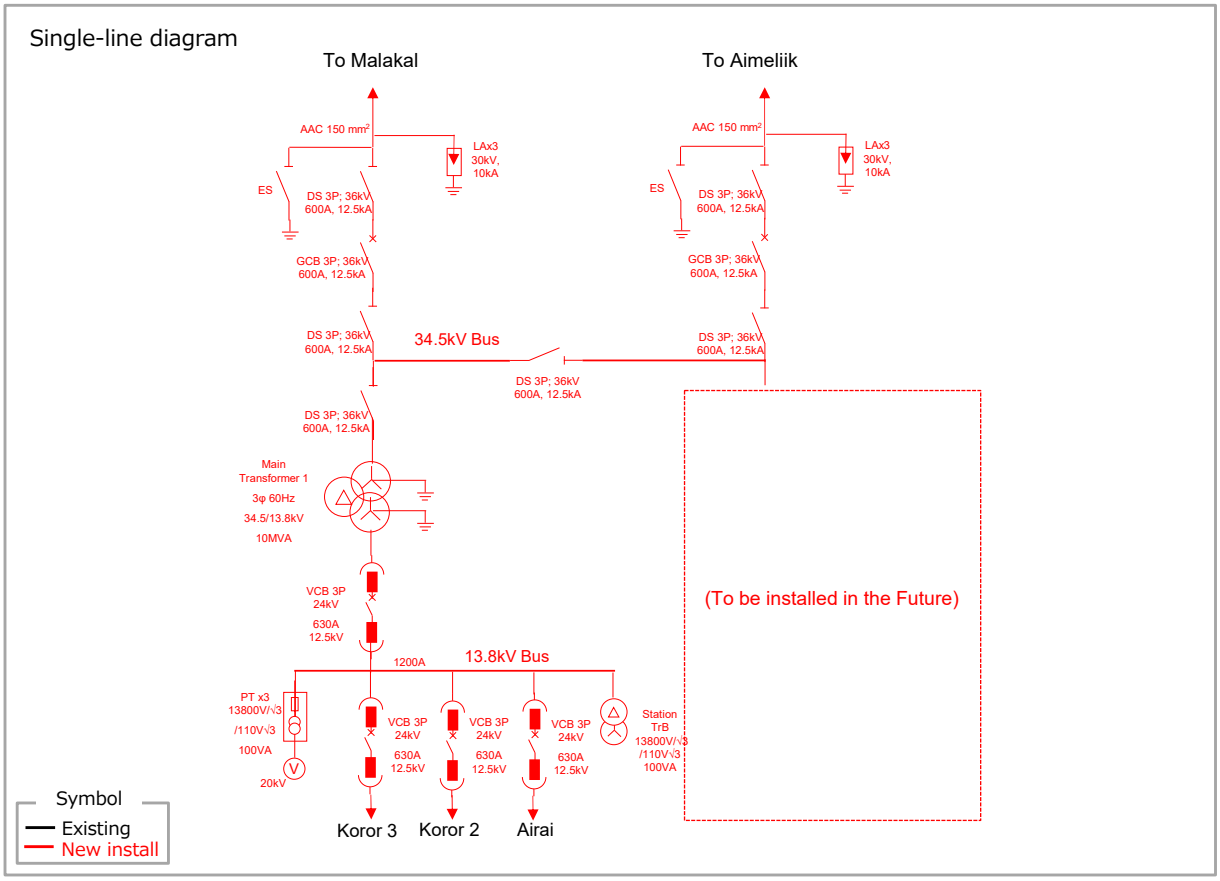


Figure 10-3-2-2.2 Single line diagram for Koror substation (Draft)

10-4 Economic Analysis of the listed projects

In order to analyze the economic values of the projects, the cost effectiveness is calculated by considering the benefits generated by each project in terms of the amount of electricity supplied and the degree to which it increases compared to the case without project implementation. Note, however, that the project in Palau this time will be a power transmission plan by a loop system. As a result, the FIRR economic analysis of the master plan to be applied to each listed project will have the same numerical return. Hence, it would be inappropriate to calculate the power supply benefit separately for each project.

Therefore, the weightings adopted in the judgment on the economic efficiency of each product were based on the amount of money expended for the main purpose of rehabilitating the transmission system, that is, for measures focused on ease of maintenance, improved power supply reliability, etc.

The implementation of transmission and distribution projects brings about the following decreases in maintenance and inspection costs and improvements in power outages. The data on cost-cutting and the treatment of logs in relation to transmission cable maintenance were provided by PPUC.

- Period for cost estimation: FY2017 (October 2016 - September 2017)
- Project Area: Transmission and distribution area by PPUC

(1) Cost reduction for maintenance: 291,374 USD

Personnel expenses US$ 150,488, vehicles for construction US$ 32,000, other equipment US$ 108,886

(2) Estimated cost reduction for maintenance and operation

Cost for outside maintenance contractors: US$ 99,692

This cost is based on the track records of outside contractors calculated by the PPUC Procurement Dept.

(3) Estimated reduction of power blackouts

Power supply value of US17,100, based on the blackout power supply of 57,000 kWh by the current transmission system.

10-5 Environmental and Social Considerations

10-5-1 Scoping

Since the components of the priority project are roughly divided into the new construction (including extension) or relocation of power transmission lines and the establishment or renewal of substation equipment, we have scoped the environmental and social impacts for each of these kinds. The results are shown in Table 10-5-1.1 (transmission line) and Table 10-5-1.2 (substation equipment).

Table 10-5-1.1 Results of the scoping (transmission lines)

Type	No.	Item	Assessment			Reasons for the assessment
			Construction		Ope-ration	
			New	Re-location		
Environmental consideration	1	Air quality	B-	B-	D	Negative impact on air quality from the exhaust gas of construction vehicles is expected at the construction stage.
	2	Water quality	D	D	D	Works that affect water quality are not expected.
	3	Waste	B-	B-	D	The expected waste includes sand and waste materials generated at the construction stage and utility poles and concrete foundations to be removed from the sites of existing transmission lines.
	4	Soil contamination	B-	B-	D	Negative impact on soil from the oil discharged from construction vehicles and heavy machinery is expected at the construction stage.
	5	Noise and vibration	B-	B-	D	Noise and vibration from the operation of construction vehicles and heavy machinery is expected at the construction stage.
	6	Land subsidence	D	D	D	Works causing land subsidence are not expected.
	7	Offensive odor	D	D	D	Works causing offensive odors are not expected.
	8	Bottom sediment	D	D	D	Works affecting bottom sediment are not expected.
	9	Preservation areas	B-	B-	D	Depending on the installation routes for new construction and for the existing transmission lines to be relocated, a negative impact on protected areas is expected.
	10	Ecosystem	B-	B-	D	Depending on the installation routes for new construction and for existing transmission lines to be relocated, a negative impact on the ecosystem is expected.
	11	Water condition	D	D	D	Works affecting the water condition are not expected.
	12	Topography / Geology	D	D	D	Works affecting the topography/geology are not expected.
Social consideration	13	Land acquisition / involuntary resettlement	D	D	D	The power transmission lines are to laid and moved to public places along public roads where no residents are present, so no land acquisition or resident relocation is expected.
	14	Poor people	D	D	D	Negative impacts on the poor are not expected in either the construction stage or operation stage.
	15	Ethnic minorities / indigenous peoples	D	D	D	Negative impacts on ethnic minorities / indigenous peoples are not expected in either the construction stage or operation stage.
	16	Regional economy and livelihood	B-	B-	B+	Negative impacts on the regional economy are expected in the construction stage from the temporary stagnation of traffic, etc. when the roads are occupied by construction vehicles. At the operational stage, positive impacts on the regional economy from the stabilization of electricity supply are expected.
	17	Land use and local resource use	D	D	D	Works affecting the use of land and local resources are not expected.
	18	Water use	D	D	D	Works affecting water use are not expected.
	19	Existing social infrastructure and social services	D	D	B+	Positive impact on the social infrastructure from the stabilization of the power supply at the operation stage is expected.
	20	Social capital and social organizations	D	D	D	Works affecting social capital and social organizations are not expected.
	21	Uneven distribution of damage and benefits	D	D	D	The stabilized electricity supply will widely benefit the community, so an uneven distribution of damage and benefits is not expected.
	22	Regional conflict of interest	D	D	D	The stabilized electricity supply will widely benefit the community, so conflicts of interest within the region are not expected.
	23	Cultural heritage	B-	B-	D	A negative impact on cultural heritage is expected, depending on the laying route for new development and the installation route for the existing transmission lines

Type	No.	Item	Assessment			Reasons for the assessment
			Construction		Ope-ration	
			New	Re-location		
						to be relocated.
	24	Landscape	B-	B-	D	A negative impact on the landscape is expected, depending on the laying route for new development and the installation route for the existing transmission lines to be relocated.
	25	Gender	D	D	D	Works affecting gender (e.g., gender-wise division of labor) are not expected.
	26	Child's rights	D	D	D	Works affecting the rights of children (e.g., child labor) are not expected.
	27	Infectious diseases such as HIV / AIDS	B-	B-	D	Although large-scale construction is not expected, it will be necessary to heed the possibility of a spread of infectious diseases from the influx of construction workers.
	28	Working environment (including occupational safety)	B-	B-	B-	The working environments for the construction workers and maintenance workers at the construction and operation stages must be considered.
Others	29	Risk of accident	B-	B-	B-	Accidents during the construction work at the construction stage and during maintenance and management activities at the operation stage should be considered.
	30	Transboundary impacts and climate change	D	D	D	Works that cause transboundary impacts and negative impacts on climate change are not expected.

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected.
C+/-: The extent of positive/negative impact is unknown. D: No impact is expected.
[Source] JICA Project Team

Table 10-5-1.2 Results of the Scoping (substation)

Type	No.	Item	Assessment			Reasons for the assessment
			Construction		Ope-ration	
			New	Re-location		
Environmental consideration	1	Air quality	B-	B-	D	Negative impact on air quality from the exhaust gas of construction vehicles is expected at the construction stage.
	2	Water quality	B-	D	D	The discharge of earth and sand into rivers and sea areas is expected as a consequence of construction work and rainfall.
	3	Waste	B-	B-	D	The expected waste includes sand and waste materials generated at the construction stage and existing facilities to be removed.
	4	Soil contamination	B-	B-	D	Negative impact on soil from the oil discharged from construction vehicles and heavy machinery is expected at the construction stage.
	5	Noise and vibration	B-	B-	B-	Noise and vibration from the operation of construction vehicles and heavy machinery is expected at the construction stage. Noise from the substation equipment at the operation stage is also expected.
	6	Land subsidence	D	D	D	Works causing land subsidence are not expected.
	7	Offensive odor	D	D	D	Works causing offensive odors are not expected.
	8	Bottom sediment	D	D	D	Works affecting bottom sediment are not expected.
	9	Preservation areas	B-	D	D	Depending on the sites selected when facilities are newly established or relocated, negative impact on protected areas is expected. In instances of facility renewal at the same locations, no negative impact is expected.
	10	Ecosystem	B-	D	D	Depending on the sites selected when facilities are newly established or relocated, negative impact on the ecosystem is expected. In instances of facility renewal at the same locations, no negative impact is expected.
	11	Water condition	D	D	D	Works affecting the water condition are not expected.
	12	Topography / Geology	B-	D	D	Negative impact on the topography/geology from the construction work is expected.

Type	No.	Item	Assessment			Reasons for the assessment
			Construction		Ope-ration	
			New	Re-location		
Social consideration	13	Land acquisition / involuntary resettlement	B-	D	D	Depending on the sites selected when facilities are newly established or relocated, land acquisition and the relocation of residents are expected to occur. In instances of facility renewal at the same location, no land acquisition or resident relocation is expected.
	14	Poor people	D	D	D	Negative impacts on the poor are not expected in either the construction stage or operation stage.
	15	Ethnic minorities / indigenous peoples	D	D	D	Negative impacts on ethnic minorities / indigenous people are not expected in either the construction stage or operation stage.
	16	Regional economy and livelihood	B-	B-	B+	Negative impacts on the regional economy are expected in the construction phase from the temporary stagnation of traffic, etc. when the roads are occupied by construction vehicles. At the operational stage, positive impacts on the regional economy from the stabilization of the electricity supply are expected.
	17	Land use and local resource use	D	D	D	Works affecting the use of land and local resources are not expected.
	18	Water use	D	D	D	Works affecting water use are not expected.
	19	Existing social infrastructure and social services	D	D	B+	Positive impact on the social infrastructure is expected from the stabilization of the power supply at the operation stage.
	20	Social capital and social organizations	D	D	D	Works affecting social capital and social organization are not expected.
	21	Uneven distribution of damage and benefits	D	D	D	The stabilized electricity supply will widely benefit the community, so an uneven distribution of damage and benefits is not expected.
	22	Regional conflict of interest	D	D	D	The stabilized electricity supply will widely benefit the community, so conflicts of interest within the region are not expected.
	23	Cultural heritage	B-	D	D	Depending on the sites selected when facilities are newly established or relocated, a negative influence on cultural heritage is expected. In instances of facility renewal at the same locations, no negative impact is expected.
	24	Landscape	B-	D	D	Depending on the sites selected when facilities are newly established or relocated, negative impact on the landscape is expected. In instances of facility renewal at the same locations, no negative impact is expected.
	25	Gender	D	D	D	Works affecting gender (e.g., gender-wise division of labor) are not expected.
	26	Child's rights	D	D	D	Works affecting the rights of children (e.g., child labor) are not expected.
	27	Infectious diseases such as HIV / AIDS	B-	B-	D	Although large-scale construction is not supposed, it will be necessary to heed the risk of a spread of infectious diseases from the influx of construction workers.
	28	Working environment (including occupational safety)	B-	B-	B-	The working environments for the construction workers and maintenance workers at the construction and operation stages must be considered.
Others	29	Risk of accident	B-	B-	B-	It will be necessary to consider accidents during the construction work and maintenance and management activities at the construction and operation stages.
	30	Transboundary impact and climate change	D	D	D	Works that cause the transboundary impacts and negative impacts on climate change are not expected.

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected.
C+/-: The extent of positive/negative impact is unknown. D: No impact is expected.
Source: JICA Study Team

10-5-2 Survey on Environmental and Social Considerations Based on the Scoping

Regarding the survey items expected to have negative impacts, the following items were studied and surveyed based on the scoping: the existing distribution lines / substation facilities, newly established / migration destination candidate sites, distribution of protected areas / historic sites by GIS data, and the views and expectations of PPUC officials (through face-to-face interviews). Field surveys and estimates on environmental and social impacts were also carried out based on the results of the above, and the necessary measures were examined. The results are shown in Table 10-5-2.1.

Table 10-5-2.1 Estimates on and countermeasures against environmental and social impacts based on field survey

Item	Transmission line	Substation
Air quality	Small heavy machinery such as 7t crane cars and small excavator cars are to be used in the construction activities. In addition, relatively lightweight steel tubular columns are used for the development of power transmission lines at high locations (photo) where heavy machinery cannot be carried in but removal work can be performed manually. From the above, the air quality is expected to be influenced by exhaust gas only temporarily during the very limited construction period. 	Mixer cars, small excavator cars, and trucks for material handling are to be used when the foundations are built during new construction and relocation works. In instances of new construction, relocation and renewal, trucks and crane trucks will be used for the transportation and installation of substation equipment and the replacement of existing facilities. Presumably only one or two trucks will be deployed, however, so the influence on the air quality from exhaust gas is expected to be limited near the site during the construction period.
Water quality	N/A	The candidate sites for the new construction and relocation of substations are all separated from river and sea areas by certain distances, so the influence on water quality from the construction is expected to be limited.
Waste	In addition to the sand and waste materials generated during new construction, it will be necessary to properly remove and process existing utility poles, electric wires, concrete foundations at the original sites.	It will be necessary to properly process the waste materials generated by the construction during new construction or the replacement of existing facilities and parts.
Soil contamination	Although minimal, oil discharge is expected from the operation of heavy machinery and trucks. Care should therefore be taken at the construction site to minimize the influence of soil contamination.	
Noise and vibration	Noise and vibration will accompany the use of heavy machinery during the construction period, but both are expected to be minor, temporary, and local.	Noise and vibration will accompany the use of heavy machinery during the construction period, but both are expected to be temporary and local. In addition, the noise confirmed during operation at the Airai substation (photo), a facility comparable in scale to the new Koror substation, has been minimal and has had little negative impact on the surrounding environment.

Item	Transmission line	Substation
Preservation area	The transmission line is basically to be laid on a public land along the public road, not in a designated protected area. On the other hand, a part of the existing transmission line subject to transfer is located in a protected area (photo). It will be necessary to take steps to minimize the influences on vegetation and wildlife in the protected area during the relocation. 	No protected areas are located around the candidate sites for the new establishment of Koror substation (photo) or the sites for the other substations to be relocated (Ngardmau, Ngaraard 1, Ngaraard 2). 
Ecosystem	Transmission lines are basically relocated to public lands along public roads that are already well-grounded, so no impact on the ecosystems is expected. Most of the existing transmission lines subject to relocation are laid along the old road, where vehicles can enter and heavy machinery can be carried in (photo). Since PPUC regularly maintains the old road, there will be no need to develop new access roads for construction to remove the existing transmission lines. Thus, the impact on the ecosystem is expected to be limited. 	There are no protected areas or rare animals or plants found around the candidate sites for the establishment of the Koror substation or the candidate sites for the existing substations (Ngardmau (photo), Ngaraard 1, Ngaraard 2).  The vegetation at all of the candidate sites can be characterized as grasslands with scattered shrubs. The scale of the Koror substation site is 500m^2 at most, so the impact on the ecosystem is expected to be limited.
Topography / Geology	N/A	All of the candidate sites for new construction and relocation of substations are relatively small and flat, and significant changes in the existing topography and geology due to construction work are not expected.
Land acquisition / involuntary resettlement	The transmission lines are basically laid in public land along the public road, so no expropriation of private land is expected. No dwellings were found on the visits to the candidate location for the Nekken transmission line (along the Compact Road). Only a light scattering of structures were found (resting places, bus stops, etc.) Further, there is ample room to avoid the existing buildings in the basic design for the transmission lines alignment. Thus, no involuntary resettlement is expected.	The new candidate site for the Koror substation is private land with a single owner, so land acquisition will be necessary. No dwelling units or buildings have been found at any of the candidate destinations for the Koror substation or the candidate destinations for the existing substations to be relocated (Ngardmau, Ngaraard 1, Ngaraard 2), so no involuntary resettlement is expected.
Regional economy and livelihood	While construction vehicles will occupy the roads at the construction stage, they will do so only temporarily and not to an extent that will hinder the traffic of general vehicles. Hence, the influence on the regional economy is expected to be minor.	
Cultural heritage	The transmission line is to be laid basically in public land along the public road, with no specified historic sites nearby. Further, the existing transmission lines targeted for relocation are not laid in historic sites.	The candidate site for Ngardmau is located within a historic site, but the site has an area of up to 100 m^2, and there is also land outside of the historic site nearby. When considering the plan, it will be necessary to avoid or minimize the influence on the historic site through prior consultation with the Historic Preservation Office (HPO). None of the other candidate sites are designated as historic.
Landscape	The landscape where the transmission line is newly installed is expected to be impaired. The existing transmission line is extended along the road, however, so the same level of existing landscape will be maintained.	In establishing the Koror substation, it will be necessary to select a site that avoids influences on the landscape as much as possible. If any negative impact on the landscape is expected, it will also be necessary to minimize the negative impact by

Item	Transmission line	Substation
		afforestation, etc.
Infectious diseases such as HIV / AIDS	If an inflow of construction workers is anticipated, it will be necessary to periodically monitor the health of the workers and secure and maintain a certain level of hygiene at the work site.	
Working environment (including occupational safety)	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed in the safety management under the supervision of a work supervisor and secure and maintain a certain level of occupational safety at the work site.	
Risk of accident	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed for safety management under the supervision of a work supervisor. It will also be necessary to thoroughly implement measures to ensure safety, including the proper installation of equipment and the inspection of facilities and equipment.	

Source: JICA Study Team

10-5-3 Evaluation of environmental and social impacts

Table 10-5-3.1 (transmission line) and Table 10-5-3.2 (substation equipment) show the results of the evaluation of the environmental and social impacts of the priority project based on the results of the scoping and site survey in the previous section.

Table 10-5-3.1 Results of the evaluation of environmental and social impacts (transmission line)

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
Environmental consideration	1	Air quality	B-	B-	D	B-	B-	N/A	Few construction vehicles and heavy machinery are required for construction, so the exhaust gas is expected to have only a minor influence on the air quality, and only transiently during the construction period.
	2	Water quality	D	D	D	N/A	N/A	N/A	
	3	Waste	B-	B-	D	B-	B-	N/A	It will be necessary to properly process the earth and sand/waste material generated at the construction stage, along with the utility poles and concrete foundations to be removed from the transfer source, etc.
	4	Soil contamination	B-	B-	D	B-	B-	N/A	Minor negative impact on soil from the oil discharged from construction vehicles and heavy machinery is expected at the construction stage.
	5	Noise and vibration	B-	B-	D	B-	B-	N/A	Although noise and vibration will accompany the use of heavy machinery during the construction period, they are expected to be minor, local, and temporary.
	6	Land subsidence	D	D	D	N/A	N/A	N/A	
	7	Offensive odor	D	D	D	N/A	N/A	N/A	
	8	Bottom sediment	D	D	D	N/A	N/A	N/A	
	9	Preservation area	B-	B-	D	D	B-	N/A	The public lands along the public road where the power transmission lines are to be laid are not designated as

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
									protected areas, and no negative impacts are expected. It will be necessary, however, to take steps to minimize the influences of vegetation and wildlife in the protected area during the removal work, given that some parts of existing transmission lines are located within protected areas.
	10	Ecosystem	B-	B-	D	D	D	N/A	As the transmission line is to be laid along grassland along a public road that has already been grounded, no impact on the ecosystem is expected. It will also be unnecessary to construct a construction access road during the removal of the existing transmission line, so no impact on the ecosystem from the removal work at the relocation source is expected.
	11	Water condition	D	D	D	N/A	N/A	N/A	
	12	Topography / Geology	D	D	D	N/A	N/A	N/A	
Social consideration	13	Land acquisition / involuntary resettlement	D	D	D	N/A	N/A	N/A	
	14	Poor people	D	D	D	N/A	N/A	N/A	
	15	Ethnic minorities / indigenous peoples	D	D	D	N/A	N/A	N/A	
	16	Regional economy and livelihood	B-	B-	B+	D	D	N/A	Construction vehicles will occupy roads, but only temporarily and not to an extent that will hinder the traffic of general vehicles. Hence, virtually no influence on the local economy is anticipated.
	17	Land use and local resource use	D	D	D	N/A	N/A	N/A	
	18	Water use	D	D	D	N/A	N/A	N/A	
	19	Existing social infrastructure and social services	D	D	B+	N/A	N/A	N/A	
	20	Social capital and social organizations	D	D	D	N/A	N/A	N/A	
	21	Uneven distribution of damage and benefits	D	D	D	N/A	N/A	N/A	
	22	Regional conflict of interest	D	D	D	N/A	N/A	N/A	

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
	23	Cultural heritage	B-	B-	D	D	D	N/A	There are no designated historic sites in the public land along the public road where the power transmission lines are laid out, and no negative impacts are expected. Also, none of the existing transmission lines to be relocated are laid in historic sites.
	24	Landscape	B-	B-	D	B-	B-	N/A	Although the landscape is likely to be impaired where the transmission line is newly installed, the landscape will remain at the same level as that where the existing transmission line has been laid.
	25	Gender	D	D	D	N/A	N/A	N/A	
	26	Child's rights	D	D	D	N/A	N/A	N/A	
	27	Infectious diseases such as HIV / AIDS	B-	B-	D	B-	B-	N/A	It will be necessary to regularly monitor the health condition of workers and to secure and maintain a certain level of hygiene environment at the work site.
	28	Working environment (including occupational safety)	B-	B-	B-	B-	B-	B-	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed in the safety management under the supervision of the work supervisor and to secure and maintain the working environment at the work site at a certain level.
Others	29	Risk of accident	B-	B-	B-	B-	B-	B-	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed for safety management under the supervision of the work supervisor. It will also be necessary to thoroughly implement measures to ensure safety, including the proper installation of equipment and inspection of facilities and equipment.
	30	Transboundary impact and climate change	D	D	D	N/A	N/A	N/A	

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected.
C+/-: The extent of positive/negative impact is unknown. D: No impact is expected.
Source: JICA Study Team

Table 10-5-3.2 Results of the evaluation of environmental and social impacts (substation)

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
Environmental consideration	1	Air quality	B-	B-	D	B-	B-	N/A	Few construction vehicles and heavy machinery are required for construction, so the exhaust gas is expected to have only a minor influence on the air quality, and only transiently during the construction period.
	2	Water quality	B-	D	D	B-	N/A	N/A	The candidate sites for the new construction and relocation of substations are all separated from river and sea areas by certain distances, so the influence on water quality from the construction is expected to be limited. However, proper drainage channel designs and considerations at the construction site will be necessary.
	3	Waste	B-	B-	D	B-	B-	N/A	It will be necessary to properly process the waste materials generated by the construction when facilities are newly established or relocated, along with existing facilities and parts to be replaced.
	4	Soil contamination	B-	B-	D	B-	B-	N/A	Minor negative impact on soil from oil discharged from construction vehicles and heavy machinery is expected at the construction stage.
	5	Noise and vibration	B-	B-	B-	B-	B-	D	Although noise and vibration will accompany the use of heavy machinery during the construction period, they are expected to be minor, local, and temporary.
	6	Land subsidence	D	D	D	N/A	N/A	N/A	
	7	Offensive odor	D	D	D	N/A	N/A	N/A	
	8	Bottom sediment	D	D	D	N/A	N/A	N/A	
	9	Preservation area	B-	D	D	D	N/A	N/A	The candidate site for the establishment/relocation of the substation is not designated as a protected area, and no negative impact is expected.
	10	Ecosystem	B-	D	D	B-	N/A	N/A	Scattered weeds and shrubs grow at the candidate site for the establishment/relocation of the substation, but no rare animals or plants are found. While the influence on the ecosystem is expected to be limited, it will be necessary to minimize the cutting of trees and other activities that could impact the ecosystems.
	11	Water condition	D	D	D	N/A	N/A	N/A	
	12	Topography / Geology	B-	D	D	B-	N/A	N/A	All of the candidate sites for new construction and relocation of substations are relatively small and flat, and significant changes in the existing

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
									topography and geology from construction work are not expected. However, appropriate designs and considerations at the construction site will be necessary.
Social consideration	13	Land acquisition / involuntary resettlement	B-	D	D	B-	N/A	N/A	The new candidate site for the Koror substation is privately owned by a single owner, so land acquisition will be required. No dwelling units or buildings are found in any of the candidate sites for the establishment and relocation of substations, so no involuntary resettlement is expected.
	14	Poor people	D	D	D	N/A	N/A	N/A	
	15	Ethnic minorities / indigenous peoples	D	D	D	N/A	N/A	N/A	
	16	Regional economy and livelihood	B-	B-	B+	D	D	N/A	Construction vehicles will occupy roads, but only temporarily and not to an extent that will hinder the traffic of general vehicles. Hence, virtually no influence on the local economy is anticipated.
	17	Land use and local resource use	D	D	D	N/A	N/A	N/A	
	18	Water use	D	D	D	N/A	N/A	N/A	
	19	Existing social infrastructure and social services	D	D	B+	N/A	N/A	N/A	
	20	Social capital and social organizations	D	D	D	N/A	N/A	N/A	
	21	Uneven distribution of damage and benefits	D	D	D	N/A	N/A	N/A	
	22	Regional conflict of interest	D	D	D	N/A	N/A	N/A	
	23	Cultural heritage	B-	D	D	B-	N/A	N/A	Among the candidate sites, that for Ngardmau is located within a historic site. The site, however, spans an area of up to 100m^2, and there is also land outside of the historic site nearby. When considering the plan, it will be necessary to avoid or minimize the influence on the historic site through prior consultation with the Historic Preservation Office (HPO). None of the other candidate sites are designated as historic.
	24	Landscape	B-	D	D	B-	N/A	N/A	In establishing the Koror substation, it will be necessary to select a site that avoids influences on the landscape as much as possible. If any negative

Type	No.	Item	Assessment in scoping			Evaluation after field survey			Reason for the evaluation
			Construction		Ope-ration	Construction		Ope-ration	
			New	Re-location		New	Re-location		
									impact on the landscape is expected, it will also be necessary to minimize the negative impact by afforestation, etc..
	25	Gender	D	D	D	N/A	N/A	N/A	
	26	Child's rights	D	D	D	N/A	N/A	N/A	
	27	Infectious diseases such as HIV / AIDS	B-	B-	D	B-	B-	N/A	It will be necessary to regularly monitor the health condition of the workers and to secure and maintain a certain level of hygiene environment at the work site.
	28	Working environment (including occupational safety)	B-	B-	B-	B-	B-	B-	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed in the safety management under the supervision of the work supervisor and to secure and maintain the working environment at the work site at a certain level.
Others	29	Risk of accident	B-	B-	B-	B-	B-	B-	It will be necessary, in both the construction and operation phases, to observe the work procedures prescribed for safety management under the supervision of the work supervisor. It will also be necessary to thoroughly implement measures to ensure safety, including the proper installation of equipment and inspection of facilities and equipment.
	30	Transboundary impact and climate change	D	D	D	N/A	N/A	N/A	

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected.
C+/-: The extent of positive/negative impact is unknown. D: No impact is expected.
Source: JICA Study Team

10-5-4 Proposal of monitoring structure and monitoring method

Table 10-5-4.1 shows the monitoring items and monitoring methods used to keep track of the environmental and social impacts assumed at the construction and operation stages of the priority project.

As one of the organizations responsible for monitoring, we propose that the monitoring be performed by a construction contractor at the construction stage and PPUC at the operation stage.

Table 10-5-4.1 Proposed monitoring items and monitoring methods for ascertaining the environmental and social impacts

No.	Item	Indicator and standard values	Measurement method	Frequency	Responsible organization	Budget
Construction phase						
1	Air quality	NO2, NO, SO2, dust WHO Standards (Table 7.1.1-1)	Atmospheric analyzer	Quarterly	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
2	Water quality	Suitability of drainage route at site	Visual observation	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
3	Waste	Type of waste, amount, storage location, storage method, treatment method	Visual observation, confirmation of construction site management records	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
4	Soil contamination	Status of oil leakage from heavy machinery, vehicles, etc.	Visual observation	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
5	Noise and vibration	Noise and vibration level (Noise: 85 db, Vibration: 75 db, Standard values in Japan)	1) Sound level meter / vibrometer 2) Monitoring of complaints	1) Quarterly 2) Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
9	Preservation area	Status of conservation of animals and plants at the work sites for removal of transmission lines in protected areas	Visual observation	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant, NGOs	Included in construction costs
10	Ecosystem	Effects of cutting of plants in the course of construction work; animals inhabiting areas around the sites	Visual observation	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant, NGOs	Included in construction costs
12	Topography / Geology	Changes in the topography and geology of the site due to construction work	Visual observation	Daily	(Responsibility) Construction contractor (Support) PPUC, Environmental consultant	Included in construction costs
23	Land acquisition / involuntary resettlement	Status of conservation around the construction site	Visual observation	During construction period	(Responsibility) Construction contractor (Support) PPUC	Included in construction costs
24	Landscape	Continuity of the landscape between new and existing transmission lines; landscape of the substation facility site	Visual observation	During construction period	(Responsibility) Construction contractor (Support) PPUC	Included in construction costs
27	Infectious diseases such as HIV / AIDS	1) Health condition of workers 2) Sanitary environment around the construction site	1) Interview with workers 2) Visual observation	1) Quarterly 2) Daily	(Responsibility) Construction contractor (Support) PPUC, Occupational health consultant	Included in construction costs
28	Working	Status of compliance	On-site	Daily	(Responsibility)	Included in

No.	Item	Indicator and standard values	Measurement method	Frequency	Responsible organization	Budget
	environment (including occupational safety)	with labor conditions and labor environmental standards	inspection		Construction contractor (Support) PPUC, Occupational health consultant	construction costs
29	Risk of accident	Labor conditions, labor environment standards, safety management standards, status of compliance with manuals, status of accidents occurred	On-site inspection, confirmation of accident records	Daily	(Responsibility) Construction contractor (Support) PPUC, Occupational health consultant	Included in construction costs
Operation phase						
28	Working environment (including occupational safety)	Status of compliance with labor conditions and labor environmental standards	On-site inspection	Daily	(Responsibility) PPUC (operation) (Support) PPUC (human resource), Occupational health consultant	Includes in the operation costs of PPUC
29	Risk of accident	Labor conditions, labor environment standards, safety management standards, status of compliance with manuals, status of accidents occurred	On-site inspection, confirmation of accident record	Daily	(Responsibility) PPUC (operation) (Support) PPUC (human resource), Occupational health consultant	Included in the operation costs of PPUC

Source: JICA Study Team

Appendices

A-1 List of Parties Concerned in the Recipient Country

A-1 List of Parties Concerned in the Recipient Country

Organization and Name	Title
Palau Public Utilities Corporation (PPUC)	
Mr. Kione J. Isechal	CEO / General Manager
Mr. Samy Masang	Board of Director / Chairman
Mr. Ted T. Merep	Board of Director
Mr. Greg Decherong	Board of Director
Mr. James Mengeolt	System Control Division Manager
Mr. Hilton Hideos	Power Distribution Division Manager
Mr. Tito Cabunagan	Power Generation Division Manager
Mr. Kennard Sugiyama	Renewable Energy Division Manager
Mr. Anthony Rudimch	Project Planning and Implementation Department Manager
Ms. Marcie Olkeriil	Human Resource Manager
Mr. David Dengokl	Active Manager - WWO
Ms. Hasinta Idechong	Chief Financial Officer
Ms. Aline Rehoner	Accounting Manager
Mr. Sherwin Wasai	Renewable Energy Division
Mr. Aries Amanonce	Renewable Energy Division
Mr. Kyoshi Ngual	Renewable Energy Division
Mr. Michael S. Allejos	System Control Division
Mr. Keyslee Kewii	System Control Division
Mr. Sano Sakurai	System Control Division
Mr. Waylan Skilang	Power Distribution Division
Mr. Peter Tadao	Power Distribution Division
Mr. Robert Patris	Power Distribution Division
Mr. Dee Lola Reklai	Project Planning & Implementation Department
Mr. Sammy Hesus	Malakal Plant Operator
Ms. Lucia Santos	Executive Secretory
Ms. Rhea Isebong Rengulbai	Public Relations Officer
Ms. Turang Rengiil	WIA
Mr. Yuzo Yasui	Senior JICA Volunteer - RED
Mr. Megumi Gunji	Senior JICA Volunteer - PGD
Ministry of Public Infrastructure, Industries & Commerce (MPIIC)	
Mr. Charles I. Obichang	Minister
Ministry of Finance (MOF)	
Mr. Casmir E.Remengesau	Director
Mr. Darren Fritz	Bureau of Budget & Planning
Palau Energy Administration (PEA)	
Mr. Gregorio Decherong	Executive Director

Mr. Tutii Chilton	Energy grants coordinator
Mr. Jesse Ngiratreked	Energy grants coordinator
Mr. Gerald Tulop	Energy Specialist

Bureau of Public Works

Mr. Brian Melairei	Director

Environmental Quality Protection Board (EQPB)

Ms. Roxanne Blesam	Executive Officer
Ms. Lynna Thomas	Compliance Specialist

Foreign Investment Board (FIB)

Ms. Margie Bechab	Administrative Officer

Palau Public Land Authority (PPLA)

Ms. Vameline Remeldil Singeo	Legal Counsel
Mr. Debed Luii	Board of Trustee
Ms. Allison Philip	Administrative Assistant

Palau Automated Land and Resource Information System (PALARIS)

Ms. Darlynne Takawo	Assistant GIS Analyst

Melekeok State Government

Mr. Henaro Polloi	Governor
Mr. Ngiraigas Villiany Thomas	Chief Legislator
Mr. Hidencio Kintaro	Legislator
Mr. Ray Orgino	Administrate Officer

Koror State Government

Ms. Maggy Antonio	Executive Officer

Airai State Government

Mr. Tmewang Rengulbai	Governor

JICA Palau Office

Mr. Nobuaki Miyata	Resident Representative
Mr. Yoshikazu Tachihara	Resident Representative

Embassy of Japan in the Republic of Palau

Takao Mochida	Economic Researcher

A-2 List of Data / Information collected

A-2 List of Data/information collected

No.	Name of Data/Information	Authorities/Office visited	Preparer	Date
1	Palau Energy Policy 2010	Palau Energy Administration	Palau Energy Office	2017/7/13
2	Palau Energy Roadmap – Draft for discussion	Palau Energy Administration	IRENA	2017/7/13
3	PALAU INTERNATIONAL AIRPORT GRID CONNECTED SOLAR SYSTEM	PPUC Renewable Energy Division	PPUC	2017/7/13
4	Palau Intended Nationally Determined Contribution November 2015	PPUC Project Planning & Implementation Dep.ion	PPUC	2017/7/14
5	KB YEARLY LOAD GRAPH FOR 2016	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/17
6	KB YEARLY LOAD GRAPH FOR 2017	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/17
7	PGD GROSS GENERATION	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/17
8	TEST REPORT FOR ON-LOAD TAP-CHANGING TRANSFORMER	PPUC Renewable Energy Division	PPUC Accounting & Finance	2017/7/17
9	Electric Power Operation (EPO) Generation, transmission, and Distribution Cost, and all others	PPUC Renewable Energy Division	PPUC Accounting & Finance	2017/7/17
10	PPUC EPO History-Fuel cost and KwH Sold	PPUC Renewable Energy Division	PPUC Accounting & Finance	2017/7/17
11	EXISTING ONE LINE DIAGRAM AUG 16, 2016	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
12	PPUC TECHNICAL DATA	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
13	FINAL REPORT ISSYSTEMS	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
14	Power Generation Table of Organization	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
15	A SUMMARY OCTOBER 2015 – SEPT 2016	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
16	A SUMMARY OCTOBER 2016 – SEPT 2017	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
17	OKAY final PDD report 2017 sen hearing	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
18	PDD ORG CHART	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
19	SUMMARY OCT 2013 TO SEPT 2014	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
20	SUMMARY OCT 2014 – SEPT 2015	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
21	TREE MANAGEMENT PLAN	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/18
22	EQPB Regulations: CHAPTER 2401-01 EARTHMOVING REGULATIONS CHAPTER 2401-11 MARINE AND FRESH WATER QUALITY REGULATIONS CHAPTER 2401-13 TOILET FACILITIES AND WASTEWATER DISPOSAL SYSTEMS REQUIREMENTS CHAPTER 2401-31 SOLID WASTE MANAGEMENT REGULATIONS CHAPTER 2401-33 PESTICIDE REGULATIONS CHAPTER 2401-51 PUBLIC WATER SUPPLY SYSTEM REGULATIONS CHAPTER 2401-61 ENVIRONMENTAL IMPACT STATEMENT REGULATIONS CHAPTER 2401-71 AIR POLLUTION CONTROL REGULATIONS CHAPTER 2401-81 OZONE LAYER PROTECTION REGULATIONS	PPUC-Project Planning and Implementation Department	EQPB	2017/7/19
23	EQPB Permit Process rev 08-03	PPUC-Project Planning and Implementation Department	EQPB	2017/7/19
24	Lab Testing w fees	PPUC-Project Planning and Implementation Department	EQPB	2017/7/19
25	General Application Modified Dec2015	PPUC-Project Planning and Implementation Department	EQPB	2017/7/19
26	Earthmoving Application Modified Dec2015	PPUC-Project Planning and Implementation Department	EQPB	2017/7/19
27	Org Chart RED	PPUC Renewable Energy Division	PPUC Renewable Energy Division	2017/7/19
28	DOI Economic Review FY 2015	Ministry of Finance	U.S. Department of the Interior	2017/7/19
29	Palau Climate Change Policy 2015	Ministry of Finance	Government of Palau	2017/7/19
30	Population Projection to 2030	Ministry of Finance	Ministry of Finance	2017/7/19
31	GDP and Tourism Numbers Projection to 2030	Ministry of Finance	Ministry of Finance	2017/7/19
32	Palau's Public Projects	Ministry of Finance	Ministry of Finance	2017/7/19
33	MOF Balance-of-Payments	Ministry of Finance	Ministry of Finance	2017/7/19
34	MOF Employment Statistics	Ministry of Finance	Ministry of Finance	2017/7/19
35	MOF Foreign-Trade	Ministry of Finance	Ministry of Finance	2017/7/19
36	MOF Government Finance 2015	Ministry of Finance	Ministry of Finance	2017/7/19
37	MOF National-Accounts	Ministry of Finance	Ministry of Finance	2017/7/19
38	MOF palau_Next Five Year 2016-2021	Ministry of Finance	Ministry of Finance	2017/7/19
39	Checklist of Requirements for Environmental Assessments (EAs)	EQPB Website (http://palaugov.pw/eq	EQPB	2017/7/20

A-2 List of Data/information collected

No.	Name of Data/Information	Authorities/Office visited	Preparer	Date
40	OZONE LAYER PROTECTION REGULATIONS – ADOPTED AMENDMENTS August 2016	EQPB Website (http://palaugov.pw/eq	EQPB	2017/7/20
41	Palau Erosion and Sedimentation Control Filed Guide	EQPB Website (http://palaugov.pw/eq	Horsley Witten Group, Inc.	2017/7/20
42	Palau National Code Title 31Land Planning	Pacific Islands Legal Information Institute Website (http://www.paclii.org/pw/indices/legis/palau-national-code-index.html)	Government of Palau	2017/7/21
43	Palau National Code Title 35Public Lands	Pacific Islands Legal Information Institute Website (http://www.paclii.org/pw/indices/legis/palau-national-code-index.html)	Government of Palau	2017/7/21
44	Environmental Quality Protection Act (Chapter 1 of Title 24 of Palau National Code)	ECOLEX Website (https://www.ecolex.org/details/legislation/environmental-quality-protection-act-chapter-1-of-title-24-of-palau-national-code-lex-faoc006997/)	Government of Palau	2017/7/21
45	The Republic of Palau Revised National Biodiversity Strategy and Action Plan 2015-2025	PPUC-Project Planning and Implement	Ministry of Natural Resources, Environment and Tourism	2017/7/21
46	Foreign Investment List (Hotel)	Foreign Investment Board	Foreign Investment Board	2017/7/21
47	Power generation from 2008 to 2017	PPUC Power Generation Division	PPUC	2017/7/21
48	WWO Power consumptions & payment	WWO	WWO	2017/7/21
49	NBSAP Complete Document	PPUC Power Generation Division	PPUC	2017/7/24
50	SCD Org Chart	PUCC System Control Division	PPUC	2017/7/24
51	LOAD FLOW DIAGRAM(Peak time in 2016)	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/25
52	JUST COORDINATION STUDY	PPUC	IS Systems Pty Limited	
53	TARIFF SCHEDULES (11.1.2006 – 7.1.2017)	PUCC- Finance	PUCC- Finance	2017/7/27
54	KWH BILLED & CUSTOMER# (2007-2017)	PUCC- Finance	PUCC- Finance	2017/7/27
55	TECHNICAL PRESENTATION AUGUST 7	PPUC Power Generation Division	PPUC Power Generation Division	2017/7/28
56	PPUC Transmission and Distribution Lines	PUCC System Control Division	PUCC System Control Division	2017/9/14
57	ADB Loan Disbursements – Sanitation Project	PPUC Renewable Energy Division	ADB	2017/9/19
58	20170920 PV location	Palau Energy Administration	Palau Energy Administration	2017/9/22
59	PPUC State wide power consumption	PUCC- Finance	PUCC- Finance	2017/9/25
60	Renewable Energy Report Funds and Projects Sept 2017	Palau Energy Administration	Palau Energy Administration	2017/9/27
61	EXECUTIVE ORDER No.403	PPUC	Office of the President	2017/9/27
62	PPUC 2008-16 sales data	PPUC	PPUC	2017/9/28
63	Additional Solar PV Sites	PPUC	PPUC	2017/12/8