7.7 MID AND LONG TERM POWER SYSTEM DEVELOPMENT PLAN

This section provides the mid and long term transmission plan for Ramu power system. This plan is based upon the demand forecast and generation expansion plans presented in the previous chapters of this report and also upon the mindset and study result which is described in Section 7.6 “Consideration of Power System Development Plan for Middle-Long Term”.

The development planning scope of work covers the transmission system for the years 2025 and 2030.

The start point for the planning of additions is Year-2020 system after being reinforced by “Ramu Transmission Reinforcement Project”.

7.7.1 Basic Mindset for Power System Development Plan

There is no standard for power system development plan in PNG. Therefore, considering international connecting in future, following standards are set regarding standard around PNG.

(1) Basic matter about power system development plan

On Power system development plan, in order to take into consideration local conditions, the customer's public interest, demand density, etc. and to plan rational and economical supply facilities, the optimal plan is performed after studying the following basic matters sufficiently.

a) To secure supply reliability; In case of the fault of the facility [itself] which consists a system, or the influencing fault from other systems, a suitable supply reliability is secured so that large-scale and long-term supply trouble may not arise.

b) To maintain power quality; voltage and frequency are maintained proper.

c) To pursuit of economic efficiency; Economical efficiency is pursued about the cost of construction of supply facilities, the cost of facility maintenance, and power loss.

d) To countermeasure for future power system; power system has flexibility to a future system expansion, improvement of a facility, and operation in consideration of the future supply demand situation, the local characteristic, and a land situation.

e) Class of voltage; In order to aim at improvement in system reliability and economic efficiency, the combination of voltage class is simplified as much as possible, and it is based on 132kV - 22 (11) kV - 400V.

(2) Basic way thinking regular transmission capacity

The deciding factor of thermal capacity limitation of overhead T/L is thermal capacity, transient stability, voltage drop and frequency drop. Regular transmission capacity is decided at minimum value of those factors. However, since the current power system capacity in PNG is too small, generator failure of Ramu1 P/S leads to under frequency and power system operation have forcedly been load shedding to maintain standard frequency. Furthermore, as this operation continues for the time being, it is desirable for requirement of frequency to be considered after more than larger power system capacity.

a) Limitation for thermal capacity

Thermal capacity of overhead T/L is decided based on highest permissive temperature of conductor used. Since the utilized conductor is ACSR, continuous permissive temperature is 90 degrees for rated transmission capacity, short time permissive temperature is 120 degrees for short time permissive transmission capacity, instant permissive temperature is 180 degrees for instant permissive transmission capacity of short-circuit failure. PPL have applied 75 degrees for continuous permissive temperature of rated transmission capacity. In some cases, the height of the tower is to be lowered. In the future, when the city area and railroad will be developed by regional development project, it may be necessary for lower the tower to increase trouble transference. Therefore, 90 degrees which is the world standard should be applied to tower design higher to countermeasure flexible development of future. Transmission capacity for each conductor per one circuit is to be set as shown in Table 7.7-1.

Table 7.7-1 Transmission Capacity per One Circuit

Conductor type	Ampere [A]	Transmission capacity [MW] (power factor = 0.9)		
		66kV	132kV	275kV
Deer	749	77	154	321
Tiger	361	37	74	-
Dog	312	32	64	-

b) Limitation for transient stability

When T/L malfunctions, it may become massive blackout by stepping out of generator or by unstable phenomenon of the system voltage. To be able to prevent massive blackout, stability analysis using PSS@E software is done with considering condition as below.

- Aspect of the accident is three lines grounding failure (3LG). In case the accident will be removed by main relay, there is no step-out of generator. And if partial power source step out or supply outage will occur, total power system is stable. It is not considered an accident occur at two place of same time.

c) Limitation for voltage

Regarding to voltage stability, it is necessary to satisfy criteria that in case any T/L will occur one circuit outage and demand increase.

(3) Limitation of overload

Limitation of overload means that in case it is possible to supply overrated capacity short term without abnormalities for equipment. It is different for overload length and rated overload by around condition. Transformer is 120% and one hour based on criteria. Overhead T/L is 100% because PPL have only one transmission circuit. After construction of dual-circuit T/Ls, T/L is operated rated 75% in normal condition per one circuit, in case three circuit, T/L is operated rated 100% in normal condition per one circuit. When one T/L failure, remaining T/L transit 150% overload and 10 minutes. During 10 minutes, it is necessary to be restrained until rated capacity for overload of remaining T/L by changing the excess load to another power system and distribution lines. Conversely, it is necessary to be consisted of power system to utilize 110%

continuous overload for long term during recovery fault equipment.

(4) Basic condition of reinforcement of power system

Reinforcement of power system is planned in case of shortage of power supply capacity in normal condition. One is to reinforce facilities when existing facilities cannot transit power flow from P/S where develop. Second is to reinforce facilities when demand in that region may be forecast to be over capacity of existing facilities. It is necessary to be considered next condition.

a) Supply reliability

Basic thinking way of supply reliability is to prevent power service outage when any T/L will occur one failure or any transformer will occur one failure. When single failure will occur, facilities may be reinforced in case remaining facilities connected parallel cannot supply by short time permissive transmission capacity or by continuous overload for long term.

b) Voltage

Facilities may be reinforced in case voltage of supply and demand point of customer cannot satisfy ±5% under normal condition, except short term voltage variation by failure.

c) Short-circuit current

Facilities may be reinforced in case permissive short circuit current of existing equipment exceed by short circuit failure.

(5) Standard for 132kV substation planning

a) Selection of substation location

Location of S/S is desirable to be planned to locate demand center to be cost down of constructing distribution lines. It is also desirable to be planned to be close roads to transport easily heavy equipment such as transformer and to secure clearance for many T/Ls and distribution lines. Furthermore, it is desirable to be planned to be shape without waste vacant land in future. It is necessary to consider natural disaster such as past flood and earthquake and having buried cultural properties or not, the land use results. Furthermore it is necessary to consider city planning and road planning. The location which is cheaper with land cost, transmission and S/S construction cost and distribution construction cost will be desirable to be selected.

b) Property capacity of substation

Facilities capacity of S/S is applied Table 7.7-2 regarding to demand density of the region. 132/22(11) kV S/S is final configuration with three transformers and with consideration of limitation of distribution lines.

Table 7.7-2 Capacity of Substation

Demand density [MW/km^2]	Unit capacity [MVA]	Number of transformer	Total capacity [MVA]	Number of distribution line
More than 4	30	3	90	12 – 15
Less than 4	20(10)	3	60 (30)	8 – 10 (4 – 5)

The number of transformer is basically two when new S/S will be constructed to be able to recovery service outage earlier by changing remaining transformer. Because Ramu power system have long distance between S/Ss and there is seldom connected distribution line, it takes long time to recovery service outage.

c) Reinforcement of transmission line

Reinforcement of T/L will be planned when service outage cannot recover by continuous overload for long term long after changing load at failure in case normal availability exceed 75% per one line as double T/L and in case normal availability exceed 100% per one line as one T/L or three T/Ls.

(6) Regulatory requirement of power system planning

Short-circuit capacity is value to satisfy Grid Code and facilities will be reinforced when short-circuit current exceed existing facilities rated capacity.

Terminal number which means connected the number of S/S and P/S that have device to detect accident is basically two and less three. Power system protection is described section 7.9. Reclosing system is three phases both high speed and low speed.

The countermeasure for voltage flicker and harmonics is basically done at demand side by utilizing Static Var Compensator (SVC) or filters. Voltage regulator is done at transformer with LR; reactive power control is done by STATCOM and AVR of hydropower station. When power static condenser will be used, single capacity of Static Capacitor (SC) is selected not to exceed 2% of voltage variation when SC operate to open.

132kV T/L is basically to consist of two circuit by two route to be able to reconstruct to boost 275kV double T/Ls from 132kV one T/L using one 132kV T/L route with supplying demand without outage by the other 132kV T/L.

7.7.2 Objectives and the Flow of the Planning

The objectives of this system planning are to;

- Determine the location, capacity and type of the required power transmission upgrades and additions over the planning horizon up to 2030.
- Establish the timing of the transmission upgrades and additions across years 2020, 2025 and 2030, and
- Estimate the construction cost associated with the transmission system upgrades and additions.

The flow of the planning is as follows.

- The fundamental mindset of the system planning described in Section 7.6 “Consideration of Power System Development Plan for Middle-Long Term” to Year-2020 system shown in Section 7.5 “Review for Short-Term Power System Development Planning” is applied and preliminary planning of the Year-2030 system is performed;

- Based on the result of the demand forecast and the power source planning, the pattern of basic demand-and-supply balance is made for the system made by Preliminary planning of the Year-2030 system and the system which has the state of the demand-and-supply balance is assumed to Year-2030 preliminary system;

- System analyses, such as Power flow analysis, transient stability analysis, N-1 analysis and short-circuit current analysis, are performed to Year-2030 preliminary system verifying some assumption in Section 7.6;

- When not satisfying system planning criteria mentioned later on the system analyses, the countermeasure for making it satisfactory is studied;

- The system which satisfies system planning criteria is assumed to Year-2030 system;

- Among upgrades and additions to Year-2020 system of the Year-2030 system, after checking in the demand forecast and power source planning in 2025, required items are taken up. The result is assumed to Year-2025 preliminary system, system analyses are similarly performed with having performed to Year-2030 preliminary system described above and Year-2025 system is determined;

7.7.3 Basic Technical Standard and Study Conditions

(1) Power flow analysis and N-1 Analysis

The planning of the transmission grid considers the operation of a power system under two possible situations, that is.

Normal operating conditions (n-0): the transmission infrastructure is entirely available (no equipment has been forced out of service).

Contingency operating conditions (N-1): one piece of transmission equipment (line or transformer) is out of service.

For each of these two operating conditions, the following criteria are applied to the analyses.

1) System Voltage Criteria

The acceptable voltage range for operating the system based on the factors such as equipment limitations and motor operation under normal and contingency conditions is shown in Table 7.7-3.

It is important to note that from an operational standpoint, healthy systems usually target a minimum voltage close to 1.0 pu in the bulk system.

Table 7.7-3 System Voltage Criteria

Condition	Acceptable Voltage Range
Normal System Conditions	95% - 105%
Contingency Conditions	90% - 110%

2) Equipment Thermal Loading Criteria

The transmission system shall be planned and designed to allow all T/Ls and equipment to operate within the limits for the defined conditions as shown in Table 7.7-4.

Table 7.7-4 Equipment Thermal Loading Criteria

Condition	Thermal Loading Limit
Normal System Conditions	Defined Normal Load Capacity
Contingency Conditions	Defined Emergency Load Capacity (120% of normal rating)

Normal Load Capacity is defined as follows;

Transmission lines: line currents are not to exceed the thermal limits with the conductor at 75°C, ambient of 32°C and 0.5 m/s wind velocity.

Transformers: under normal operating conditions, the load is not exceed the rating permissible by the mode of cooling applied. Under emergency conditions, short time (1 hour) overload of 20% is not to be exceeded providing the load immediately prior to emergency does not exceed 80% of rating permissible by the cooling mode.

However, according to the interview result to the PPL staff, normal load capacity of T/L is also considered to be 80% of the thermal limit and the existing data was also set up based on the way of thinking. Then, also in this analysis, normal load capacity of T/L set to 80% of the thermal limit.

3) System Design Contingencies

The transmission system shall be planned and designed to maintain the defined System Voltage Criteria and Equipment Thermal Loading Criteria for the outage of any of the transmission equipment (i.e. N-1 criteria).

4) Transmission system parameters

This section presents the parameters used for the various transmission system reinforcements.

a) Transmission lines

It was assumed that the conductor capacity would be de-rated to 80% of its full value due to ambient conditions. The emergency rating is assumed to be 120% of normal rating. The emergency rating is considered only under contingency conditions (N-1).

Moreover, regarding electrical parameters of T/Ls, the values offered from PPL as data of existing T/Ls and the values printed in "FYPDP (2014-2028)" of PPL were used as they were. The conductor type of the new 132 kV T/L was assumed to be Deer in principle. The conductor type of a 275kV new T/L was Deer of two conductors. However, as electrical parameters, the standard constant of the 275 kV T/L used in a Japanese electric power company was used (see Table 7.7-5).

Table 7.7-5 Standard Constant of the 275 kV Transmission Line

Rated Capacity	R	X	B
1,660 A	0.00506	0.0497	0.304

per unit on 100 MVA base for 100 km line

b) Substation (Transformer)

Regarding the impedance of a transformer, like the T/L, when data was known, the data value was used and the values shown in Table 7.7-6 were assumed for the other new transformers.

Table 7.7-6 Impedance of New Transformer

Voltage [kV]	%X on self MVA
275/132	18.0
275/11	10.0
132/66	5.0
132/22	12.0
132/11	15.0
66/22	13.0

c) Reactive compensation

Fixed capacitor banks were sized to ensure the system operating conditions were adequate in the planning criteria.

It was assumed that each 275 kV line would be compensated by two line-connected reactors located at either ends of the lines. The magnitude of each reactor was taken as 50% of the full line charging value, equivalent to a total of 100% compensation.

(2) Short-circuit current analysis

Facilities may be reinforced in case the permissive short circuit current of existing equipment is exceeded due to short circuit failure. Detailed permissible short-circuit current values were below those shown in Table 7.7-7 (see Section 7.3 (4) “Short-circuit capacity”).

Table 7.7-7 Allowable Maximum Short-Circuit Current

Voltage	Allowable maximum short-circuit current
275kV	50.0kA
132kV	31.5kA
66kV	25.0kA
33kV, 11kV	12.5kA

Besides, the various conditions at the time of short-circuit current analysis were as follows;

- Pre-fault conditions are the results of the power flow study.
- Subtransient reactance is used for generator reactance.

(3) Transient stability analysis

1) The mindset of transient stability

When a T/L malfunctions, a massive blackout may result, due to stepping out of the generator or unstable system voltage. To prevent this, a stability analysis using PSS@E software is performed considering the following conditions;

- The aspect of the accident is 3LG. In case the accident is eliminated by the main relay, there is no step-out of generator, while if a partial power source steps out or a supply outage occurs, the total power system is stable. There is not considered to be a risk of an accident occurring at two places at the same time.

- The fault interception time by the main protection relay was assumed to be the value shown in Table 7.7-8.

Table 7.7-8 Fault Interception Time by Main Protection Relay

Voltage	Fault interception time
275kV	120ms
132kV	200ms

2) Generators and Control systems

The round rotor generator model (GENROU) for thermal plants and the salient pole generator model (GENSAL) for hydro plants are shown here.
(Source: Developing Generic Dynamic Models for the 2030 Eastern Interconnection Grid, Dec 2013)

Typical dynamic model parameters were used (Source: PSS@E Program Application Guide).

Table 7.7-9 Typical Parameters of GENSAL (Salient Pole Generator Model)

CONs	#	Value	Description
J		5	T'_{do} (>0) (sec)
J+1		0.05	T''_{do} (>0) (sec)
J+2		0.06	T''_{qo} (>0) (sec)
J+3		5.084	Inertia, H
J+4		1	Speed damping, D
J+5		1.5	X_d
J+6		1.2	X_q
J+7		0.4	X'_d
J+8		0.25	$X''_d = X''_q$
J+9		0.12	X_l
J+10		0.03	S(1.0)
J+11		0.25	S(1.2)

Table 7.7-10 Typical Parameters of GENROU (Round Rotor Generator Model)

CONs	#	Value	Description
J		6	T'_{do} (>0) (sec)
J+1		0.05	T''_{do} (>0) (sec)
J+2		1	T'_{qo} (>0) (sec)
J+3		0.05	T''_{qo} (>0) (sec)
J+4		3	Inertia, H
J+5		0	Speed damping, D
J+6		1.4	X_d
J+7		1.35	X_q
J+8		0.3	X'_d
J+9		0.6	X'_q
J+10		0.2	$X''_d = X''_q$
J+11		0.1	X_l
J+12		0.03	S(1.0)
J+13		0.4	S(1.2)

Table 7.7-11 Typical Parameters of SEXS (Simplified Excitation System)

CONs	#	Value	Description
J		0.1	T_A/T_B
J+1		10	T_B (>0) (sec)
J+2		100	K
J+3		0.1	T_E (sec)
J+4		0	E_{MIN} (pu EFD base)
J+5		3	E_{MAX} (pu EFD base)

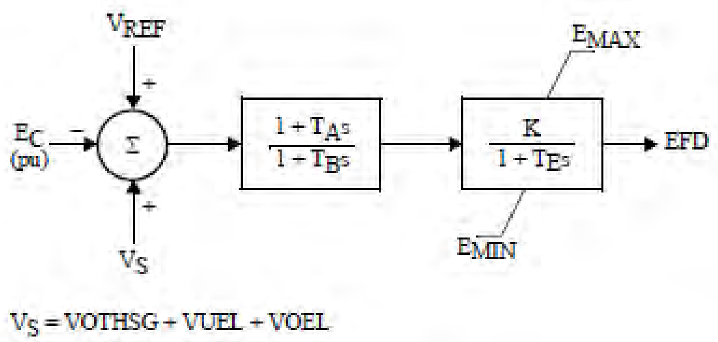


Fig. 7.7-1 Typical Excitation System Model SEXS

Table 7.7-12 Typical Parameters of GAST

CONs	#	Value	Description
J		0.05	R (speed droop)
J+1		0.4	T_1 (>0) (sec)
J+2		0.1	T_2 (>0) (sec)
J+3		3.0	T_3 (>0) (sec)
J+4		1.0	Ambient temperature load limit, AT
J+5		2.0	K_T
J+6		1.0	VMAX
J+7		-0.05	VMIN
J+8		0.0	D_{turb}

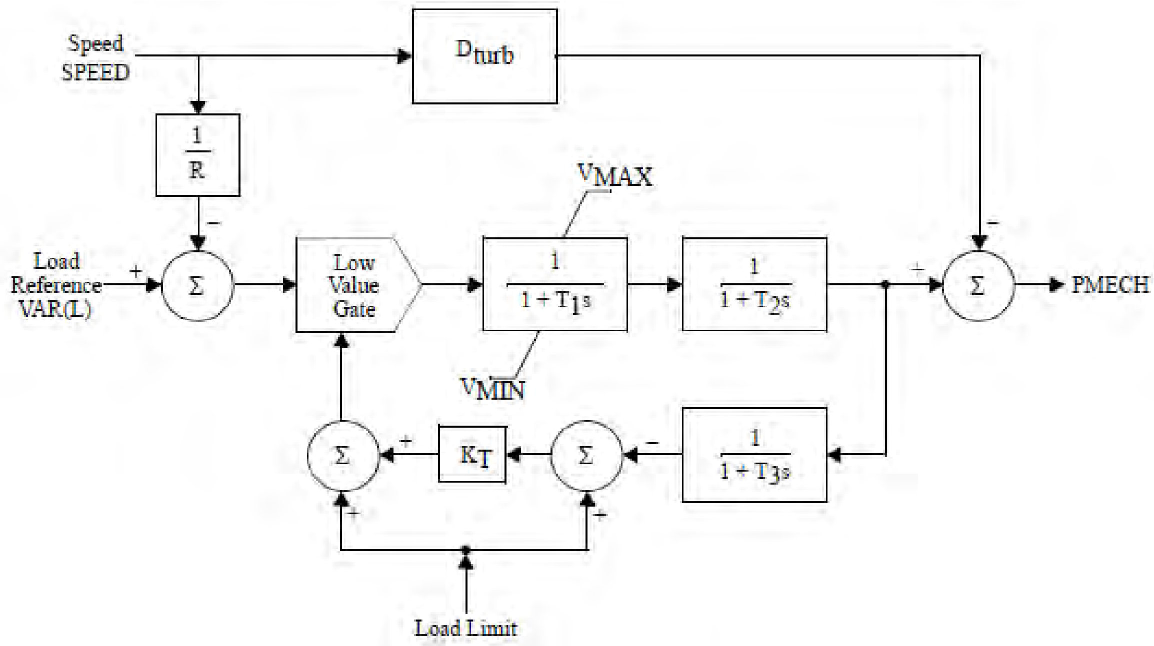


Fig. 7.7-2 Gas Turbine and Governor System Model GAST

Table 7.7-13 Typical IEEEG3 Parameters

CONs	#	Value	Description
J		0.2	T_G (>0) (sec), gate servomotor time constant
J+1		0.04	T_P (>0) (sec), pilot value time constant
J+2		0.167	U_O (pu per sec), opening gate rate limit
J+3		-0.167	U_C (pu per sec), closing gate rate limit (< 0)
J+4		0.95	P_{MAX} maximum gate position (pu on machine MVA rating)
J+5		0	P_{MIN} minimum gate position (pu on machine MVA rating)
J+6		0.05	σ, permanent speed droop coefficient
J+7		0.31	δ_S, transient speed droop coefficient
J+8		6	T_R (>0) (sec)
J+9		1.16	T_W (>0) (sec), water starting time
J+10		0.5	a_{11} (>0)
J+11		1	a_{13}
J+12		1.5	a_{21}
J+13		1	a_{23} (>0)

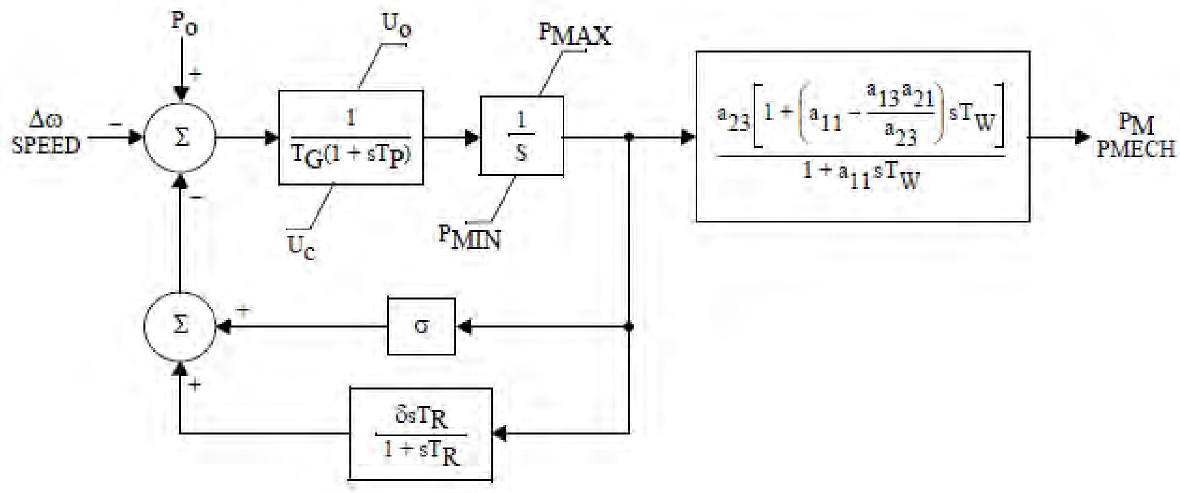


Fig. 7.7-3 Hydro Turbine and Governor System Model IEEEG3

7.7.4 Preliminary Planning of the Year-2030 System

In Section 7.5 "Review for Short-Term Power System Development Planning", the short-term transmission expansion plan was described and the recommended practice for the present planning was presented. Meanwhile, in Section 7.6 "Consideration of Power System Development Plan for Middle-Long Term", a study for deciding on transmission expansion planning over a medium-to-long period was described; also based on the analytical result described in this section.

Here, the preliminary planning of the system in 2030 as the target of study, such as N-1 analysis, is performed, reviewing those study results.

(1) Erap substation neighborhood system

The secondary voltage of the Erap S/S transformer shall be 22 kV, to which the load of the new Nadzab airport is connected. The existing 66 kV T/L between Taraka and Nadzab S/Ss is not used (see Fig. 7.5-6).

The power to Wafi gold mine is supplied by a 132 kV, dual-circuit T/L from Erap S/S.

(2) Power supply to the Lae area

Milford S/S is upgraded from 66/11 kV to 132/11 kV and Taraka and Milford S/Ss are connected by a 132 kV, dual-circuit T/L. Lae Port P/S is interconnected to the 11 kV bus of Milford S/S (see Fig. 7.6-5).

Three transformers of 30 MVA are installed in Taraka and Milford S/Ss, respectively.

After the Munum P/S operates, based on the PPL plan, the diesel generators in Taraka and Milford will stop.

(3) Power supply to the Madang area

1) Meiro substation

The transformers in Meiro S/S are upgraded from 66/22 kV to 132/22 kV and three transformers of 30 MVA are installed there. Moreover, Meiro S/S and Walium S/S are connected by a 132 kV, dual-circuit T/L (see Fig. 7.6-10).

2) Gusap and Walium substations

A 132 kV, 1 circuit T/L between Gusap and Singsing S/Ss is reinforced to a 132 kV, dual-circuit T/L. The transformers in Walium S/S are upgraded from 66/22 kV to 132/22 kV and Walium and Gusap S/Ss are connected by a 132 kV, dual-circuit T/L (see Fig. 7.6-10). The power to Ramu Nico mine (Kurumbukari; for drilling) is supplied by a 132 kV, dual-circuit T/L from Walium S/S (see Fig. 7.6-10). Besides, the power supply to the Ramu Nico mine (Basamuk Refinery; for smelting) is mentioned later.

(4) Preliminary planning regarding the power development planning

1) Ramu2 power station

In Section 7.6.2 (1) "Ramu2 power source", three plans are shown as the connection method of Ramu2 P/S. Because the connection method of Plan C is considered to offer the cheapest construction and most reliable electric supply (see Table 7.6-5), here, Plan C is temporarily considered as the connection method for Ramu2 and Ramu2 P/S is temporarily connected to Singsing S/S via a 132 kV dual-circuit T/L (Deer, 2 conductors / circuit). See Fig. 7.6-13.

2) Mongi power station

Mongi P/S is connected to a Taraka S/S by a 132 kV dual-circuit T/L.

3) Gowar power station

Gowar P/S is connected to the Gusap S/S by a 132kV dual-circuit T/L and Ramu Nico mine (Basamuk Refinery; for smelting) is connected to Gowar P/S by a 132kV dual-circuit T/L (see Fig. 7.6-15).

4) Power stations in the Highland area

As a method of transmitting the P/S outputs in the Highland area located on the west side, Plan A shown in Table 7.7-14 is temporarily employed. Besides, PPL has the intention to upgrade Dobel S/S to 132kV and connect Hides and Kaugel P/Ss to Dobel P/S. Accordingly, a 132/66 kV transformer is newly installed in 66/22 kV Dobel S/S, Hides P/S and Dobel S/S are connected by a 132 kV dual-circuit T/L and Dobel and Walium S/Ss are connected by a 132 kV dual-circuit T/L. Moreover, a configuration where Kaugel P/S also connects to the 132 kV bus of Dobel S/S by a dual-circuit T/L was assumed.

(5) Demand-and-supply balance

With the demand-forecast result in 2030 (Normal Case) and the supply capability by the power source planning, the reserve power becomes quite considerable. Accordingly, the P/Ss (Lae Port thermal power plant, Mongi hydropower station and Gowar hydropower station) which exist on the demand side (east side) were stopped and also, with the dry season in mind, the outputs of all hydropower plants are about 70% of rated output and the remaining thermal power plants go from full output to the basic output condition of P/Ss, so the system analysis may show a severe state.

The Year-2030 preliminary system and its power flow diagram based on descriptions (1) to (5) are shown in Fig. 7.7-4 and Fig. 7.7-5.

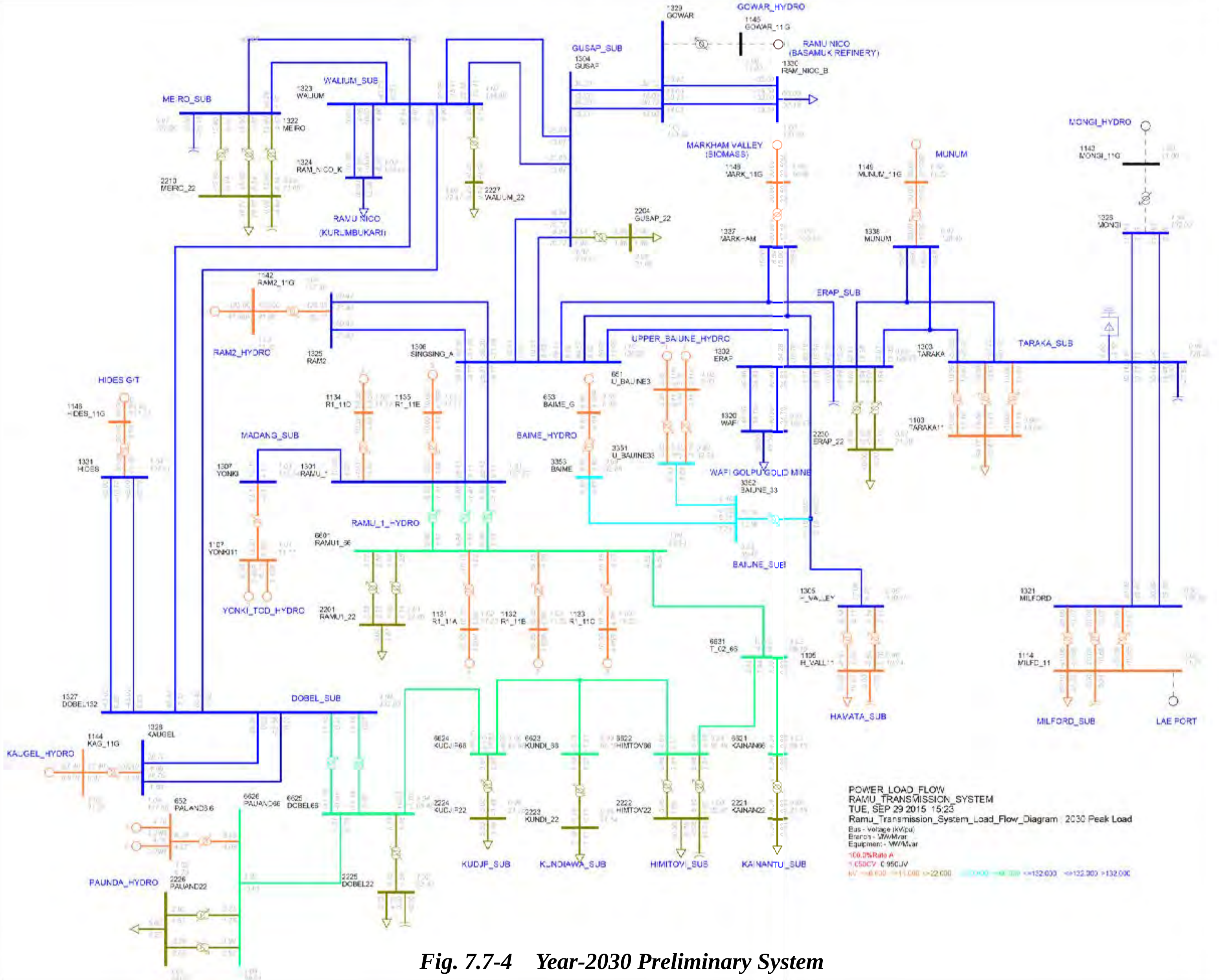


Fig. 7.7-4 Year-2030 Preliminary System

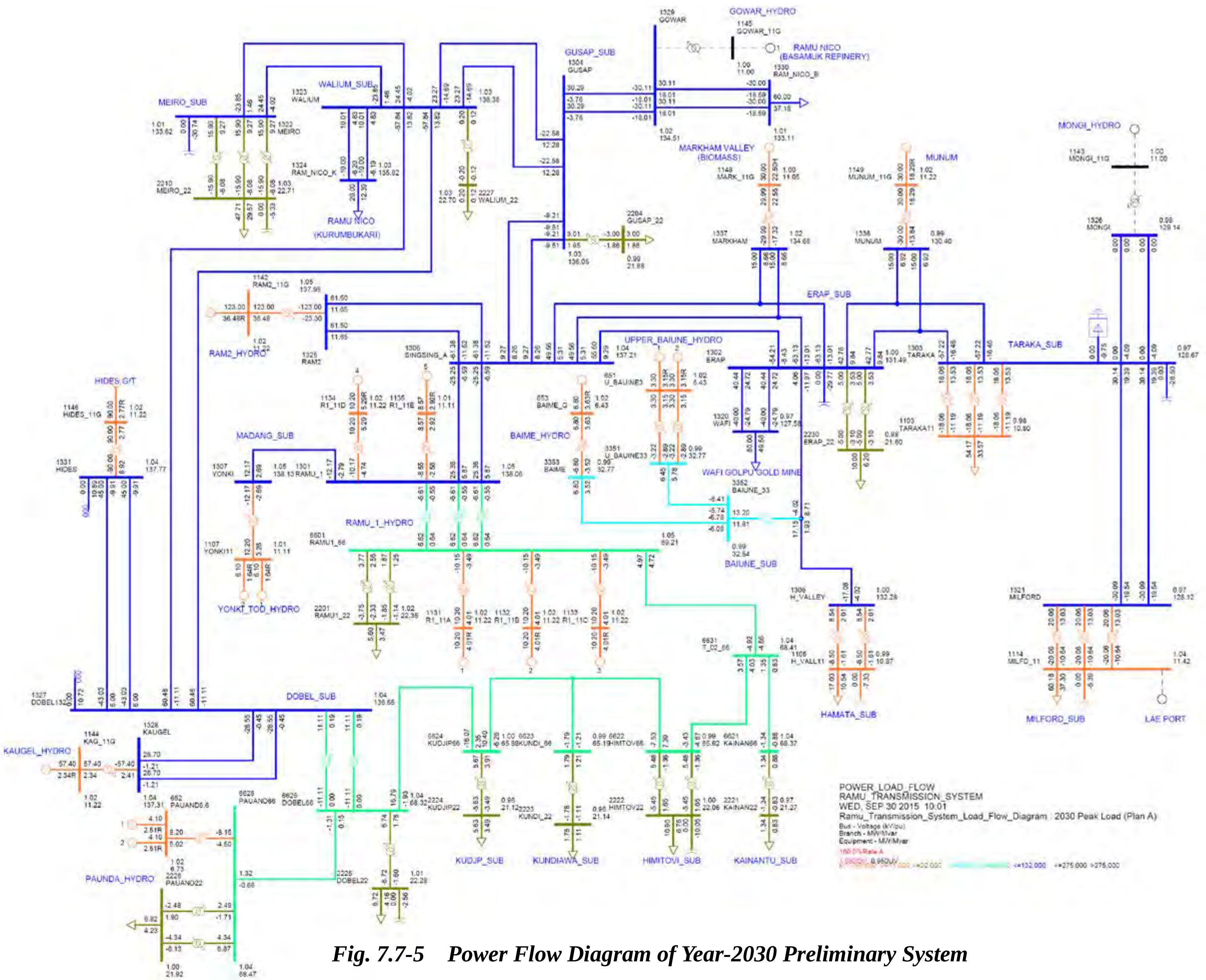


Fig. 7.7-5 Power Flow Diagram of Year-2030 Preliminary System

7.7.5 Planning and Analytical Result of the Year-2030 System

(1) Study result of the transmission method of the power station outputs in the Highland area

The transmission method of the P/S outputs in the Highland was considered from the perspective of transient stability.

1) Plan A

Plan A is a configuration connecting Hides P/S and Dobel S/S by a 220km 132 kV dual-circuit T/L and Dobel and Walium S/Ss by a 160km 132 kV dual-circuit T/L as shown in Fig. 7.7-6.

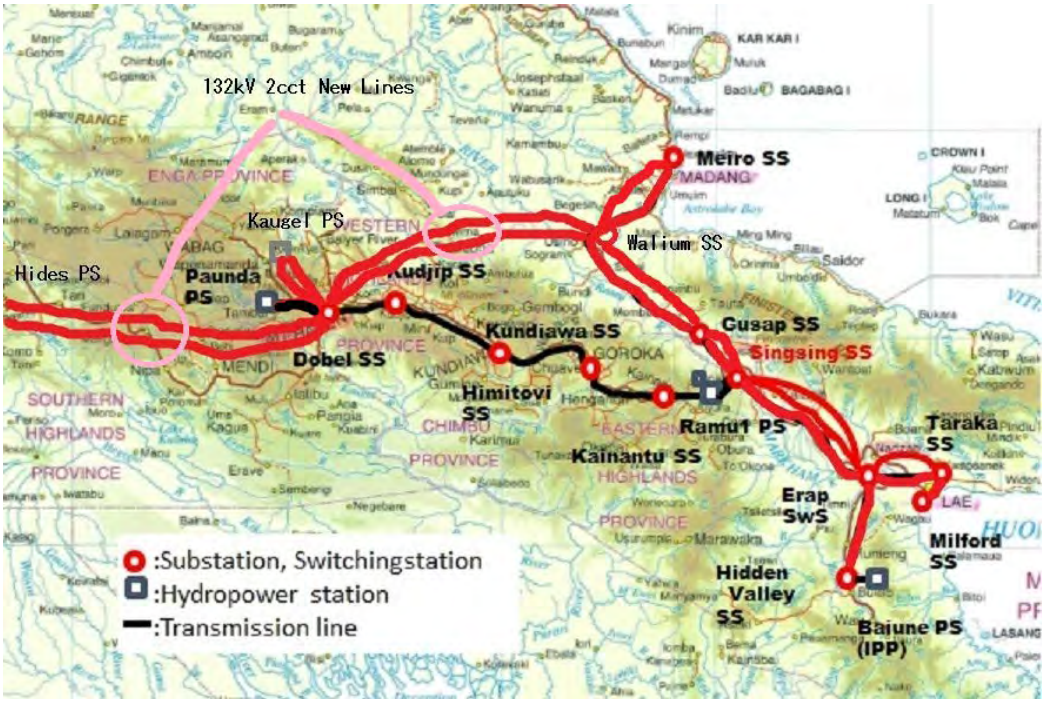


Fig. 7.7-6 Plan A

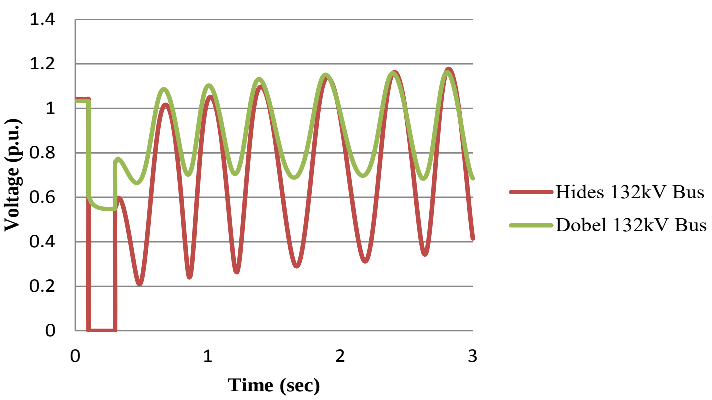


Fig. 7.7-7 Bus Voltages at the Time of Hides near End Fault

As a result of the transient stability analysis at the time of the fault at the P/S near the end of the power source line of Hides P/S, as shown in Fig. 7.7-7, the voltage of Hides P/S and Dobel S/S was shaken and it became clear that this system configuration was unstable.

As alternatives to Plan A, transient stability analysis of three plans shown in Fig. 7.7-8, Fig. 7.7-9 and Fig. 7.7-10 was performed. In Plan A-1, the power source line of Hides P/S was upgraded to a 275 kV dual-circuit T/L, in Plan A-2, the T/L between Dobel and Walium S/Ss was upgraded to a 275 kV dual-circuit T/L and in Plan A-3, both T/Ls were upgraded.

As a result, Plans A-1 and A-2 were unstable and Plan A-3 was stable. Examples are shown in Fig. 7.7-11 - Fig. 7.7-14 as a result of the stability analysis of Plan A-3.

Plan A-3 is hereafter called Plan A'.

Fig. 7.7-8 Plan A-1

Fig. 7.7-9 Plan A-2

Fig. 7.7-10 Plan A-3

Note: Blue line: 275 kV T/L, Red line: 132 kV T/L

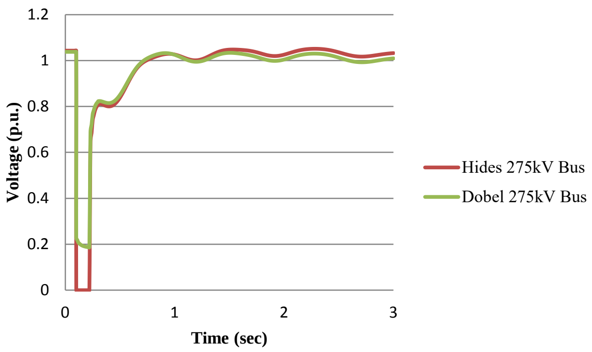


Fig. 7.7-11 Bus Voltages at the Time of Hides near End Fault

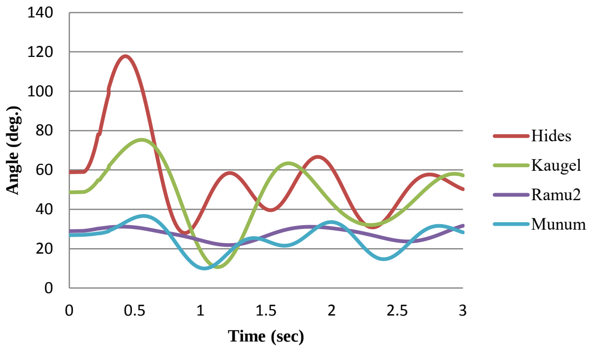


Fig. 7.7-12 Generator Internal Angles at the Time of Hides near End Fault

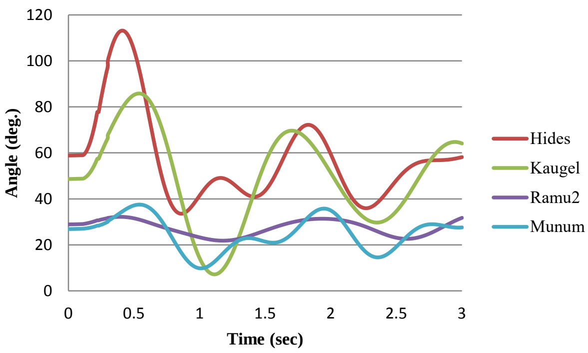


Fig. 7.7-13 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Walium

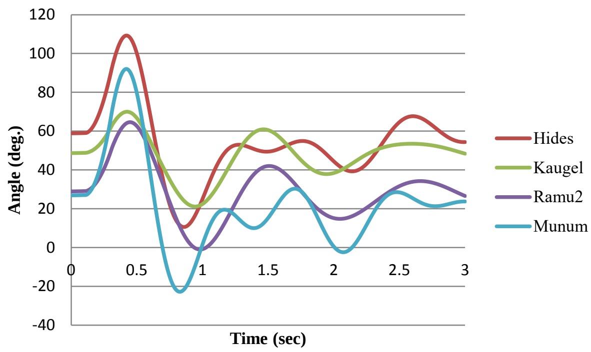


Fig. 7.7-14 Generator Internal Angles at the Time of Singsing near End Fault of Singsing - Erap

2) Plan B

Plan B is a configuration in which Hides P/S is connected to Singsing S/S by a 275kV dual-circuit T/L about 400km long and Dobel and Walium S/Ss are connected by a 160km 132kV dual-circuit T/L like Plan A as shown in Fig. 7.7-15.

Fig. 7.7-15 Plan B

In the case of Plan B, as shown in Fig. 7.7-16, Fig. 7.7-17 and Fig. 7.7-18, the transient stability at the time of the main T/L fault is stable.

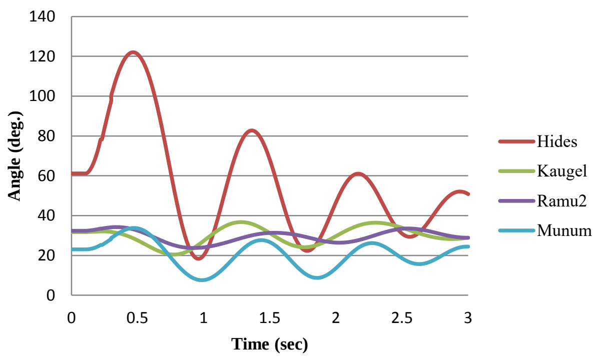


Fig. 7.7-16 Generator Internal Angles at the Time of Hides near End Fault

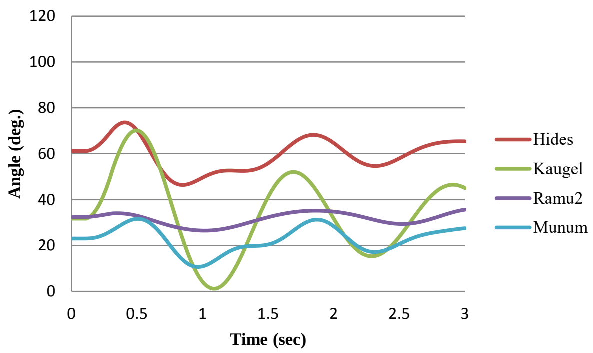


Fig. 7.7-17 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Walium

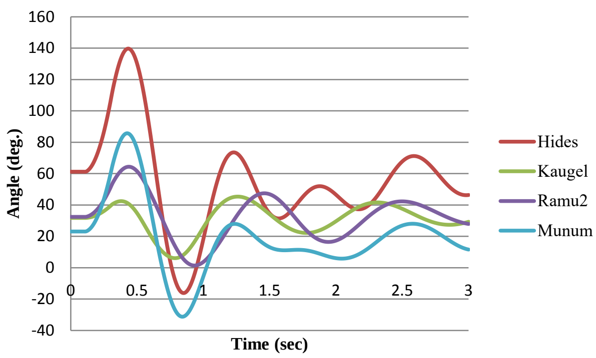


Fig. 7.7-18 Generator Internal Angles at the Time of Singsing near End Fault of Singsing - Erap

3) Plan C

In Plan C, Hides power source line is connected to Dobel S/S by a 132 kV dual-circuit T/L and Dobel and Ramu1 S/Ss are connected by a 132 kV four circuit T/L. However, for a while, lower dual-circuits are operated at 66 kV and when it becomes impossible to supply the demand of the Highland area by a 66 kV Deer dual-circuit, they are upgraded to 132 kV. In addition, as described in the study of Plan A, the system is unstable in Hides power source lines being 132 kV two circuit T/L. Therefore, as shown in Fig. 7.7-19, Hides power source line is considered here, on the assumption that it is a 275 kV dual-circuit T/L.

Fig. 7.7-19 Plan C

In the case of Plan C, it is stable at the time of Hides near the end fault of the Hides power source line (see Fig. 7.7-20), but unstable at the time of Dobel near the end fault of the T/L between Dobel and Ramu1 (see Fig. 7.7-21).

Moreover, in the case of Plan C, to cancel the overload of steady state, it is necessary to reinforce the 132kV dual-circuit T/L between Singsing and Gusap S/Ss in three circuits and to maintain the voltage criteria, installation of SC of about 30 MVA is needed for Singsing, Walium and Gusap S/Ss, respectively.

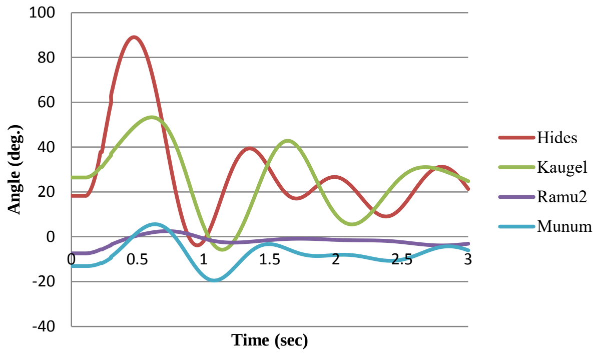


Fig. 7.7-20 Generator Internal Angles at the Time of Hides near End Fault

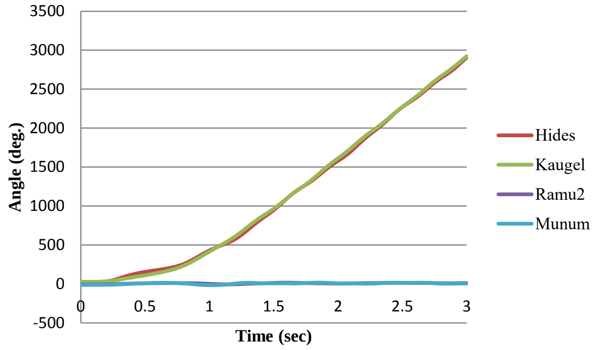


Fig. 7.7-21 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Ramu1

The case where the upper circuit of four circuit T/L between Dobel and Ramu1 S/Ss was 275 kV as Plan C' which is another plan of Plan C as shown in Fig. 7.7-22 was studied.

Fig. 7.7-22 Plan C'

In the case of Plan C', as shown in Fig. 7.7-23, Fig. 7.7-24 and Fig. 7.7-25, the transient stability at the time of main T/L fault is stable.

However, as well as the case of Plan C to cancel the overload of steady state, it is necessary to reinforce the 132 kV two circuit T/L between Singsing and Gusap S/Ss in three circuits and maintain the voltage criteria, installation of Sc of about 30 MVA is needed for Singsing, Walium and Gusap S/Ss, respectively.

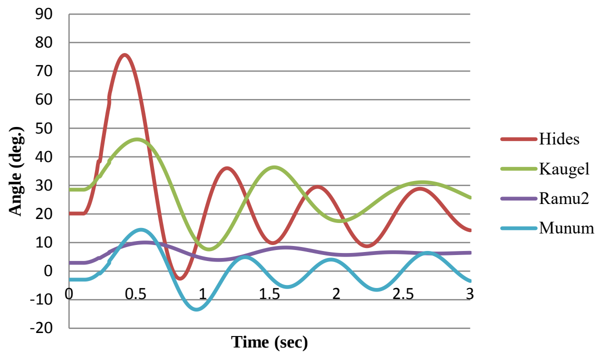


Fig. 7.7-23 Generator Internal Angles at the Time of Hides near End Fault

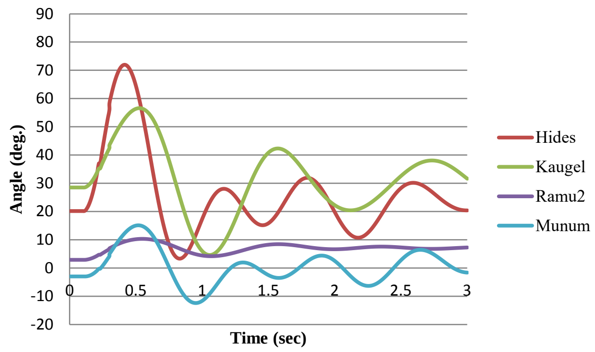


Fig. 7.7-24 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Ramu1

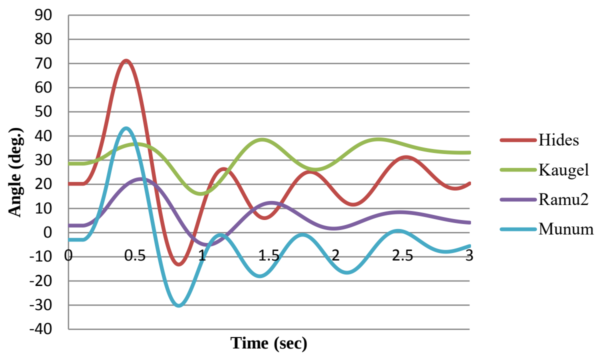


Fig. 7.7-25 Generator Internal Angles at the Time of Singsing near End Fault of Singsing-Erap

4) Plan D

Plan D was studied here as a plan having advantage of both Plan A, where Walium S/S serves as a transmission hub and Plan C, which reinforces the weak 66 kV system of the Highland area.

In Plan D, as shown in Fig. 7.7-26, Hides power source line is connected to Dobel S/S by a 275 kV dual-circuit T/L and Dobel and Walium S/Ss are connected by a 132 kV dual-circuit line. Moreover, Dobel and Ramu1 S/Ss are connected by a 132kV one circuit T/L. However, the T/L between Dobel and Ramu1 S/Ss is constructed as a single circuit of the steel tower for dual-circuits and when it becomes impossible to meet the demand of the Highland area via the existing 66kV one circuit T/L in future, it will be upgraded to 132kV.

Fig. 7.7-26 Plan D

In the case of Plan D, as shown in Fig. 7.7-27 - Fig. 7.7-30, the transient stability at the time of the main T/L fault is stable.

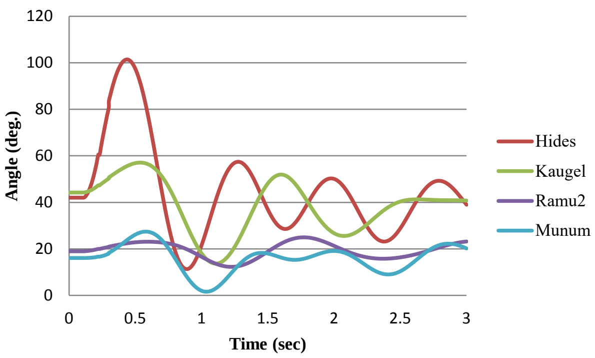


Fig. 7.7-27 Generator Internal Angles at the Time of Hides near End Fault

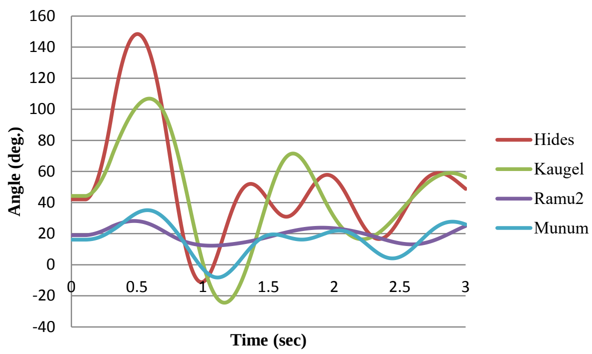


Fig. 7.7-28 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Walium

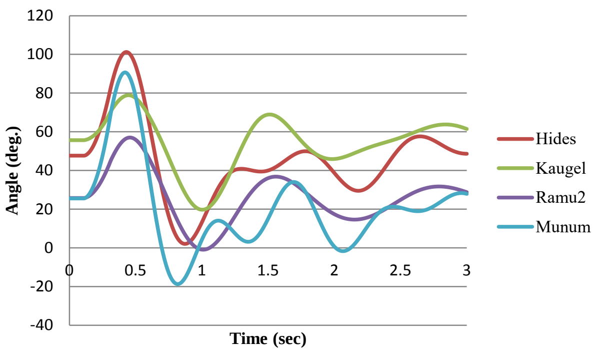


Fig. 7.7-29 Generator Internal Angles at the Time of Singsing near End Fault of Singsing-Erap

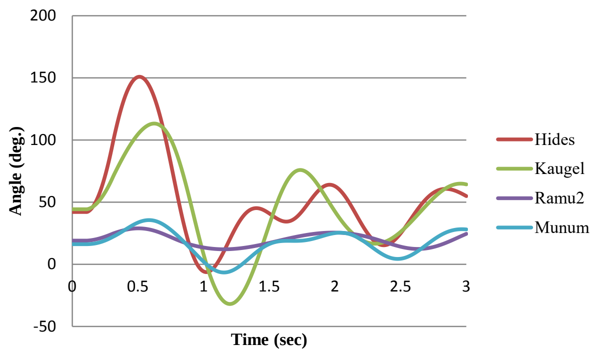


Fig. 7.7-30 Generator Internal Angles at the Time of Dobel near End Fault of Dobel-Ramu1

In addition, in the case of Plan D, it is said in Table 7.7-15 that it is necessary to confirm how much MW can be transmitted to the east side using the Hides power source line. In this case, the transient stability of the system was analyzed by the following methods and for transmission up to 140 MW, the system was confirmed as stable. The outline power flow conditions at the time of 140 MW transmission are shown in Fig. 7.7-31.

- The load of Erap S/S was increased and the output of Hides P/S was made to increase to an equivalent extent.
- The transient stability at the time of Dobel near the end fault of the T/L between Dobel and Walium and Singsing near the end fault of the T/L between Singsing and Erap was confirmed.

Furthermore, as substitution of Plan D, when the T/L between Dobel-Walium was assumed to be one circuit, it was unstable.

Fig. 7.7-31 Outline Power flow Conditions at the Time of 140 MW Transmission

When each plan shown in Table 7.7-14 is compared, it can be said as the transmission method of the P/S output of the Highland area that Plan D is optimal from perspectives of transient stability, power loss and possibility.

Table 7.7-14 (1) Comparison regarding the Transmission Method of the Power Station Output of the Highland Area

	Plan A	Plan A’
Voltage Drop	Need some reactive power compensator	Same as on the left
Transient Stability	Unstable	Stable
Power Loss	Base MW	-8.63 MW
Construction Cost	Base mUS$	+99 mUS$
Review regarding Plan with Stable Transient Stability	-	-Power flow restrictions may occur in the T/L between Walium and Singsing in future. -Upgrading of existing 66 kV T/Ls is needed with the future increase of demand of the Highland area. -In the case of a 275kV T/L, the connection cost of the potential middle-scale power source which exists in the direction of Madang etc. becomes expensive.
New Construction Lines	Hides - Dobel 132 kV, 2cct, 220 km Dobel - Walium 132 kV, 2cct, 160 km	Hides - Dobel 275 kV, 2cct, 220 km Dobel - Walium 275 kV, 2cct, 160 km
System Diagram		

Table 7.7-14 (2) Comparison regarding the Transmission Method of the Power Station Output of the Highland Area

<table>
<tr><th></th><th>Plan B</th><th>Plan C</th></tr>
<tr><td>Voltage Drop</td><td>Same as on the left</td><td>Same as on the left</td></tr>
<tr><td>Transient Stability</td><td>Stable</td><td>Unstable</td></tr>
<tr><td>Power Loss</td><td>-7.93 MW</td><td>+4.65 MW</td></tr>
<tr><td>Construction Cost</td><td>+125 mUS$</td><td>+104 mUS$</td></tr>
<tr><td>Review regarding Plan with Stable Transient Stability</td><td>-Upgrading of existing 66 kV T/Ls is needed with the future increase of demand of the Highland area.</td><td>-</td></tr>
<tr><td>New Construction Lines</td><td>Hides - Singsing
275 kV, 2cct, 400 km
Dobel - Walium
132 kV, 2cct, 160 km</td><td>Hides - Dobel
275 kV, 2cct, 220 km
Dobel - Ramu1
132 kV, 2cct, 223 km
66 kV, 2cct
(designed for 132 kV)</td></tr>
<tr><td>System Diagram</td><td>
</td><td>
</td></tr>
</table>

Table 7.7-14 (3) Comparison regarding the Transmission Method of the Power Station Output of the Highland Area

	Plan C'	Plan D
Voltage Drop	Same as on the left	Same as on the left
Transient Stability	Stable	Stable
Power Loss	-2.02 MW	-6.43 MW
Construction Cost	+177 mUS$	+111 mUS$
Review regarding Plan with Stable Transient Stability	-It is necessary to reinforce the 132kV dual-circuit T/L between Singsing and Gusap S/Ss to a 3-circuit T/L. - Compared to other plans, to maintain voltage criteria, many amounts of Sc(s) are installed.	-It is necessary to confirm how much MW can be transmitted to the east side using the Hides power source line (The result of confirmation is 140 MW).
New Construction Lines	Hides - Dobel 275 kV, 2cct, 220 km Dobel - Ramu1 275 kV, 2cct, 223 km 66 kV 2cct (designed for 132 kV)	Hides - Dobel 275 kV, 2cct, 220 km Dobel - Ramu1 132 kV, 1cct, 223 km Dobel – Ramu1 66kV, 1cct (Existing) Dobel - Walium 132 kV, 2cct, 160 km
System Diagram		

(2) The study result of power source connection

The connection method of the large-scale P/S for which connection is scheduled to be performed by 2030 was considered from the perspective of transient stability. A connection study of each P/S was performed under conditions whereby the P/S for study was operating at maximum output.

1) Connection study of Ramu2 power station

Regarding the connection to the Ramu2 P/S system, as shown in Table 7.6-5, three plans exist. Any case was stable when transient stability at the time of Ramu2 near the end fault of each of the three power source lines between Ramu2 and Gusap, Ramu2 and Singsing and Ramu2 and Ramu1 regarding Plan A and at the time of Ramu2 near the end fault of the power source line between Ramu2 and Singsing, was analyzed.

Therefore, Plan C is optimal as the connection of Ramu2 P/S was described in Section 7.6.2 (1) “Ramu2 power source”.

2) Connection study of Mongi power station

Since Mongi P/S is located about 80 km northeast of Taraka S/S as described in Section 7.6.2 (2) “Mongi power source”, the connection with Taraka S/S is natural and was stable when the transient stability was analyzed at the time of Mongi near the end fault of the power source line (132 kV dual-circuit T/L) between Mongi and Taraka. Therefore, the connection method of Mongi P/S is satisfactory with connection by a 132 kV dual-circuit T/L to Taraka S/S.

3) Connection study of Gowar power station

As for Gowar P/S, as described in Section 7.6.3 (3) “Gowar power source”, it is desirable to connect with Gusap S/S by a 132 kV dual-circuit T/L with the configuration shown in Fig. 7.6-15. It was stable when the transient stability at the time of Gusap near the end fault of the power source line between Gowar and Gusap was analyzed. Therefore, the connection method of Gowar P/S is satisfactory at connection by a 132kV dual-circuit T/L to Gusap S/S.

(3) N-1 analysis of the Year-2030 system

A contingency analysis (N-1) for the Year-2030 system was performed under contingency conditions whereby the voltage check was based on the (0.9-1.1 pu) limits and the loading was based on the T/L/transformer emergency capacity. A summary of the N-1 results and countermeasures is shown in Table 7.7-15.

Regarding individual overloading problems, the overload is small and since it also depends on the load power factor, countermeasures need not be considered at present. Here, subsequent analyses progress without these countermeasures.

Table 7.7-15 Summary of N-1 Results and Countermeasures

Contingency			Problem	Violated facilities	Countermeasures
S/S	S/S	No			
Ram1 66 kV	Ram1 22 kV	2	Overload	Ram1 66/22 kV Tr. No. 1	Expansion of Transformer (at least 4 MVA)
Pauanda 66 kV	Pauanda 22 kV	2	Overload	Pauanda 66/22 kV Tr. No. 1	Expansion of Transformer (at least 1 MVA)
Erap 132 kV	Erap 22 kV	1	Overload	Erap 132/22 kV Tr. No. 2	Expansion of Transformer (at least 1 MVA)
Erap 132 kV	Erap 22 kV	2	Overload	Erap 132/22 kV Tr. No. 1	
Milford 132 kV	Milford 11 kV	1	Overload	Milford 132/11 kV Tr. Nos. 2&3	Expansion of Transformer (at least 2 MVA)
Milford 132 kV	Milford 11 kV	2	Overload	Milford 132/11 kV Tr. Nos. 1&3	
Milford 132 kV	Milford 11 kV	3	Overload	Milford 132/11 kV Tr. Nos. 1&2	
Singsing 132 kV	Erap 132 kV	3	Under Voltage	Erap 132 kV bus & 22 kV bus Wafi 132 kV bus Munum 132 kV bus Taraka 132 kV bus & 11 kV bus Hamata 132 kV bus & 11 kV bus Milford 132 kV bus & 11 kV bus	Installation of SC (10 MVA) at 132 kV bus of Erap S/S

(4) Short-circuit study of the Year-2030 system

A short-circuit study was performed on the year-2030 system, the results of which are given in Fig. 7.7-32 and Fig. 7.7-33.

Initial transient impedance was used for the generator impedance.

All fault currents for 275, 132 and 66 kV S/Ss are well below the practical switchgear ratings for these levels, as shown in Fig. 7.7-32 and Fig. 7.7-33. Therefore, the year-2030 system will not experience any switchgear short-circuit rating problems.

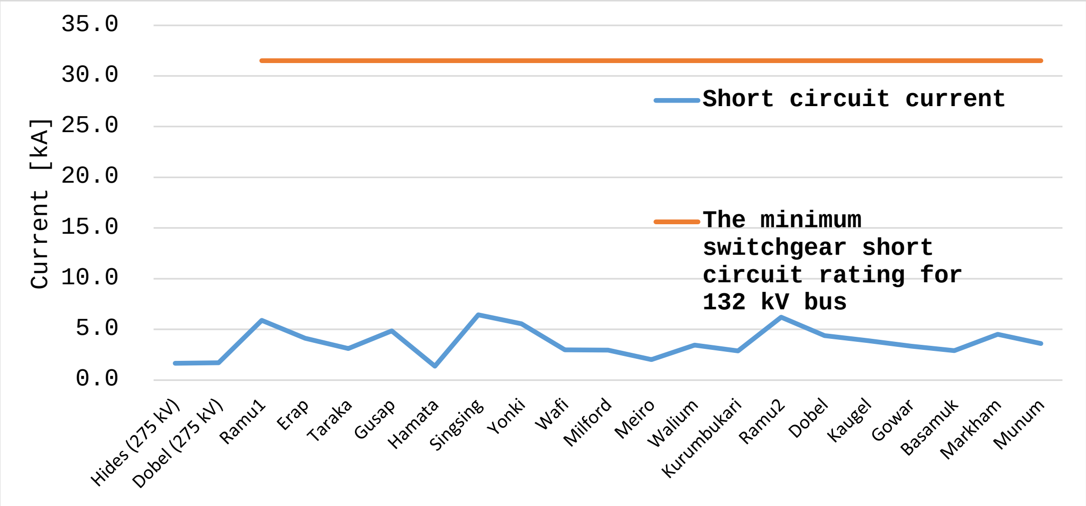


Fig. 7.7-32 Results of Short Circuit (275 kV Buses and 132 kV Buses of the Year-2030 System)

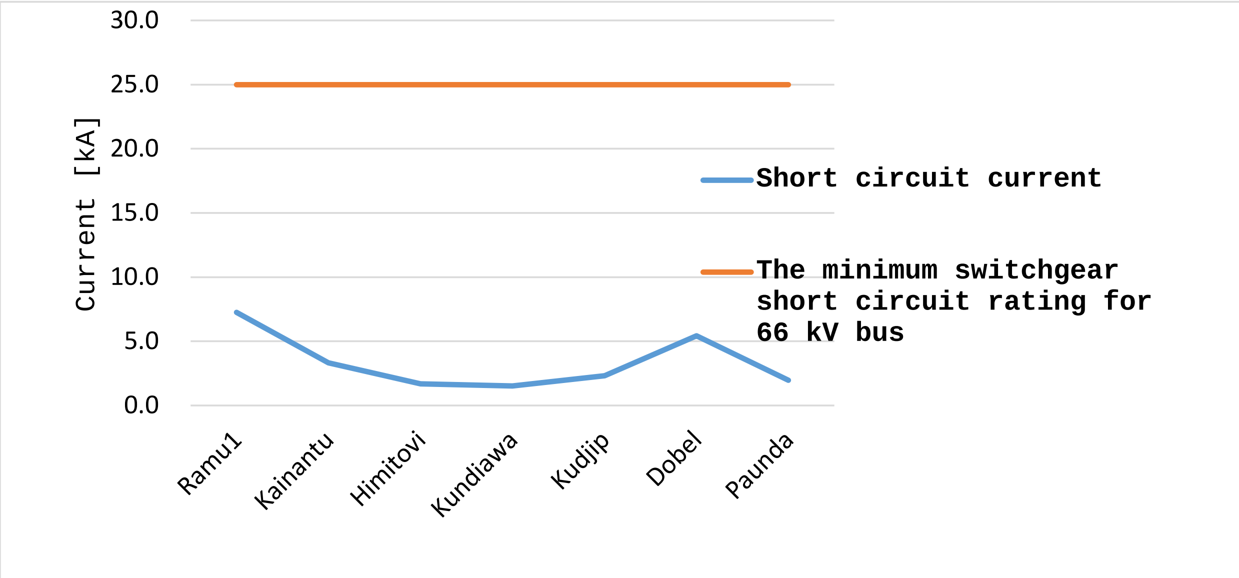


Fig. 7.7-33 Short Circuit Results (66 kV Buses of the Year-2030 System)

(5) Power flow analysis of the Year-2030 system (voltage profile)

The outline of the Power flow state of the Year-2030 system is shown in Fig. 7.7-34 and the single line diagram for Year-2030 system is shown in Fig. 7.7-35, respectively.

The voltage profile of 132 kV buses is shown in Fig. 7.7-36. Under normal conditions, all bus voltages are within the limits (0.95-1.05 pu), as defined in the planning criteria.

Fig. 7.7-34 Outline of the Power Flow State of the Year-2030 System

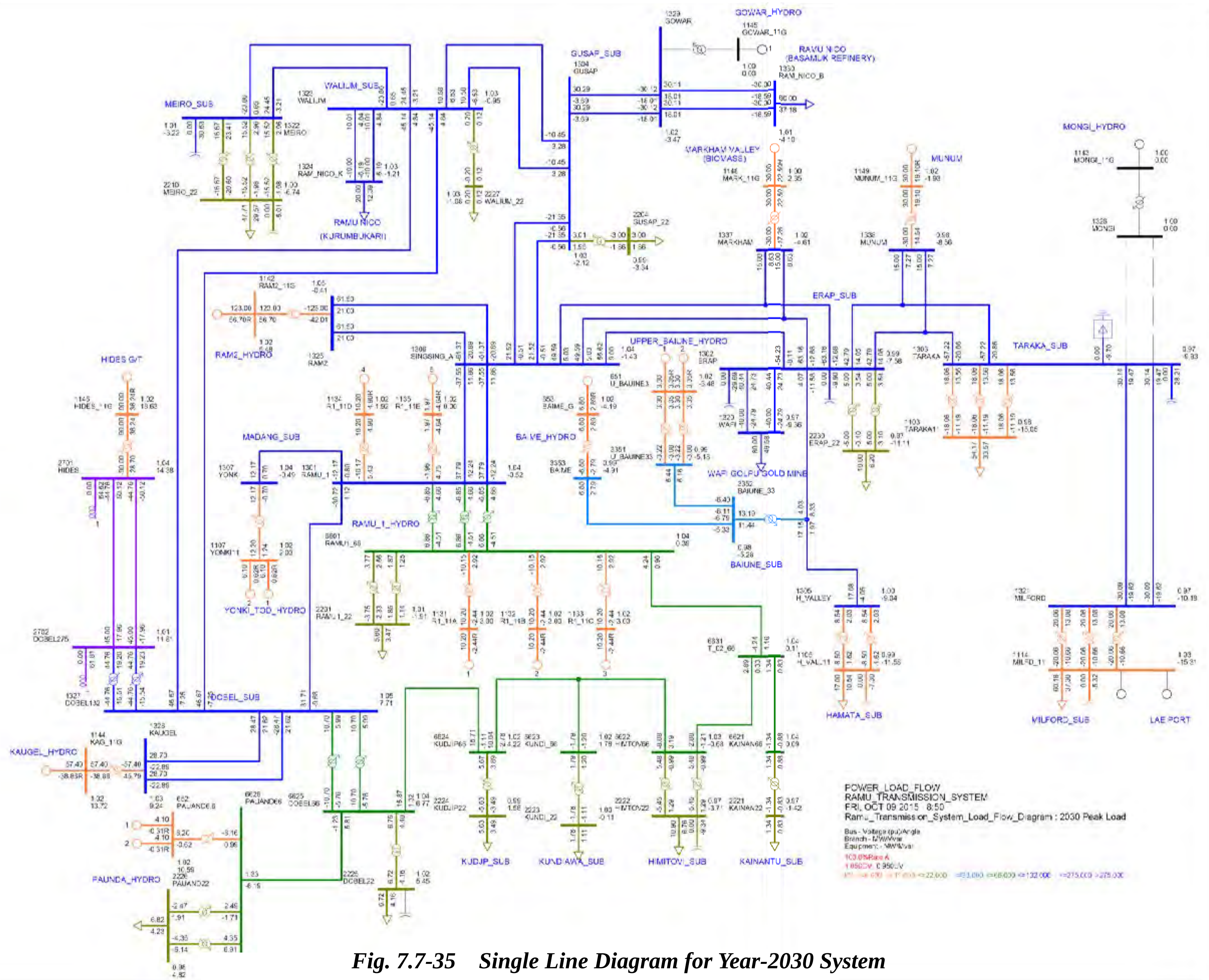


Fig. 7.7-35 Single Line Diagram for Year-2030 System

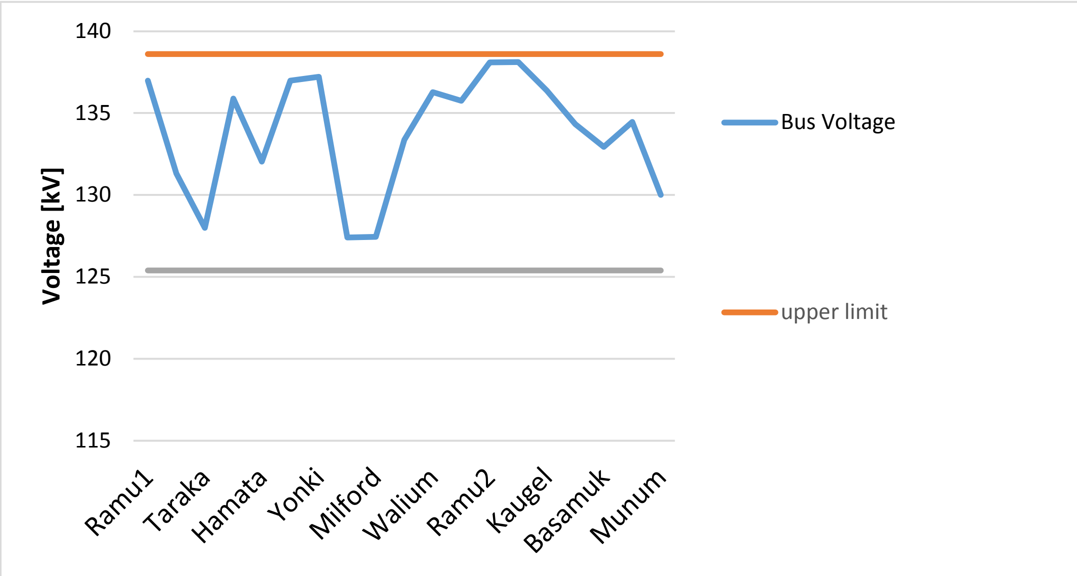


Fig. 7.7-36 Voltage Profile of 132 kV Buses

(6) Facility enhancement of the Year-2030 system

The facility enhancement required for the Year-2030 system is shown in Table 7.7-16, Table 7.7-17 and Table 7.7-18.

Table 7.7-16 Transmission Lines

S/S	S/S	kV	No. of Circuits	Type	Length [km]	Comments
Taraka	Milford	132	2	Deer	7.2	
Mongi	Taraka	132	2	Deer	80	Out of plant line
Erap	Taraka	132	1	Deer	20	
Munum	Erap - Taraka	132	2	Deer	1	Out of plant line (T)
Markham	Singsing – Erap	132	2	Deer	1	Out of plant line (B)
Erap	Wafi	132	2	Deer	40	
Baime	Baiune	33	1	Tiger2	1.8	Out of plant line
Singsing	Gusap	132	1	Tiger2	25.7	
Ramu2	Singsing	132	2	Deer2	15	Out of plant line
Gusap	Gowar	132	2	Deer	40	Out of plant line
Gowar	Ramu Nico (Basamuk Refinery)	132	2	Deer	20	
Gusap	Walium	132	1	Tiger2	66.8	
Walium	Ramu Nico (Kurunmbukari)	132	2	Deer	25	
Walium	Meiro	132	1	Tiger2	68.5	
Dobel	Ramu1	132	1	Deer	223	
Dobel	Walium	132	2	Deer	160	
Kaugel	Dobel	132	2	Deer	40	Out of plant line
Hides	Dobel	275	2	Deer2	220	Out of plant line (T)

"Out of plant line" denotes hydro plant, "Out of plant line (B)" denotes biomass plant and "Out of plant line (T)" denotes thermal plant.

Table 7.7-17 Transformers

Substation	HV/LV [kV]	Rating MVA	No. of Tr.
Milford	132/11	30	3
Taraka	132/11	30	3
Erap	132/22	10	2
Meiro	132/22	30	2
Himitovi	66/22	10	1
Dobel	132/66	30	2
Pauanda	66/22	10	1
Dobel	275/132	100	2

Generator step-up transformers are not included.

Table 7.7-18 Reactive Compensation

Substation	Voltage [kV]	Rating MVA	Sc or ShR
Taraka	132	30	Sc
Erap	132	30	Sc
Erap	132	10	Sc
Meiro	132	30	Sc
Himitovi	22	10	Sc
Hides	275	60	ShR
Dobel	275	60	ShR

(7) Off-peak operation of the Year-2030 system

It was confirmed that no voltage issue occurs at the time of the off-peak operation in the Year-2030 system.

Specifically, voltage profile was examined in the system of the following states.

- The ratio to the peak value of the off-peak value of general demand is 48.6% from the track record of a daily load curve in 2014.
- The off-peak value of mining demand is same as the peak value.
- Regarding the supply side, hydropower stations and biomass power plants are operating with priority.

From the result, it was confirmed that the operation within the limits of reference voltage (95 to 105%) was possible only by the tap change of transformers.

7.7.6 Consistency with Optimal Power Generation Development Plan

In the foregoing paragraph, the year-2030 system and the enhancement plan for its system construction was shown. The system was studied based on the Normal case as a result of the demand forecast described in Chapter 4. And about the result of Optimal Power Generation Development Plan described in Chapter 6, the system planning was carried out assuming installation of all the power sources which would have an installation possibility by 2030 and the demand-and-supply balance considered to be the severest on system analysis.

In Chapter 6, as results of Optimal Power Generation Development Plan for Basic Scenario, the demand-and-supply balance of the normal-demand case and high-demand case is described. And the demand-and-supply balance of high-demand case is described as results of Optimal Generation Plan for Alternative Scenario.

Here, it is verified whether the year-2030 system shown in the foregoing paragraph is a necessary-and-sufficient system to three kinds of demand-and-supply balance described in Chapter 6.

(1) For the Power Supply and demand balance for the normal-demand scenario

For Normal-Demand Scenario, the capacity of the development power source in 2030 is shown in Table 7.7-19 (Table 6.6-15). As actual outputs, since these capacities include reserve margin, Lae GT was stopped and the output of Mongi hydropower plant was decreased so that it might become severe on system analysis (Refer to the column of Output). The Power flow outline at that time is shown in Fig. 7.7-37. The transient stability regarding fault at the power source lines and main T/Ls of this system was stable.

Table 7.7-19 Capacity and Output Power Station as of 2030 for Normal-Demand Scenario

Option	Capacity (MW)	Output (MW)
Lae GT	30	0
Refurbishment of Pauanda	5	5
Refurbishment of YTOD	6	6
Munum	30	30
Baime PNGFP	10	10
Markham Valley Biomass	15	15
Hides G/T	25	25
Refurbishment of Pauanda	5	5
Ramu 2 Hydropower Scheme	120	120
Mongi/Bulum Hydropower Scheme	116	33
Kaugel Hydropower Scheme	84	84
Total	446	333

Fig. 7.7-37 Outline of the Power Flow State as of 2030 for Normal-Demand Scenario

This system has a point different very largely from the 2030-year system shown in Section 7.7.5. It is that the Mongi hydropower plant near east demand is operating. Therefore, the severity on the system analysis assumed in Section 7.7.5 has faded very much. The transmission capacity of the power source output of the Highland area by the Hides power source line may also increase, and the upgrade to 275kV of the Hides power source line may be unnecessary. It is verified about the point.

First, when Hides power source lines were two 132kV circuits, it was studied what amount of transmission is possible in consideration of transient stability. As a result, it proved that 70 MW can be transmitted using 132kV and two circuits. The Power flow outline in that case is shown in Fig. 7.7-38 (The output of Ramu2 P/S was reduced as an equivalent for the increment of the output of the Hides power source). However, it is study as reference on assumption of "if the Mongi hydropower plant is operating", and it is very important to recognize that it is not the result of being employed on the master plan.

However, when the upper study result is considered paradoxically, as shown in Table 6.6-11, Construction Cost of the Mongi P/S is a large sum, but if this P/S is constructed and it is always operated, it will be thought that power system operation becomes very easy.

About the transmission capacity when using a 275kV T/L, it is verified in the following paragraph.

Fig. 7.7-38 Outline of the Power Flow State at the Time of 70 MW Transmission

(2) For the Power Supply and demand balance for the high-demand scenario

For high-Demand Scenario, the capacity of the development power source in 2030 is shown in Table 7.7-20 (Table 6.6-17). As actual outputs, since these capacities include reserve margin, Lae GT was stopped, Additional Thermal Generation (IPP) in which the place is not determined was stopped, the output of Ramu2 power plant was made into about 70 percent and the remaining supply depends on power generation of Highland area so that it might become severe on system analysis (Refer to the column of Output). The Power flow outline at that time is shown in Fig. 7.7-39. The transient stability regarding fault at the power source lines and main T/Ls of this system was stable.

Since the Mongi P/S near the east demand area is connected to this system as well as Normal-Demand Scenario, when Hides power source lines were two 132kV circuits, it was studied what amount of transmission is possible through the Hides power source lines in consideration of transient stability. As a result, it proved that 170 MW can be transmitted. The Power flow outline in that case is shown in Fig. 7.7-40.

Table 7.7-20 Capacity and Output Power Station as of 2030 for high-Demand Scenario

Option	Capacity (MW)	Output (MW)
Lae GT	30	0
Refurbishment of Pauanda	5	5
Refurbishment of YTOD	6	6
Munum	30	30
Baime PNGFP	10	10
Markham Valley Biomass	15	15
Hides G/T	25	25
Refurbishment of Pauanda	5	5
Ramu 2 Hydropower Scheme	180	130
Mongi/Bulum Hydropower Scheme	90	90
Kaugel Hydropower Scheme	60	60
Additional Thermal Generation (IPP)	30	0
Highland G/T	30 30 120 30	85
Total	696	461

Fig. 7.7-39 Outline of the Power Flow State as of 2030 for High-Demand Scenario

Fig. 7.7-40 Outline of the Power Flow State at the Time of 170 MW Transmission

(3) For the Power Supply and demand balance for the Alternative scenario

For alternative Scenario, the capacity of the development power source in 2030 is shown in Table 7.7-21 (Table 6.6-19). As actual outputs, since these capacities include reserve margin, Lae GT was stopped, Additional Thermal Generation (IPP) in which the place is not determined was stopped, power generation of Highland area was made to equal to the amount in the high demand case and the output of Ramu2 power plant was made to almost the same so that it might become severe on system analysis (Refer to the column of Output). The Power flow outline at that time is shown in Fig. 7.7-41. The transient stability regarding fault at the power source lines and main T/Ls of this system was stable.

Table 7.7-21 Capacity and Output Power Station as of 2030 for Alternative Scenario

Option	Capacity (MW)	Output (MW)
Lae GT	30	0
Refurbishment of Pauanda	5	5
Refurbishment of YTOD	6	6
Munum	30	30
Baime PNGFP	10	10
Markham Valley Biomass	15 15 15	15 15 15
Hides G/T	40	25
Refurbishment of Pauanda	5	5
Ramu 2 Hydropower Scheme	180	115
Highland G/T	30 30 120 30	85
Kaugel Hydropower Scheme	84	84
Gowar Hydropower Scheme	54	54
Total	699	464

Fig. 7.7-41 Outline of the Power Flow State as of 2030 for Alternative Scenario

(4) Consideration regarding the high case demand forecast

When a demand forecast is high case, Yandera mining is assumed as demand. As shown in Fig. 7.6-15, as for the power to this mine, the supply from Walium S/S is planned. If the power supply is depended on Ramu2 P/S and the dependence becomes above to some extent, the power flow of the T/L between Gusap and Singsing may become about 280 MVA. Therefore, the necessity of constructing two circuits T/L which considered the conductor type of the T/L as an equivalent for two conductors of Deer as the power source line between Ramu2 and Singsing arises at the time of one circuit extension of the T/L between Gusap and Singsing.

Moreover, the facility enhancement shown in Table 7.7-22 is needed as voltage compensation and countermeasures against overload. Where, transformer extension of Dobel S/S is needed when the power flow of the Hides power source line exceeds 120MVA.

Table 7.7-22 Facility Enhancement of the Year-2030 System for High-Demand Case

Substation	Tr or Sc	Voltage [kV]	Rating MVA	No. of Tr.
Meiro	Sc	132	30	-
Walium	Sc	132	60	-
Ramu1	Tr	66/22	10	1
Dobel	Tr	275/132	100	1

7.7.7 Planning and Analytical Result of the Year-2025 System

(1) The mindset about the Year-2025 system

Based on the demand forecast and the Electric Power Development Planning (Normal-Demand Scenario) in 2025, the case where it is considered as severe demand-and-supply balance is assumed on system analysis as the time of the system planning in 2030.

(2) N-1 analysis of the Year-2025 system

Overload occurs in a healthy transformer at the time of one-unit fault of the transformer for load supply of five S/Ss of Milford, Taraka, Ramu1, Meiro, and Erap. Extension of the transformer of these S/Ss in the 2025 is an issue of the policy how to consider supply trouble.

(3) Short-circuit study of the Year-2025 system

The year-2025 system will not experience any switchgear short-circuit rating problems.

(4) Power flow analysis of the Year-2025 system (voltage profile)

The single line diagram for year-2025 system is shown in Fig. 7.7-42, under normal conditions, all bus voltages are within the limits, as defined in the planning criteria.

(5) Facility enhancement of the Year-2025 system

It is as follows when the facility enhancement required for the Year-2025 system is summarized with facility enhancement required for the year-2030 system shown previously.

Table 7.7-23 Transmission Lines

S/S	S/S	kV	No. of Circuits	Type	Length [km]	Year 2025	Year 2030	Comments
Taraka	Milford	132	2	Deer	7.2	+		
Mongi	Taraka	132	2	Deer	80	+		Out of plant line
Munum	Erap - Taraka	132	2	Deer	1	+		Out of plant line (T)
Markham	Singsing – Erap	132	2	Deer	1	+		Out of plant line (B)
Erap	Wafi	132	2	Deer	40	+		
Baime	Baiune	33	1	Tiger	1.8	+		Out of plant line
Singsing	Gusap	132	1	Tiger	25.7	+		
Ramu2	Singsing	132	2	Deer*2	15	+		Out of plant line
Gusap	Gowar	132	2	Deer	40	+		Out of plant line
Gowar	Ramu Nico (Basamuk Refinery)	132	2	Deer	20	+		
Gusap	Walium	132	1	Tiger	66.8	+		
Walium	Ramu Nico (Kurunmbukari)	132	2	Deer	25	+		
Walium	Meiro	132	1	Tiger	68.5	+		
Dobel	Ramu1	132	1	Deer	223	+		
Dobel	Walium	132	2	Deer	160	+		
Kaugel	Dobel	132	2	Deer	40		+	Out of plant line
Hides	Dobel	275	2	Deer*2	220	+		Out of plant line (T)

"Out of plant line" denotes hydro plant, "Out of plant line (B)" denotes biomass plant and "Out of plant line (T)" denotes thermal plant.

Table 7.7-24 Transformers

Substation	HV/LV [kV]	Rating MVA	No. of Tr.	
			Year 2025	Year 2030
Milford	132/11	30	2	1
Taraka	132/11	30	2	1
Erap	132/22	10	2	-
Meiro	132/22	30	3	-
Himitovi	66/22	10	1	-
Dobel	132/66	30	2	-
Pauanda	66/22	10	1	-
Dobel	275/132	100	2	-

Generator step-up transformers are not included.

Table 7.7-25 Reactive Compensation

Substation	Voltage [kV]	Sc or ShR	Rating MVA	
			Year 2025	Year 2030
Taraka	132	Sc	30	
Erap	132	Sc	-	30
Erap	132	Sc	10	
Meiro	132	Sc	-	30
Himitovi	22	Sc	10	
Hides	275	ShR	60	
Dobel	275	ShR	60	

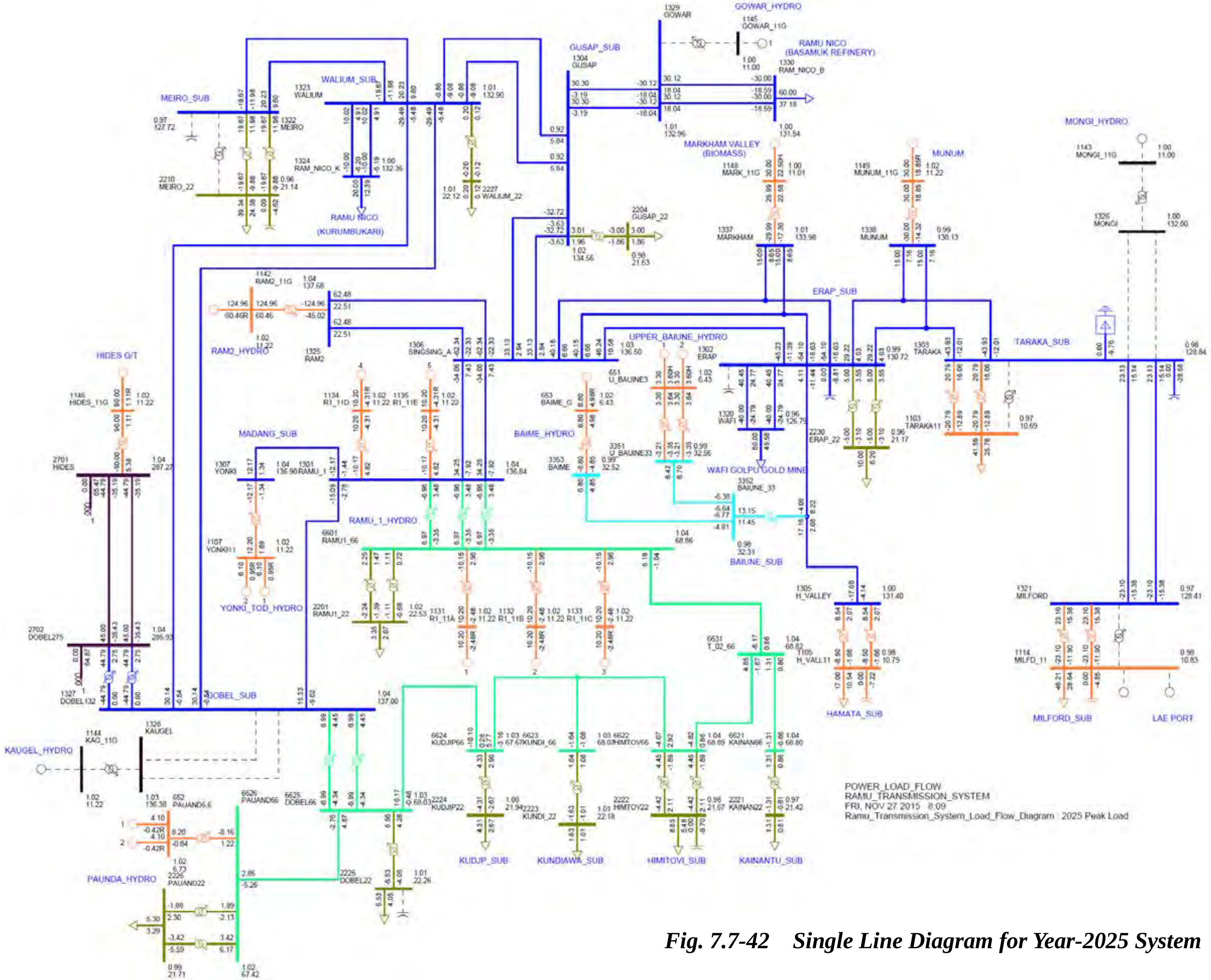


Fig. 7.7-42 Single Line Diagram for Year-2025 System

7.7.8 Interconnection between the RAMU System and the POM System

A study for the interconnection between the RAMU system and the POM system is undertaken. The study consists of consideration from perspectives of the power system development planning (system analysis) and economic evaluation, and the result of the study is shown in Appendix 7-1.

7.8 POWER SYSTEM OPERATION

7.8.1 Structure of Power System Operation

(1) Facility

There are 15 S/Ss in Ramu power system, all of which unmanned. There are also four hydropower stations and seven thermal power stationP/Ss stations in the Ramu power system, all of which are manned.

There is one dispatch center in the Ramu1 P/S, three switching officers and two maintenance officers for the S/S in the Ramu1 power plant and Taraka S/S and one maintenance officer for the T/L in the Ramu1 power plant.

Refer Fig. 7.8-1 to Fig. 7.8-4.

The result of an investigation into how these P/Ss and S/Ss are operated and maintained is described below.

(2) Load Dispatch Center

A Load Dispatch Center (LDC) for the Ramu power system is placed at Ramu1, which controls and adjusts overall power system demand.

There are four people in LDC, operating on four shifts and monitoring for 24 hours.

LDC makes a generation plan based on daily and weekly demand forecasts, requests power generation to hydropower stations (Ramu1, Pauanda, Yonki) and thermal power stations (Madang, Taraka, Milford) and gives orders to all P/Ss and S/Ss.
That day, when adjusting demand and supply, using a frequency meter on the table, LDC instructs power plants to control their generation and requests mining facilities to reduce their load by phone if necessary.

LDC has used the SCADA system installed in 2011 to monitor frequency and voltage. The SCADA system can monitor only the Gusap S/S, the circuit breaker indication of which is “open” or “closed” and the frequency, voltage, current and power flow. It also operates the remote control for the circuit breaker at Gusap S/S, as required. This information is gathered by telecommunication using OPGW, which means the Ramu Load dispatch center doubles as a switching officer for Gusap S/S.

If any defect or fault occurs at a P/S, S/S or transmission, power flow, the frequency and voltage will change, which notifies LDC when something happened. When LDC notices an incident, LDC instructs the switching officer to confirm the phenomenon by telephone. LDC ultimately confirms the same until recovery.

(3) Switching officers

Switching officers are deployed at Taraka, Meiro, Himitovi and Dobel S/S and inform LDC about the current of each feeder for all jurisdictional S/Ss.

Two other people operate as standby switching officers and are called out to attend and handle switching activities.

Since Madang and Dobel were not surveyed this time, there is the SCADA system in Taraka S/S switching officer, which monitors the Erap S/S, Hidden Valley S/S by the SCADA system. In the SCADA system installed in 2011, the Taraka switching officer can monitor both S/Ss, but not Hidden Valley S/S. Accordingly, the Taraka switching officer requests that IPP read the meter of each feeder current and send this data by telephone. Since Taraka and Milford S/S are not connected to the SCADA system, which assists Taraka switching officers, somebody will be assigned at Milford to read the meter of each feeder current and send this data to Taraka switching officer by telephone, while the Taraka switching officer will read the meter of each feeder current personally and record this data. The gathered data will then be input into the computer by hand via the Taraka switching officer.

In addition, if a switching officer is instructed to operate the circuit breaker from the dispatch center, Erap and Hidden Valley S/S will be operated by the SCADA system, but at Taraka S/S and Milford S/S, the first switching officer moves and operates a relevant circuit breaker via a relay system even at midnight.

Furthermore, if something happens, i.e. a defect or fault, when the dispatch center calls the switching officer they have to inform the confirmation result as an Operational Fault Report, manually rather than automatically. Accordingly, the switching officer instructs the maintenance personnel to determine the nature of the fault by phone.

(4) Maintenance team

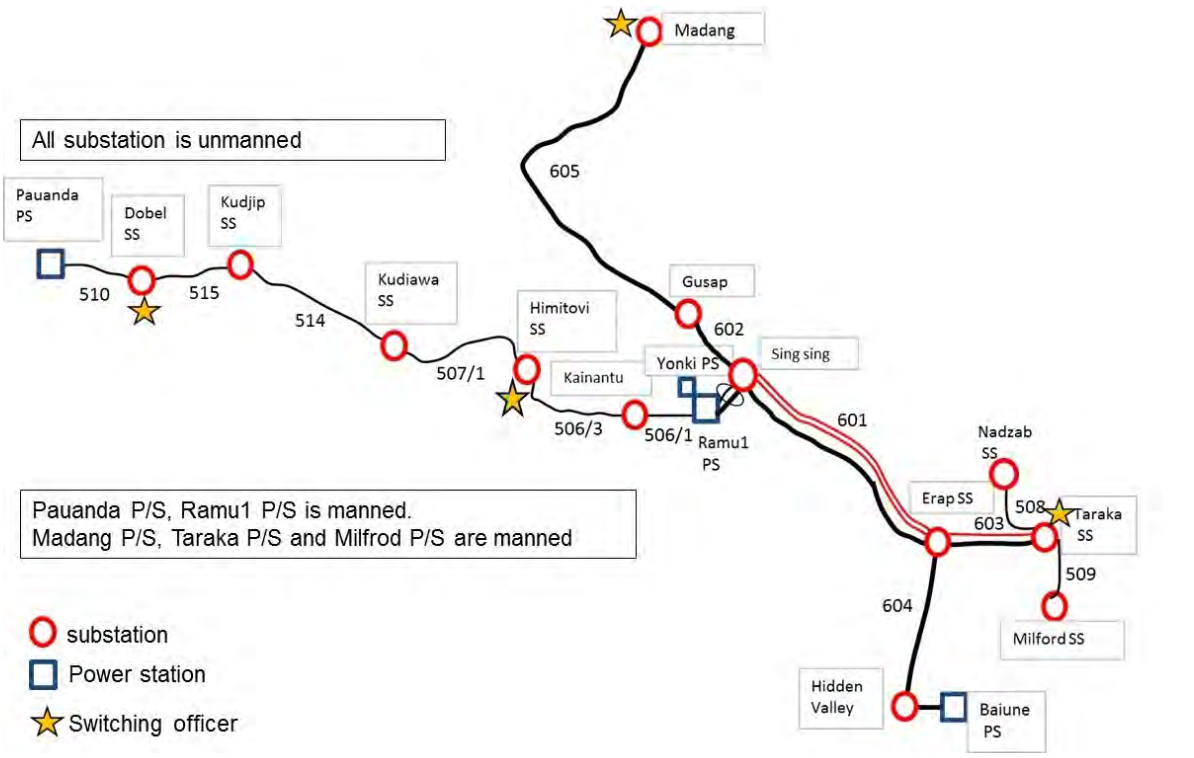
S/S maintenance offices are placed at Taraka S/S and Ramu1 P/S while a maintenance office for T/Ls is placed at Ramu1 P/S. Dobel S/S and informs LDC about the current each feeder all jurisdictional S/S.

There are 14 persons designated for S/S maintenance. There is the Highland area office in Ramu1, with one team leader and two technicians. There is the coastal area office in Taraka S/S, with one team leader, four technicians and three casual staff. There are also two engineers and S/S manager for both areas collectively.

The maintenance team has three main roles. The first is to patrol and request spare parts if necessary. The team make a plan each year, based on which they implement patrols with a checklist. Subsequently, if the maintenance team finds any defect or deficiency, they make a list to procure spare parts and send it to head office. The head office procures the spare parts, provided it is within budget and after receiving the spare parts, the second task is to repair defective equipment and commission tests. The maintenance team repairs the equipment by themselves without engineers from the maker and then confirms the equipment recovery by examination.

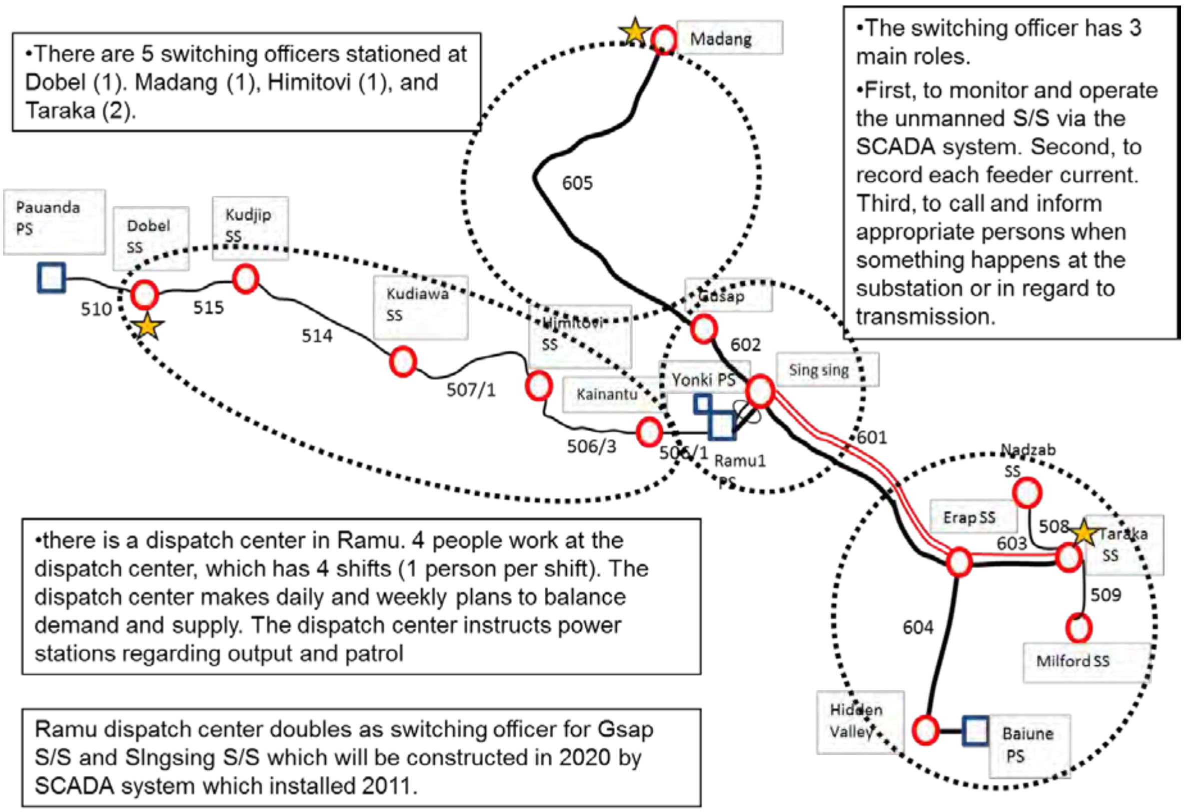
The third task is dealing with faults. It is very hard for the maintenance team because defects or faults occur frequently and they are short-staffed. Even if it is midnight, when instructed by the switching officer, they have to find defective points, assess whether the equipment is available, isolate the defective points and recover the power system as soon as possible.

They do not conduct periodical equipment inspections but transformer tap changers are checked once every 6 years by an Australian engineer.



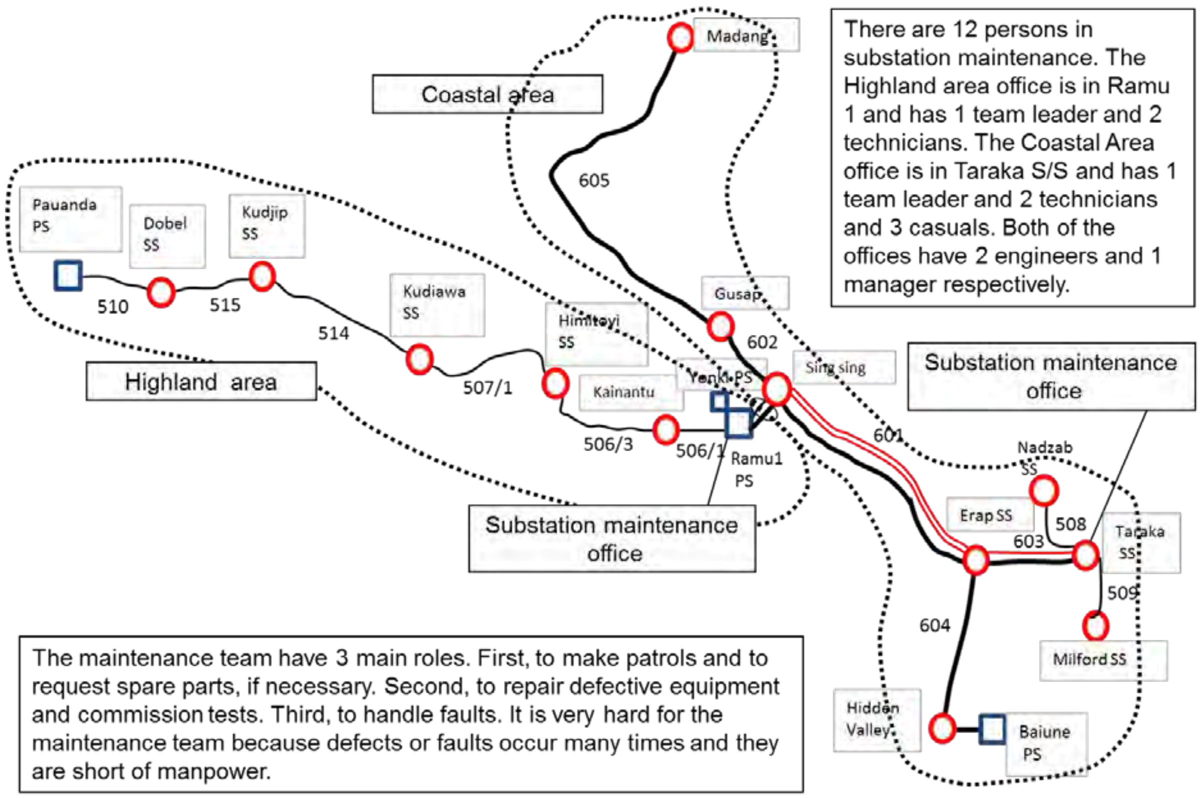
(Source: JICA Study Team)

Fig. 7.8-1 Manned Power Station and Unmanned Substation



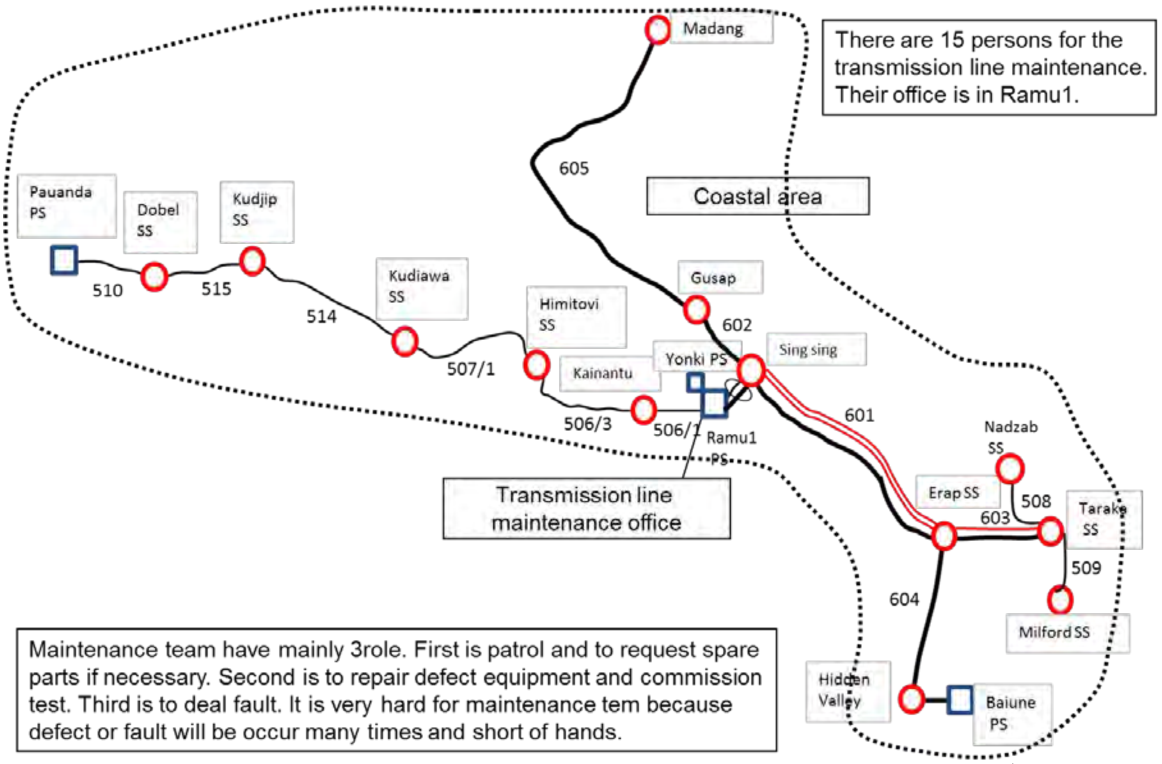
(Source: JICA Study Team)

Fig. 7.8-2 Dispatch Center and Each Switching Officer



(Source: JICA Study Team)

Fig. 7.8-3 Organization for Substation Maintenance



(Source: JICA Study Team)

Fig. 7.8-4 Organization for Maintenance about Transmission Line

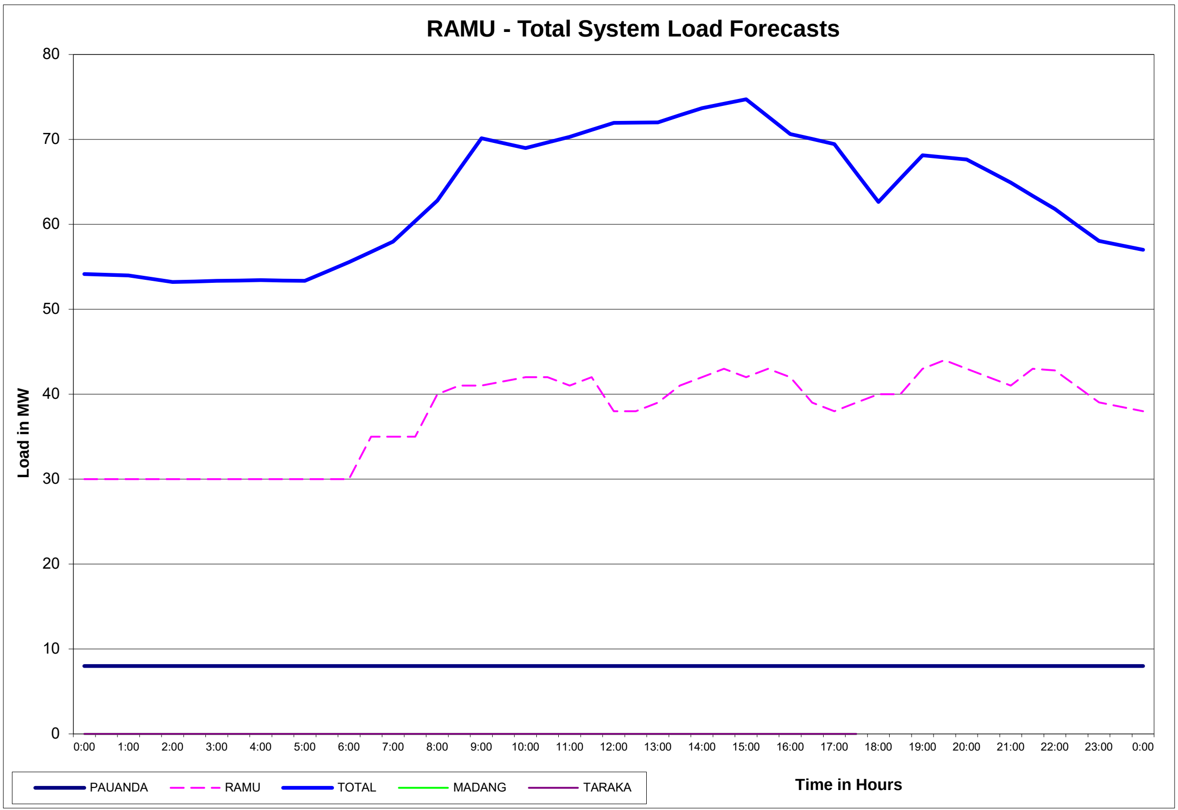
7.8.2 Mission of Power System Operation

(1) Work of the Dispatch Center

The dispatch center has two main tasks. One is to work on supply and demand operations and the other is to work on system operations.

To work on the supply and demand operation, the dispatch center first makes a demand forecast for tomorrow, as shown in Fig. 7.8-5.

This is based on the operational track record for each day of the week.



(Source: PPL)

Fig. 7.8-5 Load Forecast Tomorrow

The next thing sees the dispatch center establish a supply plan. To allow the supply plan dispatch center to determine the available capacity of each generator and merit an order from all hydropower stations (Ramu1, Pauanda, Yonki TOD, Baiune) and all thermal P/Ss (Taraka, Milford, Madang, Mendi, Wabag, Kundiawa, Goroka). Subsequently, the dispatch center makes a supply plan, with base supply power from Pauanda, middle supply power from Ramu1 and peak supply power from a thermal diesel generator. Some diesel generators are on standby when some generators are subject to outage.

For the system operation work, the dispatch center monitors the SCADA system and power system monitoring panel. There are four main areas: system operation, voltage control Power flow adjustment (frequency control), switching operation and dealing with faults or defects.

Before describing the system operation method, the PNG Grid Code is introduced.

The final draft of the PNG Grid Code was submitted in May 2014. Regarding the frequency, control is described as follows;

- The nominal fundamental frequency of the power system in PNG is 50 Hz.
- In the normal situation, frequency is controlled to between 49.5 and 50.5 Hz.
- During Single Outage Contingency, the system frequency may vary between 49 and 51 Hz.
- In the case of Multiple Outage Contingency or when the grid is in a state of emergency, the frequency may vary between 47 and 52 Hz.

Details of the voltage control are described as below.

- The nominal voltages for the high-voltage transmission of electricity shall be 66 and 132 kV or higher as adopted by the Technical Regulator
- The nominal voltages for the medium-voltage primary distribution of electricity shall be 11, 22 and 33 kV
- The nominal voltages for the low-voltage secondary distribution of electricity shall be 240/415 V
- The System Operator shall control and maintain the voltage magnitude of the grid in real-time operation within the limits of 0.95 and 1.05 per unit for Grids with demand of at least 10 MW and within the limits of 0.9 and 1.1 per unit for Grids with demand of less than 10 MW.
- Users shall ensure that their connection complies with the voltage imbalance, harmonics and flicker severity set by the Technical Regulator.

The power system for that day operates in advance based on the demand and supply plan created. The dispatch center monitors the frequency, power flow and voltage by the SCADA system.

In case the voltage drops due to increased demand, either the transformer tap or STATCOM, which is in Taraka and Meiro S/S, moves automatically. If necessary, the dispatch center instructs the switching officer to close the static capacitor and recover the regulated voltage value. There is no shunt reactor in the Ramu power system.

In case the frequency drops due to increased demand, the dispatch center instructs the P/S to increase output, while in the event of any power shortage, the dispatch center requests the mining company to reduce power consumption. Requests are also made for load-sharing customs to run their generators.

When the maintenance team repairs breakdown equipment, the area around the equipment has to be cut off. Security work is possible.

While monitoring the SCADA system, if something happens, the dispatch center notes any variation in frequency, power flow or voltage and calls the switching officer, whereupon the dispatch center makes an Operational Fault Report manually rather than automatically

The dispatch center records the RAMU NETWORK DAILY STATUS, including outages, progress of repairing defective equipment, availability of T/Ls and System Average Interruption Duration Index (SAIDI).

The dispatch center not only monitors the power system, but also operates circuit breakers, meaning it is overloaded.

To avoid exceeding the limit value of the Grid Code for frequency, when the Ramu1 hydropower station is subject to outages, the frequency declines rapidly, so the dispatch center engages in load shedding where possible.

There are three stages of outage. For each stage, the rule is decided based on the frequency and period (time in secs) for each feeder at each S/S. This load shedding is performed automatically by the under frequency relays, setting values for which are decided in advance.

(2) Introducing the SCADA system plan

An introduction plan of the SCADA system is shown in Table 7.8-1.

Table 7.8-1 Introduction Plan of SCADA System

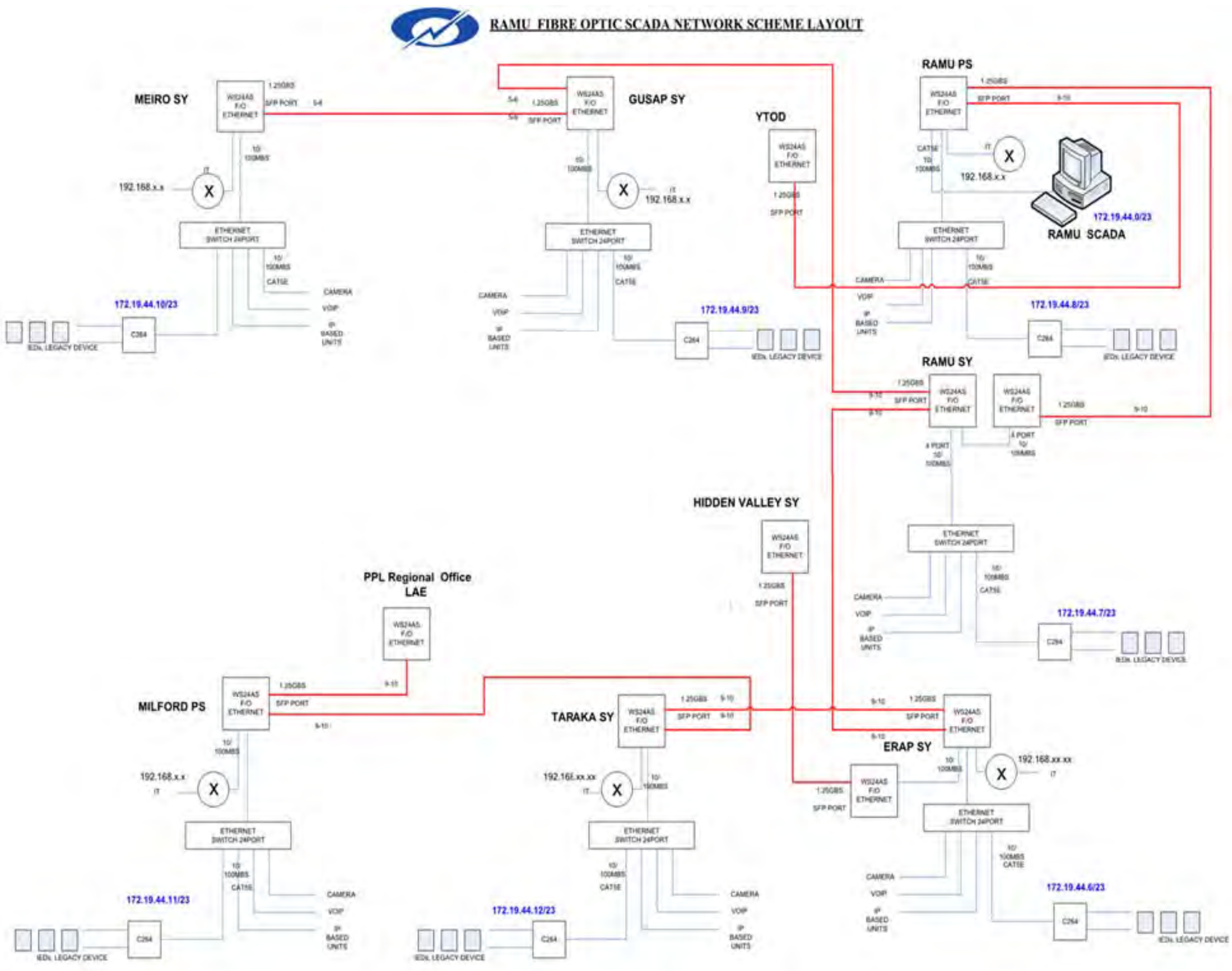
	Timing of introduction	Targeted facilities	Functions
Phase 1	2014 - June 2015	Introduce a plan for the National control Center at POM and Ramu Control Center (except the Highland area) at Ramu1 P/S are to be installed. In October 2014, the SCADA system was introduced at two S/Ss (Erap, Gusap). By the end of 2015, Ramu1 hydroP/S and four S/Ss (Milford, Taraka, Ramu Switchyard, Madang) will have the same system introduced, including a remote control function.	- Communication: FO method - Data collection of the 132 and 11kV feeder current from targeted P/Ss and S/Ss - Remote control will be operated when instructed by the dispatch center (Remarks) There are two dispatch centers at Taraka and Ramu1 as of October 2014.
Phase 2	2016 onward (Not decided)	(Highland area) Pauanda P/S, Pauanda SW/S, Dobel S/S, Kudjip S/S, Kundiawa S/S, Himitovi S/S, Kainantu S/S will have a local SCADA system introduced and be monitored and operated at Ramu1. Communication is useful existing OPGW from Pauanda to Ramu1. Implementation of a control panel complied with IEC61850	- Communication: OPGW[*2] method - Remote monitoring/control - LDC will adjust demand and supply and operate the entire Ramu power system.

*1 RCC : Regional Control Center
*2 OPGW: Optical Fiver Ground Wire
(Source: Interview from SCADA team in head office)

Currently, the SCADA system has four main functions. One is to monitor the status of the circuit breaker, line switches and earth switches, which are opened and closed. The second is the LDC ability to command circuit breakers, line switches and earth switches to open and close. The third is for the LDC to determine where faults occur. When a fault occurs, to shut down the fault, the relay trips the circuit breaker. As the information travels to LDC, the LDC can determine where the fault occurred and how, to facilitate swifter power system recovery. The fourth is to measure the voltage, current and frequency using a current and voltage transformer and calculate power, reactive power and power factor.

Currently, the reclosing system is not useful and the SCADA system includes important functions such as synchronous checks, reclosing systems, inter-lock systems and wave form recording systems.

An image of the communication system between the LDC and S/Ss, including connections within LDC, is shown in Fig. 7.8-6. FO is adopted as the communication method between LDC and each S/S with the FO communication panels. As for the inside of the LDC, the LDC server and each operator control panel are connected with a dual LAN type.



(Source: PPL)

Fig. 7.8-6 Image of the Communication System

As the T/L is a single circuit, the communication system occupies one route. There is no PLC in PPL.

When a new S/S is constructed, it can be monitored and commanded by remote control. Because the new S/S protocol must agree with the existing LDC protocol, C264 IEC61850 has been used for the common PPL gateway.

7.8.3 Recommended Issues and Countermeasures for Power System Operation

(1) Current issues of power system operation and countermeasures

The issue of power system operation currently does not involve planning for dispatch but instructing for dispatch. In particular, collecting data of active power, recording and engaging in countermeasure after failure comprises the main assignment for the dispatch center. Since there is no information on supervision of circuit breaker and telemeter information such as voltage and active power for dispatch center and switching officer, it takes considerable time to grasp the failure aspect and countermeasures for failure.

Therefore, it is desirable to install the SCADA system in all S/Ss as soon as possible. If the SCADA system is introduced, the dispatch center and switching officer can grasp which S/S malfunctions, where the T/L malfunctions and the landscape of failure, such as a short circuit or earth circuit, can rapidly recover from failure by remote control.

Since the control center currently only has one person working to balance supply and demand, power system instruction and record of dispatch data, it is desirable to appoint two people per team to the dispatch center. These can be experts to young people.

(2) Future issue of power system operation and countermeasures

In future, the issue will be instituting interconnection. The third party access code was instituted Jan. 2014 and allows permitted companies to supply power to special customers. To control the power system, a Grid Code was also instituted in Nov. 2014. But it is insufficient for limitation item to satisfy criteria, which is policy for technical interconnection requirements.

If the third party become to utilize power system under such as vague condition, power system will have problem like as power system stability, voltage fluctuation, frequency arrangement and harmonic. Therefore, countermeasure for policy for technical requirements for interconnection based on institution applied in Japan is shown as below.

Standard work flow from interconnection examination to commencement of wheeling service which is to transmit electric by using power system by Transmission and Distribution Sectors of Vertically Integrated Utilities (TDSVIU) instead of third party is shown Appendix 7-2. It is important two things, one is to be checked in advance by TDSVIU whether technical requirement is satisfied submitted document by applicant of interconnection. Only applicant of interconnection satisfied requirement can utilize power system. Second is to conclude power system operation agreement between dispatch center and applicant for interconnection.

Therefore it is possible to confirm whether installed equipment satisfy technical requirements for interconnection. Furthermore, after connecting power system, based on power system operation agreement, operation will be done such as planning and implementation for outage work, to arrange voltage by operation for switchgears, deal with fault and outage and operation for protection relay. Sample of power system operation agreement is shown Appendix 7-2.

TDSVIU request applicant for interconnection to submit information regarding with generator facilities and demand facilities which is necessary to consider for interconnection. Concretely, it is address of generating site, rated output, specification of generator, voltage at receiving point, the number of circuit, desired commencement date of wheeling service for generator facilities that is shown Appendix 7-2. Conversely, it is location of use of electricity, contract power, voltage at receiving point, number of circuit, desired commencement date of wheeling service for demand facilities that is shown Appendix 7-2.

Policy for technical requirements for interconnection of generation facilities is shown in Appendix 7-2. It is basically for generator side to deal with necessary countermeasure before utilizing interconnection. In this Appendix 7-2, explanation of "When it is necessary to implement measures coordinated with power systems, such as installation of an on-load tap changer and voltage fluctuation control to counter magnetizing inrush current" is described as below.

- Magnetizing inrush current is phenomena to occur when core saturate. Core saturation time is longer than larger residual flux and magnetizing inrush current is larger too. There are problem that one is to reduce voltage long time relatively such as 0.1 second to 60 second and second is that percentage differential relay (T87) is wrong action. Since magnetizing inrush current include secondary harmonic current, T87 is locked operation when secondary harmonic current is over regulation value.

Basically, since countermeasure of magnetizing inrush current is belong applicant for interconnection, there are one is to apply controlled switching system to minimum magnetizing inrush current. Controlled switching system control close voltage phase to be 90 degrees. There are case to be able to reduce magnetizing inrush current about from 100% to 9%. Second is to do demagnetization. But in case of those countermeasure is not effect, it is necessary to install circuit breaker with insertion resistor by TDSVIU.

Policy for technical requirements for interconnection of demand facilities is shown in Appendix 7-2. It is basically for demand side to deal with necessary countermeasure before utilizing interconnection as same as generator facilities.

7.9 PROTECTION RELAY

7.9.1 Outline of Protection Relays in the Ramu System

In the Ramu system, many kinds of protection relays are installed to protect the facilities which comprise the Ramu power system. Protection relays are classified into generator protection relays, transmission protection relays, distribution protection relays and so on. Within all voltage ranges, 132, 66, 22 and 11kV, in the Ramu system the neutral earth method is direct earth.

This section explains the existing protection relays in the Ramu system.

(1) Existing facilities

1) Transmission line protection relay

Two distance relays are installed per circuit breaker, one of which is used as back-up. In recent years, old-type analog relays have been steadily replaced with new digital relays.

The standard configuration for the two distance relays involves one made by a European manufacturer and the other by a Japanese manufacturer.

Though an automatic reclosing function is installed in the digital relays or an automatic reclosing relay panel in the S/Ss, the function or relay is set to be disabled.

In 2015, differential relays will be installed on all 132kV T/Ls and some of the 66kV T/Ls after the SCADA system is installed.

2) Bus protection relay

Bus protection relays are installed mainly in the 132 and 66kV buses in the Ramu system and the low impedance method is applied. Numerous old-type analog relays remain in the Ramu system.

3) Transformer protection relay

Transformer protection relays comprise differential relays, overcurrent (O/C) relays and an earth-fault (E/F) relay on the high-voltage side and O/C and E/F relays on the low-voltage side. Many old-type analog relays remain in the Ramu system. In the S/S, where new 11kV switchgears are installed, transformer protection relays are incorporated in 11kV switchgear panels.

4) Generator protection relay

Generators are protected by differential, overvoltage, undervoltage, frequency relays and so on. In old P/Ss, such as the Pauanda hydropower station, old-type analog relays with one function remain. In newer P/Ss, such as YTOD hydropower station, new type digital relays with multiple protective functions are installed.

5) Distribution protection relay

Distribution protection relays comprise O/C and E/F relays, while some distribution lines have analog relays and others digital relays.

Though an automatic reclosing function is installed in the digital relays the function is set to be disabled.

6) Frequency relay

Frequency relays are installed in S/Ss with 22 or 11kV distribution lines to protect the Ramu system. When the frequency decreases, the frequency relays cut off the distribution lines to maintain sound generator operation and prevent system disruption.

Some S/Ss also have a frequency relay, which sends a trip signal to each feeder, while others have a frequency relay per feeder.

The priority of the distribution line is decided based on whether the distribution line supplies important consumers and the amount of electric power in the distribution line. The setting value of frequency relays is adjusted in accordance with priority as follows.

Priority	Setting Value	
High	Disabled	(No trip)
Low	48Hz, 5s	(Stage 3)
	48Hz, 0.5s	(Stage 2)
	48Hz, 0s	(Stage 1)

The under frequency function is set to be enabled and the over frequency function disabled.

Generators in P/Ss are tripped by the frequency relay when the frequency is under 47Hz or over 53Hz.

(2) Criteria related to protection relay

Some criteria related to the protection relay as prescribed in the Grid Code are shown below.

1) Fault Clearance Time

(i) The maximum Fault Clearance Time by the main or primary protection of the Transmission Network and Connection Point at 132 kV is 200 ms, including relays and breaker action.

(ii) The maximum allowable short circuit or ground fault current in the Transmission Network and Connection Point at 66 kV is 300 ms, including relay and breaker action.

2) Minimum protection relay requirement

The Grid Code shows the requirements for the generator, transmission, transformer, bus and distribution protection relay. The requirements for the generator protection relay are shown below as an example.

Generator Protection

(m) Protective Relaying Requirements

(i) Generators shall have the following protective relaying
- (A) Stator differential protection
- (B) Overvoltage protection
- (C) Undervoltage protection
- (D) Reverse power protection
- (E) Unbalanced loading protection

(F) Loss of Excitation Protection
(G) Underfrequency protection

(ii) Generator connected to the grid thorough step-up transformer shall, in addition to the protection above, be provided with overall (generator-transformer) differential protection and high voltage overcurrent (phase and earth-fault) protection and surge diversion.

(3) Officer related to protection relay

PPL officers related to the protection relay in the Ramu system are members of the protection team in POM and the Test team in Yonki.

The protection team in POM comprises the following members, who are in charge of calculating setting values, new projects and analyzing faults in the main three power systems as well as the smaller systems in the smaller provinces in PNG.

Protection team leader	1 person
Protection team analysis	1 person
Protection team development	1 person
(Consultant calculating setting values	A few people)

PPL hire retired officers as consultants to calculate setting values because the three members of the protection team cannot afford to do so. However, they are in the process of obtaining computer software tools to perform protection studies and evaluations efficiently with no need to engage consultants for future reviews.

The test team in Yonki oversees fieldwork such as maintenance, replacement and testing and comprise two teams. One oversees the Highland area and the other looks after the coastal area in the Ramu system. Each team comprises one team leader and three engineers and the PPL officers handle all the fieldwork themselves.

(4) Operation of the protection relay

1) Routine inspection

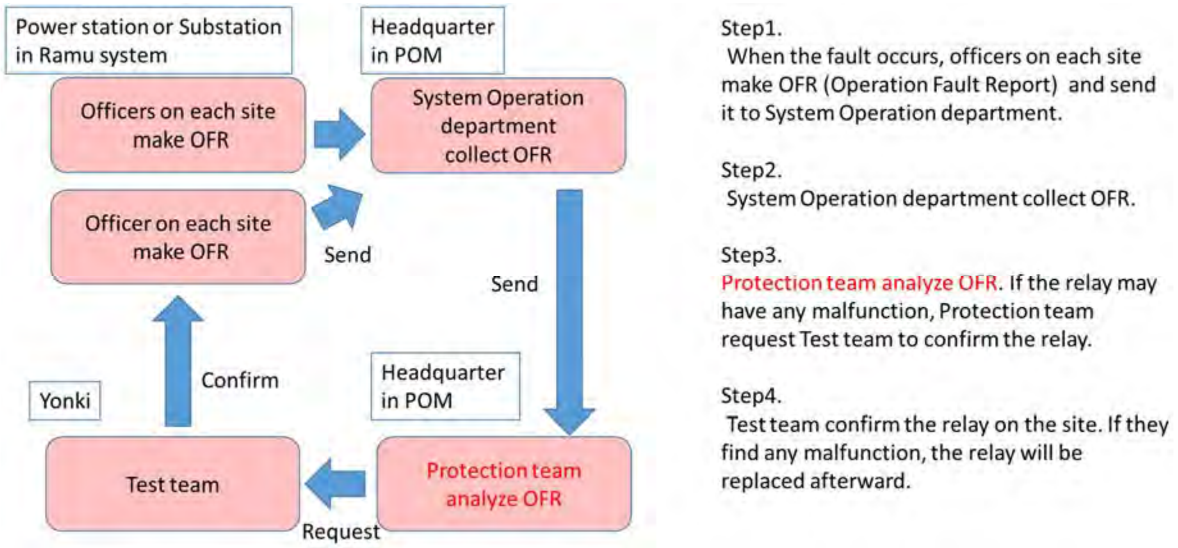
Protection relays in the Ramu system used to be inspected regularly. However, no routine inspections have been performed since the inspection equipment malfunctioned and it is difficult to stop single T/Ls for routine inspections.

2) Analysis of faults

After a fault happens, a switching officer or P/S operator writes a so-called Operation Fault Report (OFR). OFRs include details of the outage duration, what relays operated, responses to the fault and so on.

All the OFRs are gathered in the System Operation department in POM as well as being sent to the protection team in POM from the System Operation department.

The protection team then considers whether or not the protection relay operated normally. If anything is wrong, the protection team ask the test team to go on site and confirm any problem. If they find a defect, it will be replaced with a new relay. The following figure shows the flow of the fault analysis:



(Source: JICA Study Team)

Fig. 7.9-1 Flow of Fault Analysis

The protection team review whether or not the protection relay operated normally for each OFR. The following figure shows an example of the review:

Table 7.9-1 Review of Faults by Protection Team

RAMU

1.0 Details---as per the OFR supplied by Network Office

OFR No.	Day	Date	Time (off/on)	Substation	Remarks
34/14	Saturday	22-Nov-14	0:37-0:55	Taraka	Taraka fdr 5 CB LA2B8 tripped on B ph, OC. Cause C1, unknown. Fdr closed on first attempt held in OK.

2.0 Discussions/Conclusions….

OFR No.	Remarks	Action Officer/s
34/14	1) Protection operated correctly as intended.	Protection
	2) Maintenance team carry out line patrol on Taraka fdr 5 to identify the fault and take necessary action	Lae switching/Maint. Team
	3) Cause symbol C1 but stated Unknown. Conflicting statement	MSC/Lae switching Team

3.0 SUMMARY

Total Number of:	*November*
OFRs Received:	15
OFR's with correct relay operations:	13
OFR's with relay operations pending review:	2
Line Faults:	2
Feeder Faults:	10
Bus Bar Faults:	0
Transformer Faults:	0
Generator Faults:	2
Auxillary Supply Faults:	1
Unknown	1
System Blackouts	1
Partial Blackouts	14

(Source: PPL)

3) Replacement

The protection team in POM buys new relays and cables and the test team in Yonki removes the old relays, installs the new ones and connects the cables and tests. No departments in PPL have responsibility for managing drawings. Accordingly, the test team in Yonki confirms the site and makes the cable connection drawings ahead of time. These drawings are supposed to be approved by the POM protection team.

4) Setting

The protection team in POM confirm the setting values calculated by consultants and send sheets called protection Setting Advise to the test team in Yonki. The test team in Yonki sets the protection relay after receiving it.

Only the setting values of the frequency relay are determined by the System Operation department and sent to the test team in Yonki via the protection team in POM. Setting values are regularly reviewed by consultants. The following figure shows an example of PSA. CT ratio, type of relay and setting values are described in PSA

Table 7.9-2 PSA

CT Ratio and Class	Relay	Protection Setting			
400/200/100/5 (Ratio: 400/5) Class: 10P 60	CDG31 OVERCURRENT & EARTHFAULT	O/C	Plug: 5 T.M.S: 0.05	(2.5-10) (0.05-1.0)	(400A Primary)
		E/F	Plug: 1.0 T.M.S: 0.05	(1.0-4.0) (0.05-1.0)	(80A Primary)
	SEL 2C149K2	Set on 0.125 Set on 6 Sec.		(0.1-0.25) (6-120)	(10A Primary)
400/200/100/5 (Ratio: 400/5) Class: 15-BM	Metering				

(Source: PPL)

7.9.2 Problem of Current Protection Relay and Recommendation for Countermeasures.

(1) Problem of current protection relay and recommendation for countermeasures

The current problem related to the entire Ramu system is written in Section 7.4 and that related to the protection relay is written here.

It is hard to detect the malfunctions of the relays in the current Ramu system. That is the primary problem in Ramu system. There are two ways of detecting the malfunctions. One is detecting before the operation and the other is detecting after the operation of the relay. Neither of the two ways are hard in Ramu system. The reason and recommendation for countermeasures are shown below.

- **Detecting before the operation**

To detect the malfunctions of the relay before the operation, namely during normal condition, it is necessary to inspect for the analog relays. However, as mentioned previously, no routine inspections have been performed in the Ramu system.

Conversely, the digital relays can supervise their own state and trigger an alarm if a malfunction occurs. However, the alarm cannot be sent to the operators because the SCADA system has not yet been installed in the Ramu system. The malfunction will be detected when someone happens to pass in front of the relay and notices the malfunction.

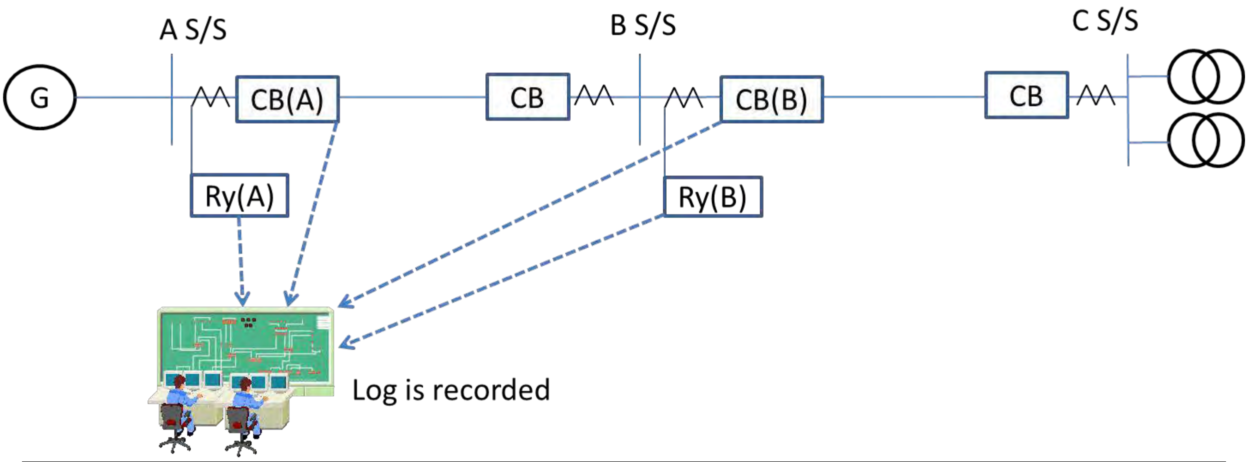
Accordingly, because there is no way to detect the malfunction before the operation of the fault, it is assumed that relays with some malfunctions cannot work and the outage area is expanded when a T/L fault actually happens.

Preparation for inspection equipment and to restart the routine inspection are recommended in analog relays. Moreover, it is necessary to decrease the interruption time of the inspection by cooperating with other departments regarding the inspection. For example the relay of a transformer should be inspected at the same time when the transformer is inspected.

- **Detecting after the operation**

One of the key tasks for the protection relays is to analyze whether the relay worked correctly or not. In the Ramu system protection relay, this analysis was not performed properly. It is hard to correct the information required for the analysis.

For example, a T/L fault occurs between B S/S and C S/S and CB(A), which means A circuit breaker, in A S/S trip though CB(B) in B S/S is supposed to trip in the below system. In this abnormal case, some causes are assumed by confirming the condition of CB(B) and Ry(B), which means B protection relay, as shown in Fig. 7.9-2. As in this case, to analyze the abnormal operation and investigate its cause, it is necessary to grasp the condition of CBs and Rys when the fault occurs. However, that could not be done in the Ramu system.



CB(A)	Ry(A)	CB(B)	Ry(B)	Assumed cause
○	○	○	○	Fault of Ry(A) or Ry(B), bad coordination, etc.
○	○	×	○	Fault of CB(B), etc.
○	○	×	×	Fault of Ry(B), bad coordination, etc.

CB : Circuit breaker
Ry : Protection relay

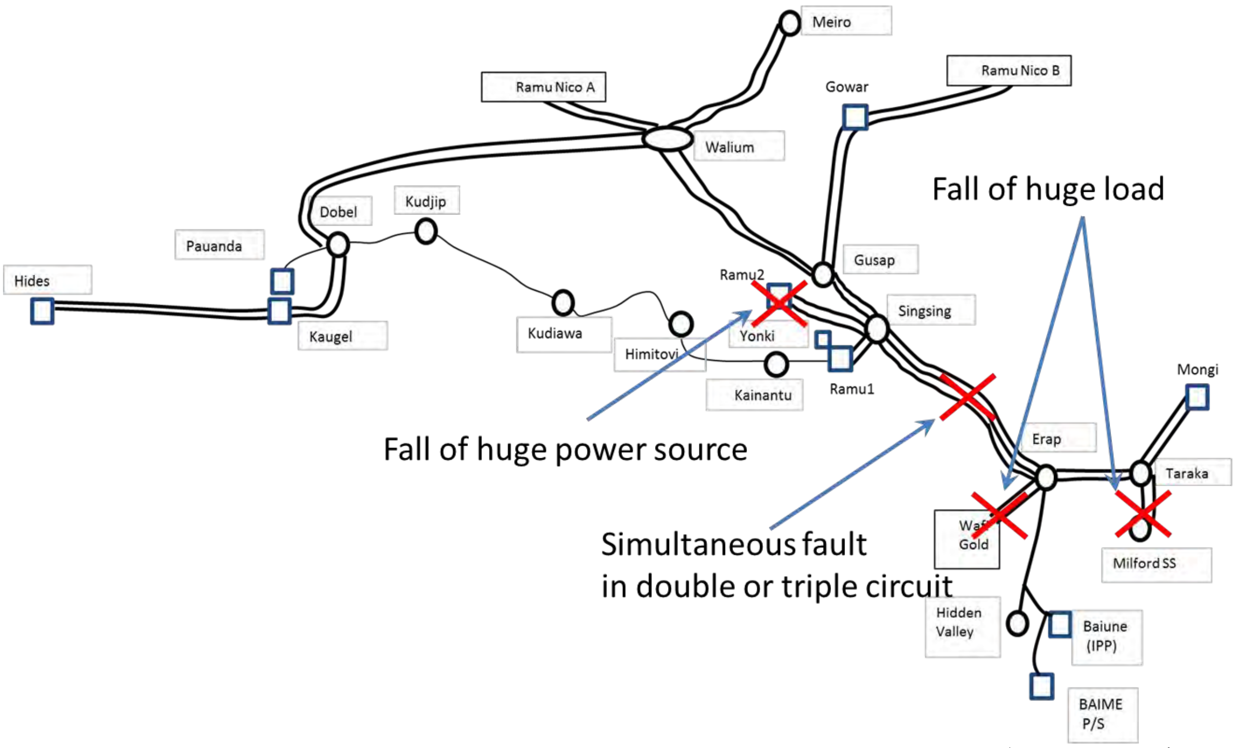
(Source: study team)

Fig. 7.9-2 Fault Record and Assumption of Cause

Normally, if CB and Ry operate, operation signals are sent to the control center by SCADA system like dotted lines in the above drawing and recorded in the control center. However, because the SCADA system is not installed in the Ramu system, the condition of CBs and Rys is manually recorded by OFR, as mentioned before. OFR usually have insufficient information because they are made during fault recovery and for each S/S. This means it is difficult to grasp the fault related with several S/Ss only by OFRs. To grasp the fault condition and analyze the relay operation, a SCADA system must be installed in the Ramu system and CB and Relay condition at the fault time must be recorded.

(2) Recommendation for future Ramu systems

As mentioned before, T/L systems are basically designed to be largely immune to the single fault known as the N-1 fault. However, countermeasures are required for rare faults in the Ramu system according to the importance of the system and the impact of the fault. The rare faults are those which hardly occur, such as dual-circuit faults. In this section, countermeasures with the relay system for some of the rare faults, which seem to largely affect the future Ramu system, are introduced. Some rare faults are shown in Fig. 7.9-3. However, false countermeasures may exacerbate the fault, so installing the kind of relay system as introduced in this report must be considered with careful simulation when the system is designed. Moreover, the relay system requires a reliable and fast communication network, which does not exist in the current Ramu system.



(Source: JICA Study Team)

Fig. 7.9-3 Rare Fault in the Future Ramu System

- **Separation of huge power source and huge load**

As mentioned before, the frequency relay in the current Ramu system operates after detecting any fall in system frequency. Because huge power sources such as Ramu2 hydropower and huge loads such as mining will be connected to the Ramu system in future, installing a relay which can detect the separation of huge power source and huge load by the current flow and the status of circuit breakers is effective.

For example, after Ramu2 is connected to the system, the double T/L connected to the Ramu2 happens to be cut off by a fault. In this case, if the current system is installed, the frequency relay operates after detecting the fall in system frequency and cuts off the equivalent load to stabilize the frequency. However, when the huge power source which occupies almost half the capacity of the Ramu system such as Ramu2 is separated from the system, cutting off the equivalent load as soon as possible is necessary to prevent the collapse of the total system. Because a huge power source is developed with the huge load such as mining, it is desirable to consider installing a system which can prevent chain reactions of faults by eliminating the corresponding power source or load after the huge power source and load are connected to the Ramu system.

- **Eliminating overload and preserving stability**

The T/L has a limited capacity to transmit stability. The target current value for the load-dispatching operation is decided in advance. However, if one of the double transmission is cut off due to a fault, the current flowing in the line will be imposed on the other sound line in addition to its own. At that time, the current after the fault may surpass the capacity limit, which may result in a loss of the synchronism in generators and melting of conductors. It is desirable to consider installing a power-shedding system, which can prevent melting and maintain stability by separating or suppressing generators. The overload phenomenon takes between several minutes and several tens of minutes while loss of synchronism phenomenon takes several hundred ms. Therefore, the time scale of the power shedding system for the overload is different from that for the stability.

For example, if two of the three T/Ls from Singsing to Erap are cut off, or the double T/Ls from Pauanda to Walium are cut off, the other sound line is assumed to be subject to the current which flowed in the fault line and that may result in the limit for the T/L being exceeded or overload.

Appendix 7-1

Interconnection between the RAMU System and the POM System

Appendix 7-1
Interconnection between the RAMU System and the POM System

A study for the interconnection between the RAMU system and the POM system (Hereafter, it is referred to as "Interconnection Project") is undertaken. The study consists of consideration from viewpoints of the power system development plan (system analysis) and the economic evaluation.

The power sector of PNG comprises two main networks: i) the POM and ii) the Ramu system. However, these two systems are separated by the Owen Stanley mountain range and no permanent vehicular roads that can traverse the country from north to south have yet been built.

If those two systems are interconnected, it may be able to complement each other and the redundancy of the power system of all the PNG could be increased. Then, the possibility of Interconnection Project was studied from viewpoints on system and economic consideration.

1. Consideration for System Development Plan on Interconnection Project

1.1 Routing

The routing of the T/L for the interconnection between the RAMU system and the POM system are shown in Fig. 1. This routing is based on the study result conducted by ADB[1], and the distances between Erap and Hidden Valley, between Hidden Vally and Tepaco, and between Tepaco and Moitaka are 110km, 90km, and 170km, respectively.

1 ADB TA 4932-PNG, Power Sector Development Plan

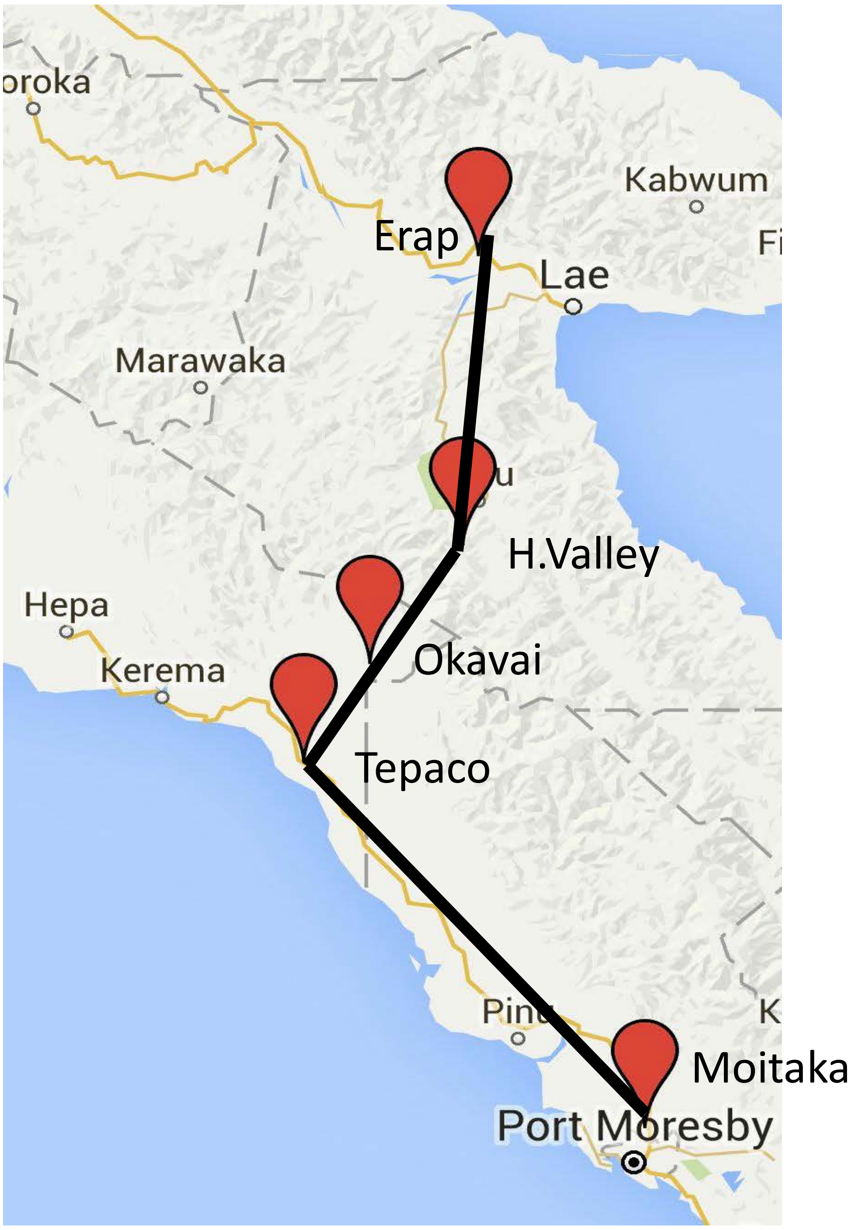


Fig. 1 Routing of Interconnection Project

<u>The study result conducted by ADB</u>

Given the southern extremity of the Ramu system at the Hidden Valley mine, one possible (and most likely) route through the mountains towards the south_would roughly follow a path traditionally called the Bulldog Track. This route was actually traffic. In 1943, Australian army engineers built the road from a point in northern Gulf Province called Bulldog (the name of an abandoned mining camp) all the way to Wau. The ravages of flooding and landslides frequently made the road impassable and, after the war, the Bulldog Road, as the vehicular route was called, was conceded to the jungle and no longer maintained. Many sections of the vehicular road have now been obliterated but many parts are still used by locals.

Fig. 2 shows a map indicating a possible T/L routing along the Bulldog Track.

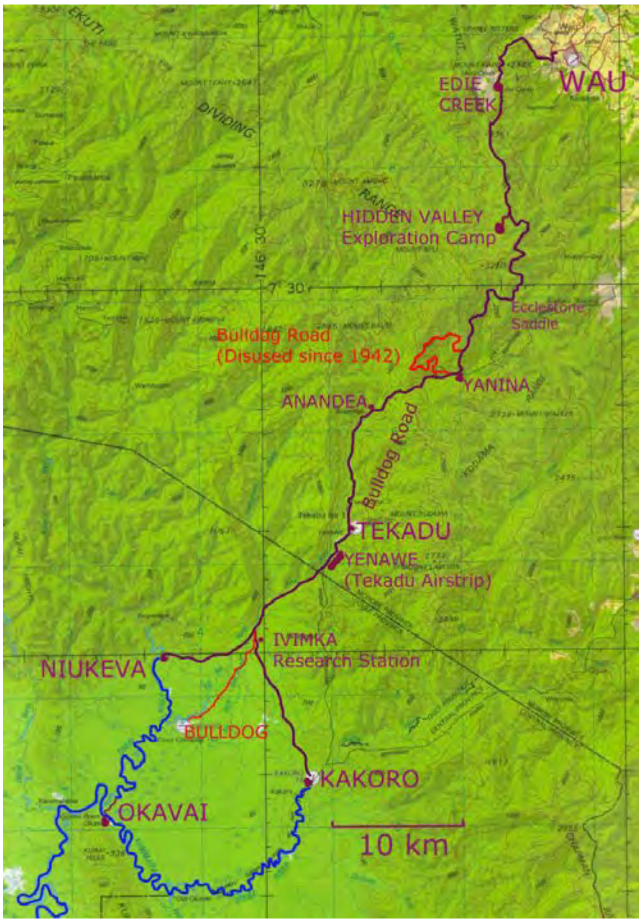


Fig. 2 Bulldog Route

The T/L would head in a north-northeast direction from POM, roughly following the Owen Stanley Range, for about 200 kilometers, entering Gulf Province near the village of Kakoro (as seen in Fig. 2) and continuing in the same direction to join the Bulldog route at a point on the Avi Avi River. From there, the line would turn northeast up the Avi Avi and Eloo River valleys, following the old Bulldog Road past the villages of Tekadu, Anandea and Yanina. The section after Yanina would be the most difficult; however, it is only 20 to 30 kilometres from here to the Hidden Valley mine and a sizeable, already-existing transmission right-of-way. If this route is impossible, other alternatives might exist. For example, locals (and trekkers) tend to follow a more eastward route from Yanina, approaching Wau from the south, through Kudjeru and Winima, as can be seen on Fig. 3.

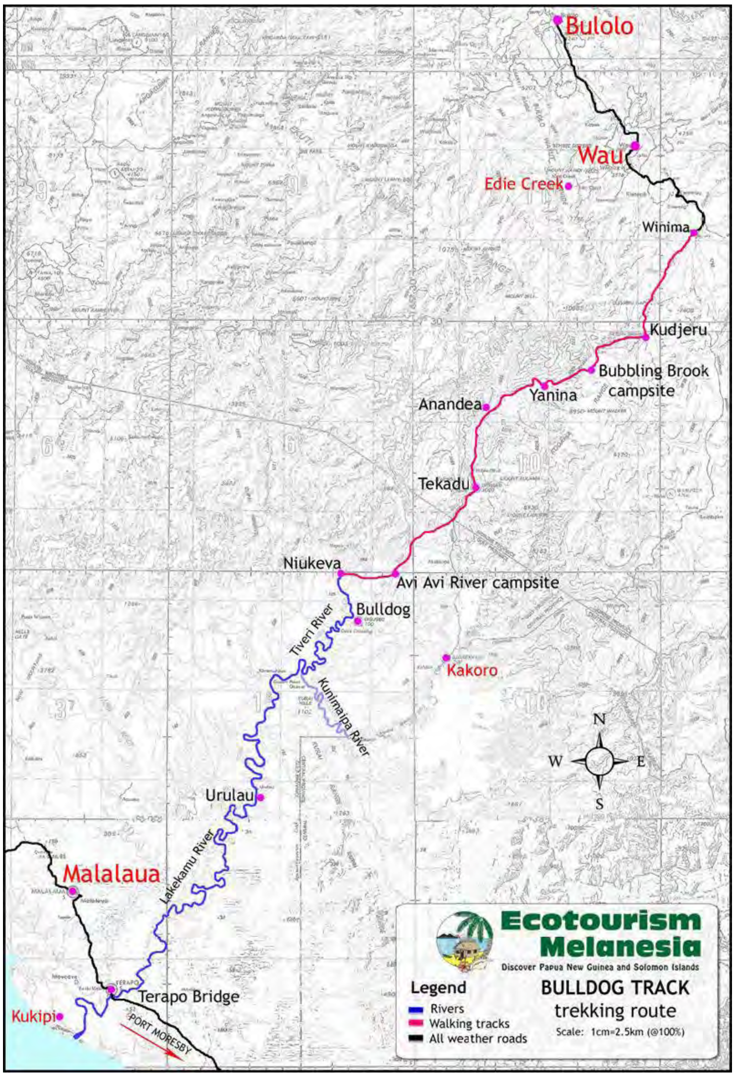


Fig. 3 Alternate Bulldog Route

1.2 Interconnection Analysis

(1) Method of interconnection plans

As the method of the interconnection between the RAMU system and the POM system, the following three options were considered.

(i) 132kV AC system plan (connected by 132kV T/L)
(ii) 275kV AC system plan (connected by 275kV T/L)
(iii) 350kV HVDC system plan (connected by 350kV HVDC light[2])

(2) Facilities to be installed

The facilities to be installed newly are as follows for three plans above.

(i) 132kV AC system plan
- 110km, 1cct, 132kV T/L (Erap-Hidden Valley)

[2] HVDC light is an example of self-excited HVDC transmission, and is the trademark of DC transmission of ABB.

- 260km, 2cct, 132kV T/Ls (Hidden Valley-Moitaka)

(ii) 275kV AC system plan
- 370km, 2cct, 275kV T/Ls (Erap-Moitaka)
- Shunt reactors for compensation at each end of the line
- 275/132kV substations (Erap, Moitaka)

(iii) 350kV HVDC system plan
- 370km, 350kV DC T/Ls (Erap-Moitaka)
- converter stations (Erap, Moitaka)

(3) Transfer Capacity

Regarding each plan of 132kV AC system plan and 275kV AC system plan, the transfer capacity was confirmed from the viewpoint of static stability. In the case of 132kV AC system, it is around 50MW and, in the case of 275kV AC system, it is around 230MW.

Regarding to the 350kV HVDC light system plan, the transfer capacity depends on the capacity of its converter station at the both end of the 350kV HVDC light system plan. In this case, it was assumed that the capacity of each converter station of 350kV HVDC light system was 230 MW for comparison purpose.

2. Economic Consideration on Interconnection Project

2.1 Project Plans and Development Costs

As discussed in the previous section, there are three development Plans identified for the interconnection project; 132 kV AC system Plan, 275 kV AC system Plan and 350kV HVDC system Plan. The capacity and the cost of these options are summarized in Table 1.

Table 1 Development Plans of Interconnection Project

System Plan	Maximum Power (Sending capacity)	Development Cost
132 kV (AC)	50 MW	US$ 87 mil.
275 kV (AC)	230 MW	US$ 163 mil.
350 kV HVDC	230 MW	US$ 160 mil.

Assume the conditions of financing of the project as below;
- Interest rate: 12%,
- Loan (project) life: 30 years.

Then, adding annual operation and maintenance cost of the Interconnection Project assumed to be approximately 2% of the development cost, the levelized annual costs of Interconnection Project for each plan was calculated as shown in Table 2.

Table 2 Annual Cost for Development Options of Interconnection

System Type	Levelized Annual cost
132 kV (AC)	US$ 12.5 mil.
275 kV (AC)	US$ 23.5 mil.
350 kV HVDC	US$ 23.1 mil.

2.2 Utilization of Interconnection Project

Levelized annual costs mentioned above would be a fixed cost once the project is implemented. However, how much it would be for a unit energy transmitted depends on the utilization level of the system. For three levels of utilization, i.e., the load factors 20, 40 and 60%, costs per unit energy transmitted were calculated.

For example, if the 132 kV AC system is utilized at the load factor 20 %, then the annual energy transmitted is calculated, assuming the loss ratio of the system 5 %, as;

Capacity (50 MW) x 8,760 hrs x 20 % x (1 – loss ratio (5 %)) = 83 GWh.

Dividing the levelized annual cost with the energy transmitted, we have the unit cost of interconnection. The results are shown in Fig. 4.

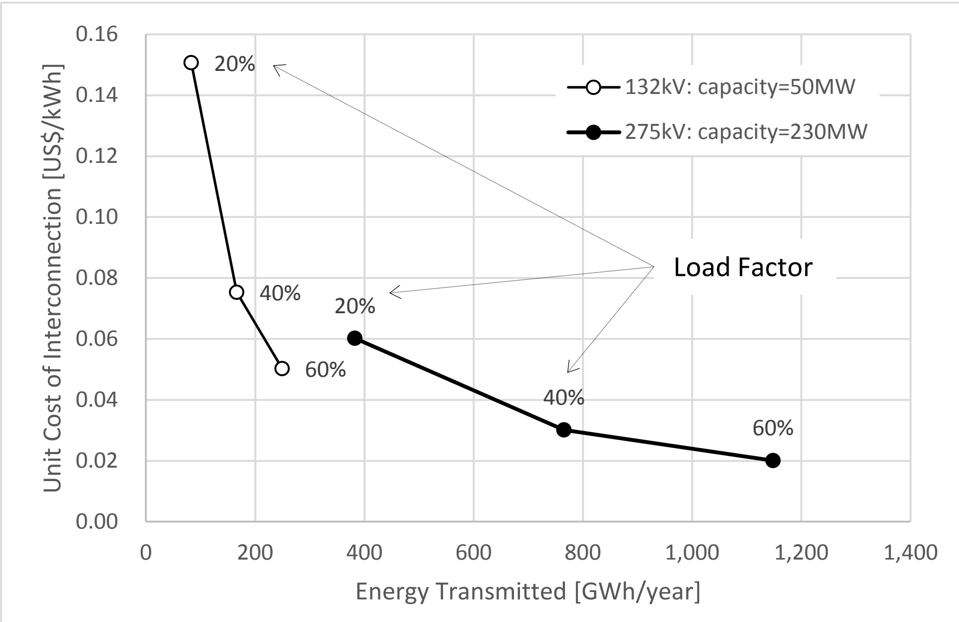


Fig. 4 Variation of Unit Cost of Interconnection for Different Utilization Level

The unit costs of interconnection would vary inversely proportional to the energy transmitted or the utilization level (load factor). And 275kV systems can achieve lower unit costs than 132 kV system, in larger energy transmission range.

2.3 Timing of Implementation and Choice of System Option

There are factors affecting the decision on timing of implementation and the choice of system option. Some discussion is made below for each affecting factor.

Size of the networks on both sides

As of 2016, the size of POM network in terms of peak demand is approximately 120 MW, and Ramu network 100 MW. Therefore, the 275 kV system whose capacity is 230 MW seems too large to connect these networks for the time being. POM network is growing fast, and is expected to reach 230 MW level in around 2027-2028. Ramu network is, on the other hand, expecting to expand rapidly by a series of connection to bulk customers starting around 2020, and will reach 400 MW by 2030.

Redundant generation capacity

To send power from one network to the other, we have to have some redundant generation capacity on the sending side. In addition, the redundant generation capacity must come from low-cost generation source, which is in many cases hydropower.

In Ramu network, generation capacity has been in short supply for a long time. Augmentation of generation capacity is planned in the form of many projects but only some small increment from rehabilitation of the existing hydro is expected in the short term. We have to wait until the completion of Ramu 2 hydro, expected for 2021, to have a jump-up in hydro capacity. However, Ramu 2 has been planned to meet bulk user’s demand, and only a fraction of its installed capacity would be able to be diverted to POM network even if we have an internetwork transmission.

Otherwise, we will have to expedite the development of multiple hydro projects if we are to secure redundant generation capacity, which at the same time will be a significant cost raising factor in the Ramu system.

Utilization and Unit Cost

As discussed in the previous section, a unit cost of the interconnection system varies widely by the utilization level of the system. Economy of scale applies here and 275 kV system can achieve unit cost lower than with 132 kV system, although more energy will have to be transmitted through the system.

The interconnection can also serve to secure emergency power supply from one system to the other. But very likely, there are much cheaper alternatives for the purpose. It will be a policy decision whether to have such a redundancy system between two networks for any emergencies.

Revenue from both networks

Implementation of interconnection project will put a large strain on the finance of the power distributor, PNG Power.

In 2016, the revenue generated in the Ramu system is about K 300 million, and in the whole PNG Power K 900 million. The levelized annual cost of K 13 million for 132 kV system or K 23 million for 275 kV system will be a fixed cost (assumed for thirty years), regardless of utilization level of the interconnection. The impact of this capital expenditure on the financial status of PNG Power, and its consequence, will have to be evaluated in detail.

3. Other Considerations

The interconnection between the RAMU system and the POM system may be able to contribute also to rural electrification. That is, by constructing substations in the middle of tie-lines, electrification of the neighborhood is enabled. In the case of this Project, electrification of the area between Tepaco and Moitaka is especially expectable. Therefore, at the time of construction of T/Ls, the policy of advancing T/L construction from the Moitaka side and advancing electrification gradually from the POM side can be considered.

Appendix 7-2

Policy for Technical Interconnection Requirements

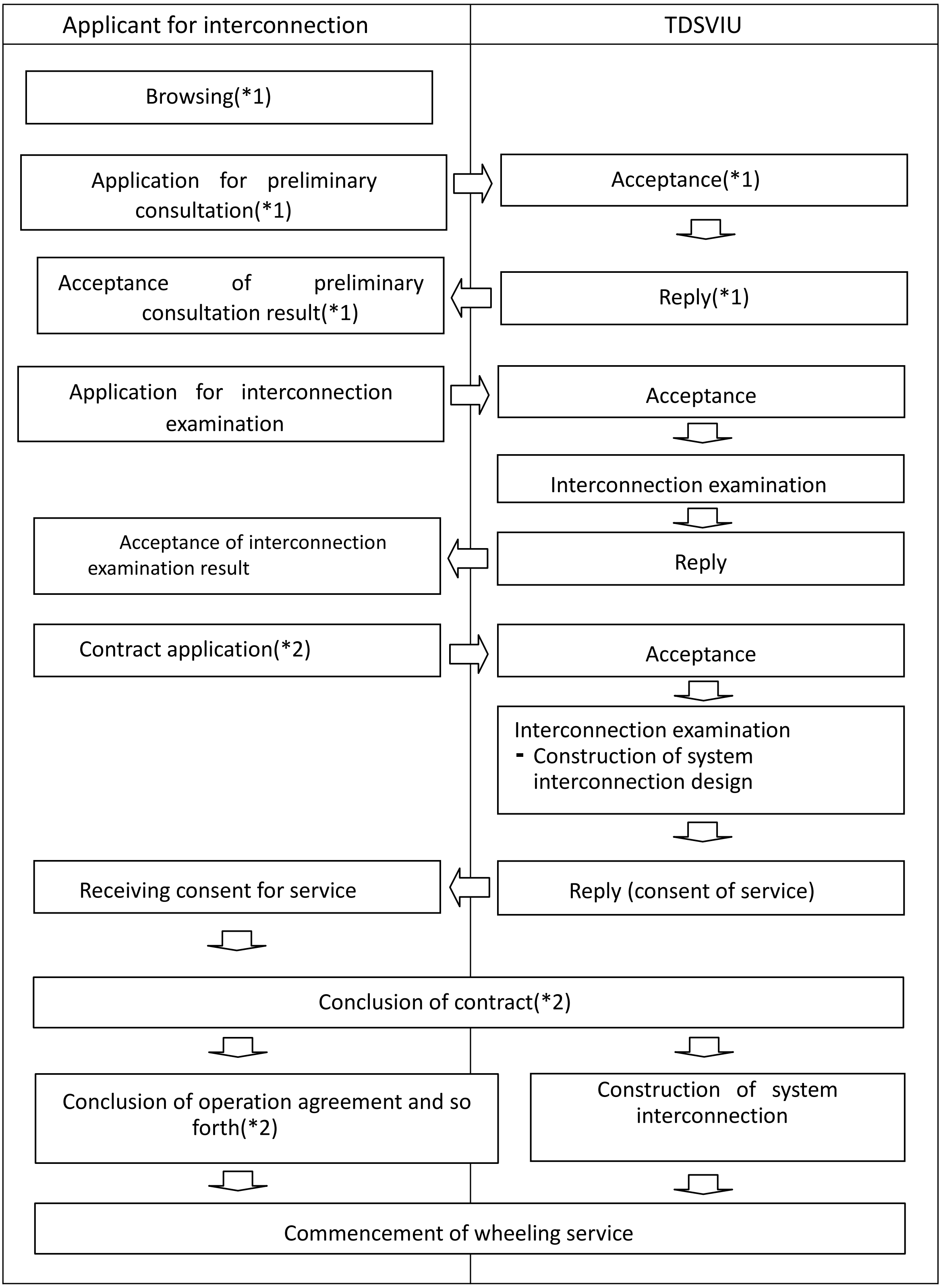


Fig. 1 Assignment flow for from consideration to commencement supply by TDSVIU

Table 1 Information on Generation Facilities for Interconnection Examination

a. Name of the power producer, generation-site location and receiving point

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Name of power producer	To manage interconnection examination	
Address of generating site	To specify the generating site location when choosing a route to interconnecting facilities	
Receiving point	To examine interconnecting facilities (transmission route, interconnection)	
Ground plan, layout of facilities	To select a route to interconnecting facilities and examine facility formation	

b. If the generation facility is located outside the VIU service area, the content of the contract for the cross-area wheeling service concluded with the VIU other than the VIU concerned or the contents of the application.

Information on generation facilities of system interconnecting power producer, as required by TDSVIU	Reason for request	Notes
Contents of cross-area wheeling service of electricity contracts concluded with other VIUs	To examine current flow of power	

c. Generation method, rated power, detailed generator specifications, various parameters of step-up transformer

<table>
<tr><th colspan="2">Information on generation facilities of system interconnecting power producer, required by TDSVIU</th><th>Reason for request</th><th>Notes</th></tr>
<tr><td colspan="2">Outline of generation facilities (rated output, number of units, type)</td><td>To compare with details of generation facilities</td><td>Submit in as much detail as possible for existing facilities</td></tr>
<tr><td colspan="2">Single-line diagram</td><td>To examine power system stability and check for conformity with technical requirements</td><td>Including demand/receiving facilities</td></tr>
<tr><td rowspan="5">Overall generation facilities</td><td>Type of motor (steam turbine, gas turbine, diesel engine, etc.)</td><td>To examine system stability of power</td><td>Submit in as much detail as possible for existing facilities</td></tr>
<tr><td>Type of generator (synchronous generator, induction generator)</td><td>As above</td><td>As above</td></tr>
<tr><td>(Existing or new/additional installation)</td><td>To judge the type of submitted data, namely whether existing or new/added</td><td></td></tr>
<tr><td>Rated voltage</td><td>To examine phase/ground fault current, system stability and voltage</td><td></td></tr>
<tr><td>Rated capacity</td><td>As above</td><td></td></tr>
</table>

Information on generation facilities of system interconnecting power producer, required by TDSVIU		Reason for request	Notes
Overall generation facilities	Rated output power	To examine power flow and power system stability	
	Number of units	To examine power flow, system stability and phase/ground fault current	
	Power factor (rating)	To check conformity with technical requirements and examine voltage	Submit in as much detail as possible for existing facilities
	Power factor (operable range)	As above	As above
	Use of damping coils	To examine power system stability	
	Operable frequency range	To check conformity with technical requirements	Submit in as much detail as possible for existing facilities
	Excitation system	To examine power system stability	
	Use of a power system stabilizer (PSS)	As above	
	Use of an automatic voltage regulator (AVR)	To examine power system stability and voltage fluctuation	
	Constants of an automatic voltage regulator (AVR)	As above	
	Constants of governor	To examine power system stability	
	Type of inverter (when in use)	To check conformity with technical requirements	Submit in as much detail as possible for existing facilities
	Point of synchronizing parallel in/off	As above	
	Saturation characteristic of a generator	To examine power system stability and phase/ground fault current	
	Use of automatic synchronism detector	To check conformity with technical requirements and examine voltage fluctuation	
	Type of motor (steam turbine, gas turbine, diesel engine, etc.)	To examine system stability of power	Submit in as much detail as possible for existing facilities
	Type of generator (synchronous generator, induction generator)	As above	As above
	(Existing or new/additional installation)	To judge the type of submitted data, namely whether existing or new/added	
	Rated voltage	To examine phase/ground fault current, system stability and voltage	
	Rated capacity	As above	
	Rated output power	To examine power flow and power system stability	
	Number of units	To examine power flow, system stability and phase/ground fault current	
	Power factor (rating)	To check conformity with technical requirements and examine voltage	Submit in as much detail as possible for existing facilities
	Power factor (operable range)	As above	As above
	Use of damping coils	To examine power system stability	

Information on generation facilities of system interconnecting power producer, required by TDSVIU		Reason for request	Notes
Overall generation facilities	Operable frequency range	To check conformity with technical requirements	Submit in as much detail as possible for existing facilities
	Excitation system	To examine power system stability	
	Use of a power system stabilizer (PSS)	As above	
	Use of an automatic voltage regulator (AVR)	To examine power system stability and voltage fluctuation	
	Constants of an automatic voltage regulator (AVR)	As above	
	Constants of governor	To examine power system stability	
	Type of inverter (when in use)	To check conformity with technical requirements	Submit in as much detail as possible for existing facilities
	Point of synchronizing parallel in/off	As above	
	Saturation characteristic of a generator	To examine power system stability and phase/ground fault current	
	Use of automatic synchronism detector	To check conformity with technical requirements and examine voltage fluctuation	
Step-up transformer	Rated voltage	To examine power system stability, phase/ground fault current and voltage	
	Rated capacity	As above	
	Leakage impedance (based on rated capacity)	To examine power system stability, phase/ground fault current, voltage fluctuation and protective relay scheme	
	Use of load tap changer (number of taps, voltage control range)	To examine voltage, power system stability and phase/ground fault current	

d. Maximum/minimum receiving power

Information on generation facilities of system interconnecting power producer, required by TDSVIU		Reason for request	Notes
Step-up transformer	Rated voltage	To examine power system stability, phase/ground fault current and voltage	
	Rated capacity	As above	
	Leakage impedance (based on rated capacity)	To examine power system stability, phase/ground fault current, voltage fluctuation and protective relay scheme	
	Use of load tap changer (number of taps, voltage control range)	To examine voltage, power system stability and phase/ground fault current	

e. Voltage at the receiving point

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Voltage at receiving point	To select the voltage class of interconnecting facilities and route to interconnecting facilities	

f. Demand/receiving facilities located within the generation site

Information on generation facilities of system interconnecting power producer, required by TDSVIU		Reason for request	Notes
Loaded facilities	Total capacity	For flow examination of power	
	Total power factor	To examine voltage	
Special facilities	Existence of harmonics sources	To check harmonics suppression countermeasure	
	Reference materials on harmonics	As above	Submit in as much detail as possible for existing facilities
	Existence of voltage fluctuation sources	To examine voltage fluctuation	
	Reference materials on voltage fluctuation	As above	Submit in as much detail as possible for existing facilities
Power receiving transformer	Rated voltage	To examine power system stability, phase/ground fault current and voltage	
	Rated capacity	As above	
	Leakage impedance (based on rated capacity)	To examine power system stability, phase/ground fault current, voltage fluctuation and protective relay scheme	
	Use of load tap changer (number of taps, voltage control range)	To examine voltage, power system stability and phase/ground fault current	
Phase modifying equipment	Type	To examine voltage and reactive power	Not necessary if phase modifying equipment is included in the total power factor
	Capacity on each voltage class (extra-high voltage, high voltage, low voltage)	As above	As above
	Total capacity	As above	As above
Protective device	Generator protection (unit number, type, cut-off point)	To check conformity with protection coordination, protective relay scheme and so forth	
	Interconnection system protection (unit number, type, cut-off point)	As above	
	Prevention of islanding (unit number, type, cut-off point)	As above	

Information on generation facilities of system interconnecting power producer, required by TDSVIU		Reason for request	Notes
Protective device	Protection of private area (unit number, type, cut-off point)	As above	

g. Desired wheeling service commencement date

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Desired wheeling service commencement date	To decide on the annual conditions for technical examination	
Desired commencement date to operate interconnecting facilities	To check the secured term for construction of a transmission and distribution system	

i. Number of circuits (regular/standby)

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Number of circuits (regular/standby)	To decide on the number of circuits of interconnecting facilities	

j. Name and contact information of applicant

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Name of applicant	To manage the result of the interconnection examination	
Name of representative applicant	As above	
Contact information	Fundamental information for making contact	

k. Name of the entity that receives electricity delivered through a cross-area wheeling service of electricity and the point of delivery

Information on generation facilities of system interconnecting power producer, required by TDSVIU	Reason for request	Notes
Name of an entity that receives electricity delivered through cross-area wheeling service of electricity and a point of delivery	For flow examination of power	

Table 2 Information on End-use Customer for Interconnection Examination

a. Name of end-use customer, demand site location and servicing point

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Name of end-use customer	To manage interconnection examination	
Location of use of electricity	To specify the location of use of electricity when choosing a route to interconnecting facilities	
Service point	To examine interconnecting facilities (transmission route, interconnection)	
Ground plan, layout of facilities	To select a route to interconnecting facilities and examine facility formation	

b. Contract power

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Contract power	For flow examination of power	

c. Voltage at the servicing point

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Voltage at servicing point	To select the voltage class of interconnecting facilities and route to the same	

d. Demand/receiving facilities located within the demand site

Information on facilities of end-use customer, required by TDSVIU		Reason for request	Notes
Single-line diagram		To check conformity with technical requirements	-Include protective relay -Include generation facilities, if any
Loaded facilities	Total capacity	To examine power flow	
	Total power factor	To examine voltage	
Special facilities	Existence of harmonics sources	To check harmonics suppression countermeasure	
	Reference materials on harmonics	As above	Submit in as much detail as possible for existing facilities
	Existence of voltage fluctuation sources	To examine voltage fluctuation	
	Reference materials on voltage fluctuation	As above	Submit in as much detail as possible for existing facilities

Information on facilities of end-use customer, required by TDSVIU		Reason for request	Notes
Power receiving transformer	Rated voltage	To examine phase/ground fault current and voltage	
	Rated capacity	As above	
	Leakage impedance (based on rated capacity)	To examine phase/ground fault current, voltage fluctuation and protective relay scheme	
Phase modifying equipment	Type	To examine voltage and reactive power	Not necessary if phase modifying equipment included in total power factor
	Capacity on each voltage class (special high voltage, high voltage, low voltage)	As above	As above
	Total capacity	As above	As above
Protective relay system	Generator protection (unit number, type, cut-off point)	To check conformity with protection coordination, protective relay system and so forth	Submit if there are existing generation facilities
	Interconnection system protection (unit number, type, cut-off point)	As above	
	Prevention of islanding (unit number, type, cut-off point)	As above	Submit if there are existing generation facilities
	Protection of private area (unit number, type, cut-off point)	As above	

e. Desired wheeling service commencement date

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Desired wheeling service commencement date	To decide annual conditions for technical examination	
Desired commencement date to operate interconnecting facilities	To check the secured term for construction of a transmission and distribution system	

f. Number of circuits (regular/standby)

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Number of circuits (regular/standby)	To decide the number of interconnecting circuits for facilities	

g. Name and contact information of applicant

Information on facilities of end-use customer, required by TDSVIU	Reason for request	Notes
Name of applicant	To manage the result of the interconnection examination	
Name of representative applicant	As above	
Contact information	Fundamental information for making contact	

h. Generating system of generation facilities, generation output, detailed generator specifications, specifications of step-up transformer

Information on facilities of end-use customer, required by TDSVIU		Reason for request	Notes
Outline of generation facilities (rated output power, number of unit, type)		To compare with details of generation facilities	Submit in as much detail as possible for existing facilities
Overall generation facilities	(Existing or new/increased)	To check the type of submitted data, according to existing or new/increased	
	Rated voltage	To examine phase/ground fault current and voltage	
	Rated capacity	As above	
	Rated output power	To examine power flow	
	Number of units	To examine power flow and phase/ground fault current	
	Power factor (rating)	To check conformity with technical requirements and examine voltage	Submit in as much detail as possible for existing facilities
	Power factor (operable range)	As above	As above
	Operable frequency range	To check conformity with technical requirements	As above
	Type of inverter (if an inverter is used)	As above	As above
	Point of synchronizing parallel in/off	As above	
	Saturation characteristic of a generator	To examine phase/ground fault current	
	Existence of automatic synchronism detector	To check conformity with technical requirements and examine voltage fluctuation	
Synchronous generator	Direct-axis transient reactance	To examine phase/ground fault current and voltage fluctuation	
	Direct-axis sub transient reactance	As above	
Induction generator	Locked rotor reactance	To examine phase/ground fault current and voltage fluctuation	
	Capacity of current-limiting reactor	As above	

Information on facilities of end-use customer, required by TDSVIU		Reason for request	Notes
Step-up transformer	Rated voltage	To examine phase/ground fault current and voltage	
	Rated capacity	As above	
	Leakage impedance (based on rated capacity)	To examine phase/ground fault current, voltage fluctuation and protective relay scheme	

Policy for technical requirements for interconnection of generation facilities

Technical requirements for system interconnection of generation facilities are as stated below. These apply regardless of the existence or lack of reverse power flow when a generation facility is installed at an end-use customer.

1. Electrical system

If a generation facility with a different electrical system is interconnected to existing power systems, it may disrupt the use of electricity or interfere with the electrical facilities of others.

When interconnecting generation facilities, their electrical system uses an alternating-current (AC) three-phase and three-wire system, with voltage and frequency identical to those of interconnected power systems.

2. Generator constants

When generation facilities are interconnected, an increase in the fault current of power systems may mean facilities in series such as circuit breakers are insufficient or affect the stability of power systems and so forth.

TDSVIUs specify the required constants of a generator and the required constants and specifications of a step-up transformer to applicants for system interconnection of generation facilities if measures for phase/ground fault current, stability and so forth are necessary.

They also explain the reason for their specifications to the applicants for system interconnection of generation facilities.

3. Power factor

When interconnecting generation facilities, reactive power must be controlled to maintain appropriate system voltage in coordination with Vertically Integrated Utilities (VIU) generation facilities and others. “Maintaining appropriate system voltage” as described above means maintaining a substation bus voltage within the targeted operation voltage ranges.

In case of system interconnection of new generation facilities, the power factor of the generation facilities is as follows;

The power factor of generation facilities must exceed 0.9 in lagging and 0.95 in leading as a standard, within which those facilities can operate stably. When power factors differ from the standard depending on the scale of power systems, distribution of generation facilities and so forth, TDSVIUs establish and publicize those power factors.

When a reverse power flow does not exist, the power factor of generation facilities at the servicing point of end-use customers, in principle, is 0.85 or more as a lagging power factor to prevent voltage drops. Further, a leading power factor should be avoided for the power systems (a lagging power factor when viewed from generation facilities).

4. Operable frequency of generation facilities

When the system frequency fluctuates due to power system contingencies, it results in the disconnection of generators, exacerbating frequency fluctuations, triggering cascading disconnection of other generators and ultimately causing catastrophic power system failure.

To prevent the generation facilities interconnected with power systems from becoming disconnected one after another within the upper/lower frequency limits, the operable frequency range should be set in coordination with the system frequency management/control system of VIUs.

The operable frequency range of generation facilities interconnected with power systems should be specified by TDSVIUs. TDSVIUs establish and publicize the operable frequency range of generation facilities coordinated with the system frequency management/control system.

5. Measures for voltage fluctuation

When the system voltage cannot be maintained properly due to voltage fluctuations on power systems associated with system interconnection of generation facilities, facility operation may be disrupted.

Those who interconnect a generation facility with power systems implement the following voltage control measures, in principle, to prevent the system voltage from deviating from the appropriate value when system interconnection takes place;

- If the system voltage deviates from the proper value (within about 1 to 2% of normal voltage) due to system interconnection of generation facilities, it ought to be controlled automatically.

- When using synchronous generators, they should come with a damping winding function (including a synchronous generator without damping winding that can prevent hunting as well as or more than the damping winding type).
  Automatic synchronism detection devices should also be installed. Besides, when induction generators are used, if the system voltage deviates from the proper value (estimated as 2% of the normal value) due to the voltage dip while being paralleled in, current-limiting reactors or similar must be installed. However, if such measures remain ineffective, synchronous generators will be necessary.

- When self-commutated inverters are used, they must have an automatically synchronizing function. Besides, when line-commutated inverters are used and the system voltage still deviates from the proper value (estimated as 2% of the normal value) due to voltage dip while being paralleled in, current-limiting reactors or similar devices must be installed. If such measures remain ineffective, self-commutated power inverters will be necessary.

When it is necessary to implement measures coordinated with power systems, such as installing an on-load tap changer and voltage fluctuation control to counter magnetizing inrush current, TDSVIUs establish and publicize details of these measures and the concept behind them.

6. Power quality measures

If power quality is affected by the system interconnection of generation facilities, it may disrupt the use of electricity and electric facilities for others. Therefore, those who interconnect a generation facility with power systems take appropriate measures to prevent deviation from the standard value of power quality due to system interconnection.

6-1 Harmonic suppression measures

When a generation facility is interconnected to the system and harmonic current flows into power systems, it may cause a harmonic strain on the voltage waveform of power systems, thus damaging electric facilities. Therefore, those who interconnect a generation facility with power systems take necessary measures against harmonics during system interconnections in line with either of the following policies;

(1) Harmonic suppression measures conforming with the facilities of end-use customers
When taking harmonic suppression measures conforming with the facilities of end-use customers.

(2) Individual harmonic suppression measures for generation facility
When an inverter is installed, the harmonic incurrent flow from an inverter itself into power systems (including its filter) must be less than 5% of the total harmonic distortion and 3% of the harmonic distortion of each order.

TDSVIUs establish and publicize policies concerning suppression measures for harmonic incurrent flow into power systems according to (1) or (2).

6-2 Other power quality measures

When there are demand facilities, Paragraph 1 of Section 9 “Measures to secure power quality” applies to them.

7. Stability measures

If the stability of power systems cannot be maintained, its influence may be extensive.

When generation facilities interconnected with special high-voltage lines and operation control are necessary for system stability, an appropriate operation control system must be installed at generation facilities. It is established as a standard that the operation control systems specified by TDSVIUs as shown below are installed;

- Power system stabilizer (function of a power system stabilizer, function of an AVR of high-response excitation)
- Power shedding system. However, when measures other than those above are necessary, TDSVIUs establish and publicize their details and policies.

8. Countermeasures for phase/ground fault current

When a generation facility interconnects with power systems, the short-circuit capacity increases, causing the phase/ground fault current to exceed the circuit breaking capability of existing circuit breakers. Consequently, the circuit may not be broken during contingencies, necessitating some preventive measures.

If the short-circuit capacity of power systems increases and a phase fault current may exceed the circuit breaking capability of other circuit breakers as generation facilities interconnect with the systems, those who interconnect generation facilities with power systems must install a device to limit the phase fault current (for example, a current-limiting reactor). If such measures remain ineffective, other short-circuit capacity countermeasures, including interconnection to different substations and higher-voltage T/Ls, will have to be taken.

If the ground fault current exceeds the phase fault current in the power systems using a neutral point solid grounding method and so forth, measures equivalent to those above must be taken for the ground fault current.

9. Protective relay system

Protective relay systems required for the system interconnection of generation facilities must be coordinated with those of interconnected power systems and others from the perspective of human/society security, power system security, protection of electric facilities from damage and efficient development of transmission facilities.

It is established as standard that the following protective relay systems be installed. When demand facilities also exist, this technical requirement applies to them.

a. To protect power systems from generation failures, protective relays are installed as follows;

- An over-voltage relay capable of detecting an abnormal rise in the voltage of generation facilities and disconnecting these generation facilities from power systems within a specified duration is installed. However, the installation of such relay can be omitted if the generator itself has detection and protection functions.
- An under-voltage relay capable of detecting an abnormal drop in the voltage of generation facilities and disconnecting them from power systems in a specified duration is installed. However, such relay need not be installed if the generator itself has detection and protection functions.

b. To protect power systems from a phase fault, the following protective relays are installed:

- When synchronous generators are in use, a short-circuit directional relay capable of detecting short-circuiting of interconnected systems and disconnecting generation facilities from power systems is installed. When the relay thus installed cannot function effectively, a short-circuit directional distance relay or current differential relay is employed.
- When induction generators or inverters are in use, an under-voltage relay capable of detecting any abnormal voltage drop of generators and disconnecting them from the interconnected power systems in case of a short circuit in the interconnected power systems is installed.

c. To protect power systems from a ground fault, a current differential relay is installed when a neutral point solid grounding method is employed. Furthermore, a ground fault over-voltage relay is installed when a method other than the neutral point solid grounding method is in use. If such relay cannot function effectively, a ground fault directional relay or current differential relay is installed. However, if any of the following conditions can be satisfied, a ground fault over-voltage relay need not be installed;

- A ground fault of the interconnected systems can be detected by a ground fault over-voltage relay installed at the generator outlet;
- The output of the generation facilities is smaller than the site load and islanding can be detected and disconnected quickly by an under-frequency relay; or
- Islanding can be detected and disconnected quickly by a reverse power relay, under-voltage relay or a passive separating device with an islanding prevention function:

d. If there is a reverse power flow, to prevent islanding that deviates from the proper voltage and frequency, over- and under-frequency relays or transfer tripping protection is installed. Note that the characteristics of the over- and under-frequency relays are impervious to voltage fluctuations.

e. If there is no reverse power flow, to prevent islanding, over- and under-frequency relays are installed. However, if the output capacity of generation facilities is balanced with the load of the power systems and an over-frequency relay or an under-frequency relay may be unable to detect/protect the islanding, a reverse power relay is installed. In addition, the following protective relay systems are installed as required:

f. On-site protection

To keep on-site failure from extending into interconnected systems, an over-current relay is installed for an on-site phase fault and a ground fault over-current relay is installed for an on-site ground fault. If these protective relays cannot coordinate with those of transmission systems, other protective relays such as bus protective and differential ratio relays for step-up transformer protection are installed.

g. Way to keep failure from spreading during step-out

To prevent faults from spreading elsewhere during step-out, an out-of-step protective relays is installed.

h. Use of multiple protective relays and so on

To improve system security, the following measures are employed in compliance with VIU standards: use of a duplex protective relay, a combination of back-up and automatic reclosing protection. TDSVIUs shall establish and publicize the policy requiring installation of standard and any additional protective relay systems.

10. Neutral point grounding device, preventive measures for obstacles to electromagnetic induction

Not only may abnormal voltage occur, line-to-ground faults may not be detected when occurring in power systems.

Therefore, when neutral point grounding is required for interconnection with special high-voltage lines, those who interconnect generation facilities with power systems must install a grounding device at a neutral point of the transformer.

As the need to install a neutral grounding device and its specifications vary depending upon the voltage/state of interconnected systems, TDSVIUs examine how abnormal voltage occurs during a line-to-ground fault and specify a neutral grounding device as required.

A ground return direct current occurs during a line-to-ground failure in neutral point grounding systems, causing electromagnetic induction and induced voltages on the neighboring communication lines. These induced voltages may cause security problems, e.g. adversely affecting communication lines and accidents such as electric shocks involving communication line workers.

If it becomes necessary to implement an electromagnetic induction preventive measure because a neutral grounding device is installed, those who interconnect generation facilities with power systems must take appropriate measures.

11. Automatic load/power shedding device

In the event of any loss of generation, stoppage of one circuit in two-circuit T/Ls and other problems, the interconnected transmission facilities may become overloaded.

If the interconnected T/Ls become overloaded, mostly during any loss of generation and other problems, those who interconnect generation facilities with power systems must take appropriate measures to automatically limit the load.

If the facilities are interconnected with special high-voltage lines, an overload detection device shall be installed, as required, for power shedding.

12. Device to confirm no-voltage on transmission lines

When generation facilities are interconnected with power systems, a device to confirm no-voltage on T/Ls must be installed to prevent failure caused by asynchronous interconnection during automatic reclosing.

Therefore, if a device to confirm no-voltage on T/Ls is not installed at the outlet of an outgoing line from a power system substation, such device must be installed at that outlet to prevent failure during automatic reclosing.

However, if a reverse power flow does not exist and a protective relay, current transformer, voltage transformer, circuit breaker and wiring of power source for control concerning the system interconnection are made in dual series and sequential so that they can be mutually backed up, a voltage confirmation device need not be installed. The above-mentioned dual systems can be simplified using one or more of the following methods;

a. The protective relays of one of the above-mentioned dual systems can be made of under-power relays only.
b. Both current and voltage transformers can be used in combination in the 1st and 2nd series when under-power and under-voltage relays are respectively installed at the end.

13. Telephone facility for security communication

When a circuit breaker for system interconnection is activated due to an on-site failure, problem with power systems and so forth, those who operate generation facilities and TDSVIUs communicate with each other promptly and accurately.

Telephone facilities for security communication (such as private telephone lines for security communication and leased lines exclusively for the telecommunications industry) must be installed between these two parties.

However, telephone facilities for security communication may use any subscriber phones or cellular phones if interconnected with a special high-voltage line not exceeding 35,000V and all the following conditions are satisfied;

- A system capable of direct communication with engineers without using the exchanger of generation facility operators is introduced (not a switchboard number system through the exchanger, but a single number system directly connected to the technical office) and is always at the place of maintenance/supervision of generation facilities;
- A system capable of interrupting, even when a call is being made (for example, catch-phone system) is introduced;
- A system that maintains communication, even during outages and;
- It is clearly specified in safety regulations that if communication with the TDSVIU cannot be established in the event of a disaster or accident, generation facilities are disconnected or cease to operate until communication is restored;

TDSVIUs establish and publicize detailed requirements for telephone facilities for security communication as it may become necessary to specify duplex telephone lines or a kind of telephone facilities with reliability and economy in mind.

14. Dispatching data transmission equipment

TDSVIUs must possess information required for system security, facility security and worker safety. Therefore, TDSVIUs and generation facility operators must exchange the necessary information with each other.

When interconnected with special high-voltage lines, supervisions and telemeters are installed between these two Parties so that information necessary for system operations can be exchanged as required.

(1) Communication system

TDSVIUs establish and publicize communication systems coordinating with existing systems.

(2) Information items to collect

TDSVIUs establish “Standard information items to collect”, including all items, one of which is supervision of circuit breakers at the drop point of the T/L and the second is the telemeter of active power at the receiving point.

- The purpose of collecting items when items other than those shown in the Attached Table 3-3 are designated as “Standard information items to collect”
- The system interconnection conditions and the purpose of collecting the items when they are designated as “Information items to collect according to system interconnection conditions”

TDSVIUs explain to those who interconnect generation facilities with power systems why “Information items to collect according to system interconnection conditions” are necessary.

Policy for technical requirements for interconnection of demand facilities

A technical requirement for the system interconnection of demand facilities is shown below. Note that electrical systems and telephone facilities for security communication apply under Section 8 “Policy for technical requirements for interconnection of generation facilities.”

1. Measures to secure power quality

Deterioration of power quality due to system interconnection of demand facilities may disrupt the use of electricity and electric facilities for others. Therefore, those who interconnect demand facilities with power systems must take measures to prevent deviation from a standard value concerning power quality during system interconnection.

1-1 Harmonic suppression measures

The harmonic current inflow into power systems due to system interconnection of demand facilities may cause a harmonic strain on voltage waveforms of power systems, thus damaging electric facilities. Therefore, those who interconnect demand facilities which generate harmonic currents with power systems must take the following measures for system interconnection:

(1) Scope

a. These measures must be taken by a party who satisfies either of the following conditions (hereinafter referred to as “Specified end-use customer” in this chapter);

- A party who receives electricity from 22 or 33kV power systems and whose total capacity of harmonics, calculated by considering the harmonics generation probability by facility type (hereinafter referred to as “Equivalent capacity” in this chapter) exceeds 300kVA.
- A party who receives electricity from power systems over 66kV and whose total Equivalent capacity exceeds 2000kVA b. Harmonics-generating facilities subject to the calculation of Equivalent capacity mentioned above are those other than devices which come under the “Guideline of measures for reducing harmonics from electrical appliances and multipurpose appliances”.

b. The measures apply to circumstances in which such harmonics-generating facilities are newly installed, added, or renewed by specified end-use customers. Moreover, the measures also apply to cases where the end-use customer becomes a specified end-use customer due to the new installation, addition, or renewal of harmonics-generating facilities.

(2) Calculation of the inflow harmonic current

The harmonic current inflow from a specified end-use customer into power systems is calculated as follows;

- The inflow harmonic current is obtained by totaling the harmonic currents, which are generated by each harmonics-generating facility operating at the rated output, multiplied by the maximum operation rate.
- The inflow harmonic current is obtained by aggregating the harmonics of each order.

- Harmonics up to the 40th order shall be aggregated.
- When there is a facility reducing an inflow harmonic current on the site of a specified end-use customer, its effect can be considered.

(3) Upper limit of harmonic current inflow

The permissible upper limit of an inflow harmonic current from a specified end-use customer into power systems is obtained by multiplying the permissible upper limit per 1kW of contract power (Attached Table 3-5) by the contract power of the specified end-use customer concerned (unit: kW) for every harmonic.

(4) Measures to control the inflow harmonic current

When the inflow harmonic current in Item (2) exceeds the upper limit of the inflow harmonic current in Item (3), appropriate measures must be taken to keep the inflow harmonic current below its upper limit.

1-2 Voltage fluctuation (voltage flicker)

As voltage fluctuations (voltage flicker) in power systems may hinder the electricity usage of others, a standard value must be required. Those who interconnect demand facilities with power systems must take necessary measures to maintain the $\Delta V10$ of voltage fluctuation, a value equivalent to the 10Hz fluctuation to which humans are most sensitive, below its standard level (the fourth maximum data among one minute average $\Delta V10$s continuously measured for one hour is below 0.45V).

1-3 Others

When measures to maintain power quality other than those mentioned above must be taken, TDSVIUs clarify their details and reasons and establish and publicize the same.

2. Protective relay system

Protective relay systems required for system interconnection of demand facilities must be coordinated with those of interconnected power systems from the perspective of human/society security, power system security, protection of electric facilities from damage and efficient development of transmission facilities.

It is established as standard that the following protective relay systems be installed;

a. On-site protection

To prevent on-site failures from affecting interconnected systems one after another, an over-current relay is installed to protect against on-site phase faults and a ground fault over-current relay for an on-site ground fault. If these protective relays cannot coordinate with those of transmission systems, other protective relays such as bus protective relays and ratio differential relays for step-up transformer protection are installed.

b. Protection of power systems from phase/ground faults

When these protective relays must coordinate with those of transmission systems, other protective relays, e.g. transverse differential and current differential relays, are installed.

c. To make protective relay multiple and so on

To improve system security, the following measures are employed in compliance with the VIU standard: use of a duplex protective relay and a combination of back-up protection. An automatic reclosing protection is installed if requested by those who interconnect demand facilities with power systems. TDSVIUs establish and publicize the standard protective relay systems and policies for additional installation of protective relay systems.

3. Dispatching data transmission equipment

TDSVIUs must possess the information required for system security, facility security and worker safety, which means TDSVIUs and demand facility operators must exchange the necessary information with each other. When interconnected with special high-voltage lines, supervisions and telemeters are installed between both Parties to exchange the information necessary for system operations.

(1) Communication system

TDSVIUs establish and publicize communication systems coordinating with existing systems.

(2) Information items to collect

TDSVIUs establish “Standard information items to collect” or “Information items to collect according to system interconnection conditions” and establish and publicize the following items;

- The purpose of collecting items designated as “Standard information items to collect”.
- The system interconnection conditions and the purpose of collecting items designated “Information items to collect according to system interconnection conditions”.

TDSVIUs explain to those who interconnect demand facilities with power systems why “Information items to collect according to system interconnection conditions” are necessary. In case of system interconnection concerning wheeling service, PPS and TDSVIUs discuss the information items to collect if an application for the wheeling service contract does not necessitate any change to existing demand facilities.

Power System Operation Agreement between Dispatch Center and Generation Company (SAMPLE)

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This agreement is concluded between, on the one hand, “A” Company (hereinafter called the “First Party”) and, on the other hand, PNG Power Ltd. (hereinafter called the “Second Party”) based on the contract of connection (transfer) (hereinafter called the “Original Agreement”) between “B” Company and the Second Party (based on the contract of supply (hereinafter called the “Original Agreement”) between the First Party and the Second Party) to facilitate power system operation.

1 Relation Company and Transmission line

(1) Relation Company

	Company Name	Department	Abbreviation
First Party	“A” Company	“B” Power station	“B” Power station
Second Party	PNG Power Ltd.	“C” dispatch center	“C” dispatch center
		Control technical group	Control group
		Communication network center	Communication center
		…	…

(Reference) Operation representative of the Original Agreement and corresponding department of the Second Party (If only based on the contract of connection (transfer))

	Company Name	Department	Abbreviation
	Xx Company	Xx group	Xx group
Second Party	PNG Power Ltd.	Central dispatch center	Central dispatch center

(2) Transmission line

Transmission Line Name	Section	Abbreviation
“D” Line	From xx to “B” Power station	“D” Line

(3) Transmission system diagram and single-line diagram

Transmission system related to the “B” Power station is shown in Appendix “x”, transmission system diagram.

Transmission system in the “B” Power station is shown in Appendix “x”, single-line diagram.

2 Demarcation point regarding equipment assets and responsibility for maintenance

Demarcation point regarding the assets of power and communication equipment and responsibility for maintenance is shown in Appendix “x”.

3 Instruction of power supply and scope of instructions

(1) Instructions of “C” dispatch center regarding power system operation and contact root are shown in Appendix “x”.

(2) The scope of instruction of “C” dispatch center is the line switchgear on the bus side of “B” Power station as shown in Appendix “x” and “B” Power station shall follow the instruction. However, in case the equipment is maintained and any problems regarding personal safety or equipment operation occur, “B” Power station can request to that the instruction of power supply for “C” dispatch center be suspended or changed, citing reasons.

(3) In case of the instruction and contact, both operators shall confirm and record the contents, timing and name of the counterpart.

4 Planning and implementation for outage work

In case the equipment of the First Party and Second Party and the power producers and customers connected to the T/L which is connected to the First Party is inevitably suspended, both Parties shall cooperate and arrange planning, e.g. by altering the implementation time as follows;

(1) Annual plan for outage work

“B” Power station and “C” dispatch center shall have a contact meeting by x/x every year regarding the outage work for the following year (or two years) and “C” dispatch center shall decide by x/x every year. With regard to the outage work related to the generator equipment in the “B” Power station, the First Party shall arrange the implementation time with the operation representative of the First Party in advance.

In case the second half of the annual plan (from July to December) has to be amended, “B” Power station and “C” dispatch center shall contact each other by x/x and “C” dispatch center shall decide by x/x every year.

(2) Monthly plan for outage work

"B" Power station and "C" dispatch center shall hold a contact meeting by x every month regarding the outage work of the following month (or two months) and "C" dispatch center shall decide by x every month. With regard to the outage work related to the generator equipment in the "B" Power station, the First Party shall arrange the implementation time with the operation representative of the First Party in advance.
If necessary, e.g. with complicated outage work (with line outage), "C" dispatch center shall contact via written document.

(3) Alteration of plan for outage work

When the plan for outage work is changed, "B" Power station and "C" dispatch center shall contact each other and cope with the change by x days before implementing the outage work.
With regard to the outage work related to the generator equipment in "B" Power station, the First Party shall arrange the implementation time with the operation representative of the First Party in advance.

(4) Confirmation in the day before implementation for outage work

When the outage work is implemented, "B" Power station and "C" dispatch center shall contact each other and confirm the contents of the work, workplace and operation time, with or without grounding, the point of grounding and so on by xx:xx the day before the implementation, based on the paper of the operation instruction.

(5) Outage work in case of emergency

When unavoidable outage work is urgently implemented, "B" Power station and "C" dispatch center shall maintain constant contact while implementing the outage work.

(6) Implementation for outage work

"B" Power station shall implement the outage work as instructed by "C" dispatch center based on the paper of the operation instruction, which is confirmed regarding the operation time of equipment related to the outage work, operation process and so on by the day before the implementation.

(7) Grounding points during outage work

Grounding points during the outage work of "D" line are shown in the paper of the operation instruction (Appendix "x").
When "B" Power station tries to connect the grounding which is not included in the operation instruction, "B" Power station shall contact with "C" dispatch center with regard to the connection and disconnection of the grounding.

(8) Basic arrangements for outage work

Outage work is basically completed during one outage because the number of outages shall be minimized to maintain supply reliability.
Outage work is basically implemented in daytime with workers' safety in mind.

5 Switchgear operation under normal conditions

(1) Operation of outage and restoration in “D” line shall be implemented along with the paper of the operational instruction (Appendix “x”).

(2) In case the paper of the operational instruction (Appendix “x”) is not applied, “C” dispatch center shall make a new paper of the operational instruction and decide it after meeting.

(3) “B” Power station and “C” dispatch center shall mutually confirm and implement the following to maintain safety when implementing outage and restoration operations.

a. Items required for safety such as workplace, work contents, time in “B” Power station and so on in the outage operation of “D” line.

b. Items required for safety such as completion time, whether or not the grounding is connected in “B” Power station and so on when restoring the operation of “D” line.

(4) During outage and restoration operations in “D” line, the operators in “B” Power station and “C” dispatch center shall be engaged in contact for operation and instructions from beginning to end of the operation to keep safe operation.

(5) In the operation of outage and restoration in “D” line, the instructed operator shall repeat the instruction and operate after appointing and saying the target equipment. The instructed operator shall report the instructing operator whenever the operation is completed.

6 Operation for voltage

(1) Power factor of generators in “B” Power station shall be adjusted so the system voltage can be maintained.

(2) “C” dispatch center may ask “B” Power station to open and close phase modifying equipment in “B” Power station to maintain the system voltage. In this case, “B” Power station shall be supposed to respond the request as far as possible.

7 Dealing with faults and outages

(1) “D” line fault

a. “D” line fault shall be coped with by the instruction (Appendix “x”).

b. In case “D” line is separated and an inspection of “B” Power station seems necessary, the inspection is implemented as instructed by “C” dispatch center. After inspecting, “B” Power station shall contact “C” dispatch center and deal with the fault after arrangement.

c. “C” dispatch center shall contact “B” Power station concerning the recovery time, cause and other necessary items.

(2) Power producer fault

a. Contact in case of a fault in “B” Power station

(a) In case of a fault on the extra-high voltage side of “B” Power station, “B” Power station shall contact “C” dispatch center as soon as possible concerning the occurrence time, status of circuit breakers used for interconnection, status of protective relays and so on.

(b) In case of a fault or abnormal condition that affects generators and their output, “B” Power station shall contact “C” dispatch center as soon as possible concerning the occurrence time, status of generators, status of protective relays, expected recovery time and so on.

b. Restoration

(a) In case a fault occurs in “B” Power station and the circuit breaker used for interconnection is triggered, “B” Power station shall cope with the fault point. When “B” Power station decide that it is possible to interconnect to the power system, “B” Power station shall contact ”C” dispatch center about the result and deal with after arrangement.

(b) In case the fault occur in “B” Power station and circuit breaker used for interconnection don’t operate and outage occur in “D” line, “B” Power station shall open circuit breaker used for interconnection and disconnectors as soon as possible. When “B” Power station decide that it is possible to interconnect to the power system, “B” Power station shall contact ”C” dispatch center about the result and deal with after arrangement.

(c) In case that it cannot be decided whether the fault occur in “B” Power station or not, “B” Power station and “C” dispatch center shall contact each other and deal with the fault.

c. Contact after dealing with the fault

In case the fault occurs in “B” Power station, “B” Power station shall contact “C” dispatch center with details of the affected equipment, cause, time, fault status and other necessary items after dealing with the fault.

(3) Others

a. In case of the following and urgently, “B” Power station may instruct adjustment or suspension of generators and adjustment or suspension of load to “C” dispatch center.

- It is inevitable in view of power demand and supply due to the abnormal lack of water or awful disaster
- A fault occurs or might occur in the supply equipment maintained and operated by the Second Party
- Supply in response to general demand is or may be interrupted
- The frequency decreases and increases rapidly, transmission equipment is loaded over the operational limit or such thing might happen
- People and equipment are or may be damaged
- It is inevitable due to inspection, repair, alteration and construction of the Second Party’s equipment

b. In case the system is separated, including “D” line, “B” Power station shall try to maintain stable generator operation until “C” dispatch center contacts “B” Power station. The system separation is basically restored by synchronization between the two separated systems. However, in case it is difficult to synchronize due to inability to adjust the frequency and voltage, “C” dispatch center shall contact “B” Power station as soon as possible and then “B” Power station shall open the circuit breaker used for interconnection or synchronization of generators as instructed by “C” dispatch center.

c. In case “D” line might be overloaded when the generators in “B” Power station are separated, “C” dispatch center might instruct that the load in “B” Power station be adjusted or suspended.

8 Operation for protective relays

(1) Changes to the settings in the protective relays related to “B” Power station and “D” line, countermeasures for faults and so on are contacted as follows and implemented after the arrangement:

“B” Power station — “C” dispatch center — Control group

(2) Settings in the protective relays related to “B” Power station and “D” line are shown in Appendix “x”:

(3) Tests of the protective relays related to “B” Power station and “D” line are implemented as follows:

		Test		Report		
		Target	Period	Time	Report to	Number of copies
Routine	Combined test	Receiving equipment (existing)	xx	After the test	“C” dispatch center	1
	Characteristic test	Ditto	xx	Ditto	Ditto	1
Construction	Combined and Characteristic test	Receiving equipment (new)	Construction and next year	Ditto	Ditto	1
Special	Characteristic test	Change of setting in receiving equipment (existing)	Change of setting	Ditto	Ditto	1

9 Operation for communication systems

(1) The constitution of the communication network is shown in Appendix “x”.

(2) In case a fault in communication systems required for power system operation occur, countermeasures and so on are contacted as follows and implemented after arrangement.

“B” Power station — “C” dispatch center — Communication center

(3) Emergency contact details during holidays, overnight, in case of malfunctions affecting direct calls and so on, are shown in Appendix “x”.

10 Submission of records

When “C” dispatch center requests the record required for power system operation, “B” Power station shall record and submit it to “C” dispatch center.

11 Organization and member to contact in case of emergency

“B” Power station and “C” dispatch center shall exchange a member list of contact representatives and operators to contact each other certainly. Member lists shall be exchanged whenever one of the members is replaced.

12 Others

(1) “B” Power station and “C” dispatch center shall contact each other about conditions of operation and other necessary items as required.

(2) When the First Party or Second Party deem it necessary to amend this agreement, this agreement shall be amended after mutual consultation. In case only the Appendix is amended, the Appendix shall be replaced subject to mutual approval instead of being amended.

(3) “B” Power station and “C” dispatch center shall handle matters of power system operation not shown in this agreement after mutual consultation.

13 Valid period

The valid period of this agreement shall be the same as that of the Original Agreement.

As a token of this agreement, the same two books are made, a copy of which shall be given to each of the First Party and Second Party.

xx/xx /2015

The First Party

The Second Party “C” dispatch center

Each Item is agreed after being amended according to the specific connection requirement based on this sample.

Regarding the power producer, with generators for the wholesale electricity business, adjustments and planned outages for generators are decided as required.

CHAPTER 8

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

CHAPTER 8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 BASELINE FEATURES OF PAPUA NEW GUINEA

8.1.1 Physico-chemical Environment

(1) Geographical and Geological Conditions

PNG, which is located directly north of Australia and east of Indonesia, comprises the eastern half of New Guinea Island and numerous islands in the Bismarck and Solomon Sea. The western portion of New Guinea constitutes the Indonesian province of West Papua. A general map outlining the administrative boundaries of PNG is shown in Fig. 8.1-1 and a geographical map is shown in Fig. 8.1-2.

PNG has the largest land area found among the Pacific Island Countries, with an area of over 462,840 km^2. PNG is located on the so-called "Ring of Fire" in the Pacific Ocean and is geologically active. Soils range from old alluvium deposits to newly formed soils due to recent volcanism. Densely forested areas with steeply sloped catchment areas characterize the land and approximately 0.5% of the land area in PNG is considered arable.

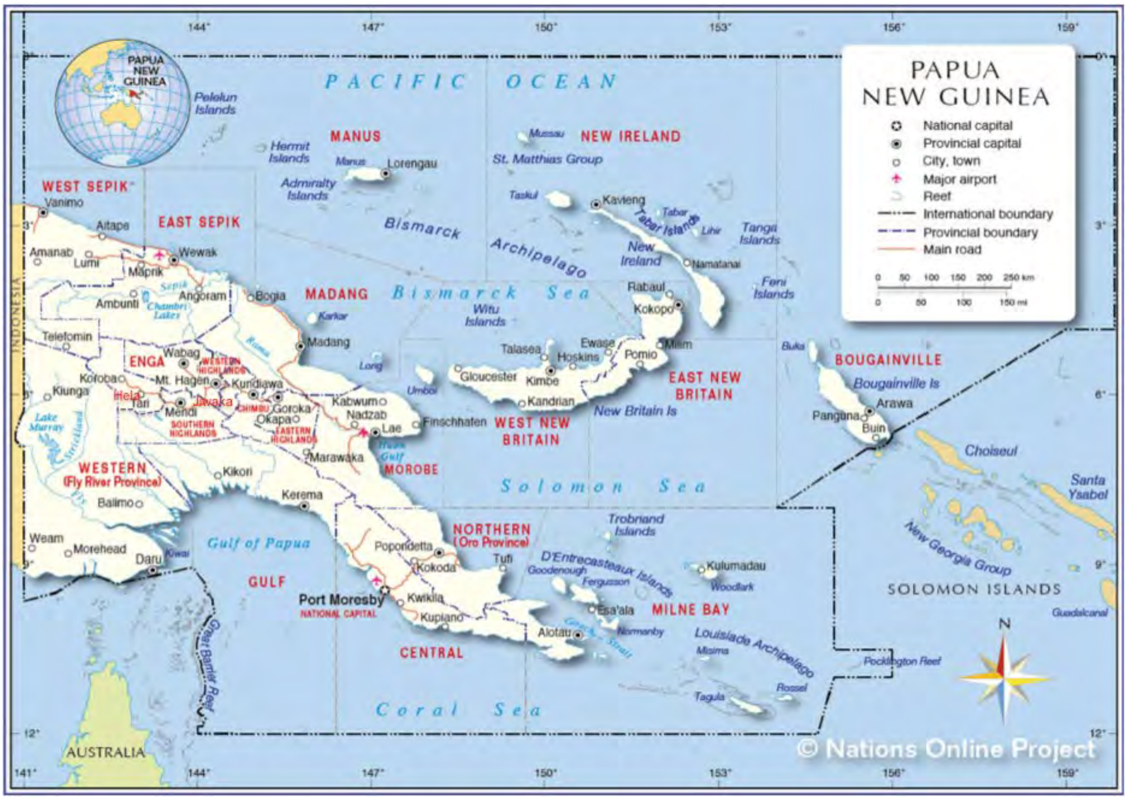
A 400 km wide area of the alluvial plain in the south of the country is bisected by the Fly River and largely situated above the flood level of its river system. The area to the south of the mouth of the Fly River is relatively flat and less than 30 m above sea level. Large portions are flooded during the wet season.

The Central Range Region that occupies most part of Ramu Grid System Area of Power supply of PPL is referred to as "the Highlands". It extends throughout the New Guinea Island mainland and includes Mount Wilhelm (4,509 m), the highest peak in PNG. This region takes up almost half the island and forms a complex of narrow ridges, V-shaped upland valleys, and volcanoes. Prominent features include the Star Mountains in the west and the Hinderburg, Muller, Kubor, Schrader, Bismarck and Owen Stanley Ranges in the east. These areas often have altitudes in excess of 3,000 m asl.

The Central Range Region is generally located on igneous and/or sedimentary rock. Very prominent structural ridges have formed in areas consisting of limestone or resistant sandstone alternating with soft sedimentary rock. This area also contains the largest area of karst in PNG, covering up to 15,000 km^2.

The structural depression in the North Trough Region comprises plains, lowlands, and swamps and is mostly flanked by steep mountains. The Sepik Plains, the most extensive plains in PNG, mainly comprise swamps, meandering rivers bisecting floodplains, and riparian fans. The Markham Ramu Valley also includes large swampy areas but is characterized by moderate to steep slope riparian/alluvial fans made of coarse material derived from the steeply sloping mountains.

The Northern Ranges Region runs parallel to the Central Ranges separated by the geographic trough. The terrain is rugged and steeply sloping. On the Huon Peninsula these mountains rise in places to 4,000 m above sea level. Along the coast the mountains descend steeply into a narrow, discontinuous coastal plain. The north coast is actively rising at a maximum rate of 3 m uplift per millennium.



Source: Nations Online Project (http://www.nationsonline.org/oneworld/maps.htm)

Fig. 8.1-1 Administrative Map of PNG

Source: Nations Online Project (http://www.nationsonline.org/oneworld/maps.htm)

Fig. 8.1-2 Geographical Map of PNG

(2) Soils and Seismic Activities

Soils range from old alluvium deposits to newly formed soils as a result of recent volcanism. In most areas, the soils are generally fertile and moderately deep with a relatively robust structure that supports a high level of organic production.

According to Food and Agriculture Organization of the United Nations (FAO) (http://www.fao.org/ag/agp/agpc/doc/counprof/southpacific/png.htm), there are seventy nine per cent of soils in PNG, covering the three main topographical groups, have major limitations as follows: (percentage coverage) salinity (1.74% - Western and Gulf), inundation or tidal flooding (16.9% - significant in Western, Gulf and East Sepik), soil depth of <25 cm (9.5% - Gulf, Southern Highlands and Morobe), extreme stoniness (16.8% - Southern and Eastern Highlands and Enga), anion fixation problems (35.1% - mainly Western but also Northern, Southern Highlands and East and West Sepik).

The main existing and potential grazing areas are dominated by soils which are: 1) in valleys and plains; 2) undifferentiated, poorly drained soils; 3) undifferentiated soils with seasonal moisture stress; 4) strongly weathered, poorly drained, fine textured sub-soils; 5) low mountains and hills slightly to moderately weathered soils with altered B horizons.

PNG is located on the Pacific Ring of Fire, where the geological activity of volcanoes, tsunami, earthquakes, and subsequent landslides profoundly influence the local population. Relatively minor volcanic eruptions are commonplace along the north coast of mainland PNG. Madang Province, one of the major provinces supplied with electricity by the Ramu Grid System contains a number of active volcanoes.

Large vertical movements along major fault lines have created most of the present landforms, and the uplift is still underway in the Northern Ranges. Widespread volcanic activity induced by plate movements in the Highlands has formed large volcanoes such as Mount Hagen and Mount Giluwe. Glaciation has more or less altered the coastline, pushing the land surface down by around 130 m. The country's landscape is still undergoing rapid changes caused by volcanic activity, landslides triggered by seismic activity, and denudation processes following heavy rainfalls.

(3) Climate

1) General Climate of PNG

PNG's climate is influenced by the Inter-Tropical Convergence Zone that moves south over the equator in October-November and north in March-April as it is associated with monsoonal activity from the north and north-west.

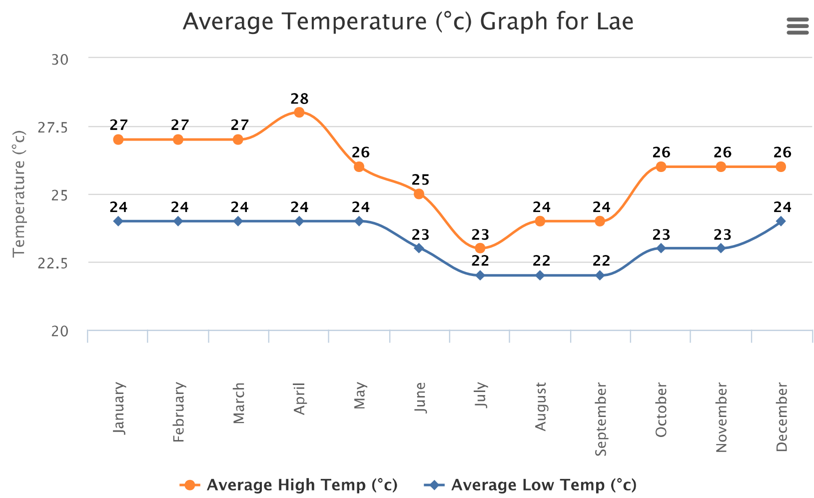
Wet monsoon rain and wind prevails from December to March, followed by a dry trade wind from May to October. Annual rainfall varies widely depending on the monsoon patterns, ranging from as little as 1,270 mm at POM to an average of 5,840 mm in the western river basin.

The high rainfall of much of the highland areas gives rise to many landslides that temporarily bury or dislocate the vegetation. Large areas of soil and rock are often exposed in the process, resulting in temporarily severe siltation in the downstream watercourses.

Most of the lowland and island areas record daily mean temperatures of approximately 27°C, while humidity is uniformly high (approximately 80%) in the lowlands and averages between 65 and 80% in the Highlands.

2) Climate in Lae

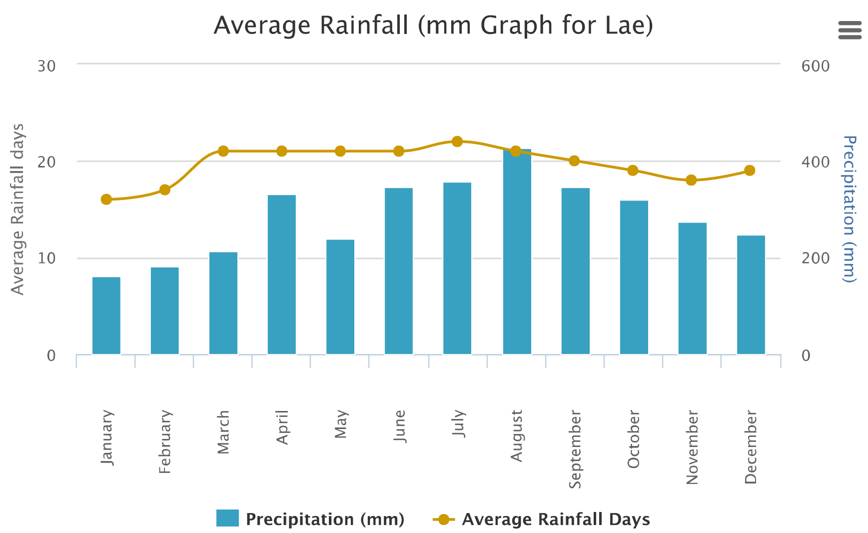
Climate in Lae, the eastern most city of Ramu Grid System Area of electricity supply subject to the Master Plan Study is wet tropical lowland type with high temperatures throughout the year as is shown in Fig. 8.1-3. Average low temperatures are in the range of 22ºC – 24ºC throughout the year while highs are in the range from 23ºC to 28ºC. There is a relatively small seasonal valiation.



http://us.worldweatheronline.com/Lae-weather-averages/Morobe/PG.aspx

Fig. 8.1-3 Average Temperatures in Lae

As is shown in Fig. 8.1-4, number of rainfall days is 19.7 days per month based on the data from 2010-2014. Average rainfall per month is 286.5mm, or 3,438 mm per year. There is no large difference between the number of rainy days in wet season, which is 21 days per month and dry season, which is 18.3 days per month in average.

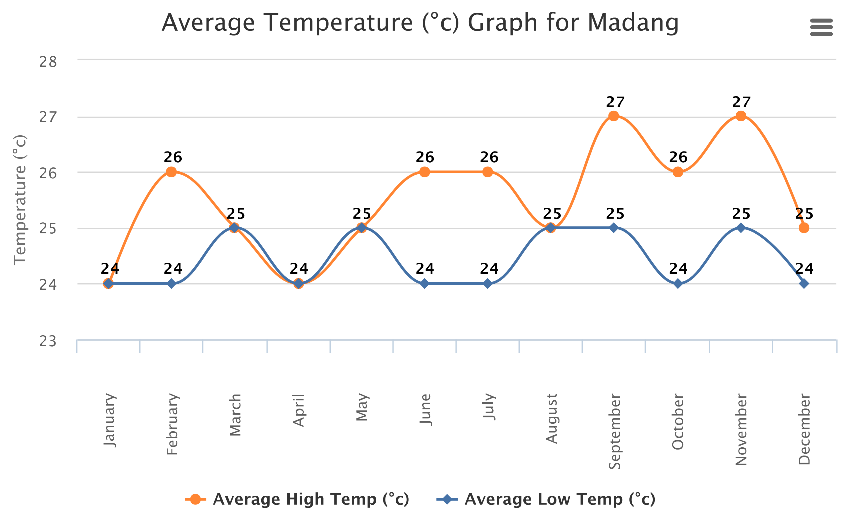


http://us.worldweatheronline.com/Lae-weather-averages/Morobe/PG.aspx

Fig. 8.1-4 Average Rainfall and No. of Rainy Days in Lae

3) Climate in Madang

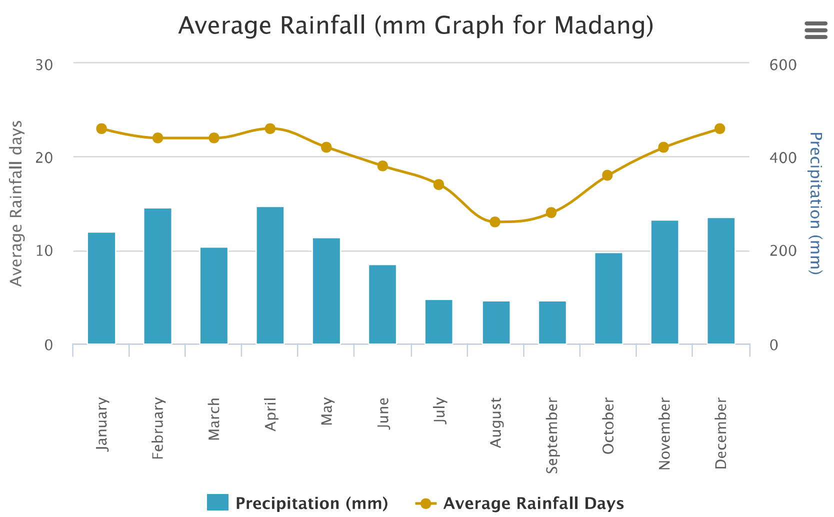
Climate in Madang, the northern most city of Ramu Grid System Area of electricity supply subject to the Master Plan Study is also a wet tropical lowland type with slight difference from that of in Lae. As is shown in Fig. 8.1-5, Average low temperatures are in the range of 24ºC – 25ºC throughout the year while highs are in the range from 24ºC to 27ºC. There is relatively small seasonal valiation.



http://us.worldweatheronline.com/madang-weather/madang/pg.aspx

Fig. 8.1-5 Average Temperatures in Madang

As is shown in Fig. 8.1-6, number of rainfall days is 19.7 days per month based on the data from 2010-2014. Average rainfall per month is 236.5mm, or 2,442mm per year. The amount of rainfall during dry season is very small comparing to that of in Lae. There is no large difference between the number of rainy days in wet season, which is 21.5 days per month and dry season, which is 17.8 days per month in average.



http://us.worldweatheronline.com/madang-weather/madang/pg.aspx

Fig. 8.1-6 Average Rainfall and No. of Rainy Days in Madang

It is important to show climatic conditions of highland areas where Ramu Grid System reaches in order to compare the climate of the coastal areas and mountainous areas. However, because of the lack of reliable data in the highland areas, it is not possible to present and compare them with that of the lowland areas.

4) Draught in PNG

Periodic droughts and frosts affect the vegetation in PNG. Periodic wild fires, usually started by the local people sweep through the woodlands and grassland of highland areas in many parts of the country. Most of these fires could have anthropogenic causes as remnants of the traditional slash-and-burn agriculture.

Droughts in PNG are related to the El Niño Southern Oscillation phenomenon (ENSO). The latest ENSO episode, which impacted the country most severely, took place in 1997/98, causing dry spells throughout PNG. About 80% of the subsisting population suffered from shortages of food production and was severely affected by the drought during this period. Conversely, in the POM urban area, water availability for electricity production and water supply in Sirinumu reservoir fell to a critically low level.

In 2015, probably the strongest ENSO of the recorded history of meteorology occurred. Similar to the 1997/1998 event, unseasonal low temperatures in the highland areas caused severe damages to the agricultural activities. In POM, as before, Sirinumu Reservoir fell to a critically low level. Details of the 2015 ENSO event are described in the Section 8.5.6.

(3) Water Resources

The inland water resources of PNG are dominated by the major river systems that drain the central highland areas. There are two main river systems in the north: 1) the Sepik River basin, the largest river system in PNG (77,000 km^2) with a deep main channel navigable for 500 km upstream, in the west; 2) the Ramu River basin, which has a relatively small catchment area flowing out about 720 km in a westerly direction toward west and discharges through a flat, swampy floodplain to the east of Sepik River mouth; 3) Markham River, a third system further to the east, is formed of long wide-braided channels flowing eastward over a distance of about 170 km and discharges into Huon Gulf to the south of Lae city. The Markham River flows along the collision line of the Australian and Pacific tectonic plates. Thus, Asiatic plants dominate to the north of the river and plants of Australian origin dominate to the south.

In the south, the Fly River and Strickland River systems drain into the Flay River Alluvial Plain, PNG’s largest low lying land, an extensive delta that discharges into the Gulf of Papua.

There are more than 5,000 lakes or swamp areas in PNG. Most of them are relatively small. Only 22 have water surface areas exceeding 10,000 ha. More than 80% of them are located below 40 m asl and generally draw their water from near-by rivers.

The per capita available freshwater in PNG is 170,258 cubic meters. This is the largest water stock in the world. The main water uses are for domestic consumption, industrial use including hydropower power and small industry. Agricultural use is generally more limited because of the lack of infrastructure such as irrigation system and associated technology. It is important to note that the urban areas in Ramu Grid System do not use river water for domestic water supply. Lowland urban areas us ground water because of the unreliability of river water in terms of its quality, which is in general turbidity is high. Rivers are also violent and causing flood incidents and land slide. Thus no water barrage for clean water supply from the river has been done to date.

There are two significant hydroelectric storage reservoirs, the Yonki Dam on the Ramu River in the Highlands and Sirinumu Dam on the Laloki River close to POM. The main sources of potable water in rural areas are rainwater, hand-dug wells, springs, creeks, and rivers.

8.1.2 Biological Environment

(1) Classification of the Vegetation Zones of PNG

As described above, PNG is inhabited by plants of Asiatic origin in the north and Australian origin in the south. The mountain area known as Finisterre Range to the north of Lae city is generally classified as an area dominated by Asiatic plant species, while the rest of mainland PNG is generally classified as Australian species. PNG has various terrestrial, coastal, and marine ecosystems ranging from very high mountain peaks to humid tropical forests and swampy lowlands and pristine coral reefs. A detailed study on the biodiversity is still underway to further refine the classifications. Unless a specific area is studied, it would probably be impossible to paint an overall picture of biodiversity in PNG.

Vegetation zones are generally classified from sea level to the high mountain level as 1) coastal vegetation, 2) mangrove forests, 3) anthropogenic grassland, 4) swamp vegetation, 5) savanna, 6) monsoon forest, 7) lowland tropical rain-forest, 8) mountain forest, and 9) alpine (see Table 8.1-1).

Table 8.1-1 Classification of Vegetation Zones in PNG

Type of Vegetation/ Forests	Classification Criteria/Features
Coastal Vegetation	In areas with well-drained ridges and slopes aligned parallel to the beaches. Coastal vegetation is relatively common in the coastal areas of PNG.
Mangrove Forest	In coastal and estuarine areas around the river mouths and along the shores of estuaries forming tidal forests.
Anthropogenic Grassland	In the dry hilly countryside along the north-east coast to mid-mountain areas where the main vegetation is dominant. Common in many populated highland areas.
Swamp Vegetation	In areas inundated for part or most of the year in the alluvial planes.
Savannah	Dominant in the monsoonal southwest of PNG.
Monsoon Forest	In areas near the coast with annual rainfall of less than 2,500 mm
Lowland Tropical Rain Forest	Much of lowland PNG lies below 1,000 m and receives more than 2,500 mm of rain per year. This type of forest is separated into two sub-categories: 1) lowland wet forest – below 500 m with more than 3,000 mm of rain; and 2) Lowland Humid Forest –below 1,000 m with 2,500 – 3,000 mm of rainfall per year.
Lower Montane Forest	Between 1,000 – 2,000 m above sea level.
Mid-Montane Forest	At 2,000 – 2,500 m above sea level.
Upper Montane Forest	Between 2,500 – 3,000 m above sea level.
Sub-alpine Forest and Grassland	In the uppermost slopes of the mountains higher than 3,200 m above sea level to 3,900 m above sea level.
Alpine	In areas higher than 3,900 – 4,400 m above sea level.

Source: Consultancy on Multiple National Forest Inventory for Sustainable Forest Management, ITTO

The "Handbook of the Flora of Papua New Guinea, Vol. 1 (1978), Vol. 2 (1981) and Vol. 3 (1995)" by Melbourne University Press covers the most of the plant species in PNG, though detailed study on vegetation is still ongoing.

The geologically young PNG is remarkably diverse in terms of landscapes, ecosystems, and species, with habitats ranging from tidal swamps at sea level to alpine conditions. Most of the country is covered by tropical and savanna rainforest housing valuable trees such as Kwila (Intsia bijuga) and cedar. Orchids, lilies, ferns, and creepers also abound in the rainforests, and large stands of pine grow at elevations of 910–1,220 m. Over 20,000 species of plant are estimated to exist nationwide.

Forest cover is the dominant vegetation in PNG, but man-made grassland resulting from slash-and-burn agriculture is replacing the large swaths of forest. The extensive mangrove forests characterizing the major river deltas along the southern coast of PNG and the coral reefs are all significant in terms of global biodiversity. The unique mixture of Australian and Asian plant and wildlife species in PNG is seen nowhere else in the world. Many of these species are endemic to New Guinea Island. The number of known species is estimated at approximately 26,000. When unknown or undocumented species are added, the estimate rises to somewhere between 400,000 to 700,000. If the estimates are accurate, an equivalent of about 5% of world species live in an area comprising only 1% of the land area of the planet.

(2) Forest Resources

The FAO reports that forests cover 291,600 km^2, or 67.6% of the PNG's total land area of 452,860 km^2. In contrast, the ADB's "Power Sector Development Plan (July 2008)" states that forests cover an area of 306,000 km^2. Compared to other tropical forests in the world, PNG's forested areas are characterized by abundant tall tree species reflecting the country's wide-ranging climatic, geographical, and geological conditions. The myriad tree species provide diverse forest habitats for a vast range of unique animals, plants, and microorganisms.

In PNG, forest resource belongs to the customary landowners, which are the tribal groups or clans. Several families constitute a clan, several clans form a village, and several villages make a "community". It is estimated that 95% of the total land area of the country is customarily owned while the remaining 5% is owned either by the State (Government), private companies, religious groups belonging to the Catholic or Protestant Churches, and individuals. Table 8.1-2 shows ownership of forest. This table so happened to reflects the current conditions of the customary landownership of PNG as well.

Table 8.1-2 Ownership of Forest in PNG

(Unit: 1,000 ha)

Ownership	Forest		Other Wooded Area	
	1990	2000	1990	2000
Prvate Ownership	0	0	0	0
Public Ownership	977	934	139	139
Customary Ownership	30,546	29,198	4,335	4,335
Total	31,523	30,132	4,474	4,474

Source: FAO Global Forest Resources Assessment 2005 (FRA 2005)

Most rural people live on their own land and maintain forest, which they own under customary title. The PNG Forestry Authority does not formally administer customary land that is accounted for 95 % of the total land area and title documents are not issued. Some formal settlement schemes have been developed, particularly for development of cash crops such as oil palm. In that case, local people do have formal title on land and are eligible for bank loans to fund housing and cash crop development.

The forest that grows on a piece of land is by default owned by the clans, which possesses that land. In order to carry out any forest related operations such as harvesting of timber or other forest product, or reforestation, extensive consultations must take place between the state agencies including the PNG Forest Authority and the landowners often referred to as the resource owners. A forest resources map of the mainland PNG is shown in Fig. 8.1-7.

Source: Saunders J.C., Australian International Development Assistant Bureau 1993

Fig. 8.1-7 Forest Resources of PNG

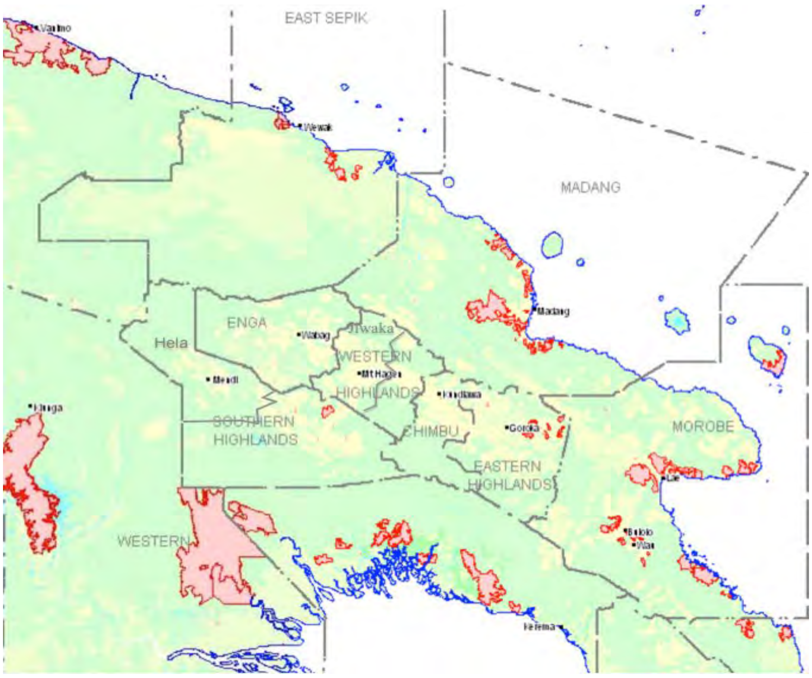
The Fourth Goal of the Constitution is to ensure that the national forest resources are used and replenished for the collective benefit of all PNGs, now and for future generations. Based on this principle, logging concessions are set up nationwide.

The PNG Forest Authority has developed a logging code of practice and other supportive tools and processes to enhance sustainable forest management in PNG. The Authority has adopted and applied the International Tropical Timber Organization (ITTO) set of criteria and indicators for the sustainable forest management of natural tropical forests on a national level. Reforestation and afforestation of anthropogenic-degraded areas are also part of the forest management system in PNG.

Round log extraction in the production forests is the main forest priority of the government and of the private forest companies, which are the main actors presently of the management of the forest resources. While primary forests comprise more than 2,000 tree species, of which about 200 have a timber of commercial value, more that 80% of exports of wood products and 80% of log exports are from 5 to 8 species only.

The lack of a strict control of logging, wood transport, processing and export activities makes it difficult to know in particular how much timber is actually felled, the amount of waste left in the forest and the damage caused by logging to the residual stands.

A map showing logged-over areas as of 2002 is shown in Fig. 8.1-8. As is shown, most of the logging areas are on the coastal area where transportation of heavy logs is relatively easy. As road conditions are improved in the future, forest concessions will be moved into inland area. The PNG Forestry Authority is inventorying the forest areas for the future practice of selective cutting. With this practice, total area forest concessions will be reduced while a number of forestry operators could increase in the future.



Source: Forestry Department, GoPNG

Fig. 8.1-8 Deforested Areas of the Study Area (as of 2002)

(3) Wildlife Distribution

PNG has a great diversity of birds, over 700 species of which have been recognized. The bird of paradise, Bower bird, cassowary, kingfisher, and many kinds of parrot are particularly well known. Over 320 endemic bird species have been identified in New Guinea so far. A full inventory, however, has yet to be made.

There are also over 270 species of mammals, many of which are nocturnal, most typically rodents and marsupials. PNG has the highest number of assessed endemic mammals. One in five assessed mammals in PNG is endemic to the country. The Cuscus, for example, is a family of marsupials closely related to the possums of Australia. The kangaroos inhabiting the open grasslands of New Guinea are also endemic. Australian kangaroos such as the agile wallaby are close relatives and also inhabit open grasslands. As biological and genetic resources, the mammals of New Guinea are largely unexplored. They have potential to deliver genetic source materials that are impossible to find in other areas of the world.

There are several large river systems in New Guinea, including the Fly, Sepik and Mamberamo; all of which are rich in fish species. The Fly River Basin contains 105 fish species – more than any other river - including the “River Shark” (Glyphis garricki) discovered in 2008. The Sepik River Basin, meanwhile, has 57 species. Selected endemic species of wildlife in PNG are shown in Fig. 8.1-9.

i. http://en.wikipedia.org/wiki/List_of_mammals_of_Papua_New_Guinea
ii. /http://en.wikipedia.org/wiki/Fauna_of_New_Guinea

From left to right: Tree kangaroo (Tree-climbing kangaroo) / Round-eared tube-nosed bat (Murina cyclotis) / Short-beaked echidna (Tachyglossus aculeatus), an egg-laying mammal.
Source: WWF, http://wwf.panda.org/what_we_do/where_we_work/new_guinea_forests/area_ forests_new_guinea/plants_animals_ new_guinea_forests/mammals_forests_new_guinea/

Dactylopsila tatei (Fergusson Island Striped Possum)

Littoria infrafrenata (White-lipped Tree Frog)

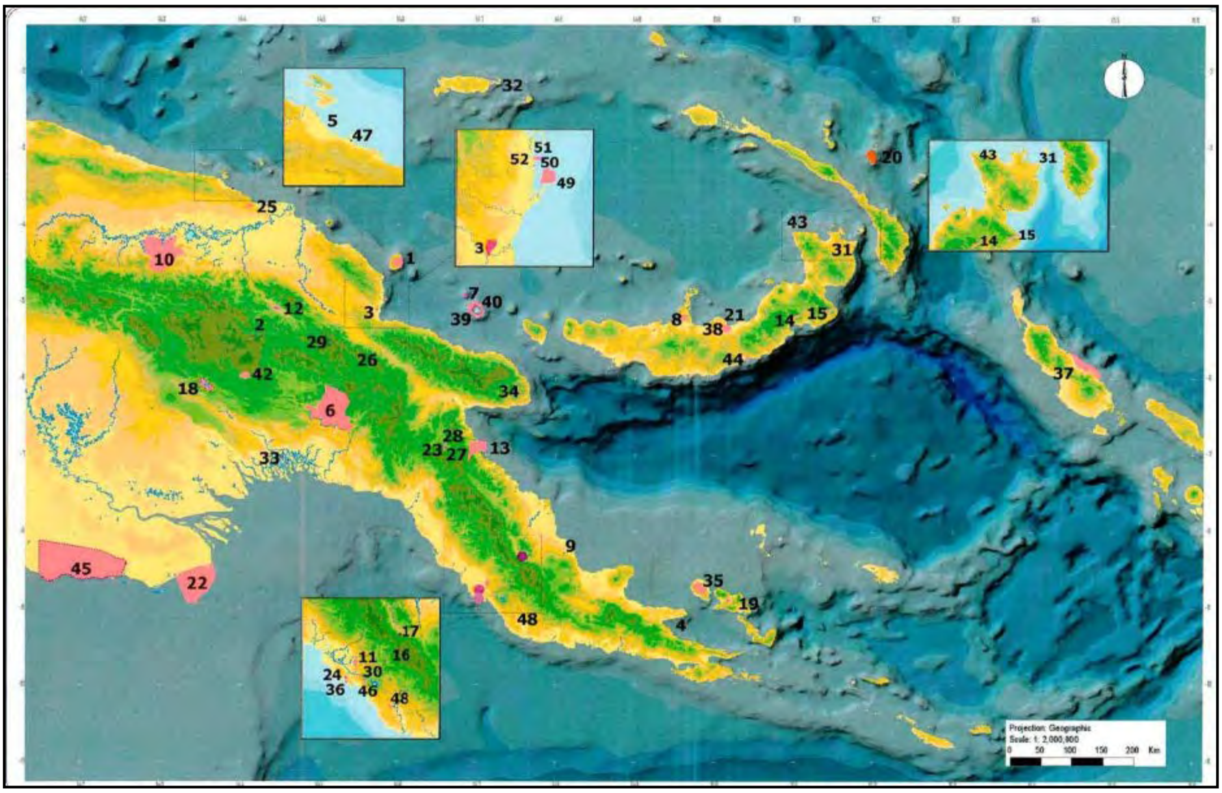
Source: IUCN Red Databook, (http://www.iucnredlist.org/details/6224/0)

Fig. 8.1-9 Selected Endemic Species in PNG

The species living within the land area of PNG are too vastly numerous to list in this report. A number of new species have also emerged in recent years, such as the River Shark found in Gulf Province in 2008. Accordingly, readers of this report are encouraged to visit the following two Internet sites to access the most comprehensive and updated list of wildlife in PNG.

(4) PNG's Conservation Areas

PNG is endowed with vast untouched tropical high-biodiversity terrestrial ecosystems and endemic species due to mountainous isolation, topographic and soil habitat heterogeneity, low forest disturbance rates, and abundant year-round rainfall. Through its constitution and legislation, PNG has empowered different conservation sectors to ensure the protection of areas containing important natural resources. Table 8.1-3 lists the PNG's conservation areas and Fig. 8.1-10 shows their respective locations.



Source: from Papua New Guinea Forest Stewardship Council (FSC), 2005

Fig. 8.1-10 Wildlife Management Area and National Parks in PNG

Since local communities own 95% of the land in PNG, wildlife conservation activities cannot be carried out without relying on the local communities in order to maintain the currently declared Wildlife Management Areas (WMA) in a manner compatible with the PNG land tenure system.

The PNG constitution recognized this and empowered local groups of landowners to get involved in wildlife conservation on their own land, but work to manage these areas remains at a relatively early stage. In general, the wilder the area, the more difficult managing wildlife or national parks becomes.

Table 8.1-3 Wildlife Management Areas and National Parks of PNG

No.	Name	Area (ha)	No.	Name	Area (ha)
1	Bagiai WMA	13,760	27	Mr. Kaindi WMA	1,502.8
2	Baiyer River Sanctuary	64	28	Mt. Susu National Reserve Park	49
3	Balek Wildlife Sanctuary	470	29	Mt. Wilhelm National Reserve	817
4	Baniara Island Protected Area	37.3	30	Namanatabu Reserve	27.4
5	Cape Worn Memorial Park	2.0	31	Nanuk Island District Park	12
6	Crater Mountain WMA	270,000	32	Ndrolowa WMA	5,850
7	Crown Island WS	58,969	33	Neinu (Aired Hills) WMA	3,984
8	Garu WMA	8,700	34	Nuraseng WMA	22.2
9	Hombareta WMA	130	35	Oi Mada Wara WMA	22,840
10	Hunstein Range WMA	220,000	36	Paga Hill National Park/SR	17.4
11	Hunstein Range WMA	220,000	37	Pirung WMA	43,200
12	Jimi Valley National Park	4,180	38	Pokiji WMA	9,840
13	Kamiali WMA	65,541	39	Randa WMA	41,922
14	Mavakuna Caves	-	40	Randa WS	15,724
15	Klampun WMA	184,230	41	Sawataetae WMA	700
16	Kokoda Historic Track Reserve	1,821	42	Siwi-Utame WMA	12,540
17	Kokoda Memorial Park	44	43	Talele Is. National Park Reserve	12
18	Lake Kutubu WMA	5,079	44	Tavalo WMA	2,000
19	Lake Lavu WMA	77.4	45	Tonda WMA	590,000
20	Lihir Island Protected Area	1,502	46	Variarata National Park	1,063
21	Lorako national Park	49	47	Wewak Peace Memorial Park	2.0
22	Maza WMA	817	48	Zo-oimaga WMA	1,510
23	McAdamas National Park	27.4	49	Taab WMA	964.3
24	Moitaka WS	12	50	Tabad WMA	16.2
25	Majirau WMA	5,850	51	Sinub WMA	11.8
26	Mt. Gahavisuka Provincial Park	3,984	52	Laugum WMA	72.95

Note: WMA – Wildlife Management Area, WS-Wildlife Sanctuary, SR-Scenic Reserve
Source: Papua New Guinea Forest Stewardship Council (FSC), 2005

Conservation areas in PNG are classified under the following laws and regulations:

a. Fauna (Protection and Control) Act: Species such as the Queen Alexandra Birdwing Butterfly are fully protected. The protection of its habitat is less clear, but the importance of not destroying its environmental needs is emphasized;

b. National Park Act: Provides for a process for establishing national parks;

c. Wildlife Management Act: provides for the establishment of areas of customary land as Wildlife Management Areas. Local communities are established and gazetted, for which operational rules are prepared and approved;

d. Provincial Legislation for Conservation Areas: Provincial governments have enacted various tourist sites and wildlife protection acts;

e. Conservation Areas Act: Provides for the establishment of protected conservation areas; Watershed Protection Act: A number of provisions under the old Water Resources Act protected portions of watershed areas for water yield or water quality maintenance purposes, while the new Act provides no specific provisions requiring catchment area conservation measures for urban water supplies;

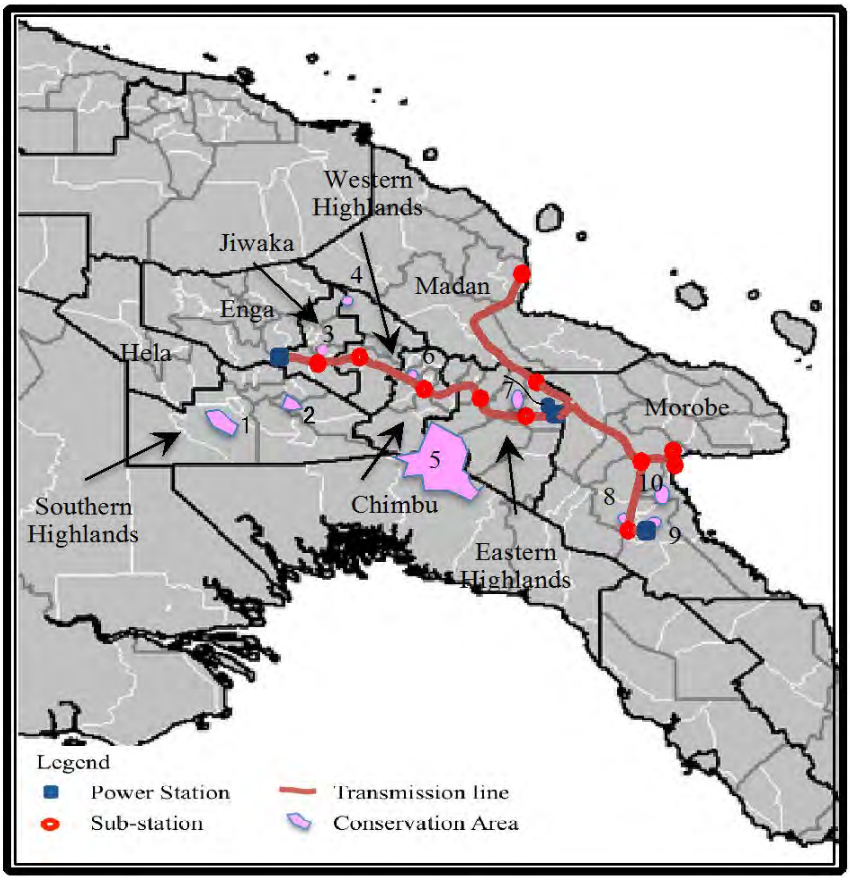
f. The Convention on International Trade on Endangered Species of Flora and Fauna (CITES): An international agreement that prevents or regulates the exportation of designated species of fauna and flora;

g. Biodiversity Convention: PNG has adopted the Convention on Biodiversity, while the Department of Environment and Convention is satisfied with the current laws and regulations for the conservation of fauna and flora of the country; and

h. Ramsar Convention: PNG became a signatory of this international agreement to protect specifically designated wetlands of the country.

(5) Conservation Areas within the Ramu Grid System Area

Out of the above 52 conservation areas, ten are subject to impact analysis within the Ramu Grid System area, as shown in Table 8.1-4 and Fig. 8.1-11. These areas are sometimes encompassed within areas protected for other purposes that are deemed important for particular conservation targets. In other instances local governments declare conservation for their own purposes, as exemplified by cases such as the important bird area (IBA), center of plant diversity (CPD), indigenous and community conservation area (ICCA), alliance for zero extinction sites (AZE), and key biodiversity area (KBA).



Source: JICA Study Team based on Papua New Guinea Forest Stewardship Council (FSC), 2005

Fig. 8.1-11 Wildlife Management Area and National Parks in PNG

Table 8.1-4 Wildlife Management Areas and National Parks in Ramu Grid System Area

	Name	Classification	Area (ha)
1	Lake Kutubu	Wildlife Management Area	5,079
2	Siwi-Utame	Wildlife Management Area	12,540
3	Baiyer River	Sanctuary	64
4	Jimi Valley	National Park	4,180
5	Crater Mountain	Wildlife Management Area	270,000
6	Mt. Wilhelm	National Reserve	817
7	Mt. Gahevisuka	National Park	3,984
8	Mt. Susu	National Reserve Park	49
9	McAdams	National Park	27.4
10	Mt. Kaindi	Wildlife Management Area	1,502.8

Source: JICA Study Team based on Papua New Guinea Forest Stewardship Council (FSC), 2005

8.1.3 Socio-economic Environment

(1) Demography

1) Population and Ethnology of PNG

A full-scale National Census is conducted every 10 years, the latest of which was conducted in 2011. Preliminary figures on the population from the 2011 census have been published in advance of the full statistics scheduled for publication sometime in 2015.

The 2011 census tallied a population of approximately 7.3 million in PNG and population growth rate of 3.1% since the previous census in the year 2000. The distribution of the population is uneven: 38% of the population lives in the interior highland region, 28% in the north coast of the mainland of PNG, 20% in the southern part of PNG, and 14% in the island region. Table 8.1-5 presents a summary of the current size of the population in PNG.

As shown in the table above, Morobe Province has the highest provincial population of 674,810, constituting 9.3% of the total PNG population. Next comes Eastern Highlands Province, with a population of 579,825 constituting 8.0% of the total population. As details are stated in the following section, the population living within the Ramu Grid System area for electricity supply totals more than 4 million. Hence, 56% of the total population of PNG is concentrated in the Ramu Grid System area.

Ethnicity of the population in PNG is a mix of Melanesian, Papuan, Negrito, Micronesian and Polynesian people. More than 800 ethnic groups compose the population of PNG, so English is adopted as the official language for government, education, and business. Pidgin English is the country’s lingua franca.

PNG is one of the most diverse nations in the world, with more than 850 indigenous tribes with different languages. Each tribe forms its own traditional society and has its own tribal structure, architecture, costumes, songs, music, dances, art, and beliefs. The indigenous people of PNG are broadly classified as Melanesian and identified as descendants of Australoids (generally inhabiting the Highlands) and Austronesians (generally inhabiting the coastal areas and on surrounding islands). The remaining population is made up of approximately 3% Polynesians, 2% Micronesians, and a few Asians and Africans.

Approximately 85% of the people in PNG are rural and maintain traditional subsistence lifestyles. Some of the rural population is involved in commercial agriculture via smallholder farms or as employees of large commercial agricultural estates. Approximately 15% of the population lives in urban areas or townships formed by large commercial agricultural, mining, or logging activities. A growing proportion of urban residents are mainly immigrants in search of employment and access to better education and health services.

There are three official languages used in PNG: English, Tok Pisin, and Motu. English is most often used in government and business organizations, as well as in schools.

Table 8.1-5 Population by Province of PNG

Province	No. of Households	No. of Persons	Average Household	% of the Total Population
Total of PNG	**1,374644**	**7,275,324**	**5.3**	**100**
Western Province	31,322	201,351	6.4	2.8
Gulf	25,819	158,197	6.1	2.2
Central	41,309	269,756	6.5	3.7
National Capital District	47,559	364,125	7.7	5.0
Milne Bay	55,262	276,512	5.0	3.8
Northern	34,117	186,309	5.5	2.6
Southern Highlands	88,041	510,245	5.8	7.0
Hela	65,271	249,449	3.8	3.4
Enga	76,421	432,945	5.7	5.9
Western Highlands	85,101	362,850	5.3	5.0
Jiwaka	65,155	343,987	5.3	4.7
Chimbu	76,198	376,473	4.9	5.2
Eastern Highlands	136,992	579,825	4.2	8.0
Morobe	130,109	674,810	5.2	9.3
Madang	86,140	493,906	5.7	6.8
East Sepik	87,465	450,530	5.2	6.2
West Sepik	44,934	248,411	5.5	3.4
Manus	10,360	60,485	5.8	0.8
New Ireland	29,634	194,067	6.5	2.7
East New Britain	58,458	328,369	5.6	4.5
West New Britain	50,744	264,264	5.2	3.6
A.R. Bougenville	48,233	249,358	5.2	3.4

Source: Preliminary figures of the 2011 Census of Housing and Population, NSO, PNG

2) Population of Ramu Grid System Provinces

Table 8.1-6 shows the populations of the provinces related to the Ramu Grid System Electricity Supply Area subject to study within the framework of the Master Plan. The general trend shows that the populations of these provinces have all grown since 1980.

Two new provinces, Hela and Jiwaka, have been gazetted in PNG national parliament since

1990. Population data for these two provinces from before 1990 are therefore unavailable. The population trend between 2000 and 2011 for these two provinces also indicates increases.

The distribution of the population in the Ramu Grid System Area is characterized by two important facts: 1) the population has more than doubled over the past 30 years; and 2) more than a half of the total population of PNG is concentrated in the above nine provinces. The major cause of the increase of population is the rapid growth of the townships currently connected by the electricity power grid of the Ramu Grid System.

Table 8.1-6 Population of Ramu Grid System Provinces

Province		Census			
		1980	1990	2000	2011
PNG		3,010,727	3,761,954	5,190,786	7,275,324
1	Morobe	310,622	380,117	539,404	674,810
2	Madang	211,069	253,195	365,106	493,906
3	E. Highlands	276,726	300,648	432,972	579,825
4	Chimbu	178,290	183,849	259,703	376,473
5	Jiwaka	na	na	185,798	343,987
6	W. Highlands	265,656	336,178	254,227	362,850
7	Enga	164,534	235,561	295,031	432,045
8	S. Highlands	236,052	317,437	360,318	510,245
9	Hela	na	na	185,947	249,449
Total		**1,642,949**	**2,006,985**	**2,878,506**	**4,023,590**

Source: Preliminary figures of the 2011 Census of Housing and Population, NSO, PNG

(2) Economic Activities

Most PNGs live in rural communities. Approximately 85% of the total population lives in remote areas far from major road networks. These areas form traditional villages and social structures based on clan systems and are dependent on subsistence agriculture, fishing, and hunting activities. Where town markets are nearby and accessible, cash crops are sold for cash income. Fishing and forest products are also sold if markets exist. The use of water is based on traditional and cultural water rights and affects fishing, food preparation, washing, and recreation activities.

Approximately 0.5% of the total land area (60,235km^2) is classified as arable land in PNG. Coffee, cocoa, coconut, palm oil, tea, rubber, sweet potatoes, fruit, vegetables, and livestock are the major and formal agricultural products in PNG. Crop and livestock production is dependent on local suitability in terms of altitude, rainfall, topography, soil fertility, and moisture content. Agricultural land use in PNG is shown in Fig. 8.1-12.

More than half the country receives at least 2,500 mm of rainfall annually, which benefits subsistence and commercial agriculture. Traditionally cultivated food crops include sweet potatoes, taros, yams, cassava, banana, breadfruit, and sugarcane. PNG grows very little rice but imports over 150,000 tons per year to meet domestic demand.

A wide variety of vegetables such as pumpkins, corn, carrots, capsicums, beans, and tomatoes are cultivated for domestic consumption as well as cash. Tree crops are grown in large plantations established as nucleus estates amid areas of natural vegetation. These crops include coffee, copra, cocoa, tea, rubber, and oil palms, all of which are sold on a large scale commercially for cash revenue. Most livestock rearing is carried out in large-scale farms, including piggeries and poultry operations.

Source: Saunders. J.C., Australian International Development Assistant Bureau 1993

Fig. 8.1-12 Agricultural Land Use in PNG

Other export commodities include whole fish, filleted and canned fish, logs, processed timber, gold, copper, silver, and both crude and processed oil.

The export of mineral resources has been very high in PNG, which possesses rich mineral resources of gold, copper, silver, nickel, cobalt, petroleum, and natural gas. The exploitation of these resources over the last 30 years has provided the country with substantial foreign currency earnings to fund the building of infrastructure and training and education for employment. The mining and petroleum sector continues to play an important role in economic development, contributing more than half of the total value of exports.

A consortium led by a major American oil company is constructing a LNG production facility that could begin exporting in 2014. As the largest investment project in the country's history, it has the potential to double GDP in 2016 and triple PNG's export revenue.

2014 saw the completion of a large LNG plant which is expected to provide a significant boost to PNG's overall GDP. Yet while exports from this project will eventually provide revenue to the state, they are unlikely to be felt in the short term. Furthermore, non-mining GDP is forecast to grow by four percent in 2015, supported by a rebound in the construction sector, driven mostly by increased infrastructure expenditure associated with facilities constructed for the 2015 Pacific Games, and the ongoing upgrading of the roads.

The GDP composition of agriculture in 2014 is estimated at 27.6%, industry – 39.1 %, and other sectors – 33.3 % including services, forestry, fishing and other sectors.

(3) Employment

Because the population of PNG is 85% rural, most of the population relies on informal employment or self-employment jobs to make a living, mainly from agriculture. In the urban areas, employed persons pay high costs for transportation and other necessaries for living. Under the most optimistic scenarios, growth of employment in the formal sector of PNG is limited and has not absorbed more than 5% of high school graduates in the past decades. In 2010 to 2013, unemployment rate has been 2.4% while it went down to 2.1% in 2014 based on the trading Economics (http://www.tradingeconomics.com/papua-new-guinea/unemployment-rate).

While relatively modest income increases have been achieved, increased cash incomes are spent for purchasing living goods such as lighting and school fees and medicines. The accumulation of disposable income thus appears to be very small unless extra income comes in through a number of side jobs. Minimum wages in PNG remained unchanged at 140.80 PGK/Week in the first quarter of 2015 from 140.80 PGK/Week in the fourth quarter of 2014, reaching an all time high based on the heritage site. (http://www.heritage.org/index/country/papuanewguinea)

(4) Religions

In the 2000 census, 96% of citizens claimed to be Christians. However, many combine their faith with traditional and indigenous spiritual and witchcraft practices. The Christians of PNG are members of the Roman Catholic Church as well as protestant denominations. The non-Christians are Bahai, Muslims, and Buddhists.

(5) Education

The education system of PNG has yet to develop from its primitive level to a relatively modern level. A large number of people are excluded from the formal education system, so literacy rates are low. Table 8.1-7 shows the current literacy level of population within the provinces of the Ramu Grid System.

Table 8.1-7 Literacy of the Population in Ramu System Provinces

	Province	Total Population	Literacy	
			No.	%
1	Southern Highlands	510,245	204,751	40.1
2	Enga	432,045	171,760	39.8
3	Western Highlands	362,850	155,841	42.9
4	Simbu	376,473	184,834	49.1
5	Eastern Highlands	579,825	265,757	45.8
6	Morobe	674,810	345,989	51.3
7	Madang	493,906	235,343	47.6
8	Hela	249,449	87,188	35.0
9	Jiwaka	343,987	185,744	54.0

Source: National Census 2011

Education in PNG has not been improved since the 1990s. A large number of populations of the Ramu Grid System provinces are missing out on the educational system of the country. While the population is increasing very fast, the pace of educational facility development is lagging behind. The lack of electricity supply for both schools and home use should also be blamed as a cause for the low literacy rate.

(6) Health Indicators

Formal infrastructure development works does not take place on the customary land in the urban settlements of Lae, Madang and other urban areas. As a result, people live in relatively crowded areas without appropriate water or sewage systems. As many as 88-92% of the urban areas have access to clean water, versus only 56% of the rural areas. Many of the public areas of the urban centers are unhealthy and untidy as the speed of urban migration is much faster than the local government can catch up infrastructure development.

Both from cultural and sanitation development viewpoints, urban facility areas have yet to be developed to improve living conditions to levels necessary to contain infectious diseases such as tuberculosis, dengue fever, and malaria. HIV/AIDScases are on the increase and could rise to a half of a million people by the year 2025 according the statistics of the Department of Community Development in 2007.

The child mortality rate is still high, at around 61 per 1,000 live births while number of live birth is at 211.6 over 1,000 birth in 2013 based on the World Health Organization (WHO). Death due to malaria is at 38.5 over 100,000 populations while HIV-related death is at 46.6 over 100,000 populations.

(7) Women in Development of Electricity Supply

The national Goals and Directives Principles of the Department of Community Development of PNG aspire toward “Equal participation by women citizens in all political, economic, social, and religious activities.” In practice, however there are major barriers to women’s participation at all levels of the country, especially in the rural communities. UNDP’s human development Reports show that the gender-related index is lower than the overall Human Development Index for all provinces. Women’s life expectancy, income, and education levels are considerably lower than those of men in many sectors of the economy in the country.

Traditionally, women attend gardens, collect firewood, fetch water, sell crops for cash income, look after the children, and cook meals. In villages without electricity they also wash clothes and clean in and around their houses. In the electrified villages the women spend less time cooking over open fires. They use fridges to store food and make breads for extra cash income. Thus, women become aware of the use of electricity. They also learn that the “Easipay” system is less expensive than the meter reading system for electricity and quickly become wise enough to pay the extra cost of electricity for the convenience it brings. Based on the hearing survey, local women, though a limited number are more willing to pay for electricity than men. On the other hand, some of them have to disconnect their electricity when they receive large monthly electricity bills.

(8) Administrative Structure

PNG is divided into four administrative regions: 1) Southern Region; 2) Momase Region; 3) Highland Region; and 4) Island Region. These regions correspond to the geological features and administrative structure of PNG and each of them houses regional offices.

There are 21 provinces, one National Capital District, and 87 other districts within the administrative regions. The 87 districts contain 325 LLGs, under which more than 6,000 wards are formed. (PNG 2011 Census.)

8.1.4 Baseline Features of the Provinces along the Ramu Electricity Supply System

(1) Concerned Provinces

The study area for the Formulation of the Ramu Grid System Power Development Master Plan is the area where the Ramu Grid System exists at present and where reinforcements are planned for the power generation system and distribution lines. The study area covers nine provinces, the main townships of which are shown in Table 8.1-8 and Fig. 8.1-11 which indicated in the previous section.

The social conditions of these provinces are generally described in the "National Research Institute: Papua New Guinea District and Provincial Profiles" (2010). The general features in the proposed project areas of the Ramu Grid systems are shown in the following sections.

Table 8.1-8 Provinces and Major Townships Covered by the Study

Province	Township
Morobe	Lae
Eastern Highlands	Goroka, Kainantu, Yonki
Chimbu	Kundiawa
Western Highlands	Mount Hagen
Jiwaka	Banz
Enga	Wabag
Southern Highlands	Mendi
Madang	Madang
Hela	Komo/Magarima

Source: National Census 2011

(2) Hela Province

Hela Province covers the westernmost area of the Central Range and Lagaip Valley in the north, while the Tagari Valley runs through the center of the province. The south of the province includes a limestone plateau. Most people in Hela Province have low incomes, generally earned from the sale of food crops and firewood.

The Highlands Highway runs through the province from Nipa to Koroba and other rural roads run to Komo. Remote areas in Komo Margarima and Nipa Kutubu, particularly near Mt. Karoma, are more than a day away from the nearest service centers by automobile. A brief description of the socio-economic conditions of the province follows;

Provincial Headquarters	:	Komo/Magarima
Number of Districts	:	Komo/Magarima, Fulia Rural, Komo Rural, Lower Wage Rural, Upper Wage Rural, Koroba/Kopiago, Awi/Pori Rural, Lake Kopiago, North Koroba, South Koroba, Tari/Pori, Hayapuga, Tagali, Tari Bebi
Number of LLGs	:	29
Number of Wards	:	618
Population	:	Total 249,449 (Male/Female: 128,895/120,554)
No. of Households	:	65,271
Area (km^2)	:	15,587
Literacy rate (%)	:	Total 34.9% (Male/Female Ratio: 19.5% / 15.4%)
Economic Activities	:	Food crops 44.7% Livestock 32.2%

Coffee 20.3%
Poultry 15.4%
Fishing 2.9%

Electricity Customers : 17

The data on electricity customers was recorded in 2014. The absolute number of customers is small compared to other provinces of the Ramu Grid System.

(3) Southern Highlands Province

The Southern Highlands Province covers the Central Range and Lagaip Valley in the north, while the Tagari Valley runs through the center. The south of the province includes a limestone plateau; Lake Kutubu; the Hegigio, Mubi, and Digimu Valleys; and Mt. Bosavi, a volcano. Most people in the Southern Highlands Province have low incomes, generally earned from the sale of coffee, food crops and firewood. Small pockets of high-income areas exist, as oil and gas exploration takes place. A proposed Liquefied Natural Gas Project in the future should provide more high-income pockets in the province in the future.

The Highlands Highway runs through the province from Imbonggu to Kopiago and other rural roads run to Komo, Erave, and Pangia. Remote areas in Komo Margarima and Nipa Kutubu, particularly near Mt. Bosavi, are more than a day away from the nearest service centers by automobile. A brief description of the province follows;

Provincial Headquarters	:	Mendi
Number of Districts	:	Ialibu Pangia, Imbonggu, Kagua Erave, Komo Margarima, Koroba Lake Kopiago, Mendi, Nipa Kutubu, Tari Pori
Number of LLGs	:	32
Number of Wards	:	729
Population	:	Total 510,245 (Male/Female: 263,523/246,722)
No. of Households	:	88,041
Area (km^2)	:	25,587
Literacy rate (%)	:	Total 36.5% (Male/Female Ratio: 40.6% / 32.2%)
Economic Activities	:	Food crops 78.0% Livestock 62.2% Coffee 50.3% Poultry 15.4% Fishing 4.9%
Electricity Customers	:	1,131

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 1.3% of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(4) Enga Province

Geographically, the Central Range runs through the north of Enga Province, with two river valleys of Lagaip and Lai Valley supporting densely populated townships. The Lagaip River runs south to join the Fly River, while the Lai River joins the Sepik River in the north. Agriculture provides only low to moderate income for the province from the sale of coffee, food, and firewood. Cultivated areas suffer from both drought and frost. The Porgera Goldmine provides royalties and wage employment for the province.

A branch of the Highlands Highway runs from Mt. Hagen up to Wapenamanda, Wabag, and the Porgera Goldmine, while another road connects Kandep with the Southern Highlands Province. Those living in the north of the province are cut off and must travel for more than a day to reach large population centers. A brief description of the province follows;

Provincial Headquarters	:	Wabag
Number of Districts	:	Kandep, Kompiam-Ambum, Lagaip-Porgera, Wabag, Wapenamanda
Number of LLGs	:	15
Number of Wards	:	334
Population	:	Total 432,045 (Male/Female: 224,663/207,382)
No. of Households	:	76,421
Area (km^2)	:	11,704
Literacy Rate (%)	:	Total 35.0% (Male/Female Ratio: 40.2% / 29.5%)
Economic Activities	:	Food crops 79.8% Livestock 70.1% Coffee 36.9% Poultry 20.2% Betel nuts 6.7%
Electricity Customers	:	1,396

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 1.8 % of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(5) Western Highlands Province

The Western Highlands Province covers the Jimi, Wahgi, Baiyer, Lai, Kaugel, and Nebilyer Valleys; the Hagen Range and Kubor Range; and the mountains of the Sepik-Wahgi Divide running through the entire province. This province has some of the most productive smallholder agriculture and coffee plantations in PNG. People in the Wahgi, Baiyer, and Nebilyer Valleys earn high incomes from the sale of coffee and food. People in the more remote lower Jimi Valley and Mera area earn much lower incomes. Wage employment is also available in the township of Mt. Hagen.

The Highlands Highway runs through the Wahgi and Nebilyer Valleys and other smaller road networks travel through the Tambul Nebilyer, Baiyer Mul, and Jimi Districts. People in the far north, the lower Jimi Valley, and far south near Mera are isolated from service centers. A brief description of the province follows;

Provincial Headquarters	:	Mt. Hagen
Number of Districts	:	Anglimp South Wahgi, Baiyer Mul, Dei, Hagen, Jimi, North Wahgi, Tambul Nebilyer

Number of LLGs	:	15
Number of Wards	:	479
Population	:	Total 362,850 (Male/Female: 183,791/179,059)
No. of Households	:	85,101
Area (km^2)	:	9,097
Literacy Rate	:	Total 38.4% (Male / Female Ratio: 44.1% / 32.6%)
Economic Activities	:	Food crops 77.7% Coffee 77.0% Livestock 63.6% Poultry 23.7% Betel nuts 5.9%
Electricity Customers	:	6,175

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 0.7% of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(6) Jiwaka Province

"Jiwaka" is a portmanteau tribal word combining the first two letters each of Jimi, Waghi and Kambia. The area was part of Western Highlands Province until it officially and came into being as its own province on May 17, 2012. The provincial capital has yet to be decided. Meanwhile, all provincial matters are handled in Banz. Mount Wilhelm, the tallest mountain in PNG, is on the border of Jiwaka and Western Highlands.

Jiwaka Province spreads across the fertile Wahgi Valley, which accommodates the Wahgi River and Highlands Highway. The province is bordered by the Bismarck Range to the north, which forms a natural boundary for Jimi District from Madang Province. It also shares boundaries with Western Highlands Province to the west and Simbu and Southern Highlands Provinces to the east and south, respectively.

The land in the Wahgi Valley is very fertile and thus densely populated. A notable power supply infrastructure construction is the Kudjip Hydropower plant. On completion it will provide power to this province. A brief description of the province follows;

Provincial Headquarters	:	Banz
Number of Districts	:	Anglimp South Waghi District, Jimi District and North Waghi
Number of LLGs	:	6
Number of Wards	:	216
Population	:	Total 343,987 (Male/Female: 178,418/165,569)
No. of Households	:	65,155
Area (km^2)	:	4, 798
Literacy Rate (%)	:	Total 54% (Male/Female Ratio: 54% / 34%)
Economic Activities	:	Sale of food crops: 27.3%

		Other Income generating activities: 42.8%
Electricity Customers	:	1,605

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 2.5 % of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(7) Chimbu Province

Chimbu Province includes the highest mountain in PNG, Mt. Wilhelm, in the Wilhelm Range in the north. The densely settled Wahgi Valley is to the west of the province, and the lowlands near Karimui and the Purari Valley are to the south. There are pockets of agricultural activity in the north, where high income comes from the sale of coffee and food. The rest of the province, however, earns relatively little income. The area along the Highlands Highway provides a few opportunities for running small stores.

A network of roads, including the Highlands Highway, covers most of the northern areas of Simbu Province, while the Wahgi River Gorge divides the province south of Kundiawa. The small township of Karimui in the center of Karimui Nomane District is not linked by road to anywhere else in the province. An impassable road also leads north to Usino in Madang. A brief description of the province follows;

Provincial Headquarters	:	Kundiawa
Number of Districts	:	Chuave, Gumine, Karimui Nomane, Kerowagi, Kundiawa, Sinasina Yonggamugl
Number of LLGs	:	20
Number of Wards	:	308
Population	:	Total 376,473 (Male/Female: 197,307/179,166)
No. of Households	:	76,198
Area (km^2)	:	6,112
Literacy Rate	:	Total 41.8% (Male/Female Ratio: 48.7% / 34.5%)
Economic Activity	:	Coffee 87.8% Food crops 81.2% Livestock 72.8% Poultry 25.6% Betel nuts 3.3%
Electricity Customers	:	1,721

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 2.3% of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(8) Eastern Highland Province

Eastern Highlands Province includes the Bismark Range and Upper Ramu Valley in the north and the agriculturally productive Asaro, Benabena and Dunantina Valleys. The area around

Henganofi is a good agricultural area, with a relatively high income level, as local people earn cash from the sale of coffee, food, tobacco, and firewood. Most of the people in the north of the province earn moderate incomes. The area in the south of the province, particularly near Marawaka, is mountainous. There are very few income-earning opportunities for those in Obura Wonenara, Okapa and Lufa.

The Highlands Highway and a network of smaller roads cover the north of the province. Roads traversing the Lufa and Okapa Districts have limited length and deteriorated surfaces, while the Obura Wonenara area has very limited roads, particularly in the remote southern areas. A brief description of the province follows;

Provincial Headquarters	:	Goroka
Number of Districts	:	Daulo, Goroka, Henganofi, Kainantu, Lufa, Obura Wonenara, Okapa, Unggai Bena
Number of LLGs	:	24
Number of Wards	:	261
Population	:	Total 579,825 (Male/Female: 301,048/278,777)
No. of Households	:	136,992
Area (km^2)	:	11,157
Literacy Rate (%)	:	Total 43.9% (Male / Female Ratio: 51.5% / 48.5%)
Economic Activities	:	Coffee 88.4% Food crops 76.7% Livestock 47.8% Betel nuts 13.5% Poultry 12.5%
Electricity Customers	:	5,445

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 4.0 % of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

(9) Morobe Province

Morobe Province stretches from the Sarawaget Range in the north along the Huon Peninsula to the east. Markham Valley stretches through the center of the province. The Bulolo and Watut Valleys run from north to south, with the Ekuti and Owen Stanley Ranges to the south. Those living in the Markham and Watut Valley earn high agricultural incomes from the sale of betel nuts and fresh food, while moderate incomes are earned from fish, food, coconut and betel nuts in the coastal areas around Lae. Remote areas earn very low incomes. Other sources of income include mining near Wau, forestry near Bulolo, and cattle in the Markham Valley.

The Highlands Highway and a road between Lae and Wau provide reasonable access to the province, although the roads along the Huon Peninsula do not connect to Lae. The areas in the north of the province in Kabwum District and the areas in the south around Garaina are very remote, with limited accessibility by road. A brief description of the province follows;

Provincial Headquarters	:	Lae

Number of Districts	:	Bulolo, Finschhafen, Huon Gulf, Kabwum, Lae, Markham, Menyamya, Nawae, Tewai Siassi
Number of LLGs	:	33
Number of Wards	:	547
Population	:	Total 674,810 (Male/Female: 350,902/323,908)
No. of Households	:	130,109
Area (km^2)	:	33,705
Literacy Rate (%)	:	Total 63.6% (Male / Female Ratio: 60.2% - 39.8%)
Economic Activities	:	Food crops 69.2% Betel nuts 59.4% Coffee 45.7% Coconut 36.9% Livestock 34.5%
Electricity Customers	:	12,136

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 9.3 % of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future. However, this is an indicator that Morobe is catching up to industrialize the province as it contains Lae, the second largest city in PNG and other industrializing towns.

(10) Madang Province

Madang Province runs along the coast from the head of the Ramu River south to Saidor. Moving inland, it covers the Ruboni, Adelbert, Schrader, Bismarck and Finisterre Ranges and the Ramu, Sogeram and Golgol Valleys. Karkar Island and the coastal area earn relatively high incomes from the sale of cocoa, betel nut, copra, and food crops. The rest of the province has less access to markets and thus earns lower incomes. Wage-earning employment opportunities are also available in the town of Madang, where operations by Ramu Sugar Corporation and mining and forestry companies take place.

The road network is relatively limited along the coast of the province from Bogia to Saidor, as well as inside Golgol Valley near Madang Township. A main road runs inland to Josephstaal through the Ramu Valley linking Lae to Madang. The areas in the west of the province such as Simbai are remote, with limited accessibility. Water transport is also common along the coast, particularly to the islands along the coastal area. A brief description of the province follows;

Provincial Headquarters	:	Madang
Number of Districts	:	Bogia, Madang, Middle Ramu, Rai Coast, Sumkar, Usino Bundi
Number of LLGs	:	19
Number of Wards	:	451
Population	:	Total 493,906 (Male/Female: 257,581/236,325)
No. of Households	:	86,140
Area (km^2)	:	28,886

Literacy Rate (%)	:	Total: 55.2% (Male / Female Ratio: 61.2% / 38.8%)
Economic Activities	:	Food crops 76.3% Betel nuts 70.7% Coconut 58.6% Cocoa 39.7% Livestock 39.3%
Electricity Customers	:	3,297

Based on the PPL's rate of electrification which number of customers divided by the number of households in the province, the number of electricity customers only constitutes 3.8 % of all households in the province, which means that the economic activities linked to commerce, industry, and education in the province have ample room to develop in the future.

8.2 LEGAL FRAMEWORK

8.2.1 Overview of the Government System and Laws and Regulations of PNG

(1) Origins of the Constitution of PNG

The Independent State of Papua New Guinea promotes the development of its energy resources through various policies to encourage investment. A priority aim for the government is to ensure that the people of Papua New Guinea benefit from the development of energy resources. The PNG constitution includes national goals and directives that outline the aspirations and principles to develop the nation.

There are five National Goals and Directive Principles, as indicated in the preamble of the Constitution:

i. Integral human development
ii. Equality and participation
iii. National sovereignty and self-reliance
iv. National resources and the environment
v. Papua New Guinea ways

The fourth of these national goals and directive principle states:

"We declare our Fourth Goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all and be replenished for the benefit of future generations".

(2) Laws and Regulations of PNG

1) General Composition of the Laws and Regulations

The laws and regulations of PNG comprise:

- The Constitution;
- Organic Laws, which are Acts of Parliament that have quasi-constitutional status and are passed by majority votes at Parliament;
- Acts of Parliament;
- Emergency regulations, which are laws of limited duration made by executives under special circumstances;
- Provincial laws;
- Laws made under or adopted by the constitution; and
- Underlying laws.

The principles and rules of common laws and equity in England at the time of PNG's independence of 16th September 1975, with certain exceptions, were adopted by the Constitution. Those principles and rules, together with customary laws, comprise the underlying laws of PNG.

2) Acts of Parliament Relevant to Master Plan Study

a. Electricity Industry Act

The Electricity Industry Act is one of the acts relevant to the Master Plan Study. It states that all the generated electric energy within the borders of PNG belongs to the state and that licenses are required to supply or sell these energy resources. The Electricity Act is the principal legislation governing the generation, supply, and sale of electricity in PNG and is administered by the ICCC.

b. The Physical Planning Act 1989

The Physical Planning Act 1989 incorporates a comprehensive mechanism for physical planning at the national and provincial government levels. The Act provides powers to plan and regulate physical development.

An application for planning permission can either seek outline planning permission for subsequent approval or full planning permission (s. 7, Physical Planning Regulation). An application for full planning permission can only be made when all details of the proposed development are cleared in terms of information dissemination. Applications are submitted to the National Physical Planning Board, which either grants or refuses planning permission.

Other laws and regulations relevant to Master Plan Study are the government resolutions and policies described in the Section 8.2.2.

c. Environmental Act 2000

This Act provides a legal framework related to laws and regulations concerning the environmental impacts caused by projects. It also provides an appropriate level of environmental mitigation measures and secures their implementation by providing monitoring mechanisms through the regulatory process.

Details of the Environmental Act are described in the Section 8.2.3.

(3) The Government System of PNG

Since achieving independence in 1975, the Independent State of Papua New Guinea has been governed democratically in accordance with its Constitution. It is a member of the British Commonwealth and operates under the Westminster system. The Constitution makes clear that PNG has a unitary system of government. In other words, the country is a single unit with a national parliament. The Head of State of PNG is the British Sovereign, represented by the Governor-General, who is a citizen of Papua New Guinea nominated by parliament.

The government is led by the Prime Minister. Under the Constitution, the power, authority, and jurisdiction of the people of PNG are to be exercised by the national government, which comprises three principal arms: the legislature, the national executive, and the national judicial system. The national parliament has legislative power in connection with foreign investment, exchange control, immigration, trading and financial corporations, banking, most taxation, customs and excise, shipping, and overseas trade.

(4) Provincial Government System

Within PNG, there are 21 separate provinces and a National Capital District, each with a status similar to that of a provincial government. Provincial governments have powers delegated by national parliament and are subordinate to the national parliament. Provincial legislatures can pass laws on a limited, but important range of matters, including agriculture, fishing, trade and industry, land and land development, forestry and natural resources. Provincial governments also have certain limited powers to raise revenue, including the right, subject to certain conditions, to impose taxes on sales and services.

(5) Local Government System

A local government system was introduced to the country by the colonial administration. Councils will generally represent a number of villages and will manage and administer areas under their control. Local level governments have legislative power in connection with labor and employment, the provision of water and electricity, local trading, and local environment, among other activities and affairs.

Depending on the locations, sizes, and nature of their enterprises, foreign investors operating in the country are generally bound by the acts, regulations, and policies of PNG.

8.2.2 Government Resolution and Policies

(1) PNG 2050 Vision

While government policies and priorities may vary from year to year, there has been a broad commitment over the last two governments to a development framework covering the period until 2050, as elaborated by the Department of National Planning, which has instituted “Vision 50,” a long-term national strategic plan envisioning “a smart, wise, fair, healthy and happy society” by 2050.

Vision 50 maps out PNG’s development initiatives for forthcoming years and identifies seven strategic focus areas considered essential to the country’s economic growth and development:

- Human Capital Development, Gender, Youth and People Empowerment
- Wealth Creation
- Institutional Development and Service Delivery
- Security and International Relations
- Environmental Sustainability and Climate Change
- Spiritual, Cultural and Community Development and
- Strategic Planning, Integration and Control.

(2) Papua New Guinea Development Strategic Plan 2010-2030

The Papua New Guinea Development Strategic Plan translates the seven areas of strategic focus of Vision 50 into “directions for economic policies, public policies, and sector interventions with clear objectives, targets and indicators.” The plan’s target is for PNG to become a middle-income country by 2030. The MTDP (2011-2015), dictates PNG’s economic direction, which is a “five-year rolling development plan that sets the priorities, targets, costs and deliverables for the country’s economic sectors.”

Released in October 2010, the MTDP implements the PNG Development Strategic Plan for the 2010–2030 period. The strategy anticipates economic growth of 8.7% over the five-year period and identifies the development of the economic corridors and the development of core infrastructure in rural areas as keys to sharing the benefits of growth for the PNG population.

Among the initiatives outlined in the MTDP, the areas with the highest impact on jobs and economic growth in the 2011–15 period will be land, law and order, higher education, transport and electricity infrastructure. The plan is designed to create 290,000 new jobs over five years.

(3) Resolution for Electric Power Development

1) National Energy Policy

This policy is the overarching policy governing energy generation in PNG and embodies the main aspirations enshrined in the five national goals and directive principles of the constitution. It is also aligns with the PNG 2050 Vision and Medium Term Development Goals 2011 – 2015.

2) Rural Electrification Policy

This policy outlines the rural electrification plans set out as part of the government's plans to improve electricity access for rural areas. It emphasizes i) providing reliable, affordable and sustainable electricity; ii) promoting the use of renewable energy technologies; iii) ensuring efficient and productive end-use of electricity to develop rural areas; and iv) developing human and institutional capacity to plan and manage rural electrification.

3) Electricity Industry Policy

This policy provides a framework that will assist the government in achieving the goal set out in the PNG Development Strategic Plan 2010-2030 for "a high quality of life for all Papua New Guineans" under its Vision of PNG as "a prosperous middle-income country by 2030."
Delivering improved electricity services and achieving other key national development priorities such as improved health and education services will become a reality due to the implementation of electric power generation development plans. The electricity industry policy is also aligned with the PNG 2050 Vision as the enabler in the implementation of the seven pillars under the 2050 Vision.

4) Geothermal Policy

This Policy helps promote the development of national renewable resources such as geothermal energy as an option for electricity generation. It will help guide investors and customary landowners ("landholders") to collaborate in accordance with the spirit of the National Constitution and 2050 Vision.

8.2.3 Environmental Policy of PNG and Its Laws and Regulations

(1) Principle of the Environmental Management in PNG

Conservation of the environment is highly supported by the Constitution of PNG. Preamble 4 of the Constitution includes the following principle on environmental management and conservation:

"We declare our fourth goal to be for the natural resources and environment of PNG to be conserved and used for the collective benefit of us all and replenished for the benefit of future generations."

(2) Environmental Laws in PNG

The GoPNG has been working to consolidate environmental laws and regulations made at the turn of the century. As stated in the next section, EIA laws and regulations were improved in 2000. However, since there has been no adaptation of SEA to date, Conservation and Environment Protection Authority (CEPA) is considering the introduction of the SEA concept in the near future. If the concept is introduced, the EIA branch of CEPA will handle it.

One of the obligations of the Study is to apply the principle and methodology of SEA. Accordingly, SEA, one of the prevailing methodologies generally employed by WB, International Finance Corporation (IFC) or ADB, will be selected within the Study scope to meet the Study requirement. The details of the SEA principle and methodology are described in Section 8.3.

(3) Environmental Act 2000

This Act provides a legal framework related to laws and regulations concerning the environmental impacts caused by projects. It also provides an appropriate level of environmental mitigation measures and secures their implementation by providing monitoring mechanisms through the regulatory process.

The Environmental Act 2000 came into force in 2004 as an integration of three earlier pieces of legislation: i) Environmental Planning Act; ii) Environmental Contaminant Act; and iii) Water Resources Management Act. The following summarizes environmental protection and the promotion of sustainable development as defined in the Act;

- Protecting the environment in accordance with the Fourth National Goal and Directive Principle of the Constitution
- Regulating the environmental impacts of development activities to promote the sustainable development of the environment and economic, social and physical well-being of people by safeguarding the life-supporting capacity of air, water, soil and ecosystems for present and future generations and avoiding, remedying, and mitigating any adverse effects of activities on the environment;
- Protecting the environment from harm
- Managing natural water resources and remaining responsible for their management

(4) Environmental Regulations

The Act is a main legal instrument that regulates environmental impact assessment and management in PNG. Under the Act 2000, the five regulations listed below were enacted in 2002. Each regulation deals with EIA and licensing procedures as a comprehensive part of the Act;

- Environmental Regulation 2002 (Procedures)
- Environmental Regulation 2002 (Permits and Transitional)
- Environmental Regulation 2002 (Prescribed Activities)
- Environmental Regulation 2002 (Fee and Charge)
- Environmental Regulation 2002 (Water Quality Criteria)

(5) EIA Guidelines

A number of guidelines were issued in 2004 due to the enactment of the Environmental Act 2000 as follows;

- Guidelines for the Preparation of the Environmental Inception Report, 2004
- Guidelines for the Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement 2004
- Notification of Preparatory Work in Level-2 and Level-3 Activities, 2004
- Guidelines for Submission of an Application for an Environment Permit to Discharge Waste, 2004
- Technical Guidelines for Noise, Air and Water & Land Discharges 2004
- Technical Guidelines for Air Discharge 2004
- Technical Guidelines for Water & Land Discharges 2004

(6) Environmental Protection Authority Act

The Act commenced retrospectively on December 1, 2014. The CEPA was thereupon created and took over administration of the Environment Act, the Conservation Areas Act, the Fauna (Protection and Control) Act, the International Trade (Fauna and Flora) Act, and the Crocodile Trade (Protection) Act.

(7) Environmental Amendment Act

The Environment (Amendment) Act 2014 also commenced on December 1, 2014. The amendments to the Environment Act are set to commence in two phases: first, the consequential amendments in connection with the creation of CEPA; second, the more substantial amendments to the Environment Act that relate to the permission process and the classification of activities.

- Fauna Act (Protection and Control) 1966
- National Parks Act 1982
- Conservation Areas Act 1978

(8) Environmental Standard

The regulation of specific values for Suspended Particle Matters (SPM), SOx, NOx for air pollution and BOD, COD in water pollution is one of the key tools to administer national environmental conditions. CEPA, however, does not regulate the specific standard values for air and water quality management. Thus, the Monitoring and Compliance Branch of the Environmental Protection Division of CEPA supervises the issue of environment permits and environmental management plans in terms of air and water quality control.

(9) Environment (Fees and Charges) Regulation 2002

This regulation regulates procedures for permit fees and charges for environmental impact assessments and permits, water use, discharges to water, and disturbed area runoff. Fees and charges are set by CEPA.

(10) Environment (Permits and Transitional) Regulation 2002

This regulation defines procedures for applying for, processing, appealing against, and complying with environmental permits.

(11) Environment (Prescribed Activities) Regulation 2002

Guidelines used to determine whether the Project will be classed as a level I, II, or III activity.

(12) Environment (Procedures) Regulation 2002

This regulation regulates the procedures of the Environment Council (who will advise the Minister on the EIS).

(13) Environment (Water Quality Criteria) Regulation 2002

Permit required to set a mixing zone in which prescribed water quality criteria must be met if any project intervention is likely to disturb water quality.

(14) Fauna (Protection and Control) Act 1966

This Act regulates and requires measures to prevent wildlife poaching by the workforce.

(15) Conservation Areas Act 1978

This Act facilitates the preservation of the environment and natural and/or cultural inheritance by conserving sites and areas of particular biological, geological, historic, scientific or social importance and managing those sites and areas.

The Minister may refer any proposals for development to the National Conservation Council (formed under the Act) to consider any development affecting or in the vicinity of a conservation area, and to assist the Minister in formulating rules applicable to conservation areas.

(16) International Trade (Fauna and Flora) Act 1979

This Act requires measures to prevent wildlife poaching by the workforce specifically trained and established under this Act. It also provides powers to regulate trading of nationally and internationally important flora and fauna to and from PNG.

8.2.4 Agency for Environmental Conservation and Management

(1) Implementing Agency for Environmental Conservation and Management

The CEPA of PNG has replaced the previous DEC. CEPA is now the government agency responsible for administering the Environment Act 2000, the Conservation Areas Act (Chapter 362), the Fauna (Protection and Control) Act (Chapter 154), the International Trade (Fauna and Flora) Act (Chapter 391), and the Crocodile Trade (Protection) Act (Chapter 213).

Within the framework of these laws, CEPA manages natural resources and environmental quality to enforce related regulations. It is the body under which the Environment Act must be appropriately enforced, including environment permit applications from the government and private organizations. It also collects fees and charges related to the enforcement of environmental laws. CEPA comprises the following three divisions;

- Policy Coordination and Evaluation Division
- Sustainable Environment Management Division
- Environment Protection Division

(2) Role of the Director of CEPA

The Director of CEPA has authority to administer the Act and issue environmental permits, as prescribed in Section 16 of the Act.

(3) Role of the Environmental Council

Environment Council is established to review the Director's decision and advise the Minister as prescribed in Section 19 of the Act.

(4) Role of the Environmental Protection Division

The Environment Protection Division of CEPA has three separate branches;

- EIA Branch
- Environmental Permit Branch
- Monitoring & Compliance Branch

The above three branches are responsible for environmental assessment and issuance of permits.

The EIA branch is responsible for dealing with Level 3 (equivalent to Category A of the classification system within the framework of JICA Guidelines) project proposals requiring detailed environment impact assessment.

The Environmental Permit Branch is responsible for processing the environment permit application for any development project under Levels 2A, 2B, and 3.

The Environmental Monitoring & Compliance Branch is responsible for ensuring that the environment permit conditions are enforced and that the contents of each application meet the relevant requirements. The branch further ensures that project activities are periodically audited.

8.2.5 EIA Procedure in PNG

(1) Categorization of Projects

Under the Environment Act 2000, project proponents must submit obligatory Environmental Impact Statements (EISs) in order to obtain Environmental Permits before project implementation.

Projects are prescribed on the basis of the classification in the Environment Regulation 2002 (Prescribed Activities). Activities are categorized into three levels based on the project size or environmental impact level. When level 2 or 3 activities are performed, an Environmental Permit is required.

1) Level 1 activity

Level 1 activity is assumed to have a very low risk of causing environmental impacts, with no application for environmental permits required. According to the regulation, Level 1 activity covers all activities not prescribed as Level 2 or 3. The sactivities categorized as Level 1 are as follows:

- Hydroelectric plants with capacities of less than 2 MW constitute Level 1 activity. If they impact the environment, Level 2A activity applies;
- Fuel-burning power stations with capacities of less than 5MW constitute Level 1 activity. If they impact the environment, Level 2A activity applies;
- Fuel-burning appliances (including furnaces and boilers) with rated thermal outputs of less than 20MW constitute Level 1 activity. If they impact the environment, Level 2A activity applies;
- Construction of electricity T/Ls of less than 10 km long constitutes Level 1 activity. If they impact the environment, Level 2A activity applies; and
- Construction of electricity distribution lines constitutes Level 1 activity.

According to the Environmental Officer in PPL, there was no EIS submission for distribution line projects in PPL.

2) Level 2 Activity

Level 2 activities are activities with the potential to cause environmental harm. These activities are divided into two categories, namely, Levels 2A and 2B.

Level 2A activities are expected to involve relatively lower potential risk than Level 3 activities. Level 2A activities do not require applications for approval permits, hence no submission of an EIS is required. Mining exploration and minor forest activities are categorized as Level 2A activities. There are no prescriptions for power sector projects if the projects are categorized at Level 2A.

Level 2B activities are expected to involve higher potential risk than Level 2A activities. Level 2B activities are subject to a permit approval process with submission of an EIS. However, a full EIS level assessment need not be prepared when applying for an environment permit in the Level 2B category.

Level 2B involves manufacturing, chemical processes, and mid-sized mining. In the power sector, Level 2B includes the following prescribed activities:

- Hydroelectric plants with capacities exceeding 2 MW;
- Fuel burning power stations with capacities exceeding 5MW;
- Fuel-burning appliances (including furnaces and boilers) with rated thermal outputs of 20MW;
- Damming or diversion of rivers or streams; and
- Construction of electricity T/Ls of more than 10 km long.

These prescriptions mean that run-off-river type hydropower plants and other activities that divert runoff from original rivers or streams are categorized as Level 2B, regardless the length of the diverted sections.

3) Level 3 Activity

Level 3 activities are essentially defined as projects of national importance that have serious environmental and social impacts. A Level 3 activity requires the compilation of a fully studied EIS.

Level 3 activities generally constitute industrial activities such as manufacturing, large-scale mining, industrial waste disposal projects, and projects resulting in large-scale resettlement. In the power production sector, Level 3 activities include the following:

- Major hydropower schemes or water supply reservoirs inundating areas of greater than 5 km^2; and
- Activities with a significant potential risk of serious or material environmental impacts within Wildlife Management Areas, Conservation Areas, National Parks, or Protected Areas.

(2) Application Procedure for Environmental Permits and Screening

All project proponents should submit notification for preparatory project works. For Level 2 and 3 category projects, an Environmental Permit should be obtained before the start of project implementation. The Environmental Permit process in PNG is as follows:

- Project proponents should register their intention to carry out preparatory work with CEPA at least one month before beginning their preparatory works;
- After CEPA confirms the Categories in Levels 1 to 3, the proponent should submit an Environmental Inception Report (EIR) listing the issues to be covered in the EIS;
- Upon EIR approval, the proponent should submit the EIS; and
- When the Minister approves the EIS, the final application for the Environmental Permit can be processed.

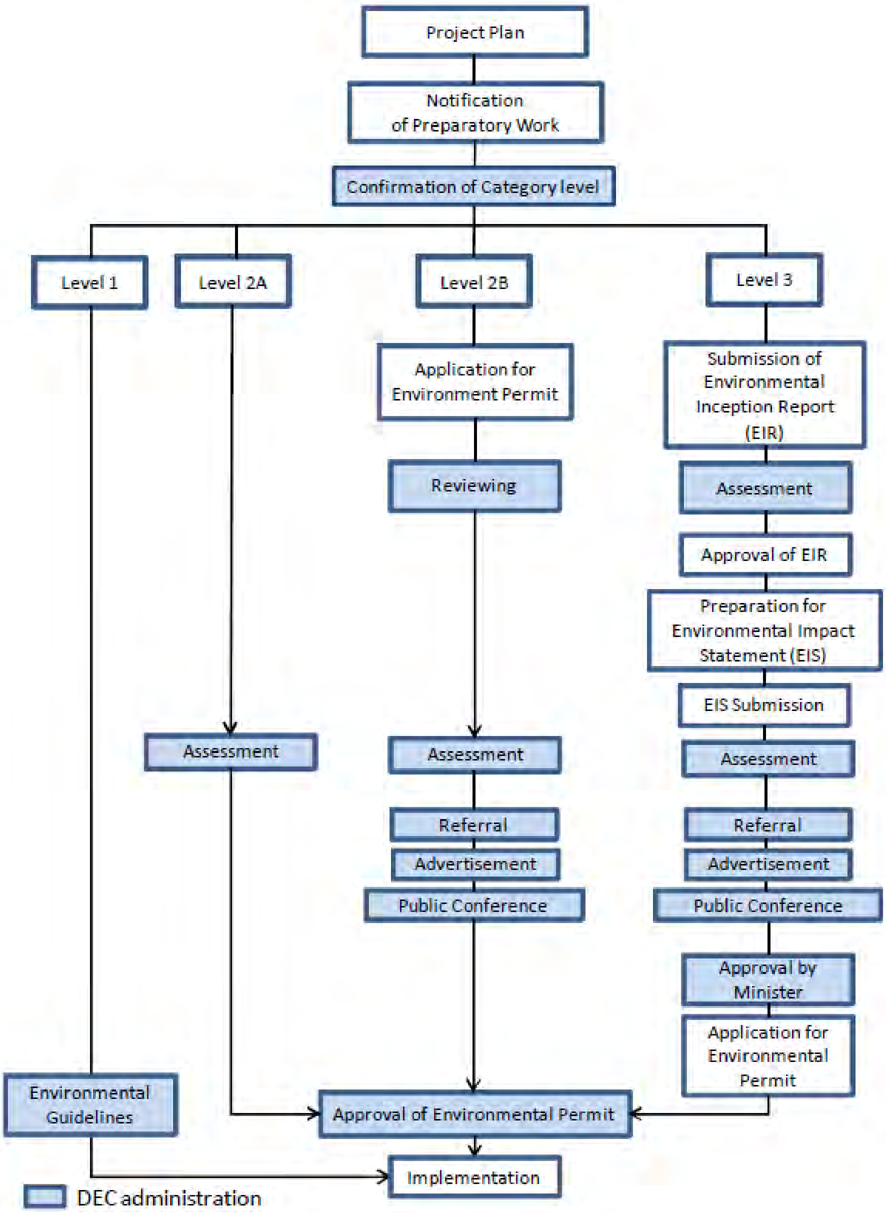
(3) Procedure for Licensing an Environmental Impact Assessment

The procedures for an environmental impact assessment are described in detail in section 51(1) of the Environmental Act 2000. They can be summarized as follows:

- Submission of an EIR setting out the issues to be covered in the EIS;
- Submission of an EIS setting out the physical and social environmental impacts likely to result from the project activity;
- Assessment and public review of the EIS;
- Acceptance of the EIS by the Director;
- In reference to the EIS, an assessment report and other materials are sent to the Minister;
- The Minister may make further requests requiring the Environmental Management Council to further assess the report;
- Recommendations by the Environmental Management Council are sent to the Minister; and
- The Minister approves the EIS, in principle.

Assessments for the Level 2A category are processed within 30 days. For the Level 2B category, 90 days is required for the approval process following the submission of applications.

After EIS assessment for 6 months, the 5 experts sitting on the Environmental Management Council jointly approve the submission, whereupon the Minister's approval for the Environment Permit is issues. Fig. 8.2-1 shows the general EIA process in PNG.



Source: CEPA, Dept. of Environment and Conservation, PNG

Fig. 8.2-1 Environmental Regulatory Process of PNG

(4) EMP, RAP, and Biodiversity Offset Plan

An Environmental Management Plan (EMP) should be attached to the EIS for a Level 2B or 3 Activity if any resettlement is involved. A Construction Environment Management Plan (CEMP) should be prepared for a Level 2A activity. When an EIA is conducted for a Level 3 or 2B activity that would significantly impact the environment on a national level, the EMP should include a Resettlement Action Plan (RAP) (if any has been formulated), a Biodiversity Offset Plan (BOP), and a BOSspecifying the identified benefits for the local communities (compulsory).

The contents of an EIS are shown in the Guideline for Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement (DEC Publication: GL-Env/02/ 2004). The EIS must include all of the following:

- Executive Summary or Overview of the Proposal;
- Purpose of Development;
- Viability of the Project;
- Description of the Proposed Development Activity;
- Development Timetable;
- Characteristics of the Receiving Environment;
  - Available Environmental Studies & Investigations
  - Physical, Biological and Social Environment
- Waste Minimization, Cleaner Production, and Energy Balance
- Environmental Management, Monitoring, and Reporting
- Other Statutory Decisions, References, and Composition of Study Team

Either the Environment Permit Branch or the Monitoring & Compliance Branch in CEPA screens the monitoring reports and monitors the Environment Management activity during the project implementation.

(5) Resettlement Framework

No policies, laws, or regulations for involuntary resettlement are provided for in the environmental impact assessment laws and regulations of PNG. A project report entitled **"Papua New Guinea: Power Sector Development Plan"** issued by ADB in April 2009 lists a set of "**Social Safeguards**" in Appendix F and a provision for a **"Resettlement Framework."** The resettlement framework outlines the principles of the Land Act of PNG and ADB's policies on involuntary resettlement. ADB's intention, therefore, was to prepare a framework that applies to all project executing agencies of PNG when economic development projects take place within PNG borders.

Conversely, under Section 85 of the Environment Act 2000, land acquisition must be addressed within an EIS that applies to the following activities:

- Construction works to generate hydroelectric power;
- Conveyance of water or electricity; and
- Construction of waterworks for the use, flow, or control of water.

In the case of a Level 3 activity, one of the requirements is to obtain consent from landowners in the form of formal agreements. This is an important requirement because CEPA facilitates public project reviews. A project proponent has to provide relevant information on the project, the scale of any negative impact on local people or the environment, and complaints and comments on the project from the general public.

The other requirement is to provide spatial data showing the scale of land acquisition or resettlement of the project. The provision of remote sensing images and other spatial data is compulsory for Level 3 activities.

The requirements of the EMP include a specific plan for environmental management and reporting activities upon land acquisition for resettlement. Accordingly, resettlement cases are assessed on a project basis within the environmental laws and regulations of PNG. At the same time, the “Power Sector Development Plan” (ADB, April 2009) includes the following statement: “the key executing agency will ensure that the requirements of ADB’s policy on involuntary resettlement will be achieved.” This means that resettlement issues within the framework of power sector development in PNG are coordinated between PNG’s EIA legislation and ADB’s safeguard policies.

(6) Land Acquisition

1) Land Tenure System in PNG

The land tenure system in PNG is classified into two categories. One is Alienated Land, which is managed by the Government. The other is Customary Land, which belongs to a citizen or a community of citizens who traditionally maintain a territory for a clan. Customary Land constitutes about 97% of the total area of PNG and Alienated Land constitutes 3%.

The Land Act 1996 stipulates two (2) types of land acquisition process, namely i) Compulsory Acquisition; and ii) Agreed Land Acquisition.

2) Characteristics of Customary Land

The key characteristics of the customary land tenure system are as follows:

- Appropriate for traditional needs - established and well understood by users;
- Responsive to internal pressure - i) flexible and controlled by landowners; and ii) less responsive to external impacts;
- Ownership by the clan; individual members have rights to use and occupy land based on verbal agreements and conventionality at the clan level;
- The clan sets aside land for meetings, signings, feasts, rituals and sports, etc.;
- The ILG within the community resolves all land issues. There is no individual registration of land in PNG. All land is registered in the name of the ILG;
- There are thousands of ILGs in the country, each of which has a certificate of registration. Once an ILG is registered and claims possession of the land, no other person can claim ownership;
- The Land Department is not involved in the process. Disputes are settled in civil court;
- Another source of conflicts is the buffer zones. The land in buffer zones is generally not owned by any clan because it lies between generalized landmark boundaries. Nevertheless, clans tend to vie over ownership whenever development takes place;

3) Laws and Registrations

a. Land Act 1996

The Act provides procedures applied to the acquisition of land. The Act also defines the national land tenure system. Land is categorized as 1) Customary Land; 2) Alienated Land; 3) Freehold land; 4) Leasehold Land; and 5) land acquired through Land Board and Land Title Commission, which usually deals with one of the four land systems.

State land acquisition is processed in two ways: 1) by agreement; or 2) by compulsory acquisition. Customary land cannot be leased. It first has to be alienated by the state in accordance with "s. 5" of the "Land Act 1996," either by compulsory or voluntary means. Customary landowners are compensated by the state for the loss of their land.

Lease applicants must first ensure that the land is appropriately zoned and apply for planning permission if the land required is part of a physical planning area. The applicant must then conduct a boundary survey of the area and register the survey plans with the Office of the Surveyor General. Once the lease application is submitted, the Valuer General will assess the value of the land to determine an appropriate annual value for the lease. On the advice of the Land Board (s. 57(2), Land Act 1996), the Minister may then grant the lease. Leases are normally granted for a period of 99 years.

b. Land Groups Incorporation Act 1974

This Act provides an outline of the registration of ILGs and its procedure. The purposes of the Act are to encourage more effective settlement of certain disputes based on legal recognition of the corporate status of certain customary groups and encourage the self-resolution of disputes within such groups.

c. Land Groups Incorporation (Amendment) Act 2009

The Act provides an outline of the registration of ILGs to update the 1974 Act.

d. Land Registration Act 1981

The Act provides details on the registration of land for use by describing examples of land leasing.

e. Land Registration (Customary Land) (Amendment) Act 2009

The Registration updates the 1981 Act to meet Land Groups Incorporation (Amendment) Act 2009

f. National Land Registration Act 1977

The Act provides national land registration for registration in the Register of National Land, for land that has been acquired or is to be acquired by the State.

g. Survey Act 1969

This Act regulates land surveying and the registration of surveyors. The Act applies to surveys of boundaries to establish titles and other surveys authorized by the Surveyor General.

h. Land (Tenure Conversion) Act 1963

This Act provides for the conversion of the tenure of Customary Land into individualized tenure and for other purposes.

i. Land Disputes Settlement Act 1975

This Act provides efficient and effective machinery to resolve disputes concerning interests in customary land by encouraging self-reliance and the use of the principles underlying traditional dispute settlement processes.

j. Valuation Act 1967

This Act provides for the valuation of property on the registration of land values and other purposes.

k. Recent Changes to the Law on Incorporated Land Groups and Voluntary Customary Land Registration - Information Booklet

Recent changes to the Law on "Land Groups Incorporation (Amendment) Act 2009" and the "Land Registration (Customary Land) (Amendment Act) 2009" are described to avoid further land disputes.

4) Process of Land Acquisition

The Incorporated Landowners' Group system has been devised within the framework of the laws and regulations of PNG to allow local landowners to organize themselves. They register their land and form entities empowered to negotiate with developers and government agencies as follows;

a. Identification of Landowners

The land acquisition process starts by identifying the owner (community and individual citizen) and boundaries.

As problems concerning land ownership arise within this process, the matters are left to be mediated by third parties (mediation by the village and land courts) based on the procedure of the Land Disputes Settlement Act 1975.

b. Establishment of the Incorporated Land Group

Negotiation on land acquisition ensues through an ILG, an ad hoc organization that represents landowners. Once permission is granted to apply for the formation of an ILG, the Land Department recognizes the ILG as the legitimate owner. This process is regulated by the Land Groups Incorporation Act 1974.

c. Registration of ILG

An ILG is a registered body for land under the Land Registration Act 1981. An ILG negotiates with developers and establishes a leasehold ship, whereupon an agreement is signed between the ILG and investor. Any disputes are settled in civil court and do not involve governmental organizations.

d. Purchasing Land for Power Development

In the case of PPL, monetary compensation normally applies for land acquisition. The negotiation process should follow the approach of the above-mentioned process and also as specified by the Valuation Act 1967.

e. Transferring Land Title

Following the acquisition of land, the land title is transferred from Customary Land to State Land and the land transfer has to be announced via the government gazette. Once the gazette details are included, the land becomes the property of the state.

f. Administrative Procedures

Administrative procedures for land acquisition are as follows:

- A Developer Proposal is submitted to the DLPP to confirm ownership;
- The DLPP directs the local government to carry out a land investigation;
- The local government and developer investigate the land, e.g., by confirming ownership or land boundaries. After the land investigation, an ILG is established;
- The DLPP reviews and approves the result of the land investigation and is then requested to prepare a Certificate of Alienability to Provincial Affairs and Village Services. At the same time, DLPP requests the Valuation General's office to provide an estimation of land values;
- The local government issues a Certificate of Alienability upon confirmation of agreement from the landowner;
- The developer submits documents and checks for payment for land acquisition to the local government; and
- The title of land transfer is registered after the local government submits the final documents to the DLPP.

5) Land Use in PPL Projects

a. Type of Land Usage in PPL Projects

- Land required for the main facilities of electric power development projects such as dams, power stations, and S/S is acquired with monetary payments based on the agreement. The payments are settled by negotiation between PPL and landowners based on the market price, whereupon the ownership is transferred to the Government.
- Land required to facilitate the right of way (ROW) for power lines, foundations for T/L towers, and access roads for dams, power station, and S/S involve fee payment under agreements called "Access Agreements." Agreements for access roads are called Lease Agreements. No ownership is transferred under these agreements.
- An Access Agreement resembles a so-called easement agreement. There are no internal guidelines in PPL, however, limiting usage by landowners. Nor do the agreements prescribe any usage limitations for building houses or growing crops or

trees. When trees grow tall as the years pass, PPL will simply clear them without compensation. There have been cases, however, where PPL provided compensation after clearing away coffee crops in Highland areas.

- Land required for ROW of power lines and foundations for distribution line poles and access roads for transmission lines is utilized without levying fees. PPL believes landowners benefit from the distribution lines and access roads for transmission lines.
- PPL provides compensation for crops, trees, houses, and so on in the above-mentioned areas. Following payment of compensation, PPL clears the crops and trees grown on the acquired land.

b. Price of Land Acquisition

The price of the land acquisition is negotiated between PPL and the landowner organization of the ILG at the market price.

c. Access Agreement

The Access Agreement is a kind of agreement governing rights of usage for the foundations of T/L towers or access roads. These rights are not prescribed in PNG laws or regulations, but they commonly apply in power developments such as those implemented by PPL or the telephone company of PNG.

The fee is decided by negotiation between the owner and PPL, taking local conditions into account. Payment may be one-time or annual. The unit price for a 132kV T/L foundation, for example, was 160 kina/km^2 as of 2014, and the unit price for telephone company poles was 10,000 kina/km^2.

d. Compensation for Crops and Trees

PPL compensates for crops and trees according to unit prices established by the Valuer General's Office

The latest schedule of unit prices was published in 2008. In each successive year, the unit prices in the regions are determined based on growth in commodity prices and announced in the "Valuer General Price Schedule for Acquisition of Trees and Plants of All Regions" published by the Valuer General's Office in the Department of Land.

e. Landownership in City Areas

In principle, the PNG government owns land, so-called "State Lease Land," in city areas such as POM and Lae. The local clans, however, still own land in these cities, as their traditional rights are maintained. Land users pay annual lease fees to the government, and the government pays annual lease fees to the traditional landowners in return.

Electricity distribution improvement projects generally do not result in disputes over the use of land for ROW, as road users and private land users generally accept such projects.

f. Disputes over Compensation

The unit responsible for land acquisition in PPL is the Cooperate Services Group, Community Support Service Unit (CSSU). A number of claims for resettlement and land acquisition related to projects implemented by PPL have emerged over the past 40 years. These claims have mainly involved compensation for resettlement caused by the Yonki and Sirinvnu dams.

6) Underground Rights

Underground rights apply to a depth of 60 m, whereby CEPA maintains the British Colonial Standard. There are no descriptions, however, in the regulations or guidelines. Some people demand compensation even beyond 60 m for activities such as mining.

7) Land Disputes in PNG

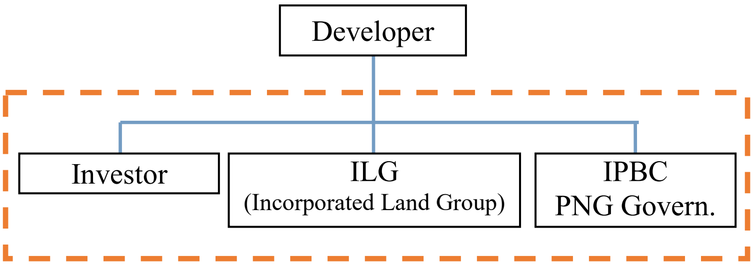
PNG has a complex land tenure system. Difficulties arise when land is required by the state, which involves developers constructing public infrastructure and extracting major resources for agricultural, industrial, and commercial projects. The mechanism of the Incorporated Landowners' Group was devised to allow local landowners to organize themselves and register their land before negotiating with project developers and the state. Following is a list of major land disputes in PNG as of 2015:

- Lae Port Extension Phase 2, a project causing resettlement, is under study for an environmental permit;
- Stanly Gas Pipeline Project in Western Highlands Province, a project causing resettlement, is under study for an environmental permit;
- Ram Nico mining is subject to protest by residents; and
- Additional compensation has been claimed since the conclusion of agreements in projects such as Yonki dam, Syrinumu dam, and a number of mining projects.

CEPA issued the following advice to help avoid land disputes: 1) Land disputes usually occur if early consultation on landowner issues is not properly addressed. Before obtaining a permit or license from CEPA and other relevant government agencies, the developer should reach agreements with the landowners; 2) Agreements or MOUs with landowners upon land acquisition or resettlement in preparation for development projects help facilitate resolution; 3) Social Mapping Studies should be performed to identify the actual landowners of the project site.

(7) Stakeholder Participation in the Ramu 2 Project

Participation of the ILG in the Ramu 2 Project has been considered more crucial than monetary compensation. Participants include three delegates of investors, the ILG as an umbrella organization representing local landowners, and the Independent Public Business Corporation (IPBC) as a government body committed to work as the implementation organization of the project, as shown in Fig. 8.2-2. Cooperation with local people toward the project was therefore effectively achieved at the site investigation stage, and the IPBC is believed to support the local people, including the ILG.



Source: Strategic and Business Development Group, PPL

Fig. 8.2-2 Stakeholder Participation in Project Development

(8) Local Government Involvement

CEPA refers the EIS to relevant local authorities, such as Provinces and Districts, in terms of the project implementation, including land acquisition. Local Authorities such as LLGs and wards should get involved in terms of assessing the EIS at the time of public hearings.

Local governments are entitled to register disagreement with the contents of the EIS at any time before signing to approve an Environmental Permit.

(9) Disclosure of Project Information and Public Consultation

There is provision for information disclosure under the Environment Act 2000. CEPA will facilitate public conferences and presentations during the public review stage of an EIA. EIS documents are open to public reading upon notification issued by the Director of CEPA. The project proponent bears the associated cost of public conferences.

CEPA will chair the public conferences. EIA laws and regulations provide no specific frequencies for the conference. Yet depending on the accessibility, logistics, and scope of project proposals, CEPA can request that the project proponent hold any number of public conferences.

After receiving the EIS, the Director of CEPA issues an official letter requesting that the project proponent hold public hearings for those likely to be affected by the project activities.

A public hearing should be held with each different group of affected people, such as displaced people, people affected only by land acquisition (i.e., absentee landowners) and downstream and upstream communities affected by the project activities.

8.2.6 International Conventions and the Environmental Agreements

(1) Function of International Agreements

Apart from local legislation and other requirements, PNG is also a signatory and party to international conventions and agreements. In general, these conventions and agreements are effective in local law only after the legislation has been enacted in a signatory country; i.e., PNG has to ratify them. Elements of these agreements may relate to mitigating and managing the environmental and social impacts of the project in instances where the PNG Government has passed local laws to fulfill statutory obligations.

(2) Protection of Flora and Fauna

PNG is a signatory and party to the following conventions:

- The International Plant protection Convention (1951);
- Plant Protection Agreement for the Asia and Pacific Region (1956);
- The convention on the International Trade in Endangered Species of Wild Flora and Fauna (1973).

These conventions and agreements promote international cooperation to control pests and diseases of plants and plant products.

(3) Biodiversity and Sustainable Development

PNG is a signatory to the "***Convention on Biological Diversity (1992).***" This convention promotes the preservation of sustainable biological diversity within the country.

(4) Energy and Climate Change

PNG is a signatory and party to the "***United Nations Framework for Convention on the Climate Change (1992)***." This treaty promotes efforts to reduce changes to the earth's climate with a particular focus on greenhouse gases and places the onus on industrialized countries to reduce emissions. Developing countries like Papua New Guinea are currently exempt from the reduction requirement, but this may change in due course.

(5) Vienna Convention and Montreal Protocol for Ozone Depleting Substances

PNG is a signatory and party to the "***Vienna Convention for the Protection of the Ozone Layer (the Vienna Convention) (1993)***," which promotes the protection of the ozone layer.

(6) Convention on the Trans-boundary Movement of Hazardous Waste

PNG is a signatory to the "Convention to Ban the Importation into Island Countries of Hazardous Waste and Radioactive Waste and to Control the Trans-boundary Movement and Management of Hazardous Waste within the South Pacific Region (Waigani Convention, 2001)." This prescribes international trade in hazardous waste and notification procedures, monitoring mechanisms, and cooperative authorities.

(7) Tangible and Intangible Cultural Heritage

PNG is a signatory to the "***Convention Concerning the Protection of World Cultural Heritage and Natural Heritage (1972)***," an international regime that protects indigenous cultural and environmental heritage.

(8) Stockholm Convention on Persistent Organic Pollutants

It is an international environmental treaty, signed in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs).

8.2.7 Environmental Impact Assessment/Social Safeguards Requirements by MDBs

(1) Performance Standards and Safeguard Policies

1) World Bank

The WB Performance Standards are imposed on borrowers in terms of the requirement for the environmental impact assessment and resettlement action plan as guidelines for environmental study. It is a compulsory requirement, in the financing arrangements for economic development projects, that developing countries borrow funds from the WB. Following are the major points of concern in the WB's Performance Standards:

a. PS 1: Assessment and Management of Environmental and Social Risks and Impacts

Performance Standard 1 underscores the importance of managing environmental and social performance throughout the life of the project.

b. PS 2: Labor and Working Conditions

The requirements governing labor and working conditions set out in part are guided by a number of international conventions and instruments, including those of the International Labor Organization (ILO) and the United Nations (UN).

c. PS 3: Resource Efficiency and Pollution Prevention

This Performance Standard outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. The Performance Standard promotes the ability of private companies to adopt such technologies and practices provided their use is feasible in the context of a project depending on commercially available skills and resources.

d. PS 4: Community Health, Safety and Security

Performance Standard 4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities already impacted by climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting public health, safety and security, this Performance Standard addresses the client's responsibility to avoid or minimize risks to and impacts on community health, safety and security that may arise from project-related activities, with particular attention to vulnerable groups.

e. PS 5: Land Acquisition and Involuntary Resettlement

Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and economic displacement due to project-related land acquisition and/or restrictions on land use. Where involuntary resettlement is unavoidable, involuntary resettlement should be minimized, and appropriate measures to mitigate adverse impacts on displaced persons and host communities should be carefully planned and implemented.

f. PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

This Performance Standard recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity. This Performance Standard addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout project lifecycles.

g. PS 7: Indigenous Peoples

Performance Standard 7 recognizes Indigenous Peoples as social groups with identities distinct from mainstream groups in national societies.

h. PS 8: Cultural Heritage

Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities.

2) Asian Development Bank

a. Latest Development of ADB Operations

The ADB’s Environment Policy mandates environmental considerations in all aspects of ADB’s operations. The “Environment Policy and Operations Manual (OM) 20: Environmental Considerations in ADB Operations” outlines ADB’s environmental assessment procedures and requirements. In 2003, ADB updated the old guidelines of 1993. The guidelines can be summarized as follows:

- Introduce a checklist system for rapid environmental assessment (REA) to determine the environment category;
- Introduce country environmental analysis (CEA) as a requirement when preparing the country strategy and program (CSP);
- Introduce SEA as an optional tool to facilitate the environmental assessment of program loans, sector development program loans, and sector loans;
- Establish a new category FI for lending activities to financial intermediaries and other intermediaries and outline the environmental assessment requirements applicable to this category;
- Strengthen the requirements of the EMPs;
- Recommend environmentally responsible procurement; and
- Strengthen public consultation as an integral part of environmental assessment and management.

b. General Contents of the EIA Study

- Coordinate with the government concerned and environment agencies;
- Prepare a project description, define the study area, collect environmental baseline

data, and prepare site maps and other relevant maps for the study area;

- Identify potential environmental impacts based on information obtained on the proposed project and the baseline environmental conditions of the study area;
- Identify alternatives, analyze the environmental impacts of each alternative, and propose measures to avoid or prevent impacts;
- Estimate the magnitude of environmental impacts and assess their significance;
- Recommend environmental mitigation measures and estimate the costs;
- Prepare an EMP to be implemented by the executing agency during project implementation, operation, and abandonment;
- Prepare EIA and SEIA reports;
- Conduct public consultations and ensure information disclosure; develop plans for public consultation and information disclosure during project implementation;
- Assess the executing agency's capacity to undertake an environmental review of the environmental assessment report and EMP recommendations and recommend measures for capacity building, if necessary; and
- Ensure that the proposed project, with EIA and EMP implementation, conforms to the Government and ADB environmental assessment requirements, policies, and regulations.
- Economic assessments should include i) costs and benefits of environmental impacts; ii) costs, benefits, and cost effectiveness of mitigation measures; and iii) a discussion of environmental impacts that have not been expressed in monetary values (in quantitative terms, if possible).

3) International Finance Corporation (IFC)

As a private sector arm of the WB Group, IFC supports small and medium enterprises and larger firms in PNG through innovative investments and advisory services. It also works with government to create an investor-friendly environment to allow businesses to formalize easily and flourish. As a member of the WB Group, it maintains performance standards equivalent to those described in the section on the WB above.

4) Equator Principles

The Equator Principles underpin the development of private sector banks and have become the de facto standard for private banks and financial institutions on how to assess major development projects worldwide.

The Equator Principles are based on environmental and social performance standards of the International Finance Corporation, one of the organizations of the WB Group responsible for providing private sector investment in developing countries. As stated in the previous section, the IFC' Performance Standards on Social and Environmental Sustainability, Environmental, Health and Safety General Guidelines underpin the social and environmental policies, procedures, and standards for investment established in-house at the private bank(s).

8.3 STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR THE MASTER PLAN STUDY

8.3.1 Definition of SEA

"Applying Strategic Environmental Assessment: Good Practice Guidance for Development Cooperation" by OECD-DAC (2006) describes SEA as follows:

"Analytical and participatory approaches to strategic decision-making that aim to integrate environmental considerations into policies, plans and programs and evaluate the inter-linkages with economic and social considerations". The principles of SEA are summarized below:

a. SEA is undertaken by the authority responsible for the policy, plan, and program;
b. SEA is applied as early as possible in the decision-making process;
c. SEA focuses on key issues in predicted environmental impacts;
d. SEA evaluates alternatives over a wide and reasonable range;
e. SEA provides opportunities for key stakeholders to get involved.

The "policy" is thought to constitute national administrative policies showing the basic principle of the plans and/or projects in the whole policy system. The policy will not decide the necessities and/or concrete contents of each project.

The "plan and program" show a scenario explaining the methodologies and schedule for implementing the project systematically, before the project details are decided. In this sense, the "plan and program" are more concrete than the policy and more abstract than the projects.

The "Guidance Notes on Tools for Pollution Management" from the WB (2012) defines the principle of SEA as follows:

> *SEA fosters and provides critical systematic considerations at the sectoral, regional and national levels to promote environmental sustainability, smart growth, and pollution prevention. The term "SEA" encompasses a spectrum of analytical processes such as Strategic Environmental and Social Assessment (SESA), Strategic Social Environmental Assessment (SSEA), Country Environmental Analysis (CEA), Combined Strategic Impact Assessment (CSIA), and Cumulative Impact Assessment (CIA).*

"Strategic Environmental Assessment in the World Bank" (WB, 2012) states that "Impact-centered SEAs," "Policy and Institution-centered SEAs" and a blend of "Impact and Institution-centered SEAs" can be implemented as SEAs for projects of the suitable types.

8.3.2 Role of SEA

(1) Recent Study on SEA in Japan

"The Study Report of Strategic Environmental Assessment 2000" by the Ministry of the Environment in Japan describes the principle of SEA as follows:

a. Assist the authorities responsible for Policies, Plans & Programs to take into account mitigation measures to avoid, reduce, or minimize adverse impacts;

b. Integrate appropriate environment and social considerations into the decision-making process; and

c. Supplement the limitation of the EIAs performed in the implementation stages of projects.

The further development of the Ramu Grid System for electricity supply is one of the most important projects for PNG's economic development. The goal of this SEA is therefore to influence the strategic decisions relating to the country's major electric supply system. SEA thus plays an important role in shaping decisions and plans to make the Ramu Grid System's development equitable and ecologically sustainable.

(2) Implementation of Strategic Environmental Assessment (SEA) by ADB

Multilateral Development Banks (MDBs) have developed the concept of SEA rapidly over the past decade, and a number of SEA analyses have been performed on MDB-funded projects. SEA is broadly sub-divided into 1) the EIA approach model and 2) the policy-institution analysis model. As the following section explains, the EIA approach model is generally an "Impact-centered analysis" and is further sub-divided into strategic social impact assessment (SSEA) and assessments of other forms.

ADB performed a "Strategic Environmental Assessment of Hydropower on the Mekong Mainstream" in 2010. Other SEAs have also been performed in countries within the greater Mekong sub-region. All of these SEA reports state that SEAs address the broader strategic issues related to multiple particular projects. While SEA follows similar steps to EIA, it deals with larger boundaries in terms of time, geographic areas, and organizational policies on particular topics of economic development activities.

ADB's key messages on the benefits of implementing SEA are: to 1) improve performance and efficiency of policy and planning by minimizing adverse impacts on the environment and society; 2) help avoid costly mistakes and missed opportunities caused by inadequate information about impact and trade-offs; 3) provide a framework for project-level assessment and coordination, particularly to understand cumulative impacts and reduce duplication; and 4) build consensus and public trust through its multi-stakeholder and participatory focus.

(3) Recent Study on SEA by the World Bank Group

"Strategic Environmental Assessment for Policies–An instrument for Good governance" published by WB (2008) states that "At one end of the spectrum, impact-based SEA integrates biophysical environmental considerations into higher levels of decision-making by predicting the potential effects of policies, plans, and programs on the environment and adopting corresponding protection and mitigation measures.

At the other end of the spectrum, institution-centered SEA aims to mainstream the environment and sustainability across higher levels of policy-making by assessing the capability and capacity of the institutional and policy framework to detect environmental risks and manage them promptly and effectively." The WB has performed a number of SEA studies for various projects. It recognizes that approaches vary from project to project. In the "Strategic Environmental Assessment in the WB - Learning from Recent Experience and Challenges" published in 2012, the various types of SEA are classified as follows;

1) Impact-centered Approach:

It best fits and integrates JICA's environmental social considerations. Originally the impact-centered approach of SEA was carried out of conventional EIA study.

2) Regional and Sectoral Environmental Assessment Approach (RSEAs):

An impact-centered SEA widely used at the WB to comply with the Bank's safeguard policies.

3) Policy SEA:

A process to establish policy dialog for mainstreaming environmental and social considerations of policy and sector reforms is termed as Policy SEA. It is generally applied to high-level plans.

4) Country Environmental Analysis:

A type of Policy SEA developed to inform dialog between the WB and client countries on national environmental priorities.

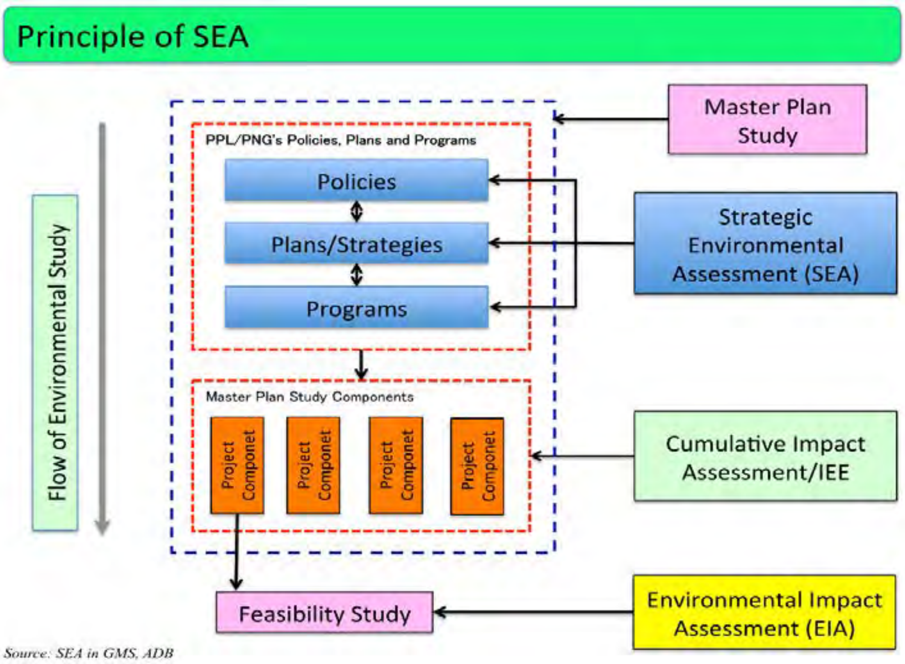
5) Hybrid SEA:

A combination of policy and the impact-centered SEA approach. Hybrid SEA particularly fits basin management or geographically wide/long development corridors.

8.3.3 Approach and Methodology of SEA for the Master Plan Study

(1) Principle of SEA

Within the framework of the SEA analysis for the Study, a cumulative Impact Assessment is defined as a set of Initial Environmental Examination (IEE) studies for a number of master plan study components to some extent, while each project component must undergo a process of IEE and EIA. The general flow of SEA to EIA is shown in Fig. 8.3-1.



Source: SEA in GMS, ADB

Fig. 8.3-1 Flow Chart from the Principle of SEA to EIA

(2) Comparison of SEA and EIA

SEA is initially applied to Policy, Plan and Program (P/P/P). Next, it analyzes each study component that is to eventually become a project to assess its viability for the country's economic development as a whole, the economic viability of individual projects, and broadly defined environmental and social impacts. The priority of each project is thus defined in relation to the country's strategic economic development policies.

Compared to the methodology for SEA, EIA is applied to individual projects and specifically addresses specific natural and social environments if a project causes significant impacts. The respective characteristics of SEA and EIA are compared and summarized in Table 8.3-1.

Table 8.3-1 Comparison of the Characteristics of SEA and EIA

[SEA]	[EIA]
a) Applied to P/P/P with a broad and long-term strategic perspective	a) Applied to specific and relatively short-term projects
b) Emphasis on key potential environmental and social impacts and mitigation upon P/P/P	b) Emphasis on mitigating environmental and social impacts upon projects
c) Suggestion of information to integrate environmental and social aspects into the decision-making process on P/P/P at an early stage	c) Focus on obtaining project development permission
d) Consideration of a broad range of alternative scenarios	d) Consideration of a limited range of project alternatives
e) Consolidation of considerations on broadly defined cumulative impacts	e) In-depth review on irrevocable impacts but not to cover regional-scale developments

Source: JICA Study Team

(3) Approach of SEA for the Master Plan Study

As above, no single "best SEA process" has yet been established. Different techniques or methodologies have been applied in various stages and activities of SEA. The choice of methodologies depends on a whole range of factors, including the purpose of SEA, the availability of information, local environmental assessment capacity, decision-making structure, and cultural and resource constraints.

The Study of "Ramu Grid System Power Development Master Plan and Long-Term Lae Area Distribution Network Improvement Plan" currently undertaken by JICA Study Team is considered to fall in the category of "Plan and Program" of PPL. It is thus examined from SEA perspectives in terms of the natural and social environment impacts caused by each planning component.

PPL is the organization in PNG with a clear-cut electric power development policy for the future and has jurisdiction over the planning scenario put out by the Study. No other sector of PNG, such as tourism or transport, is directly involved in the Study. Accordingly, no "Institution-centered SEA" approach or decision-oriented approach is considered appropriate. Rather, an "Impact-centered SEA" is thought to be the most appropriate form of assessment for the Study. This form of SEA is therefore performed in line with the integrated evaluation of the environmental and social impact assessments, as well as technical, economic and other aspects of the Master Plan Study.

(4) Methodology of SEA for the Master Plan Study

The general SEA procedure within the framework of the Study focuses on the impacts on the natural and social environments caused by electricity generation development activities:

a. In the early stage of the Study, the policy, plans, and program of the “FYPDP: 2014-2028” put out by PPL are evaluated;

b. The proposed scenario of the Study, a plan for electric power development for the period from 2016 to 2030 encompassing the above “FYPDP: 2014-2028” put out by PPL, is examined in terms of the environmental and social impacts and technical and economic merits;

c. The magnitude of impacts induced by the planning components on the natural and social environments is scoped out with a focus on the key issues of the natural and social environments;

d. If any significant adverse impacts are identified, the planning components screened in the scoping are further examined by performing an IEE level examination of the natural and social environments, and potential mitigation measures are drawn up;

e. The potential positive and negative environmental and social impacts of the alternative scenarios are evaluated;

f. Mitigation measures are examined to avoid serious adverse impacts before determining the detailed locations and specifications of the planning components; and

g. The result of SEA is presented for the final decision-making process for the Ramu Grid System Power Development Master Plan.

8.3.4 National Development Policies of PNG Related to the Master Plan Study

(1) National Development Strategies

The Department of National Planning of PNG has produced the following documents outlining the national strategies of the energy sector to provide electricity and the related targets:

a. PNG Vision 2050: Outlined to increase the availability of rural electrification to 100% by the Year 2050;

b. PNG Development Strategic Plan 2010-2030: Outlined to increase access of electricity to 70% of the total population by the Year 2030; and

c. PNG Mid-term Development Plan 2010-2015: Outlined to increase access to electricity to users by 27 % by the Year 2015.

At the time of this report, research findings showed that the electricity supply target of the PNG Medium Term Development Plan 2010 – 2015 has yet to be achieved. Its target appears to be somewhat lower than the target of the Development Strategic Plan 2010 – 2030, and rapid growth was thought to be achievable in the second half of the period of the strategic plan. The achievement based on PPL’s data in 2015, however, has been achieved only about 13%, less than half of the target of the Mid-term Development Plan 2010 - 2015.

(2) PNG Development Strategic Plan 2010-2030

PNG's "Development Strategic Plan 2010-2030" put out by the GoPNG in March 2010 clearly states that the electricity supply target should reach 70% of the total population of PNG. Thereby employment in the rural area could increase by 22,000 in the Year 2010 to 49,000 in the year 2030 in major urban areas. The economic corridor development approach is to focus on the identification of intensive economic development areas throughout the country.

Each economic corridor has to be provided with: 1) Electricity; 2) Water, sewage systems, telecommunications, including Internet; 3) Transport networks (land, sea, and air); 4) Social infrastructure such as health and education systems; 5) Agricultural, forestry, and fishery industries; and 6) Developing industrial estates, including well-serviced housing areas.

Competition is promoted across the economic sectors, including key service industries such as telecommunications, electricity, and transport. Consumers are in need of well-managed information and service providers are encouraged to provide quality goods and services. Thereby consumers are well informed and protected.

Energy is the foundation for the future prosperity and success of PNG as a nation and shapes how PNG pursues its energy development over the 2010-2030 period. All households will have to have access to a reliable and affordable energy; i.e., sufficient power will have to be generated and distributed to meet future energy requirements and demands. There is considerable potential for hydro schemes amounting to 14,000 - 15,000 MW, while only about 250 MW has been exploited to date. While diesel generators will be reduced in the near future, geothermal and other renewable sources of power generation should take over within the period of the current Development Strategic Plan.

To reach the target of access to electricity for over 70% of households by 2030, an average annual increase of 10.5% should have been achieved to date. While electricity supply is crucial to the development of rural (off-grid) areas, those areas will have to be supplied with off-grid services by a state-owned enterprise. This type of electricity supply scheme is considered socioeconomic development rather than economic investment.

(3) Fifteen Year Power Development Plan (FYPDP) of PPL

The study of the "Ramu Grid System Power Development Master Plan aims to strategically plan and realize the medium- and long-term power development plan in the area of Ramu Grid System, one of the three major electricity generation and distribution systems in PNG. An analysis of economic and electric supply stability has been carried out in consideration of the constraints on the usage of primary energies for the period 2016-2030. Consequently, the best mix of power sources is eventually studied by studying the policy, planning, and program, as well as by comparing alternative scenarios from the perspectives of electricity supply stability, energy security, engineering, investment analysis, and environmental and socio-economic factors.

This study is funded by JICA, an organization that places importance on the development of a planning tool for PPL in terms of:

"… provision of affordable, reliable and sustainable power supply within the nation, according to the economic, social and environment plans formulated by the Papua New Guinea Government and Provincial Authority Planners. Furthermore, the FYPDP aims to develop and utilize internal renewable energy sources to meet the needs of the nation's

electricity demand in line with the Electricity Industry Policy and the draft Rural Electrification Policy." (FYPDP, PPL, April 2014)

The country targets increased gas, hydro, and power generation capacity with renewable energy of other forms, as shown in Table 8.3-2. As the table suggests, PNG targets the development of renewable energy for power generation fivefold larger than the present scale of electricity supply by 2030, and a reduction of the diesel and coal generation capacity to 25 percent of the present scale (because the cost of oil and coal and currency exchange rate fluctuation will make them increasingly costly to operate). Other forms of electricity generation system that impose the use of costly imported oil are not included in the scope of national economic development.

Equally, nuclear power generation systems are not included in the Electric Industry Policy of PNG as viable electricity generation systems because energy imports and various technical impediments would be involved. Nuclear energy is thus excluded from the PPL policy, as well.

Table 8.3-2 Strategic Development of Electricity by 2030

Indicators	Baseline Information (2010)	2030 Target/Objective
Gas, Hydro and Other Renewable Generation	Gas: 72 MW Hydro: 217 MW Other: 56 MW	Gas: 390 MW Hydro: 1,020 MW Other: 500 MW
Diesel and Coal Generation	158 MW (grid-connected diesel generation)	Less than 40 MW capacity diesel generation and 30 KM coal generation
National Grid	Does not exist	All major towns and cities are to be in a national grid that will feed off of an electricity super-corridor

Source: "Papua New Guinea Development Strategic Plan 2010-2030 - Our Guide to Success"
Department of National Planning and Monitoring, March 2010

(4) Electric Industry Policy

1) Analysis of Current PPL Activities

The present operational flaws of PPL are well pointed out in the "Electricity Industry Policy" put out by the GoPNG in November 2011. These flaws are summarized as follows:

a. PPL's exclusive and monopolistic control of electricity supply in PNG has been leading to a lack of business development for a progressive power generation system based on the ever-increasing demand;

b. A lack of routine maintenance for generation and distribution assets and a lack of knowledge and skills necessary to discharge routine maintenance services lead to unreliability of power;

c. Unpaid electricity bills incapacitate PPL's ability to finance its activities;

d. Weathered and/or deteriorated equipment has not been replaced or renewed to date;

e. While additional power generation capacity necessary to sufficiently match the growing and future demands of the economy has been available, PPL has been unable to afford equipment renewals to date;

f. There is no explicit policy within the framework of PPL in terms of the CSOs for electricity supply to rural areas or effort to increase rural electrification scheme based on the present business model of PPL;

g. There has been no development of the electricity industry utilizing market mechanisms, i.e., encouraging the involvement of the private sector for competition; and

h. There have been chronic constraints on access to capital for improvement of overall operation carried out by PPL.

As a result, the access, reliability, and affordability of the electricity supply have suffered. The lack of appropriate management of the electricity supply has affected the operational downtimes of the manufacturing sectors, as well as other sectors of economy. There has thus been a significant slowdown in achieving the overall economic development goals of PNG.

2) Complications in Electric Industry Policy

The present-day electric industry policy toward complications caused by the government's policy towards the industry have been reviewed within the framework of the Master Plan Study. It is summarized as follows:

a. PPL has been granted exclusive rights to retail electricity to areas within 10 km reach of T/Ls; i.e., it does not extend further afield for rural electricity supply;

b. PPL has bilateral power purchasing arrangements with the owners of Baiune Hydro in Morobe Province and Kanudi Power Plant in POM. It also partners with Hides Petroleum Development in a joint venture in gas-fired generation. That is, PPL and the IPPs are not functioning as an integral part of the country wide-electricity supply system.

There appears to be a lack of detailed policy on the strategic electricity supply system. There is no clear policy, for example, to strengthen PPL's Ramu Grid System as a centralized network augmented by a number of decentralized generation systems. Such a network should consist of a mixture of commercially operating IPPs and socio-economically operating NGOs.

c. State provisions for CSOs add to the existing complication of the jurisdiction of PPL and IPPs in terms of geographic and financial limitations of each power producer. The CSOs have been a barrier for comprehensive access for the entry of new investors into the electricity sector. The GoPNG, meanwhile, has failed to deliver all of the CSOs without drawing from the financial capital, skills, and efficiencies of the private sector;

d. A generic definition of CSO adopted from a Commonwealth study in 1994 has been applied overall. Yet the concept of providing service "at a price less than the cost of production to some customers" has been a failure in PNG. This shortcoming stems from a lack of a proactive policy for providing incentives to encourage investment in rural areas.
It has so far been impossible to realize independent power producers who deliver CSO policy on behalf of the government without jeopardizing their commercial interests. PPL, on the other hand, carries out no rural electrification. PPL is against its own licensed business framework unless the entire cost of rural electrification is paid by other sources, usually government organizations dealing with rural electrification as an act of social development;

e. Competition will be opened when a suitable market has been identified or the need for it arises. When it does open, it will be determined by the Government in consultation with the relevant regulations. The electricity market segments, meanwhile, have been defined as 1) areas with loads of more than 10 MW; 2) areas with loads of less than 10 MW; and 3) PPL's exclusive supply areas for less than 10 MW within a radius of 10km from its distribution network.

f. Ownership on the use of indigenous resources for electricity generation lies with the government as well as the local indigenous people. These resources include land, water, geothermal energy, tidal and current energy from the oceans, natural gas, and other primary sources of energy.

g. The GoPNG will facilitate all arrangements that aim to have landowners participate in ventures with IPPs. Landowners can participate in business partnerships at an appropriate level for electric services with enhanced security and reliability.

8.3.5 Screening of the Initial Study Components

(1) Initial Screening Criteria

1) Policy, Plan and Program of PNG

Based on the above strategic electric power development policies of PNG, the selected study component for initial analysis of the preliminary SEA within the framework of the Study is shown in Table 8.3-3. The modes of electric power development listed in the left column are both theoretically possible and achievable with fully developed technologies in the real world. Details of the available primary energy are described in Chapter 3.

The preference for a power generation mode or a number of different modes in PNG significantly depends on the availability of primary energy sources. Policy of the GoPNG in terms of power generation is currently in favor of renewable energy or domestically available primary energy sources in order to reduce national expenditure.

As has clearly been stated in the Electricity Industry Policy, the GoPNG has no thinking of using nuclear energy or coal for thermal power generation. According to the government policies and economic development aims the government hopes to achieve by the Year 2030, hydropower is the most “Aimed-at-Mode” of electricity power generation, followed by: 1) natural gas that would be in full fledged production within a few years; 2) geothermal that there are high potential in the area where active volcanoes are located; and 3) biomass power generation where grassland is converted for fast-growing tree plantation for primary fuel, or the existing plantation’s waste is readily available.

On the other hand, the government policy has failed to focus more on the wind and solar energy that are also renewable energy. Their cost of installation is internationally getting to be lower in recent years. MDBs are also in favor of lending money for these power generation systems.

Table 8.3-3 Policy, Planning and Program Level of Power Development Strategy

No.	Mode of Power Development Scheme	Selection Criteria				
		Policy/Plan/Program of PNG			Technical Viability	Economic Viability
		EIP [1]	DSP [2]	FYPDP [3]		
1	Hydropower	+	+	+	+	+
2	Mini Hydropower	+	+	+	+	+
3	Oil Thermal	-	-	+/-	+	+/-
4	Natural Gas	+	+	+	+	+
5	Coal Thermal	-	-	+/-	+	+/-
6	Geothermal	+	+	+	+/-	+
7	Solar	+	+	+	+/-	+/-
8	Wind	+	+	+	+/-	+/-
9	Biomass-Plantation	+	+	+	+	+
10	Biomass-Plantation Tree Waste	+	+	+	+	+
11	Biomass-Waste	+	+	+	+	+
12	Biogass	+	+	+	+	+
13	Biofuel	+	+	+	+	+
14	Tidal/Current	+	-	-	+/-	-

Source: JICA Study Team based on the following papers:

1) EIP - "Electricity Industry Policy, Department of National Planning and Monitoring," PNG, November 2011;
2) DSP - "Papua New Guinea Development Strategic Plan 2010-2030 - Our guide to success,"" Department of National Planning and Monitoring, PNG, March 2010; and
3) FYPDP – "Fifteen Year power Development Plan: 2014-2028," PPL, PNG, 2014.

Note: "+" denotes that generally positive power development options are available; "-" denotes that the options available are generally negative; "+/-" denotes that both negative and positive options are available; "n/s" denotes not stated.

2) Economic Viability

The economic viability of each power generation mode has been assessed based on the following criteria:

a. The investors, notably MDBs assess the selected mode of power generation as the best way for the economic development of the country;

b. No costly, high-tech construction works and/or intricate operation and maintenance works are involved; and

c. Cost vs. revenue of each mode of electricity generation can remain in balance as a whole.

3) Technical Viability

The technical viability of each power generation mode has been assessed based on the following criteria:

a. Technology is presently available;

b. Construction technologies are available to introduce the power generation mode to PNG;

c. Fuel sources are readily available; and

d. Operation and maintenance technologies are available to help stabilize the electricity supply.

4) Environmentally Sound Technologies

a. Technologies that are friendly to the human and natural environments;

b. There are no tradeoffs in the quality of the socio-economic environment for the purpose of economic gain;

5) Indigenous Energy Resources

a. The use of Hydro Power should be promoted to the maximum extent, as its potential its estimated 14,000 – 15,000 MW;

b. Geo-thermal energy has strong potential in PNG and is accordingly promoted in a manner that conforms to accepted best international engineering and economic practices;

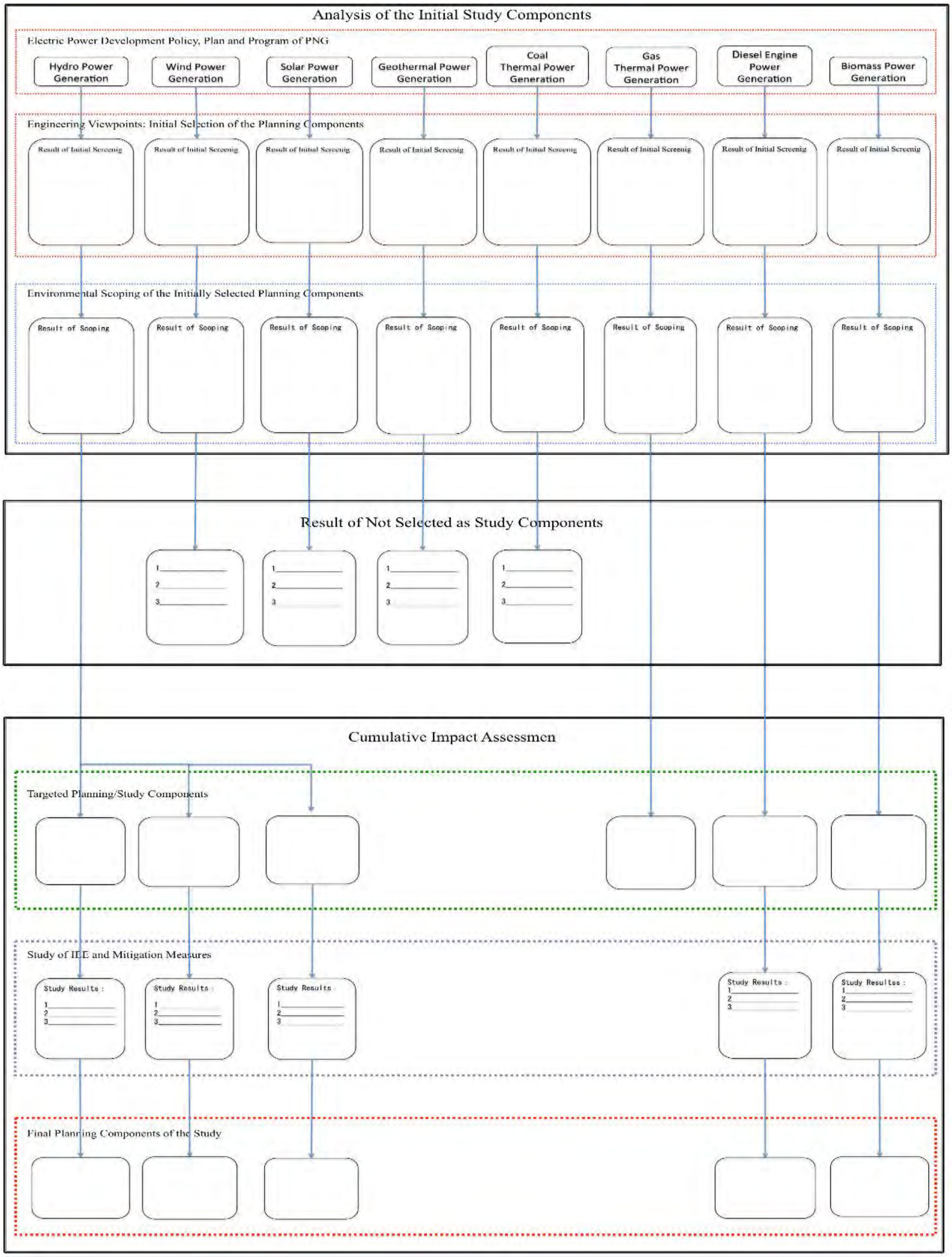
c. Solar power generation in PNG has high potential as a source of electricity in PNG in terms of the geography and topography of the country;

d. Wind power generation in PNG receives government support and facilitates the use of wind technology in the provision of electricity services, especially for rural areas;

e. Natural gas and indigenous gas can both be the main sources of electricity generation in PNG, especially the latter.

f. Ocean currents are also seen as a possible primary source of energy and have high potential in PNG, but the technology is not readily available.

Based on the above criteria, tidal and nuclear power generation systems have been left out during the initial screening process. Thus a flow chart of the initial process of SEA has been plotted out for all modes of power generation, as shown in Fig. 8.3-2.



Source: JICA Study Team based on FYPDP and "Papua New Guinea Development Strategic Plan 2010-2030 - Our Guide to Success," Department of National Planning and Monitoring, March 2010

Fig. 8.3-2 Form of Flow Analysis: Initial SEA Analysis of the Study Components

(2) Summary of Initial Screening

The initial screening result from the engineering perspectives as described in the previous section's flow chart is thus summarized as follows;

1) Hydropower/Mini-hydropower Generation

- An extensive river system is found in PNG for hydropower projects.
- Water is an indigenous form of renewable energy for power generation.
- Relatively low greenhouse gas emission during the operation for power generation.
- The carbon footprint of the hydropower generation is lowest while its construction works is still accounted for as the greenhouse gas emission.

2) Diesel Engine/Oil Thermal Power Generation

- Small units can be swiftly installed.
- Shortages of electricity can be supplemented for short periods in limited areas.
- The cost of diesel oil drives up operational costs to high levels.
- The use of diesel oil is not viable from environmental perspective viewpoints as carbon footprint is very large.

3) Natural Gas Thermal Power Generation

- Natural gas deposits exist in PNG.
- Natural gas is a relatively environment-friendly energy.
- While construction cost is comparatively high, the carbon footprint is relatively low comparing to conventional oil thermal/diesel generators.
- Natural gas is an indigenous energy.

4) Coal Power Generation

- There are no viable coal deposits in PNG.
- No coal import plan is included in the economic development plan of PNG.
- The use of coal for thermal power generation is not viable from an environmental perspective.

5) Geothermal Power Generation

- Karkar Island in Madang Province and Long Island in Morobe Province contain geothermal energy.

- These islands' potentials have not been fully studied and might be impossible to develop to an operational level by 2030.
- Geothermal energy exploration and feasibility study are relatively time consuming and costly.
- Geothermal power generation is a relatively clean and indigenous form of renewable energy.

6) Solar Power Generation

- Madang/Morobe coastal area is prospective.
- Solar power is a clean and indigenous form of renewable energy.
- Relatively wide land area is necessary if built in a large scale.
- The carbon footprint is one of the lowest modes of power generation while its materials and construction works still accounted for as the greenhouse gas emission.

7) Wind Power Generation

- Further study by the WB has to be reviewed before wind energy is added to the Master Plan Components.
- Wind energy is a clean and indigenous form of renewable energy.
- Relatively wide area of land is necessary if built inland.
- The carbon footprint is one of the lowest modes of power generation while its materials and construction works still accounted for as the greenhouse gas emission.

8) Biomass – Tree Plantation Power Generation

- A study on energy sources in Markham Valley of Morobe Province is planned.
- It is an indigenous form of renewable energy.
- The carbon footprint is relatively high. Unless otherwise the plantation area exceeds more than the required area of carbon sequestration, no carbon neutrality is achieved;
- Wide unused grasslands are reforested to counterbalance the carbon footprint

9) Biomass - Tree Plantation Waste Power Generation

- It is an indigenous form of renewable energy derived from the waste of oil palm, coconuts and sugarcane plantations.
- The carbon footprint is relatively high. Unless otherwise the plantation area exceeds more than the required area of carbon sequestration, no carbon neutrality is achieved;
- Relatively high carbon footprint is a drawback.

- It might enhance plantation agriculture to some extent.

10) Biomass - Waste Power Generation

- It is an indigenous form of renewable energy.
- The carbon footprint is relatively high.
- Unless it is located in the vicinity of urban area, solid waste as primary energy is not obtainable.

11) Biogas Power Generation

- There is no industrial use of biogas readily produced in PNG.
- Scale of operation is not suitable for Ramu Grid System.
- The carbon footprint is relatively high.

12) Biofuel Power Generation

- There is no industrial use of biogas readily produced in PNG.
- The carbon footprint is relatively high.
- Scale of operation is not suitable for Ramu Grid System.

13) Ocean Energy Power Generation

- There is no investigation carried out in PNG.
- Other indigenous renewable energy has to be fully exploited before turning to ocean energy as primary energy source.
- The carbon footprint is relatively low.
- Cost of construction and maintenance technology will have to be fully developed not only in PNG but also in other part of the world.

8.3.6 Scoping of the Initial Study Components

(1) Analytical Steps

The analytical steps of the SEA are as follows:

a. Consolidation of the outline of key environmental and socioeconomic issues of each study component;

b. Identification of environmental, socioeconomic issues of past and future trends considered important by local stakeholders (this step is important for the electricity development scheme as a whole);

c. Outline of the impacts on key environmental and socioeconomic conditions "With" and "Without" the electricity power development plan;

d. Identification and assessment of critical strategic concerns associated with the electric power development plan in Ramu Grid System area in terms of the: i) Provincial Economic Development; ii) Environmental and Socioeconomic Cost Bearing; iii) Net Biodiversity Gain; iv) Well-Being of the Indigenous People; v) Multiple Use of the Planning Components; and vi) Safe and Stabilized Operations.

e. Formulation of a comprehensive set of mitigation measures to prevent, reduce or offset any negative impacts from the proposed study components and enhance any expected positive impacts.

(2) Scoping Parameters

The scoping for the Study focuses on key impact issues on the natural and socioeconomic environment, to evaluate broadly defined environmental impacts. The same scoping exercise is performed for alternative scenarios related to the formulation of the study components of the Ramu Grid System Power Development Master Plan, which covers a number of prospective plans for various types of electric power generation plans.

As stated before, this SEA study takes an "Impact-centered SEA" approach to assess critical strategic concerns. The scoping parameters of the selected study components are thus defined as follows:

a. Provincial Economic Development: Provincial economies should not be left worse off by the planning components;

b. Environmental and Socio-economic Cost Bearing: Electricity suppliers should pitch in to meet all of the direct and indirect environmental and socio-economic costs of the planning components;

c. Net Biodiversity Gain: Avoid and minimize harm to biodiversity and introduce a biodiversity offset plan;

d. Well-Being of the Indigenous People: Reduce the poverty and increase the food security of the indigenous people; and

e. Safe and Stabilized Operations: Make institutional arrangements to manage droughts and floods and prepare for disasters and a stabilized supply of electricity.

(3) Results of Scoping

Beyond the initial screening results on engineering perspectives, various modes of power generation have been selected through the environmental scoping coupled with assessments of engineering and economic viability. The results are summarized as follows:

1) Hydropower/Mini-hydropower Generation

a. Use of the existing hydropower potential is important for the socio-economic development of the eight provinces connected to the Ramu Grid System as centralized power generation system as well as for the local governments as de-centralised power generation system;

b. Existing hydropower plants must be continuously used and upgraded in order to make maximum use of river waters for Ramu Grid System;

c. Hydropower generation produces no pollutants whether the scale of operation is large or small;

d. The existing riparian environment would be negatively affected, as the natural flow of the river water would be disrupted and the river regime would be permanently changed regardless of the scale of operation;

e. Hydropower is a familiar mode of electricity generation for which PPL would have readily available technology and maintenance as well as the staff capacity and ability. Although the number of staff is small as present, employment opportunities for the new power stations would be created over time;

f. The carbon footprint is relatively small (See Table 8.7-1);

g. While PPL's operation might not contribute to the rural electrification, mini-hydro power generation should contribute to the rural area's socio-economic conditions;

h. Relatively small afforestation area has to be developed in order to gain net biodiversity;

i. Population for rural area should be greatly benefited from the mini-hydro power generation system; and

j. Depending on the scale of drought, such as ENSO, hydropower system is prone to the lack of rainfall i.e. some sort of back-up system has to be considered.

2) Diesel Engine/Oil Thermal Power Generation

a. Diesel generators are relatively small system that it is possible to contribute to provincial economy at the time of needs;

b. The existing diesel engine power generation system must be continuously used for years to come until the major electricity generation system can take over i.e. dwindling use of diesel generator should in general contribute to gain environmental and socio-economic cost;

c. There is no net biodiversity gain as long as the system is continuously used;

d. It is the system used in urban area and no rural population is benefited from the system;

e. The cost of oil is relatively high, hence the operation cost should reflect the electricity tariff; and

f. While relatively safe and stabilized operation is possible, there is a high CO_2 emission as a negative factor (See Table 8.7-1).

3) Natural Gas Thermal Power Generation

a. Natural gas is a domestically available source of fuel for power generation that it creates a large number of employments for the rural population;

b. Natural gas is a fossil fuel source of energy that it will run out at a time in the future;

c. At a time of disasters events, the environmental cost will become tremendously large. It will also cause havoc to the rural economy;

d. The carbon footprint is relatively large comparing to oil thermal system and there is no net biodiversity gain (See Table 8.7-1);

e. There is no well being directly provided for the rural population except for the creation of employment opportunities of unskilled labor; and

f. Industrial safety and stabilized operation depends much on the elaboration of industrial safety standard, highly skilled foreign engineers and trained personnel of PPL that it would take time until local staff can operate safely and efficiently.

4) Coal Thermal Ppower Generation

a. This mode of power generation is not familiar in PNG. If realized, however, a large scale of construction works as well as the operation of it will create a number of jobs for the urban population;

b. No coal is domestically available, nor are imports planned. If realized, while there is no direct environmental cost incurred, there will be some sort of negative socio-economic impacts on the urban environment in terms of pollution control;

c. Emission of CO_2 is a largest negative factor for air quality and health conditions (See Table 8.7-1);

d. There is no contribution to the well being of the indigenous people; and

e. Safe and stabilized operation of the coal thermal plant has to be elaborated by foreign engineers until such time as local engineers and skilled laborers acquire appropriate knowledge.

5) Geothermal Power Generation

a. Government policy has been laid out, while no in-depth study has yet been performed. If realized, it will contribute to the provincial economy;

b. Technology for investigation, construction and operation and maintenance must be introduced under certain geologic conditions i.e. environmental cost can be tremendously high while socio-economic benefit during implementation and operation and maintenance could bring about the benefit to the local population;

c. A relatively large negative impact on the landscape/aesthetic perspectives of the thermal plant would have to be considered because of the piping, steam and smoke stacks, etc. in the middle of natural environment;

d. Net biodiversity gain cannot be expected unless relatively large afforestation program is carried out;

e. Geothermal is an indigenous form of renewable energy for electric power generation;

f. There is no direct and positive impact induced by the power plant to the indigenous people;

g. Location of the plant can be remote areas where relatively scarcely populated while a group of people could claim for customary land ownership; and

h. The carbon footprint is relatively large (See Table 8.7-1).

6) Solar Power Generation

a. Solar power is a pollution-free renewable source of energy and MDBs are in fabor of funding the system;

b. No in-depth study has yet been performed in PNG on large-scale power generation by solar energy;

c. If realized in large scale, provincial economy could gain momentum while relatively large land area has to be occupied by the system;

d. If realized to install on the roof-top of individual households with electricity purchase agreement, not only individual households but also the rural economy as a whole will be greatly enhanced;

e. Environmental and socio-economic cost bearing could probably be in the manner of win-win situation between individual households and PPL as electric purchaser if individual household installed solar power system and PPL purchased electricity from each household;

f. Net biodiversity gain in the case of individually installed system could be none while industrial scale operation has to sacrifice relatively large area of land;

g. There is no clear-cut policy in favor of solar power generation to date i.e. administrative endeavor and commitment is needed;

h. If individual household installation of solar power generation system was realized, rural population will be greatly benefitted;

i. The carbon footprint is medium (See Table 8.7-1); and

j. Solar power generation system could probably be the most safe and stabilized mode of power generation.

7) Wind Power Generation

a. Wind power generation system is renewable source of energy that MDBs are in favor of funding the system;

b. Wind power technology remains immature in PNG and no in-depth study has been performed to date;

c. If realized on-shore, relatively wide area has to be provided by the local government for construction as well as the operation and maintenance;

d. If realized off-shore, sophisticated operation and maintenance works has to be provided by PPL;

e. There is no clear-cut policy for this mode of power generation, despite its advantages as a pollution-free and renewable energy;

f. In the case of on-shore development, net biodiversity gain could be negative while it could be relatively small loss in the case of off-shore system;

g. There is no significant negative or positive impact on the well being of indigenous people;

h. Safe operation depends much on the level of skillfulness of PPL while stabilized operation depends much on the prevailing wind energy; and

i. The carbon footprint is relatively small (See Table 8.7-1).

8) Biomass – Tree Plantation Power Generation

a. Unused grassland is afforested if tree plantation was implemented for producing primary energy. Relatively flat and wide area of land is occupied for fast growing trees while the area could be used for agriculture. This depends much on the long term economic analysis of the local area;

b. Depending on the type and rate of biomass used for this mode of power generation, plant species as well as the consequences of food chain within the ecosystem in the surrounding area including indigenous population making use of the near-by forest area could face negative impacts;

c. As tree plantation area exceeds more than the obligation of compensating the carbon sequestration, net biodiversity gain is achieved;

d. Well being of the indigenous people is unknown as it depends much on the way indigenous forest of the customary owned land is used in relation to the afforestation program of the power generation system i.e. unknown factors should be closely monitored for the lifetime of the plant;

e. Safe and stabilized operation depends much on the level and time of the development of skills of the newly introduced mode of power generation over time i.e. no established skill is yet to develop among the staff of the power plant operators;

f. Biomass power is an indigenous form of renewable energy while the carbon footprint is very large, although a very large area of afforested plantation can cancel out most of the carbon footprint; and

g. The carbon footprint is relatively small (See Table 8.7-1).

9) Biomass - Tree Plantation Waste Power Generation

a. Generally the above analysis of "Biomass-Tree Plantation" is applied;

b. Provision of tree waste for primary energy supply depends much on the level of the development of harvesting skills of plantation. Thus stabilized operation might get affected depending on availability of the quantity of tree waste.

10) Biomass - Waste Power Generation

a. Solid waste generated in the urban environment is the only reliable source of power generation. If realized, urban waste dump area could be somewhat tidied up i.e. it contributes to improve urban environment;

b. Environmental and socio-economic cost of solid waste management could be partly born by the power generator;

c. There is no biodiversity gain;

d. There is no negative or positive contribution to the well being of the indigenous people;

e. The carbon footprint is relatively high (See Table 8.7-1);

f. Unless it is located in the vicinity of urban area, solid waste as primary energy is not obtainable i.e. stabilized operation might not be viable at this stage of urbanization in PNG.

11) Biogas Power Generation

a. There is no industrial use of biogas readily produced in PNG. In Germany, 4 MW of biogas plant processing 90,000 ton of waste meat is in operation. If realized in PNG, it would be a great contribution to the local economy;

b. Environment and socio-economic cost bearing of the power generation can be achieved to a large extent;

c. There is a net biodiversity gain although some 10,000 ton of CO_2 eq. gas emission reduction could be achieved with well-planned plant of 3-4 MW generator;

d. There could be positive contribution to the well being of the indigenous people if massive domestic animal rearing and meat processing plant producing a large amount of meat including droppings was achieved;

e. The carbon footprint could be made very small if well-planned large scale operation was realized (See Table 8.7-1); and

f. Safe and stabilized operation is yet to be elaborated until such time PPL obtain appropriate knowledge of operation and maintenance and that it involves local population and meat farms.

12) Biofuel Power Generation

a. Biofuel production requires a large amount of agricultural crops, sugar cane being the most popular. If realized, local economy, both sugar cane plantation for instance and other industry should receive much benefit;

b. Environment and socio-economic cost bearing of the power generation can be achieved to a large extent;

c. Net biodiversity gain is unknown to date;

d. Well being of the indigenous people could be achieve if collection of massive agricultural products are well-organized;

e. Safe and stabilized operation is yet to be elaborated until such time PPL obtain appropriate knowledge of operation and maintenance and that it should involve local population as well as vegetable farms and plantation farms; and

f. Carbon footprint could be relatively low (See Table 8.7-1).

13) Ocean Energy Power Generation

a. There is no investigation carried out in PNG for this mode of power generation. If realized, little contribution to the provincial economic development is achieved unless electricity is exclusively supplied to the local area;

b. Other indigenous renewable energy has to be fully exploited before turning to ocean energy as primary energy source. If realized, environmental cost bearing could be achieved by the tidal energy power generation while there is little socio-economic cost bearing as the project takes place in the ocean;

c. Net biodiversity gain has to be assessed depending on the locality of ocean;

d. There is no positive or negative contribution of the power generation system to the well being of the indigenous people in general terms;

e. The carbon footprint could be relatively low (See Table 8.7-1); and

f. Cost of construction and maintenance technology will have to be fully developed not only in PNG but also in other part of the world i.e. there is a number of unknown factors for safe and stabilized operations.

8.4 STUDY COMPONENTS AND ANALYSIS OF ALTERNATIVES AS STRATEGIC OPTIONS

8.4.1 Formulation of Prospective Study Components

As a result of scoping, prospective power plants as study components of the Master Plant based on the normal electricity demands are shown in Table 8.4-1.

Table 8.4-1 Selected Study Components Based on Normal Demands

	Fuel Type	Province	District	Power Plant	Rated Capacity (MW)	Actual Output (MW)
Existing Power Plants	Diesel	Morobe	Lae	Milford	7.8	5.4
		- ditto -	- ditto -	- ditto -	15.5	10
		- ditto -	- ditto -	- ditto -	1.7	1.4
		- ditto -	- ditto -	Taraka	10.1	7
		- ditto -	- ditto -	(Lease)	13.2	9.6
		Madang	Madang	Madang	4.6	3
		- ditto -	- ditto -	- ditto -	1.5	1
		- ditto -	- ditto -	- ditto -	8.5	7.6
		Southern Highlands	Mendi-Munihu	Mendi	1.4	1
		Enga	Wabag	Wabag	0.8	0.6
		- ditto -	- ditto -	- ditto -	0.7	0.5
		- ditto -	- ditto -	(Lease)	1.1	1
		Eastern Highands	Ramun	Ramn Aux	0.8	0.6
		Western Highlands	Mul-Baiyer	Paunda Aux	0.1	0.05
		Eastern Highlands	Goroka	Goroka	2.9	2.7
		Western Highlands	Kundiawa Gembogi	Kundiawa	1.4	1.2
		Morobe	Markham	Lae G/T	26.0	26
	Hydropower	Morobe	Bulolo	Baiune PNGFP (IPP)	14.9	8
		Western Highlands	Mul-Baiyer	Paunda #1	6.0	5
		- ditto -	- ditto -	Paunda #2	6	5
		Eastern Highlands	Obura Wonenara	YTOD #1	9.3	6.1
		Eastern Highlands	Obura Wonenara	YTOD #2	9	(6.1)
		Eastern Highlands	Obura Wonenara	Ramu 1 #1	15.0	50
		Eastern Highlands	Obura Wonenara	Ramu 1 #2	15.0	
		Eastern Highlands	Obura Wonenara	Ramu 1 #3	15.0	
		Eastern Highlands	Obura Wonenara	Ramu 1 #4	16.5	25
		Eastern Highlands	Obura Wonenara	Ramu 1 #5	16.5	
Prospective Power Plants	Natural Gas	Southern Highlands	Nipa Kutubu	Highland G/T	-	30-60
	Diesel Oil	Madang	Munum	Munum	30	30
	Biomass	Morobe	Markham	Markham Valley	30	30
	Thermal	-	-	Additional Thermal 1	30	30
	- ditto -	-	-	Additional Thermal 2	30	30
	Hydropower	Morobe	Finschafen	Mongi-Bulum	116	60
		Eastern Highlands	Obura Wonenara	Ramu 2	180	180
		Western Highlands	Mul-Baiyer	Kaugel	84	56
		Morobe	Bulolo	Baime (PNGFP)	10	8
		Madang	Gowar	Gowar	54	43.5

Note: 1) "G/T" denotes "Gas Turbine"

Source: JICA Study Team

8.4.2 Analysis of Alternatives as Strategic Options

Within the framework of SEA, a number of options are analyzed to throw the best option into relief. This analysis should help guide PPL on critical issues, whichever strategy is adopted. Fig. 8.4-1 summarizes the process of SEA adopting four hypotheses for the analysis of alternatives and the course of action to be taken when each alternative is selected.

Strategic Option	Course of Action for Each Strategic Option
1. Zero Option - Anti-market Demand/Counter Development Option	1 Manage electricity supply with the current electricity supply system of the Ramu System 2 Explore possibility of improving the current electricity supply system 3 Analysis if the current electricity supply system can achieve country's economic development goal of 2030 upon improvement 4 Consider to elaborate to improve organizational structure of PPL 5 Review effectiveness of the current environmental management plan
2. No-hydropower/Thermal Option - High Carbon Footprint Option	1 Accelerate investment in biomass, geothermal and natural gas thermal power generation 2 Develop alternative power sources for electricity generation other than currently identified sources 3 Agree to reconsider the goal of strategic economic development of the country without hydropower option 4 Improve performance, safety and impact management designs of thermal generation option to comply with the current standards 5 Review effectiveness of the environmental management and social considerations currently in effective in the country as well as to be imposed by donors 6 Recognize the importance of the natural and human resources as well as the technology mobilized for variousmode of thermal power generation 7 Develop organizational capacity to regulate, monitor, enforce compliance of the management of environment likely to be affected by thermal power generation 8 Develop appropriate institutional capacity in dealing with the technology of thermal power generation
3. No-thermal/Hydropower Option - Low Carbon Footprint Option	1 Accelerate investment in a number of hydropower generation system in order to maintain mainstream and backup system all at the same time 2 Develop alternative backup power sources for electricity generation other than thermal power generation system 3 Reconsider the goal of strategic economic development of PNG without thermal power genertion development scheme 4 Improve performance, safety and impact management of hydropower generation system in order to up-grade the current services of electricity supply 5 Review effectiveness of the environmental management and social considerations currently in effective in the country as well as to be imposed by donors 6 Empower the human resources for the environmental management of the area around reservoirs and power plants 7 Develop organizational capacity to regulate, monitor, enforce compliance of the management of environment likely to be affected by the hydropower
4. Reneewable Energ Option - Medium Carbon Footprint Option/Pro-Market and Development Option	1 A combination of the course of action taken for "Hydropower Option" and "Solar/Wind Power Option" 2 Promotion of investment by MDBs in favor of investment for solar and wind power generation system 3 Achievement of which significant contribution to fight against climate change.

Source: JICA Study Team

Fig. 8.4-1 Patterns of the Analysis of Alternatives as Strategic Options

8.4.3 Analysis of Strategic Combination of Alternative Options

(1) Zero Option

In Zero Option as per Fig. 8.4-2, no further development of the electric power supply is carried out whatsoever, with a view to keeping the current conditions of the natural and social environments intact.

Future Development of Power Supply System

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)
Natural Gas	Highland G/T	-	30-60
Diesel Oil	Munum	30	30
Biomass	Markham Valley	30	30
Thermal	Additional Thermal 1	30	30
- ditto -	Additional Thermal 2	30	30
Hydropower	Mongi-Bulum	116	60
	Ramu 2	180	180
	Kaugel	84	56
	Baime (PNGFP)	10	8
	Gowar	54	43.5

No Project Option

Consequences

No Project Option
It is obvious that the people, commerce and industries in PNG are acutely in need of additional electricity for improvement of the standard of living i.e. Zero Option is against economic development policy of PNG

Source: JICA Study Team

Fig. 8.4-2 Analysis of Strategic Combination of Alternatives – Zero Project Option

In view of the No Project Option, the following is noted:

a. The importance of the Ramu Grid System in conjunction with the population along the T/L has to be accounted for in terms of its contribution to the PNG economy;

   i. The eight provinces connected to the Ramu Grid System have a combined total population of 4,023,590 persons. This is 55% of the total PNG population of 7,275,324 persons.

   ii. The districts that the Ramu Grid System T/L passes through in the eight provinces have a combined total population of 2,117,265 persons, as shown in Table 8.4-2. Thus, 29% of the total population of the country is concentrated in the area subject to the Master Plan Study.

b. As a consequence of the "No-Project Option," a great number of people in PNG will be left behind without appropriate infrastructure development in terms of clean running water, good lighting systems, education, healthcare, and anything else dependent on a stable electricity supply;

c. Industries concentrated in the area along the T/L of the Ramu Grid System in Lae, Madang and Goroka will be unable to maintain their production systems, employment, and economic growth in the "No-Project Option" scenario. PNG's GDP cannot grow in this scenario, while the population should naturally grow over time. Consequently, the overall standard of living cannot be raised for the population living along the Ramu Grid System area;

d. The "No-Project Option" is contentious against the country's Strategic Development Plan for 2010- 2030, the Electric Industry Policy, and Vision 2050; and

e. It is the option that there is no CO_2 equivalent gas emission.

Table 8.4-2 District Population along the Transmission Line of the Ramu Grid System

1 Morobe Province

	District	No. of Population	No. of Households
1	Bulolo	101,568	20,865
2	Huon Gulf	77,564	16,075
3	Lae	148,934	21,901
4	Markham	62,495	13,352
5	Nawae	44,556	9,030
	Total	435,117	81,223

2 Madang Province

	District	No. of Population	No. of Households
1	Madang	110,978	18,996
2	Usino Bundi	60,807	10,372
	Total	171,785	29,368

3 Eastern Highlands Province

	District	No. of Population	No. of Households
1	Goroka	103,396	23,565
2	Henganofi	62,904	15,191
3	Kainantu	126,248	28,686
4	Obura/Wonenara	39,919	8,126
	Total	332,467	75,568

4 Southern Highlands Province

	District	No. of Population	No. of Households
1	Ialibu / Pangia	63,478	12,821
2	Nipa / Kutubu	147,005	22,682
	Total	210,483	35,503

5 Western Highlands Province

	District	No. of Population	No. of Households
1	Mt Hagen	123,299	25,822
2	Mul / Baiyer	83,036	19,387
3	Tambul / Nebilyer	75,499	16,969
	Total	281,834	62,178

6 Jiwaka Province

	District	No. of Population	No. of Households
1	Anglimp / South Waghi	194,109	35,086
2	North Waghi	78,499	15,892
	Total	272,608	50,978

7 Chimbu Province

	District	No. of Population	No. of Households
1	Chuave	39,092	10,461
2	Kerowagi	93,107	16,616
3	Kundiawa/Gembogl	78,521	14,327
4	Sina Sina/Yonggomugl	56,805	11,790
	Total	267,525	53,194

8 Enga Province

	District	No. of Population	No. of Households
1	Wabag	73,649	12,736
2	Wapenamanda	71,797	14,805
	Total	145,446	27,541

	No. of Population	No. of Households
Grand Total	2,117,265	415,553

Source: JICA Study Team Based on the National Census of 2011

(2) No-Hydro Power Option with Implementation of Thermal Power Generation

In this option, no hydropower generation of electric power is carried out whatsoever, while other indigenous energy is exploited for electricity generation as per Fig. 8.4-3. The following is noted:

a. No land disputes should occur, as no parts of the mountainous areas are inundated as a result of hydropower exploitation;

b. No land disputes should occur, as no transmission of electricity to large consumer centers is necessary;

c. No T/Ls are exposed to damages caused by floods, flash mud flows, or heavy rainfalls;

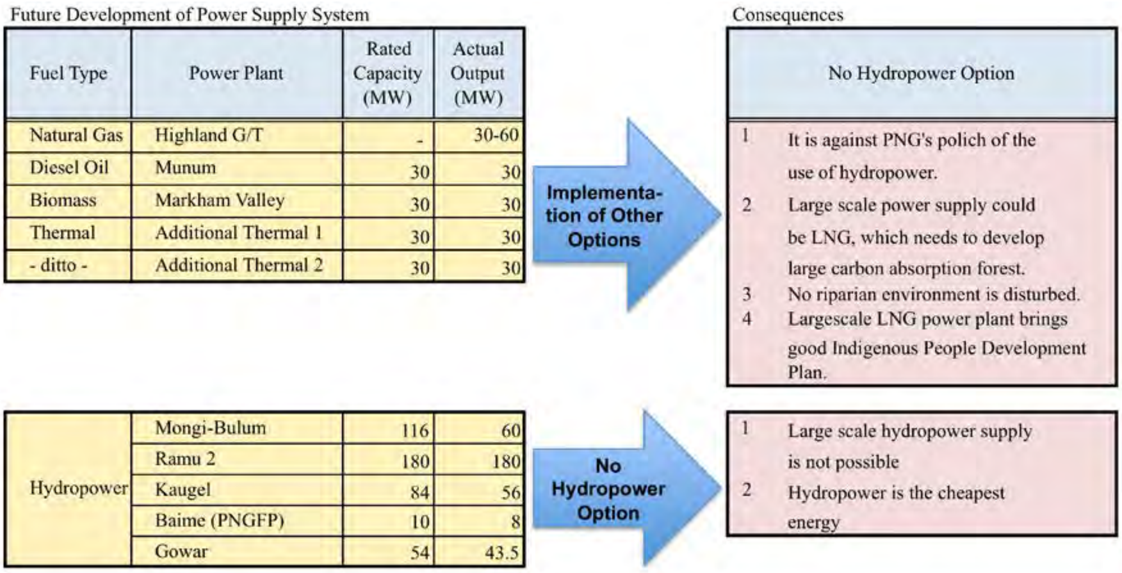
d. No riparian environments are changed downstream or upstream of the project;

e. Natural gas is an indigenous energy, but it is not renewable in the long term. The T/L to the nearest consumer centers is relatively long, requiring periodical and effective maintenance works carried out by experienced engineers;

f. Biomass fuel is limited and the regeneration of biomass is relatively slower than that of hydropower, but it can be located nearby consumer centers;

g. Any thermal power generation system involving importation of primary energy runs against the policy and budget of the country; and

h. Natural gas and biomass energy may be insufficient to support the rapid growth of industries in the Ramu Grid System in the future.



Source: JICA Study Team

Fig. 8.4-3 Analysis of Strategic Combination of Alternatives – No Hydropower Option

Further, as the above option is carried out, obligation of afforestation in order to compensate CO_2 equivalent gas emission by power generation is calculated as is shown in Table 8.4-3. These values are the highest among other options.

Table 8.4-3 Required Afforestation Area for No Hydropower Option

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)	Life Cycle (Year)	GHG Emission (cCO2 ep/kwh)	Required Afforestation Area (ha for lifetime)
Natural Gas	Highland G/T	-	30-60	30	490	16,789
Diesel Oil	Munum	30	30	30	893	15,299
Biomass	Markham Valley	30	30	30	230	3,940
Thermal	Additional Thermal 1	30	30	30	893	15,299
- ditto -	Additional Thermal 2	30	30	30	893	15,299

Note: GHG - Greenhouse Gas

Source: JICA Study Team

(3) No-Thermal Power Option with the Implementation of Hydropower

As is shown in Fig. 8.4-4, another option is to carry out hydropower generation for the Ramu Grid System while not generating electric power from any other indigenous energy i.e. to take an approach opposite to that explained in Section 8.6.3 above. The following is noted:

a. Renewable energy is available in sufficient abundance to cater to the future growth of industry within the Ramu Grid System area.

b. Hydropower is an indigenous and naturally renewable energy that PNG is encouraged to exploit as per its policies toward electricity supply for economic growth;

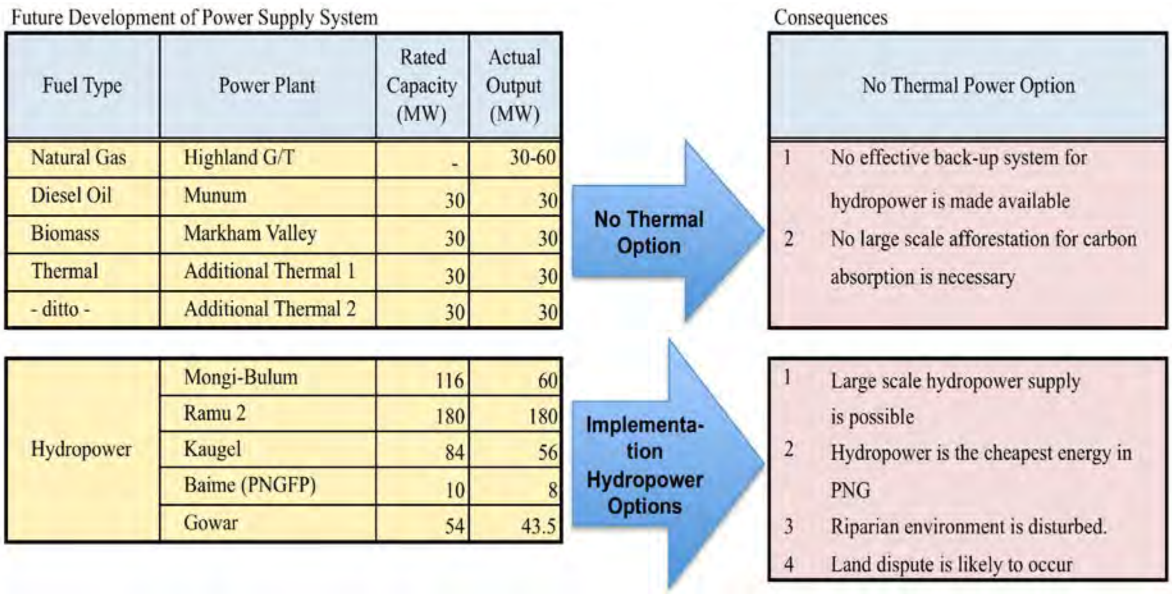
c. PNG's hydropower potential is believed to be 14,000 MW, excluding small-scale hydropower potential, according to a WB estimate in 1994. At present, PPL has developed approximately 220 MW. It would be worthwhile to further exploit the hydropower potential of the country;

d. Relatively scarcely or non-populated areas are inundated as a result of hydropower exploitation;

e. The river ecology is permanently changed upstream and downstream. The extent of the change, or whether it is significant, depends heavily on the physical and biological characteristics of the river;

f. The relatively long distance required for electricity transmission to the largest consumer centers is disadvantageous, as the T/Ls are exposed to damages from floods, flash mud flows, and heavy rainfall in places;

g. Periodical and effective maintenance with experienced maintenance staff is necessary for the T/Ls and power plants;


Future Development of Power Supply System

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)
Natural Gas	Highland G/T	-	30-60
Diesel Oil	Munum	30	30
Biomass	Markham Valley	30	30
Thermal	Additional Thermal 1	30	30
- ditto -	Additional Thermal 2	30	30

Hydropower	Mongi-Bulum	116	60
	Ramu 2	180	180
	Kaugel	84	56
	Baime (PNGFP)	10	8
	Gowar	54	43.5

Consequences

No Thermal Power Option
1 No effective back-up system for hydropower is made available
2 No large scale afforestation for carbon absorption is necessary

1	Large scale hydropower supply is possible
2	Hydropower is the cheapest energy in PNG
3	Riparian environment is disturbed.
4	Land dispute is likely to occur

Source: JICA Study Team

Fig. 8.4-4 Analysis of Strategic Combination of Alternatives – No Thermal Power Project

h. The riparian environment is permanently altered as hydropower plants are created. The extent of the changes depend on the controlled flow of river waters, physical and biological characteristics of the river;

i. Sedimentation of the dam is inevitable; i.e. a number of anti-sedimentation measures or periodical dredging should be carried out for long-term use of dam;

j. Carbon footprint for the thermal power plants are nullified; and

k. At the time of maintenance works or breakdown of hydropower plant, there will be no backup system for electricity supply i.e. hydropower plants alone will not function in view of the up-coming industrialization of the urban areas within the Ramu Grid System area.

Further, as the above option is carried out, obligation of afforestation in order to compensate CO_2 equivalent gas emission by power generation is calculated as is shown in Table 8.4-4. These values are the lowest among other options.

Table 8.4-4 Required Afforestation Area for No Thermal Option

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)	Life Cycle (Year)	GHG Emission (cCO2 ep/kwh)	Required Afforestation Area (ha for lifetime)
Hydropower	Mongi-Bulum	116	60	70	24	1,919
	Ramu 2	180	180	70	24	5,756
	Kaugel	84	56	70	24	1,791
	Baime (PNGFP)	10	8	70	24	256
	Gowar	54	43.5	70	24	1,391

Source: JICA Study Team

(4) Renewable Energy Option – Low Carbon Footprint/Pro-market Option

This option is similar to "No-Thermal Power Option with the Implementation of Hydropower" as explained above except for which solar or wind power generation is added as per Fig. 8.4-5. Thus the following is noted:

a. In addition to the pros and cons of the option of the "No-Thermal Power Option with the Implementation of Hydropower" as explained above, a new type of renewable energy sources are introduced to PNG. In view of the era of global climate change, it is essential for PPL to get exposed to brand new technology of solar and/or wind power generation system;

b. Entire power generation system in PNG will be based on the renewable source of energy and that the carbon footprint of the entire power generation remains very low;

c. This is an option favorable to fight against the global climate change;

d. Solar and/or wind energy system is also in favor of investment made by MDBs in recent years;

e. Reliability of wind energy has to be closely studied in comparison to solar energy system as well as the hydropower generation system; and

f. If carried out as "One-off Large Industrial System", solar and/or wind power generation system will require relatively large flat land area, which otherwise could be utilized for agricultural and industrial development.

Future Development of Power Supply System

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)
Natural Gas	Highland G/T	-	30-60
Diesel Oil	Munum	30	30
Thermal	Additional Thermal 1	30	30
- ditto -	Additional Thermal 2	30	30

No Thermal Plant Implemented

Consequences

No Thermal Power Option	
1	No effective back-up system for hydropower is made available
2	No large afforestation for absorption of GHG is necessary

Hydropower	Mongi-Bulum	116	60
	Ramu 2	180	180
	Kaugel	84	56
	Baime (PNGFP)	10	8
	Gowar	54	43.5
Biomass	Markham Valley	30	30

Note: GHG denotes "Greenhouse Gas".

Implementation of Renewable Enrgy Options

1	Large scale hydropower supply is possible
2	Hydropower is the cheapest energy in PNG
3	Riparian environment is disturbed.
4	Land dispute likely to occur
5	Sedimentation of dam likely to occur
6	Relatively small GHG emission
7	MDBs are in favor of investing solar or wind power plants

Source: JICA Study Team

Fig. 8.4-5 Analysis of Strategic Combination of Alternatives – Renewable Energy Option

Further, as the above option is carried out, obligation of afforestation in order to compensate CO_2 equivalent gas emission by power generation is calculated as is shown in Table 8.4-4. These values are second lowest among other options.

Table 8.4-5 Required Afforestation Area for Renewable Energy Option

Fuel Type	Power Plant	Rated Capacity (MW)	Actual Output (MW)	Life Cycle (Year)	GHG Emission (cCO2 ep/kwh)	Required Afforestation Area (ha for lifetime)
Hydropower	Mongi-Bulum	116	60	70	24	1,919
	Ramu 2	180	180	70	24	5,756
	Kaugel	84	56	70	24	1,791
	Baime (PNGFP)	10	8	70	24	256
	Gowar	54	43.5	70	24	1,391
Bio-mass	Markham Valley	30	30	30	230	3,940

Source: JICA Study Team

(5) Conclusions

1) Zero Option

"No-Project Option" cannot be considered a viable option in view of the country's ever-increasing population of 3% per year, the lack of agricultural area that cannot absorb future population, and the aspiration of industrialization that sets out the goals of economic growth by the year 2030.

2) No-Hydro Power Option with Implementation of Thermal Power Generation

The "No-Hydropower Option" should be considered as a viable option in view of the rapid economic growth of the provinces of the Ramu Grid System provided that the primary energy for thermal power generation comes from within the country. However, thermal power generation alone at the currently planned scale would not be sufficient to meet the demands of economic and population growth within the provinces of the Ramu Grid System. It also demands vigorous afforestation program in view of fighting against the global climate changes.

3) No-Thermal Power Option with the Implementation of Hydropower

a. The "No-Thermal Project Option" can be considered a viable option in view of the rapid economic growth of the provinces within the Ramu Grid System for electricity supply especially in view of the use of abundant water resources;

b. A stable supply of electricity into the future may remain precarious if no backup system is made available for electricity supply by thermal power generation;

c. A mixture of hydropower electricity generation with thermal power generation from various primary energy sources should be considered as a viable option for stabilizing the supply of electricity within the Ramu Grid System;

d. Obligation of afforestation in place of CO_2 equivalent gas emission is the lowest; and

e. In order to meet a large-scale demand from mining industries in the years to come, natural gas thermal power generation should be considered viable for the following reasons: 1) the operation of mining areas should create job opportunities in the highland provinces; 2) installation of T/Ls in the easternmost area of PNG should contribute to the rural electrification scheme to a large extent; and 3) a natural gas thermal power plant would be subject to stringent environmental monitoring in view of the impacts on the natural environment in the area hitherto remained intact.

4) Renewable Energy Option – Low Carbon Footprint/Pro-market

a. While solar and wind energy sources are renewable, construction cost is relatively expensive per unit of generated power;

b. Afforestation program could be very small comparing to the thermal power option only;

c. Solar and wind power generation alone cannot become mainstream supply of electricity, especially for industrialization of Ramu Grid System area; and

d. It would be relatively easy to encourage MDBs to invest renewable energy, especially solar and wind power generation.

8.5 TREND ANALYSIS OF THE STUDY COMPONENTS

8.5.1 Stakeholder Survey

(1) Selection of Stakeholders

Selected stakeholders notified for a hearing survey are listed as per Appendix 8-1-1. The criteria for selection are as follows:

a. Provincial and/or district organizations;
b. Large electricity consumers;
c. Public institutions such as hospitals and educational facilities; and
d. NGOs active in the Ramu Grid System region.

(2) Method of Survey

Selected stakeholders were informed of the hearing survey via an official letter from PPL. The survey took place between the 17th and 27th of June 2015. A number of selected stakeholders were absent during the actual survey. Ultimately, the following numbers of stakeholders were interviewed:

a. Morobe Province - 11
b. Eastern Highlands Province - 9
c. Madang Province - 10

A full record of the hearing survey of the interviewed stakeholders is shown in Appendix 8-1-2 to 1-4.

(3) Key Findings

1) Electricity Supply in Urban Areas

PNG Power's electricity supply systems were predominantly built in the late 1960s and early 1970s, prior to PNG's independence in 1975. Since that time, there has been relatively little expansion of the geographic coverage of the existing PNG Power networks due to the inadequacy of resources to expand and maintain beyond the urban centers, but the loads on the networks have grown. The industrial areas and growing populations of Lae city and Madang city account for most of the increase of electricity load.

The power reserve margin is small, and outdated transmission and distribution networks are working at full capacity or overloaded. As a result, poor reliability of the power supply has been causing havoc of manufacturing industries based in Lae due to generator and network outages. The relative cost of manufactured goods is therefore climbing higher than the manufacturers expected.

Generator maintenance works would have been hampered mainly by a lack of spare electricity capacity, and the cost of running diesel-based generators to replace off-line hydropower has not worked in PPL’s favor commercially. Consequently, routine maintenance has been carried out on an ad hoc or opportunistic basis. The lack of routine maintenance works has caused frequent blackouts in the industrial areas of Lae and Madang, as well as Goroka.

During the past several years, around 20% of the average electricity load has been lost.

Areas such as Eastern Highlands Province have experienced long-term losses of electricity, in some cases depriving industries of electricity for two or more months. Because of the lack of an additional hydropower generation scheme after Ramu 1 Hydropower Plant was completed, there has been a growing dependence on diesel generation as a backup power supply. The cost of the diesel fuel has hampered the commercial interests of PPL. There was also a major damage on a pylon for T/L during the flood season. Repair works were carried out for a number of electric poles that had been washed away during the following flood events.

In view of unreliable electricity supply, some of the manufacturers in Madang no longer rely on PPL for power. They maintain their own four diesel generators for their operation. Maritime College in Madan, which relies on PPL's power supply, was exposed to excessive voltage surges when the power supply was being returned after an outage. Sophisticated computer simulators and other equipment were damaged. Numerous similar stories are heard in Lae and Madang.

In conclusion, PPL's management style and capacity development appear to be more important aspects for a stabilized supply of electricity. Continuous development based on the current concept of exploitation on hydropower, gas, biomass, geo-thermal, and solar and wind power generation systems, large and individual consumers within the Ramu Grid System area should enjoy stable supply of electricity in the years to come.

2) Rural Electrification by PPL

Depending on the form of application, PPL undertakes the following program for rural electrification:

a. A group of people or LLGs should send a petition to the locally elected MP for allocation of budget for electricity distribution line construction works. Upon allocation of budget, an LLG handles the budget for mobilizing PPL to carry out the ground works, i.e., to design the electricity line from the nearest electric pole to the demand center. It then outsources to a locally available contractor, which usually carries out the actual construction works.

b. An individual house or business owner applies to PPL for electricity supply. Once the down payment for the construction works is paid, PPL carries out the ground works, i.e., designs the electricity line from the nearest electric pole to the location of the applicant. It then outsources to a locally available contractor, which usually carries out the actual construction works.

As above, the mobilization of PPL for the rural electrification system must go through a clear budget allocation system in the first place, because the rural electrification scheme is a part of a larger social development scheme. PPL does not carry out any electrification work without commercial benefit.

3) Rural Electrification: Effort of Local Governments

Rural electrification described in the EIP is based on the CSOs. Departing from the national uniform tariff, rural electricity has become cost-reflective. The competitive basis of IPPs for rural electrification sometime has made exceedingly high electricity tariff as it is somewhat backed up by the EIP and has gone beyond control at a time.

Rural electrification scheme has to be the responsibility of all levels of government, elected representatives of the province, donor agencies, and other stakeholders. It can only be implemented through constructive funding arrangements. A province like Eastern Highlands Province where hydropower potential is very high aims to support PPL's effort to construct power plant like Ramu1 Hydropower Plant as the main stream of electricity supply despite the fact that the province has to sacrifice a patch of land area for Yonki Reservoir.

In the report of "The Five Year Plan 2013-2017 of Eastern Highlands Province", Eastern Highlands seeks to have 40 % of households connected to electricity by the Year 2015. This is a provincial policy aligned with the National Strategic Development Policy 2010-2030. Since Ramu1 Hydropower Plant is in the province, it aims to give 60% of the population access to PPL's electricity supply by the Year 2030.

Madang Province, meanwhile, is promoting a biodiesel project on Karkar Island to produce coconut-derived biodiesel oil for power generation. It is also promoting a geothermal energy project on the same island. Iceland Geothermal Co., Ltd. estimated a total output of 600 MW in a study on the potential. Madang Province is also promoting wind power generation, including windmills for pumping groundwater for irrigation.

As above, depending on the characteristics of province's geography and potential primary sources of energy, rural electrification projects of a small- to large-scale are promoted for power generation bypassing PPL's jurisdiction.

8.5.2 Trend of Government Policies on Electricity Supply

(1) Central Government Policy

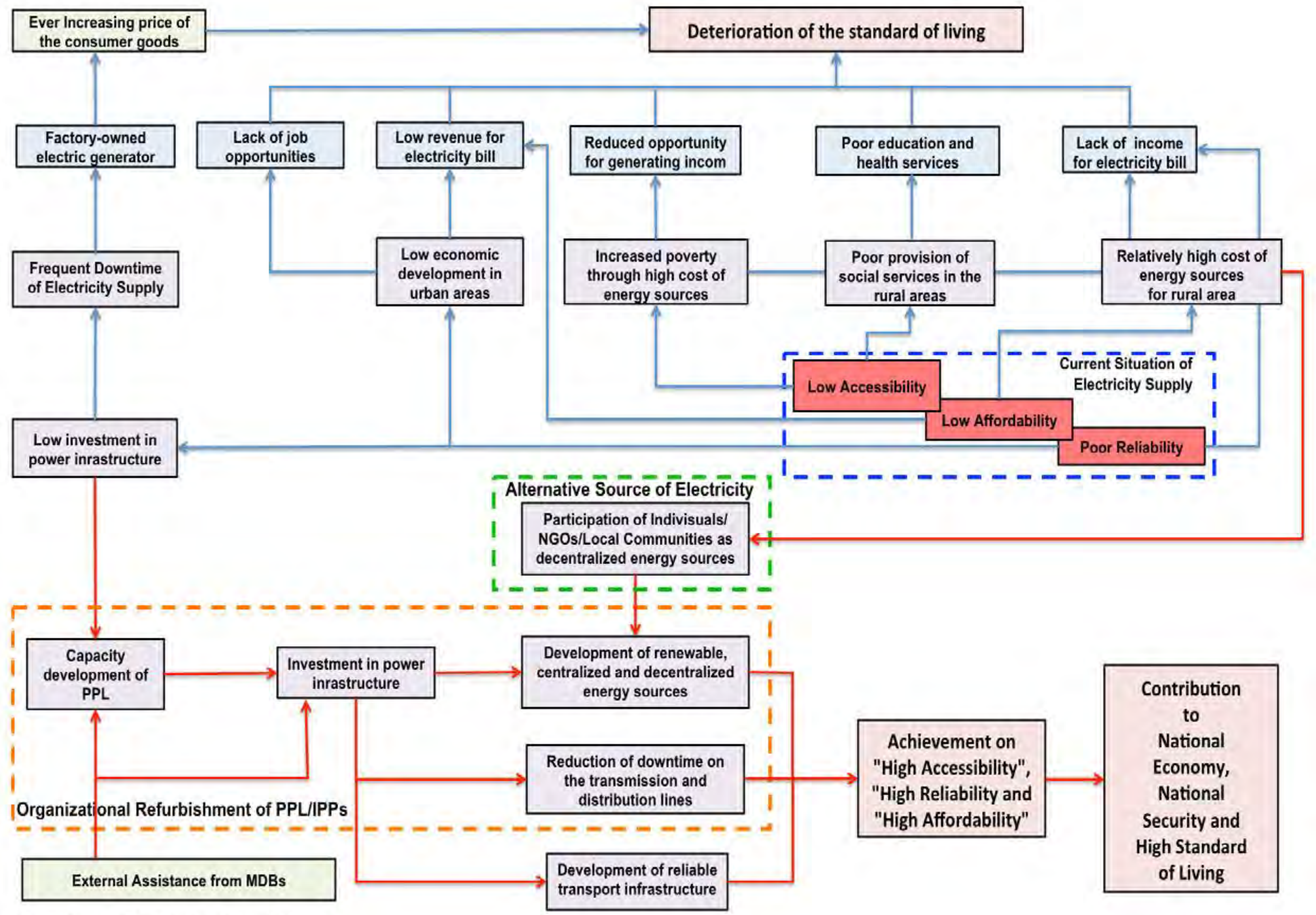
a. Urban and Commercial Electrification

The Electric Industry Policies of the GoPNG are to: 1) facilitate competition and contestability in the electricity industry; 2) expand rural electrification through government assistance for reliable, affordable and sustainable electricity using renewable energy technologies; 3) enhance technical regulations ensuring efficient and productive end-use of electricity for the development projects; 4) bring certainty to investors in the electric sector by developing a clearly defined access regime; and 5) encourage private participation in the electric sector. It also stresses the development of human and institutional capacity to plan and manage rural electrification.

Given the importance of urban and commercial electrification for export-driven economic growth, an efficient electricity supply system is integral to the success of the rural development and poverty reduction agenda of the GoPNG. On the contrary, PNG's mid-term development strategy failed to prioritize government expenditure on the development of electrification, as private participation was favored. Due to the failure of private participation, meanwhile, government investments in power generation, transmission, and distribution lines as important capital assets have simultaneously failed. PNG's policy to encourage private participation in the electric sector might not work in the future: support by donor agencies will probably have to concentrate in areas where the power sector is able to play an important role in economic development and where capacity to pay for electricity exists. A flowchart analysis of the electrification trends is shown in Fig. 8.5-1.

b. Lack of Government's Power Development Plan

The Power Development Plan generally consists of the following: 1) an Electricity Demand



Note: MDBs denotes "Multi-National Development Banks

Fig. 8.5-1 Flow Chart: Analysis of the Trend of Electrification in PNG

Source: JICA Study Team

Forecast to predict the capacity (MW) and energy (GWh) demand in the future; 2) a Least Cost Expansion Plan giving the infrastructure needed to meet that demand at all times for the forecast period and at the lowest possible cost, while maintaining system reliability and quality of supply; 3) a Transmission Expansion Plan to transmit the generated electricity to customers; 4) a Fuel Supply Assessment to determine the national energy resources (coal, gas, oil) available for energy generation, 5) a Rural Electrification Program for electricity supply to remote areas that cannot be covered by the national grid; and 6) an Investment Program on how to finance the future investments in the energy sector.

The lack of a government power development plan or of a plan for the Ramu Grid System by PNG Power alone shows that the planning ability of PNG Power's electricity supply system is in need of a stringent organizational empowerment program.

c. Rural Electrification

Because of the lack of an appropriate rural electrification policy so far, the GoPNG is trying to encourage the participation of the LLGs and its people within the jurisdiction of LLGs for rural electrification. Such a scheme requires an accumulation of experiences in the local population. While ADB and the WB address technical assistance for rural electrification, expertise available from international NGOs with accumulated knowledge about rural electrification has not been clearly mentioned. A viable partner or this might be preferred, depending on the government policy. However, since rural electrification is considered a social service rather than investment, further investigation for promoting NGOs capable handling a rural electrification scheme on the basis of affordable cost implications should be addressed within the framework of the Study.

(2) Local Government Policy

Owing to the lack of any appropriate power supply plan for PPL or provincial policy papers related to the Ramu Grid System, few provincial government policies on power supply have been studied within the framework of the Master Plan Study. Judging from the Morobe Provincial Integrated Development Plan: 2014-2018 and Lae District Five Year Development plan: 2013-2017, little to do with electricity supply is studied. The development objectives, however, are clearly stated in chorus with the Strategic Development Plan 2010-2030 of the GoPNG. Other provinces we visited for hearing surveys even lacked copies of provincial plans to quote the intentions of their economic development plans.

Based on the hearing survey, Morobe and Eastern Highlands Province depend much on PNG Power in terms of electricity supply. More specifically, they appear to depend on PPL's major hydropower plant in Eastern Highlands Province, T/Ls in Morobe Province, and diesel power plant in Lae.

In Madang Province, the current efforts to exploit power supply were much more specific than in other provinces we visited because of its ample primary resources. Geothermal energy with potential believed to be in the range of 600 MW is available on Karkar Island, along with bio-diesel production derived from coconut oil, and natural gas is available in the north of the province. One test drilling site is now undergoing a yield assessment as a primary energy source within the province. Madang Province appears to be building up its own capacity for exploitation of power supply.

Further west of Ramu Grid System Area, Enga Province will receive major electricity power from up- coming natural gas turbine power plant in the near future. Western Highlands Province holds Paunda hydropower plant, but the other provinces have no plans to hold any major power plants soon. These provinces are thus without major power plants, and Chimbu, Jiwaka, and Southern Highlands Province have to rely on electricity supply branched out from the existing major T/Ls. This puts these provinces in an economically and psychologically precarious situation for years to come. It will become more important for PPL to stabilize the electricity supply to these provinces in actuality than in the past.

8.5.3 Trend of MDBs on Electricity Supply Projects

(1) ADB's Strategy for Electricity Development Projects for PNG

ADB supports PNG in terms of renewable energy generation as well as the improvement of transmission and distribution lines to provincial centers. Electricity supply to the outskirts of the urban areas in PNG is very poor. ADB thus promotes innovative models led by the private sector for off-grid power delivery. ADB believes that efficient electricity supply should help lower business costs, increase employment, and thereby enhance economic development as a whole.

ADB is in trying to maximize development impacts by implementing a small number of high-impact projects with effective knowledge transfer and capacity development. Climate proofing infrastructures are working to mitigate the consequences of natural disasters and climate change risks for local communities. In this respect, ADB focuses on the latest climate technologies reducing CO_2 emissions expected to form parts of the project design for power generation, while at the same time carrying out capacity development works to handle those climate technologies. ADB thus aims at improved access and use of power supplies for households in rural areas: 20% of households have access to grid-connected electricity by 2020 (2014 baseline at 12%).

Outdated and poorly maintained transmission and distribution lines, as well as inadequate maintenance of substations primarily cause the energy losses. ADB aims at 1) rehabilitation to improve reliability; 2) extension of grids to serve electricity for the urban populations; and 3) expansion of disaggregated power generation systems to serve electricity for the rural populations. It also supports the expansion of power generation capacity in the Ramu Grid System through the development of mining sector projects in conjunction with the plan to expand electricity supply for the provincial centers.

(2) Energy Sector Development Strategy of the World Bank in PNG

The WB, which is active in PNG for energy development, stresses the following policy:

a. Energy supply is a crosscutting sector affecting all households. Households maintain a traditional and primitive lifestyle at low income, while businesses and industries maintain sophisticated high-technology private sector operations. Broad social development benefits are sought to bridge all households vs. commerce and industry with stable and reliable electricity supply, but the cost implications cannot easily be solved. Specifically, rural households are left far behind because of the high cost of electricity. The WB can help create a policy framework for broad-based social benefits from an improved energy sector by supporting the development of a renewable energy policy, rural electrification policy, and rural electrification strategy;

b. The PNG population is organized in small, fragmented social groups. Clan-based groups are more strongly attached to intra-group coherence than national identity. This situation poses a challenge to the pursuit of a national vision. Thus, in order not only to promote socially sustainable but also gender-equitable energy sector development that explicitly factors in the needs and concerns of both the formal and traditional elements of the economy and PNG society as a whole;

c. The development of hydropower offers the prospect of clean, sustainable, cost-effective electricity supply. Socially responsible preparation and development of hydropower resources, in combination with efficient and complementary thermal alternatives such as gas-fired generation or biomass thermal generation, would make a significant contribution to social and economic development in PNG for decades to come;

d. Strengthen policy development and a strategic framework for renewable energy and its use for rural electrification, which is at present in need of an analysis of alternative models of community and rural electrification initiatives, including a cost structure as an input to the process for developing tariffs for electricity supply. The key stakeholders are the people living outside the urban areas who currently lack access to reliable and affordable electricity supply, along with the local level governments.

8.5.4 PNG's Cultural Trend on Disputes over Customary Land Holding

(1) Common Practices Causing Disputes over Customary Land Holding

Acquiring land for various purposes in PNG can be very difficult because most of the land in the country belongs to customary landowners who do not possess government's formal title and registration papers but oral tradition. Thus a simple step is to gain the support of the local community and ethnic groups identified within the area of concern. When these groups are involved in dialogue, they can be informed of the purposes for the acquisition of their land. With ample supply of information related to the project, the local people show their willingness to support and help to achieve those purposes.

Project areas subject to mineral extraction (petroleum and natural gas) and forestry logging, energy production areas such as hydropower stations, and projects of other forms generally cause disputes over land-holding rights in PNG because of the large amounts of money paid for compensation. While these disputes can be resolved with involvement of developers, disgruntled members dispute decisions made by members of other ethnic groups. Their disgruntlement generally stems from the following common practices of customary landowners:

a. Royalty compensations are not distributed evenly;
b. The developer disturbs protected areas of land. The forestry logging operations in Western Province are a classic example;
c. Incentives for the economic sustainability of the landowners are not maintained;
d. Incentives for social sustainability are not met; and
e. Resettlement issues are not fairly implemented to all members of the affected ethnic group.

These disputes depend heavily on ethnic traditions and less so on modern and democratic solutions. Resolving them can therefore be very complicated. Flare-ups between disgruntled members of opposing ethnic groups can result in physical harm ranging from minor injuries to death. Disputes such as this are very common in the highlands of PNG.

(2) Resolving Ethnic Disputes

Resolving disputes over customary land in PNG can be very complicated. The outcomes depend on severity of the issues or grievances being expressed. Land disputes over a land area of a national project development are generally easy. The general practices for resolving land disputes are as follows:

Stage 1: The issue or grievance is made known to other members of the same or another ethnic group;

Stage 2: The issue is brought to the attention of the Land Mediator, who calls for a land mediation meeting. In normal cases, the dispute is either resolved at this stage or progresses to stage 3;

Stage 3: The Land Mediator calls for a village court hearing. This involves both the land mediator and a village court magistrate for possible solution;

Stage 4: If the issue is not resolved in stage 3, the case further escalates to either the provincial court or to the national supreme court, if necessary; and/or

Stage 5: Social and customary grievances and issues are resolved using the customary methods.

(3) Resolving Disputes Caused by Power Projects

PNG has two major hydropower systems: 1) Yonki Dam in Eastern Highlands Province and 2) Sirinumu Dam in Central Province. Land issues raised by customary land owners are addressed using the process described above. The issues differ in magnitude between these two sites because the understanding of the importance of the hydropower stations is uneven. There is still an ongoing issue with the landowners of these two sites.

PNG Power is in control of issues for the long-established case of the Yonki Dam, Upper Ramu Catchment Management Project. The catchment management project is run by the KATG Water Resources Owner Association Inc., an entity created by a group of local customary landowners. Member clans hold shares of the common interest of Yonki Reservoir.

8.5.5 Riparian Environment in the Ramu Grid System Area

(1) Flood Events along the River

PNG is a country with high mountain ranges and abundant rainfall. This leads to high runoff over the land surface of the most part of country. The 2012 report from FAO described nine hydrological drainage basins, the largest river being the Sepik, Fly, Purari Ramu, and Markham. The Sepik has the lowest annual discharge but the largest catchment area (78,000 km^2). Next, in descending order, comes the Fly River (61,000 km^2) followed by Purari River (33,670 km^2), and Markham (12 000 km^2). The other catchment areas of the other rivers are all less than 5,000 km^2.

Flooding is common on low-lying flood plains such as Laloki River close to POM, the Bhumbu, Busu, and Markham Rivers near Lae, and the Ramu River. Flood events during tropical cyclones hit the country during La Niña years. Prolonged rainfall during the wetter season often causes floods. Low-lying villages, crops, road crossings, culverts, bridges, and urban drainage infrastructure are severely damaged as a result.

The Ramu and Markham River located in the Ramu Grid System have sections where flood events occur during heavy rainfalls when heavy buildup of sedimentation hinders the normal river flow in mid-stream to down-stream areas. Ten transmission towers were washed away by a severe flood event in the Ramu River in early 2015. It took PPL a little more than 3 months to recover the T/L supplying electricity to Madang.

(2) Morphological Changes of Ramu River

Hydrological monitoring and assessment commenced in PNG during the Australian Administration. The first station was installed on the Laloki River at Sogeri in the 1950's out of need for data for hydroelectric and water supply development. A 2011 report from Pacific Islands Applied Geoscience Commission (SOPAC) stated that the BWR undertook hydrological monitoring following independence in 1975. The jurisdiction of hydrological monitoring has since shifted between several government departments and now resides with the Department of Environment and Conservation.

Visual and aerial observations of the two rivers identified in the Ramu Grid System indicate that the alluvial plain along the Ramu and Markham Rivers have expanded in recent years due to a buildup of sedimentation in the mid-stream and downstream areas. This has led to the formation of numerous new river channels and causing severe flood events.

(3) Reservoir Sedimentation

Sedimentation in reservoirs and weirs for hydropower projects can be a serious problem for generating consistent electric power. Sediment from the vast area of the upstream catchment area builds up in the reservoir. The sediment load estimation carried out from 1982 to 1983 was 516,000 tons/year, based on the suspended solids measured in the river water. A sediment study carried out in 2007 and 2013 substantiated the estimate, as some 2.3 million tons of sediment accumulated over 4 years. The following points will thus have to be monitored in the Yonki Dam, upon completion of Ramu 2 hydropower plant project:

a. Reduction in the annual and dry season water flow;
b. Sediment load during dry and rainy seasons;
c. Possible depletion of the retained volume of water in the reservoir as a result of the sediment built up in the reservoir; and
d. A sediment dredging system in view of Ramu1 and Ramu2 hydropower plant operation.

Constant anti-sedimentation measures are required for the Ramu2 hydropower station development plan.

In other river systems where new hydropower plants are constructed, permanent changes of the riparian environment take place without exception. The river developed for the hydropower project has to be closely monitored on a permanent basis as a further environmental management strategy.

(4) Water Quality in the Ramu River

The water quality is observably deteriorated in the Ramu and Markham Rivers. Although there is no record of water quality assessment for these two rivers, high sedimentation and turbidity in the mid-stream and down-stream areas of these rivers can be visibly observed. It was assumed during the field trip that the fish species and other water-dwelling species would be minimal compared to the species identified in pristine rivers.

(5) Water-Related Diseases

It has been estimated that 55% (SOPAC, 2011) of the population lacks access to safe sanitation services. Diarrhea is the number one cause of mortality and morbidity in the country. Low access to improved water sources and sanitation facilities increases the risk of infectious water-borne diseases, including cholera and typhoid. Adverse impacts on water resources in catchments arise from road construction, agriculture, logging, mining waste, and improper disposal of solid and human waste. This is a major cause for concern, as 67% (SOPAC, 2011) of the rural population obtains drinking water directly from unimproved sources of river water. The Department of Health has been promoting better hygiene, improved sanitation, and proper solid waste disposal throughout the country, but it needs the support of other government agencies and provincial and local level governments, as well as NGOs and energy resource development sectors.

(6) Fish and Other Aquatic Species

The complex geography of New Guinea has isolated many populations of aquatic species. There are 375 species of freshwater fish in PNG. Of these, 226 are general fresh water species and 149 are endemic to New Guinea. There are several large river systems in New Guinea, including the Fly, Sepik and Mamberamo, all of which are rich in fish species. The Fly River Basin, the most species-rich river PNG, has 105 identified fish species, while the Sepik River Basin has 57.

Among New Guinea's lake systems, the most important in terms of endemic fishes are Kutubu (13 endemics) and Ajamaru (4 endemics). The most common species in PNG are Rainbow fish, Blue-eyes, Gudgeons and Gobies. There are also several species of Old world silverside, Grunters, Glassfish, Arid catfish, and Eel-tailed catfish.

A striking example of a biogeographic border for freshwater fauna are the New Guinea Highlands. The species diversity is higher in the south of the mountains than in the north. Among the strictly freshwater fish, only two species (Chilatherina campsi and Oxyeleotris fimbriata) are found both north and south of these highlands.

Introduced species and pollution present serious problems to some of the freshwater regions in PNG. Lake Sentani near Jayapura city, for example, has one endemic fish species, and Lake Wanam near Lae city has one. These species are now seriously threatened because pollutants released into these lakes from mines have been causing deterioration of the rivers in other parts of PNG. By contrast, the rivers in the Ramu Grid System are still relatively pristine to date.

(7) Floating Aquatic Plants

The 2015 report from FAO stated that the massive occurrence of floating aquatic plants is a common feature of tropical and subtropical water bodies. It is commonly the result of an expansive growth of non-endemic aquatic plants. Water hyacinth and Salvinia are widespread in the tropical Asia and Latin America, representing a major problem for fishery, irrigation, hydropower production, and water transportation.

Both floating and submersed aquatic plants become "nuisance plants" for most projects related to fishery, irrigation, hydropower, and water transportation. Problematic submersed plants are: *Myriophyllum spicatum, Hydrilla verticillata, Ceratophyllum demersum, Potamogeton crispus, Potamogeton pectinatus.* Their explosive growth is often caused by a favorable nutrient environment, and also human impact through eutrophication of water bodies.

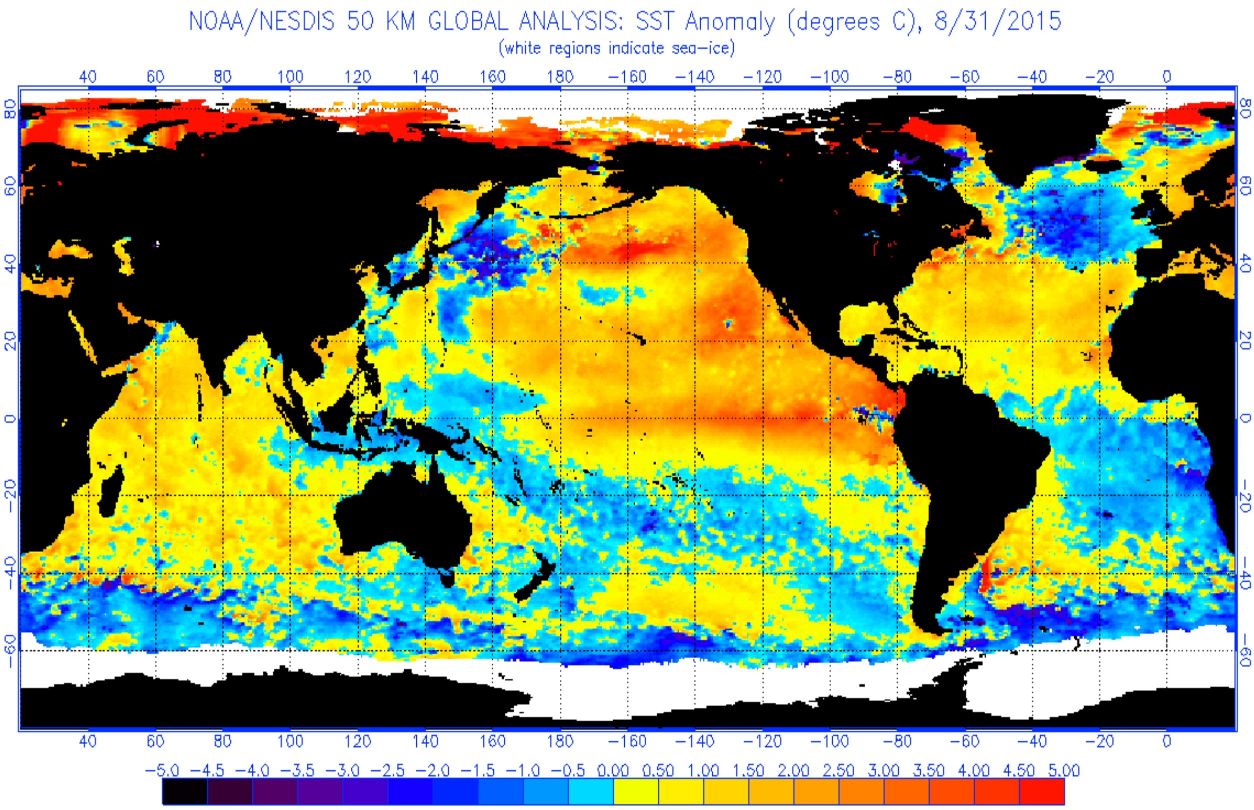
Salvinia spread over numerous floodplain lakes in the Sepik River Basin to the west of Madang Province in the late 1970s and early 1980s, eventually covering over 200 km2 of the floodplain lake areas. The Tilapia (*Oreochromis mossambicus*) fishery was severely affected as a result. The disruption of traditional subsistence lifestyle became so great that entire villages in the region were abandoned. Fortunately, biological control using Beetle (*Cyrtobagous salviniae*) was released over the infested areas. The operation was so effective that Salvinia virtually disappeared from all backwaters within only a few years. FAO stated that the impact of invasive plants on fish stocks and fisheries is poorly documented in PNG. Long-term monitoring should be performed for every project that alters biodiversity over a wide area.

8.5.6 Major Droughts in PNG

The 2011 report from SOPAC stated that the droughts in PNG are related to theENSO phenomenon. There have been 11 droughts associated with El Niño in PNG since the meteorological record began. The most severe droughts occurred in 1902, 1914, 1942, 1972, and 1997. The 1914 and 1997 events were the most severe among them, causing failures of agricultural crops, destroying wildlife and villages, and killing people and livestock.

The strongest ENSO episode took place in 1997/98, resulting in dry conditions throughout PNG. Indigenous food production was severely affected during this period, as 80% of the population depends on a subsistence lifestyle.

Water availability in the Sirinumu reservoir in the POM urban area fell to a critically low level for electricity production and water supply. During a normal year, drought effects can be experienced in rain-shadow areas such as the Laloki Catchment, an area of extreme importance to POM for water and energy supply.



Source: http://www.elnino.noaa.gov/

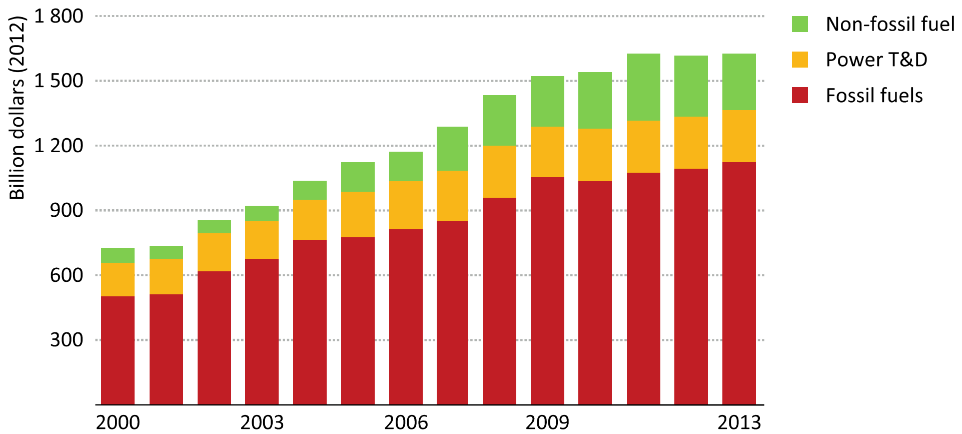
Fig. 8.5-2 Surface Temperatures of the Oceans in the World (as of August 31, 2015)

El Niño in 2015, the year of the Master Plan Study, has been considered the strongest El Niño in the history of meteorology. Unusually warm temperatures of the Easter Pacific Ocean are recorded, as shown in Fig. 8.5-2, while the water temperatures of the Western Pacific Ocean around PNG are unusually low. As a result, PNG has received unusually low rainfall and low temperatures in the highland areas, reaching levels much lower than in an average year. The rivers and reservoirs are drying as a result. Water shortages and lower crop yields have been affecting plantations and the mining industry in PNG.

Enga Provincial administration, the westernmost province within the Ramu Grid System Area, called for a meeting of a provincial disaster and emergency committee as the province's agricultural crops have already been damaged by unseasonal frost. Similar problems occurred in Chimbu and Western Highlands Province, as well as some of the provinces of the Ramu Grid System Area. Most of the other areas in the highlands also experienced reduced rainfall, drought frost, and windy weather. Thus, more than half of the total population of PNG is predicted to face severe shortages of food in the Ramu Grid System Area as a whole.

8.5.7 World Trend of Investment on Renewable Energy

The trend of world investment on renewable energy reported by International Energy Agency in 2014 is shown in Fig. 8.5-3. Historically, investment on the electricity power generation was on the fossil energy such as oil, gas or coal. However, despite the fact that the historical trend, there is a diminishing trend of investing to fossil fuels since 2000. As is shown in the figure, non-fossil fuel investment has been growing steadily during the 2000-2013 period. It is also interesting to note that power transmission and distribution has remained somewhere in the range of 15 - 22 % since 2000.

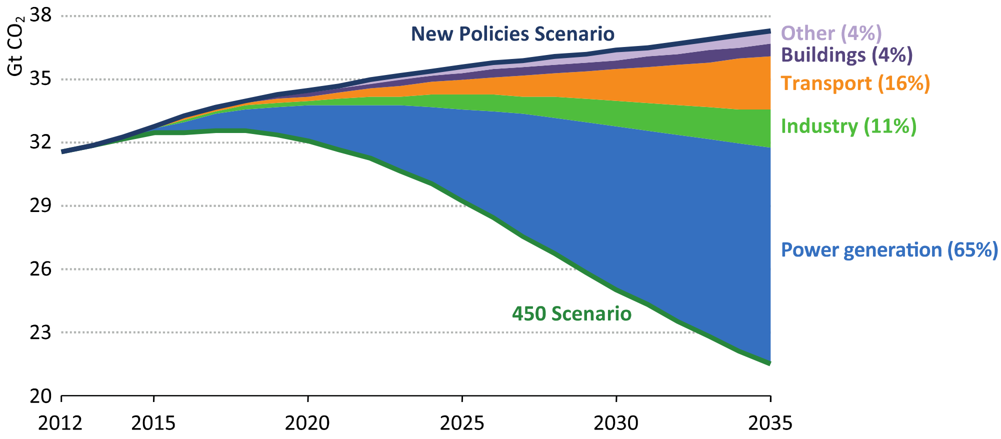


Notes: Non-fossil fuel includes all renewable technologies, nuclear and biofuels. Power T&D is transmission and distribution for the power sector: this cannot be assigned to either fossil-fuel or non-fossil fuel use.

Source: World Energy Investment Outlook 2014, International Energy Agency

Fig. 8.5-3 Trend of the World Investment of Energy 2000-2013

While there is a commitment required in the world that the low- to zero- emission of carbon equivalent gases, energy sector remain as the largest source of greenhouse gases. However, as is shown in Fig. 8.5-4, emission reduction achieved after 2020, 65 % of the World's CO_2 emission abatement should still has to be made from power generation by the Year 2035 because of the current trend of investment on renewable energy sources.



Source: World Energy Investment Outlook 2014, International Energy Agency

Fig. 8.5-4 World Energy-related CO_2 Emissions Scenario by 2035

8.5.8 PNG's Electric Industry: Commitment for the Climate Change

The 2015 United Nations Framework of Climate Change Conference, COP21, or COP-2015 has agreed on the outcome with which legal force applicable to all participants for which reduction of CO_2 emissions has to be implemented. Industrialized countries agreed to raise \$100bn (£66bn) a year by 2020 to help developing countries transform their economies. The overall agreement is legally binding, but some elements – including the pledges to curb emissions by individual countries and the climate finance elements – are not.

In this climate change, agreement was made that measures to meet the achievement of global warming at less than 2 °C by 2050 has to be implemented. At COP21, PNG government announced that PNG would opt for a national target in the electricity sector that the country should become carbon free by 2030. There are many options in terms of renewable energy sources such as solar power, geothermal, biomass-fueled power plants and additional hydropower to achieve the target. ANZ in POM reported in August 2015 that the goal could be accomplished if external funding could be made available in time.

The key to COP 21 commitment is development of fare technology of renewable energy for power generation. PPL is expected to make a significant contribution in order to aptly implement the measures. It is therefore essential for PPL to consider primary energy transition from fossil fuel to renewable source of energy. At the same time, it is important to increase forested areas, or not to reduce tropical rain forest areas throughout PNG in view of absolving CO_2 emission at this stage of PNG's strategic development initiatives.

In a paper published February 2016 in Nature, a groups of American forest experts revealed that the secondary forest growth of rain forest i.e. trees growing after the damages made on the primary natural rain forest are much efficient to dissolve carbon from the atmosphere. The rate of biomass recovery is fastest in areas with high rainfall. PNG's tropical rainforest is one of them. Thus instead of planting trees, conservation of secondary forest should contribute to electricity industry's carbon emissions i.e. electricity industry has to collaborate with forestry industry very seriously for which carbon sequestration of the secondary growth of tropical rain forest should be considered as a part of electricity power development.

PNG Office of Climate Change and Development (OCCD) states that the reduction of greenhouse gas emissions by at least 50 % by 2030 and become carbon neutral by 2050. In view of the world trend indicated in Fig. 8.5-4, emission reduction should be achieved with vigorous effort. Thus OCCD states that gas or diesel power generation should be stopped. PNG's low-carbon initiatives in terms electricity power generation should come from rural electrification through rehabilitation of mini-hydropower system, renewable energy through a hydro or geothermal power system.

Conversely, the WB reported in its "Climate Change in Papua New Guinea: Framework for the National Climate Change Strategy and Action Plan", three quarters of mini/micro hydro systems installed are no longer in use, a large percentage of PV systems have failed, and the majority of distributed power systems are operating poorly. Thus bulk of potential greenhouse gas reductions should come from hydropower, geothermal, solar power system or wind energy.

8.6 CUMULATIVE IMPACT ASSESSMENT OF THE IDENTIFIED STUDY COMPONENTS

8.6.1 Identified Study Components

Table 8.6-1 shows identified study components that are prospective to develop in view of the Strategic Economic Development 2010-2030 of PNG in order to meet the normal demand forecast of the period. Details are described in Chapter 6 of the selection of these study components.

Table 8.6-1 Identified Study Components

Fuel Type		Province	District	Power Plant	Rated Capacity (MW)	Actual Output (MW)
Prospective Power Plants	Natural Gas	Southern Highlands	Nipa Kutubu	Highland G/T	-	30-60
	Diesel Oil	Madang	Munum	Munum	30	30
	Biomass	Morobe	Markham	Markham Valley	30	30
	Thermal	-	-	Additional Thermal 1	30	30
	- ditto -	-	-	Additional Thermal 2	30	30
		Morobe	Finschafen	Mongi-Bulum	116	60
		Eastern Highlands	Obura Wonenara	Ramu 2	180	180
	Hydropower	Western Highlands	Mul-Baiyer	Kaugel	84	56
		Morobe	Bulolo	Baime (PNGFP)	10	8
		Madang	Gowar	Gowar	54	43.5

Source: JICA Study Team

Based on a format shown in Fig. 8.3-2, a flow chart analysis of the study components for the cumulative analysis has been carried out as shown in Appendix 8-3.

8.6.2 Environmental Implications of the Mongi-Bulum Hydropower Plant

(1) Natural Environment

a. A run-of-river type concrete weir of 5-6 m in height is planned to construct one across Mongi River and the other across Bulum River. Tunnels from each weir meets several kilometers in the downstream area where two tunnels join together for sending water to the power plant that drains water out to Bulum River.

   The plant species in the area of the project site are of Asian influence, as is characteristics of the area north of Markham River and Ramu River;

   Although the speed of changes may not be visible, the river water regime and riparian environment are permanently altered as a result of the implementation of project. However, changes of the riparian environment might take gradually over time, i.e., no drastic or abrupt changes of the riparian environment should take place;

b. Since the project site is near the coastal area, construction debris should not contaminate the coastal waters of Huon Gulf. A designated disposal area where no soil particles can contaminate the river water must be established before the construction works commence;

c. The entire project area is generally well drained and turbidity is very low;

d. There is no aquatic species, wildlife, or plant species subject to conservation. PNG's natural environment, however, has not been fully studied. Therefore a detailed investigation of the natural environment has to be carried out;

e. There are no protected areas expected to be negatively affected;

f. The T/L should be installed generally along the road that partly runs in the mountainous area. In places it has to go through the area of natural vegetation along the coast. Small patches of land would have to be cleared for pylon of the T/L in the area of unstudied natural environment within the mountainous area along the river; hence, the area subject to the T/L should be thoroughly studied; and

g. The T/L to the existing grid is relatively short. As there is no major road along which a T/L can be installed, the T/L construction works can be expected to cause light but adverse impacts to the natural environment.

(2) Socio-economic Environment

a. No significant socio-economic impact is envisaged in the project area, as no human settlements are found there. There are several human settlements, however, in both the upstream areas and the areas to the east and west of the mouth of Bulum River;

b. The T/L should be installed over a 77 km distance along the road in the coastal area, where it will pass through areas of customary owned land. Negotiations should thus be made with a number of local residents for the acquisition of land or lease-hold agreements; and

c. There are no established water rights in the project area that might otherwise cause disputes over water usage.

8.6.3 Environmental Implications of Ramu 2 Hydropower Development

(1) Natural Environment

a. This is the most studied hydroelectric site to date among others within the Ramu Grid System Area in terms of engineering feasibility, the conditions of the natural environment, and socio-economic considerations. The project site is in the middle of the narrow gorge of Ramu Valley that runs through Eastern Highlands Province. Its mid- to downstream portion runs through the lowland flood plain in Madang Province;

b. There are no known significant or and plant species inhabiting the steeply sloped area (up to 35% slope gradient) where the Ramu2 hydropower plant is located;

c. The entire project area is generally well drained, turbidity is very low, and there are no fish species that the local resident use for food or aquatic rare species in the river;

d. There is no protected area expected to be negatively affected nearby the Ramu2 hydropower plant;

e. The alterations in the construction of the riparian environment attributable to the construction of Ramu2 as well as the previously constructed Yonki Dam and Ramu1 hydropower plant are summarized as follows:

   i. The area upstream of Ramu River has already been permanently inundated by Yonki

Dam;

ii. The river water is regulated: there is no longer any natural flow from the reservoir to the discharge point of Ramu1 hydropower plant; and

iii. The flow rate of the river in the downstream area, which has already been regulated by the Ramu1 hydropower plant, should be further regulated by the construction of the Ramu2 hydropower Plant.

f. During the construction period, debris produced from excavation works should be appropriately treated and disposed to the designated site in order to keep the natural environment of the surrounding area as intact as possible;

g. River water regime between Yonki Dam and the Ramu2 hydropower plant's discharge point would be permanently altered. Such changes of the river flow regime cause invisible but permanent changes of the riparian environment. The changes should become gradually visible over a long period of time;

h. Changes of the river water flow regime could cause positive and negative impacts to both the human and natural environments. An appropriate monitoring program for the entire stretch of river should be planned for the lifetime of the project. Mitigation measures are further planned as a part of the environmental management plan; and

i. A T/L is installed along the existing haul road. Thus, no significant impact is caused to the natural environment.

(2) Socio-economic Environment

a. There is no local population occupying the inundated area or the area of construction works, i.e., no resettlement is involved in the project;

b. The concrete weir construction site of the Ramu2 hydropower plant is in in the customary land and PPL is involved in the process of land acquisition. To date, the land owner is committed to work amicably with PPL;

c. There are no established water rights in the project area that might otherwise cause disputes over water usage;

d. The T/L should be installed generally along the haul road that runs on the existing haul road. Thus, no negotiation with the customary landowners is involved;

e. Local residents could be employed as non-skilled labor during the construction period; and

f. No residents in the downstream area would be affected by discharged river water from Ramu2 hydropower plant.

8.6.4 Environmental Implications of Kaugel Hydropower Plant

(1) Natural Environment

a. Although the speed of changes may not be visible, the riparian environment should be permanently altered as a result of the development of a run-of-river type hydroelectric scheme;

b. The T/L should be installed for 260 km to the existing grid. In places, it would have to be installed through the natural environment. Thus natural environment should be cleared for a number of the patches land for pylon should cause light but obvious impacts on the natural environment near Mt. Hagen;

c. Details of the fauna and flora associated with the Kaugel hydroelectric scheme are subject to further study; and

d. The T/L to the existing grid would be relatively short but would pass through mountainous areas. The T/L construction should cause light but adverse impacts to the natural environment. A detailed study should thus be conducted for the area where the T/L is installed, in addition to the area of the power plant and intake weir.

(2) Socio-economic Environment

a. No significant negative socio-economic impact is expected in association with the inundated area;

b. There are a number of tea plantations in the vicinity of the project area. These tea plantations and tea processing industries would greatly benefit from the scheme;

c. The coffee industry in Western Highlands Province is the second largest in PNG after that in Eastern Highlands Province. Thus, a stable supply of electricity would greatly benefit the area and coffee plantations around Mt. Hagen, the capital city of Western Highlands Province ;

d. T/Ls would be installed in areas held by a number of customary landowners. These areas are subject to negotiations for land acquisition or lease-hold agreements;

e. Local residents could be employed as non-skilled labor during the construction period; and

f. The operations of other industries like tobacco, sugar, cocoa and timber industries would also be enhanced by the availability of a stable electricity supply.

8.6.5 Environmental Implications of Baime Hydropower Plant

There are Upper Baime Hydropower Plant and Lower Baime Hydropower Plant in Bulolo, where PNG Forestry Products Co. Ltd. (PNGFP) has built for their own operation of gold mining as well as forest products processing works. It appears that PNGFP's hydropower plants appear to produce surplus electricity in the future. PPL has undertaken to arrange purchasing of the surplus when it is available. Thus, any environmental and socio-economic impact assessment, elaboration of environmental management and monitoring works are all within the framework and jurisdiction of PNGFP.

8.6.6 Environmental Implications of Gowar Hydropower Plant

(1) Natural Environment

a. Although the speed of changes may not be visible, the riparian environment is expected to be permanently altered;

b. The T/L should be installed generally beside the road that runs along the coastal area. No significant natural land would have to be cleared. However, in places it might go through underutilized grassland without significant impacts to the natural environment.; and

c. Gowar River originates from the Finisterre Mountains, where the vegetation and wildlife are of Asian origin. The details of the natural environment have not been fully studied to date. Thus, at the time of project implementation, a study on the natural environment should be carried out not only for the project, but also to accumulate data for educational organizations for PNG. A number of local universities and forestry institutes should be involved in the study for this matter.

(2) Socio-economic Environment

a. No significant socio-economic impact is envisaged, as the inundated area is not occupied by local population;

b. T/Ls would be installed over 70 km distance to Madang, where a major grid system exists. There are a number of customary land owners along the road subject to negotiations for land acquisition or lease-hold agreements;

c. Local residents could be employed as non-skilled labor during the construction period; and

d. The power plant and intake for the run-of-river type weir would be in customary owned land. Details should be studied during the feasibility study.

8.6.7 Environmental Implications of Markham Valley Biomass Power Plant

(1) Natural Environment

a. Fast-growing tree species have been planted over grasslands in the lowland area of Markham Valley for primary energy supply. The total dedicated plantation area should become 12,000 ha at its full capacity;

b. While biologically rich grassland is valuable in terms of which natural land area should remain intact, the land area is underutilized for socio-economic activities to date;

c. Biomass incineration plant emit a large amount of CO_2 equivalent gas contaminating the air in the surrounding areas;

d. Water requirement of the biomass plant is very high. Prior to implementation of the project, exploration of groundwater availability or surface water availability has to be carried out i.e. contamination of groundwater or depletion of surface water should be ensured for the life time of the project; and

e. The T/L from the power plant to the existing power grid is relatively short and installed generally on the roadside. In places it might go through underutilized grassland without significant impacts to the natural environment.

(2) Socio-economic Environment

a. No significant socio-economic impact is envisaged, as the power plant and plantation areas are not occupied by local population at present;

b. Customary land owners have formed an ILG at each district in order to develop businesses for the related and unrelated to the power plant;

c. Five hundred local residents would be exposed to direct employment opportunities associated with the power plant;

d. Local residents could be employed as non-skilled labor during the construction period; and

e. Increased electric power supply to Lae provides additional development opportunities for commerce and industries and should create 5,000 job opportunities.

f. The T/L is installed within a road reserve unencumbered by any landowner claims for land use rights.

8.6.8 Environmental Implications of the Natural Gas Thermal Power Plant

(1) Natural Environment

1) Emissions from the Natural Gas Power Plant

The burning of natural gas produces nitrogen oxide and carbon dioxide, but in lower quantities, usually 50-60% less than the levels produced by burning coal or oil. Methane, a primary component of natural gas, is a greenhouse gas and can be emitted into the air when natural gas is burned incompletely. Methane can also be emitted as a result of leaks and losses during transportation. The emissions of sulfur dioxide and mercury compounds from the combustion of natural gas are generally negligible.

In the United States, natural gas-fired generation emits 1) 515 kg/MWh of carbon dioxide, 0.045 kg/MWh of sulfur dioxide, and 0.77 kg/MWh of nitrogen oxides. Compared to the average air emissions from coal-fired power generation, natural gas produces half as much carbon dioxide, less than a third as much nitrogen oxide, and only 1% as much sulfur oxide. The processes of natural gas extraction, treatment, and transport to the power plant generate additional emissions.

2) Water Resources

The burning of natural gas in combustion turbines requires very little water. However, natural gas-fired boilers and combined cycle systems do require water for cooling purposes. When power plants remove water from a lake or river, fish and other aquatic life can be killed, affecting animals and people who depend on these aquatic resources.

Combustion turbines do not produce any water discharges, but pollutants and heat build up in the water used in natural gas boilers and combined cycle systems. When these pollutants and heat reach certain levels, the water is often discharged into lakes or rivers. This discharge usually requires a permit and has to be constantly monitored to avoid thermal pollution of the lake or river water.

3) Land Resource Use

The extraction of natural gas and the construction of natural gas power plants can destroy natural habitats for animals and plants. Possible land resource impacts include erosion, loss of soil productivity, and landslides, depending on the location of plant.

4) Solid Waste Generation

The use of natural gas to create electricity does not produce substantial amounts of solid waste.

5) Civil Works for Pipelines

Because of an extensive pipelines buried in the ground from gas field to power plant, the natural environment on the steep hillside, riparian environment and forest areas are disturbed. For construction works of pipelines as well as for maintenance works, haul road is also constructed in the middle of thick forest area, near the watercourse and swamp areas.

(2) Socio-economic Environment

1) Land Acquisition

The area of natural gas extraction and construction of natural gas power plants could be in the customary owned land of Southern Highlands Province. There is a possibility of a small number of local resident’s farming shelters subject to relocation. Negotiations for land acquisition with a landowner or a group of customary landowners would have to begin in the early stage of planning of the power plant.

2) Customary Use of Natural Plants and Wildlife

Wild greens, several varieties of bananas, coconuts, mango, and fruits of forest origin will have to be thoroughly studied in order to compensate the loss. Domesticated animals use certain areas of land, and the hunting of fowl, bush pig, birds, and marsupials takes place elsewhere. These uses of plants and wildlife should be studied, and compensation should be provided for any loss of natural species customarily used in the project areas.

3) Ceremonial Use of Land

Locals hold ceremonial occasions at which hundreds of pigs or other valuables are distributed to guests. Competitive feasting ("fighting with food") between big men and chiefs features oratory, dancing, singing, drumming, and feasting that go on for days, along with the payment of bride-prices and other exchanges. An appropriate interview survey on this ceremonial use of land should be identified to avoid impacts on socio-cultural customs.

4) Transmission Line

The T/L could be installed generally along the existing road. In places, it would have to go through forested areas. In general, it would also have to go through customary owned land. Thus, negotiation for land acquisition with a number of local landowners has to begin in the early stage of planning.

8.6.9 Environmental Implications of Diesel Generators

(1) Natural Environment

Within the framework of this Master Plan Study, diesel oil generator systems form part of the thermal power generation system, as well as gas turbines with light oil. Both systems are used for relatively small-scale power generation, as in the case of Lae Wharf and Lae IPP. The upgrades of Taraka Power Plant in Lae and the other plant in Madang also entailed the introduction of diesel power generating systems using diesel engines.

These diesel power generators are installed within city limits where the functions of the natural environment have already been nullified, hence no significant impacts to the natural environment of any significant value are brought about by the diesel generator systems.

(2) Socio-economic Environment

1) Environment of Diesel Generator Installation Area

These diesel generators are installed within city limits, where commercial and industrial activities are concentrated. Installation area is the area already established as power generator station where mitigation measures for socio-economic impacts have already been implemented.

2) Noise and Vibration

Residential areas are found in in places in the nearby area. These generators are generally housed in large storehouse types of buildings. The noise emanating from the generators is thus generally confined within the buildings. Diesel engines are installed on the concrete foundation with rubber dumpers/bushes inserted between the generators and foundations. Most of the vibration induced by the generators is absorbed.

3) Resettlement and Land Acquisition

Although the locations are in the middle of urban areas, there is no resettlement or land acquisition involved in these project areas.

8.6.10 Environmental Implications of Ramu-Port Moresby Interconnection

(1) General Description of the Project

Based on the study whose details are discussed in Chapter 7, T/L interconnected to from Ramu System to POM System has to be developed in view of stable supply of electricity to the capital city in the near future.

Ramu System and POM system are separated by the Owen Stanley mountain range. There is no permanent road interconnected from two large urban centers of Bulolo or Lae in Morobe Province to POM. Because of the isolation of the capital city from a high potential area for hydropower development, POM is in need of interconnection of T/L from Ramu System.

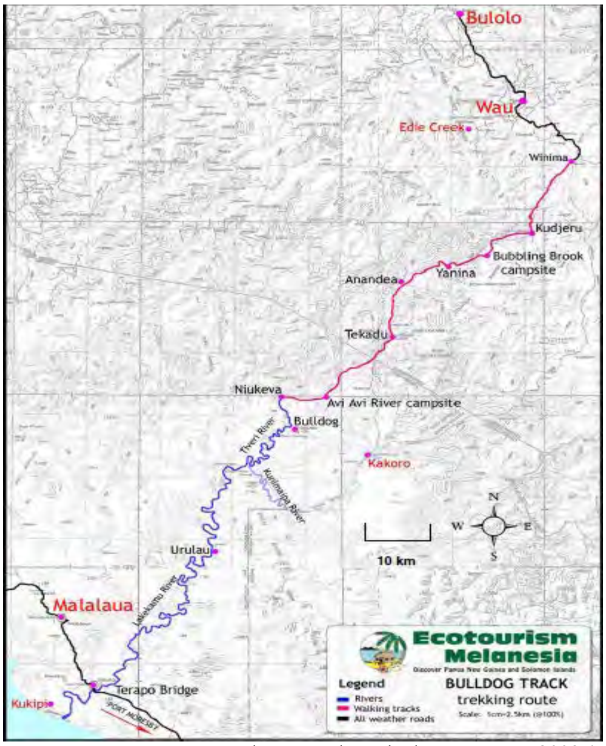
Fig. 8.6-1 shows approximate route of T/L from Bulolo in Morobe Province to Kukipie on the southern coast of PNG for further connection to POM in the direction of southeast. Pending the development of large scale and inexpensive power generation system, this interconnection should become important in the future.

(2) Natural Environment

Because of the interconnection route goes through mountainous area, the following is noted:

a. Haul road of approximately 200 km is constructed along the interconnection route where possible; and

b. Aerial operation for steep hillside for the construction of pylon and install T/L should be considered viable, approximately 90 km in the mountains where appropriate.



Source: Power Sector Development Plan, Final Report, ADB2009 (TA 4932-PNG)

Fig. 8.6-1 Ramu-Port Moresby Interconnection

Thus significant impacts to the natural environment are caused by the construction of haul road, which could be made use of for maintenance works of the T/Ls. Local people should also use the haul road for their daily life. The consequence of road construction work is often associated with further exploitation, on the long term, of the area for agricultural and other activities.

The details of the natural environment have not been fully studied to date in most mountainous area of PNG. Thus, at the time of project implementation, a study on the natural environment should be carried out not only for the project, but also to accumulate data for research and educational organizations of PNG. A number of local universities and forestry institutes should therefore be involved in the study.

During the rainy season, the area along the river is usually flooded and/or landslide should occur regularly. Thus, careful location of the pylons for T/L has to be carried out in order to safeguard the transmission system as a whole.

(3) Socio-economic Environment

1) Land Acquisition

The area of construction works for haul road and pylon for T/L could be in the customary owned land of Western Province. Identify landowners or a group of customary landowners of indigenous tribes. Negotiations of land acquisition with them should have to begin in the early stage of planning of the interconnection.

2) Customary Use of Natural Plants and Wildlife

Wild greens, several varieties of bananas, coconuts, mango, and fruits of forest origin will have to be thoroughly studied in order to compensate the loss if any. Domesticated animals use certain areas of land, and the hunting of fowl, bush pig, birds, and marsupials takes place in the remote areas. These uses of plants and wildlife should be studied, and compensation should be provided for any loss of natural species customarily used in the project areas.

3) Ceremonial Use of Land

Locals hold ceremonial occasions at which hundreds of pigs or other valuables are distributed to guests. Competitive feasting ("fighting with food") between big men and chiefs features oratory, dancing, singing, drumming, and feasting that go on for days, along with the payment of bride-prices and other exchanges at the time of marriage ceremony. An appropriate interview survey on this ceremonial use of land should be identified in order to avoid impacts on socio-cultural customs.

8.7 RESULT OF SEA ANALYSIS

8.7.1 Key Conditions of the Natural and Socio-economic Environment

In order to implement effective environmental management and monitoring with respect to the electricity supply of Ramu Grid System, there are a number of areas that need to be kept in mind when the electricity supply system development is planned in respect to consideration of the environment as follows:

a. The need to institutionalize the community consultation system of PPL with appropriately trained staff for implementation of the participatory development process;

b. Institutional weakness in socio-economic management at the PPL's administration in terms of information database availability for the planning of Ramu Grid System in relation to the sustainable economic development;

c. Institutional weakness, and probably a lack of budget and staff for the environmental conservation and management needs, especially a lack of data that should be made available for development perspectives;

d. In-depth knowledge on the traditional land tenure system based on the oral history that is not integrated into the land use management and planning;

e. The need for greater environmental awareness and appreciation of the exploitable values of the environment in Ramu Grid System area. A number of small-scale hydropower development areas, for example, have not been fully studied to date by the local and central office of PPL. Greater awareness and appreciation as a central organization for electrification of the country should contribute to the sustainable economic growth;

f. Natural population increase in the rural areas leads to migratory population increase in urban areas for employment, while the development of urban infrastructure and industry, including appropriate supplies of electricity, cannot catch up with the trend of urbanization;

g. The need to institutionalize environmental management and monitoring systems for the whole electricity generation system; and

h. The need to strengthen partnership between government, donor, and NGO groups for centralized and decentralized electricity supply services.

8.7.2 Establishment of Environmental Unit

In view of the political and economic ability among Pacific countries, PNG should play probably the strongest and largest role of powerhouse in the years to come. Thus it is imperative to build a nation with leading role of which environmental care in conjunction with development project is very significant. Thus it is important to improve performance and efficiency of policy and planning by minimizing adverse impacts on the environment and society at the time of project implementation.

There has been little effort to avoid costly mistakes and missed opportunities caused by inadequate information about impact and trade-offs when power generation project was implemented. Thus provide appropriate framework for project-level assessment and coordination, particularly to understand cumulative impacts and reduce duplication of the past mistakes related to the environmental management. Thereby it is possible to build consensus and gain public trust through its multi-stakeholder and participatory focus. It is particularly important to therefore establish a unit dedicated for environmental matters within the framework of Ramu Grid System area. It means another dedicated unit should be established within other grid system area of PNG.

PPL's environmental unit should consists of: 1) Team Leader experienced with power generation projects for more than 10 years with a back ground of socio-economy of PNG; 2) Environmental Officer – Reservoir Environment dedicated for reservoir environment of the power generation in terms of sedimentation, water quality and afforestation; 3) Environmental Officer – Land and Socio-economics should be able to dedicate land tenure system of PNG; and 4) Environmental Officer – EIA should be able to dedicate for assessment of the environmental impacts caused by the power generation projects as well as to overlook out-sourced contract for environmental management and monitoring works.

8.7.3 Establishment of Planning Unit

There is the lack of electricity power development plan for Ramu Grid System, which covers nearly 60 % of the total population of PNG. Despite the fact that foreign donors can provide technical assistance, it would be time for PPL to be able to hold planning ability of electricity supply system. It has to be a stringent organizational empowerment program. In view of the future and probably rapid industrialization that will take place in the country, PPL is acutely in need of the senior staff with highly skilled planning ability so as not to rely on the technical assistance of donors. The following is thus suggested:

a. Electricity demand forecast expert in order to predict the capacity (MW) and energy (GWh) demand in the industrial centers of Ramu Grid System;

b. Least cost expansion plan expert in order to plan infrastructure needed to meet the demand at all times for the forecast period while maintaining system reliability and quality of supply;

c. Transmission expansion plan expert in order to plan transmission and distribution lines for the generated electricity to customers;

d. Fuel supply assessment expert in order to determine the national energy resources available for energy generation as a matter of follow-up study for the Master Plan;

e. Rural electrification program expert for electricity supply to remote areas that cannot be covered by the national grid; and

f. Investment program expert on how to finance the future investments in the energy sector.

8.7.4 Rehabilitation of PPL Training College

Ramu Grid System area covers the mountainous highlands area whose mountain slopes are prone to torrential rain and the flat land with a large number of rivers causing a number of flood events in recent years. It is very difficult to maintain a good electricity services in such areas with limited number of trained staff. However, during the hearing survey carried out in June 2015, a number of customers suggested to sign up as customers if reliability is restored.

During the 20 century, when the size of population is small and electricity generation is confined in the central part of province only, there was much reliability than today. In view of expanding operation for ever-increasing population, PPL is in need expanding its mobility of skilled field staff in order to maintain high level of services.

It appears that PPL has resumed its staff training in 2015 after ceased its operation of training college in 2000. However, it appears that the training facility has been left idle for 15 years and that they are malfunctioning after years of the lack of maintenance works. Thus it is imperative to rehabilitate the facilities.

Details of suggested refurbishment of training college's facility is indicated in Appendix 8-4.

8.7.5 Centralized Power Generation vs. Decentralized Power Generation

There has been a huge electricity loss that took place in 2015 in Madang because of the transmission failed by severe mudflow and a large number of pylons were washed away. It is a major drawback of centralized power plants. If realized, similar incident could happen to the T/L linking from Ramu Grid System to POM Grid System, unless a back-up T/L is provided. This is a major drawback of centralized power generation system.

It cost less per unit of generation to build large plants than to build smaller plants. These conditions prevailed from 1910 through 1960, and everyone in the power industry and government came to assume that remote, central generation was optimal, that it would deliver power at the lowest cost versus other alternatives. Such business model might be of an outdated scheme of power generation.

PPL as an electric monopoly was allowed to charge tariff to give a fair return and to prevent excessive or monopoly profits, electric company like PPL has long been required to pass 100 percent of any gain in efficiency to the customers. This leaves an electric company with no financial incentive to adopt new technologies for decentralized power generation system. In fact, such local generation erodes the rationale for continued monopoly protection.

In view of the primary energy available in PNG, power generation has to take place in the remote areas and hundreds of kilometers of T/L has to be constructed within the framework of this Master Plan. While it is inevitable to do so, one might look at the practice of old business model has to cease sooner or later.

There has been a discussion therefore that the emergence of decentralized power generation has to be more reliable i.e. where power is generated from renewable energy sources such as wind and sunlight could be reliable. These sources generate less harmful emissions, meaning plants can be built in residential areas and decreases lose during transmission. Solutions are required to store this additional energy, which has led to the emergence of the Grid Energy Storage System. The more the solar and wind power generation becomes popular, the more the grid energy storage system should become reliable source of energy storage system, which probably is very expensive at this stage of economic development in PNG.

At present, solar power generation system is the only electricity generation system that individual household can sell energy to an electricity monopoly like PPL. If realized, PPL has to provide distribution line capable to absorb electricity purchased from a group of individual households. In the case only rural electrification is a matter of concern, there is no need to purchase electricity from the local people but simply the local households should make use of the electricity generated from their own power generator. This should save the cost of T/L.

Carefully crafted system of decentralized power generation could be not limited to but including as follows:

a. Marketing system of solar power unit should be carefully planed if commercial companies should distribute solar system to every remote corner of the country, or use the network of local level governments for distribution of solar power units, or PPL's field office could be the point of sales;

b. Price of solar power unit might have to reflect no cost of its own but collect with electricity tariff in the case of electricity purchase agreement with household is signed up, or solar power unit should be sold at its full price without electricity purchase agreement;

c. A model district should be selected and establish them with electricity purchase agreement so as to be able to install distribution line with a capacity for absorbing purchased electricity. The model district should be with "Cellphone Easipay System" i.e. device money transfer system using cell phone such as the system already quite popular in Kenya. Thereby customers do not have to physically visit and queue at PPL's pay counter;

d. Establish a model district without electricity purchase plan i.e. conventional customer payment system;

e. Compare the efficiency of two model districts in terms of socio-economic achievement as well as the way decentralized power generation contributes to PPL's business model in terms of conventional distribution plan vs. Saving on the T/L, etc.

If individuals installing solar power system are considered as investor for electrification of the rural area in the Ramu Grid System, some 750,000 households are one way to the other available for solar power electrification. If one household can dedicate for 1 KW of electricity sales, the amount of electricity generation is by simple calculation 750 MW of installed capacity is obtained. The figure is by all means ambitions but somewhere from 100 MW to 250MW of electricity could be generated without significant effort of the administration of PPL.

8.7.6 Poverty Elimination and Indigenous Population Development Plan

The relationship between the GoPNG rural communities in PNG is highly sensitive, particularly related to infrastructure development projects that involve land acquisition. Also, due to limited access and difficult information dissemination systems, there is a high risk of communication gaps, creating conflicting situations. The issue of voluntary registration of customary land has already received a setback in PNG due to lack of consultation and information dissemination. To avoid any kind of communication gap and mistrust amongst key stakeholders, it will be critical to hold continuous consultation and participation with communities in PNG for successful planning and implementation of projects.

Because of the rural areas are remote and without modern infrastructures, 37 % of the population with poverty in PNG exists in the Highlands Region, according to ADB's web site (http://www. adb.org/sites/default/files/linked-documents/cps-png-2016-2020-pa.pdf). There is no official and modern definition of poverty in PNG. This is because of an assumption that all native populations are customary landowners and therefore have a right to a life of "subsistence affluence" in the rural village communities to which they belong or to which they could easily return. In modern terms, "Land Owner" cannot be on the level of poverty.

Customary landowners, however, easily become those on the poverty level at the time of which they release their right on land to economic development as they lose their rights of "subsistence affluence", the rich endowment of the natural environment. Because of a lack of information and future planning for making a living without land, often very wide area is necessary for slush and burn agriculture, rural population flows out to urban areas. They eventually exercise real urban poverty. Thus, it is a role of Environment Unit as described above for establishment within PPL that it has to disseminate information on the project, predicted consequences of the project implementation, or the project's intention of which is has to carry out a program for elimination of poverty in order to safeguards rural population from falling their current standard of living. It is as a matter of course one of the best ways to increase electricity customers. Thus Appendix 8-5 suggests a program for rural population development plan based on ADB's Social Safeguard policy.

8.7.7 Greenhouse Gas Emissions of Power Plant

(1) CO_2 Equivalent Gas Emissions of the Power Generation System

A measure of life-cycle greenhouse gas emissions is an attempt to calculate the global-warming potential of electrical energy sources by doing a life-cycle assessment of each energy source and presenting the findings in units of global warming potential per unit of electrical energy generated by that source.

The scale uses the global warming potential unit, the Carbon dioxide equivalent (CO2e), and the unit of electrical energy, the kilowatt hour (kWh). These assessments attempt to cover the full life of each type of power generation, from material & fuel mining, through construction, to operation and waste management. (https://en.wikipedia.org/wiki/Life-cycle_greenhouse-gas_ emissions_of_ energy_sources).

Table 8.7-1 shows CO_2 equivalent gas emissions of various types of power generation based on IPCC's study.

However, the above site also refers to another study result on the same subject made by Benjamin K. Sovacool's "Valuing the greenhouse gas emissions from nuclear power: A critical survey" "*Energy Policy*" 36, 2950-2963, 2008). As is shown in Table 8.7-2, values of CO_2 equivalent gas emissions of various types of power generation are somewhat different from those shown in Table 8.7-1. Thus these values will have to be adjusted at the time of implementation of each project whose characteristics are different from one project to the other.

Table 8.7-1 CO_2 Equivalent Gas Emissions of Power Generation (IPCC)

Technology	Min	Median	Max
Currently commercially available technologies			
Coal – PC	740	820	910
Biomass – cofiring with coal	620	740	890
Gas – combined cycle	410	490	650
Biomass – dedicated	130	230	420
Solar PV – utility scale	18	48	180
Solar PV – rooftop	26	41	60
Geothermal	6.0	38	79
Concentrated solar power	8.8	27	63
Hydropower	1.0	24	2200
Wind offshore	8.0	12	35
Nuclear	3.7	12	110
Wind onshore	7.0	11	56
Pre-commercial technologies			
CCS – Coal – PC	190	220	250
CCS – Coal – IGCC	170	200	230
CCS – Gas – combined cycle	94	170	340
CCS – Coal – oxyfuel	100	160	200
Ocean (tidal and wave)	5.6	17	28

(https://en.wikipedia.org/wiki/Life-cycle_greenhouse-gas_emissions_of_energy_sources)

Unit: gCO_2eq/kWh

Table 8.7-2 CO_2 Equivalent Gas Emissions of Power Generation (Sovacool)

Technology	Description	Estimate (g CO_2/kWh_e)
Wind	2.5 MW offshore	9
Hydroelectric	3.1 MW reservoir	10
Wind	1.5 MW onshore	10
Biogas	Anaerobic digestion	11
Hydroelectric	300 kW run-of-river	13
Solar thermal	80 MW parabolic trough	13
Biomass	various	14-35
Solar PV	Polycrystaline silicon	32
Geothermal	80 MW hot dry rock	38
Nuclear	various reactor types	66
Natural gas	various combined cycle turbines	443
Fuel Cell	hydrogen from gas reforming	664
Diesel	various generator and turbine types	778
Heavy oil	various generator and turbine types	778
Coal	various generator types with scrubbing	960
Coal	various generator types without scrubbing	1050

(https://en.wikipedia.org/wiki/Life-cycle_greenhouse-gas_emissions_of_energy_sources)
Unit: gCO_2eq/kWh

(2) Afforestation Area Development for Carbon Absorption

It is well known that trees could absorb CO_2. Thus in view of the global climate change, every development project that emit CO_2 equivalent gas is required to play a role of carbon reduction; developing tree planting areas using tree's carbon sequestration capacity in order to compensate what is otherwise emitted by the project as CO_2 equivalent gas. Concept of carbon sequestration and the method of calculation of carbon absorption are shown in Appendix 8-2.

Based on the calculation and using the values of emissions as per Table 8.7-1 or Table 8.7-2 as above, Table 8.7-3 shows the selected study components of the Master Plant that each one of them is obliged to develop minimum afforestation area during the lifetime of respective power generation system. Thereby each mode of power generation system can compensate what it otherwise emit greenhouse gas and that it has to form a part of the contribution for COP 21's agreement on the global climate change.

As is indicated, it is noticeable that renewable energy sources of the listed study components of hydropower plant show much smaller afforestation area.

Table 8.7-3 Minimum Required Afforestation Area by Power Generation System

Fuel Type		Power Plant	Actual Output (MW)	Life Cycle (Year)	GHG Emission (cCO2 ep/kwh)	Required Afforestation Area (ha for lifetime)
Prospective Power Plants	Natural Gas	Highland G/T	30-60	30	410	14,048
	Diesel Oil	Munum	30	30	778	13,328
	Biomass	Markham Valley	30	30	130	2,227
	Thermal	Additional Thermal 1	30	30	778	13,328
	- ditto -	Additional Thermal 2	30	30	778	13,328
	Hydropower	Mongi-Bulum	60	70	1	80
		Ramu 2	180	70	1	240
		Kaugel	56	70	1	75
		Baime (PNGFP)	8	70	1	11
		Gowar	43.5	70	1	58

Source: JICA Study Team

Note: 1. The above calculation does not include capacity factor of each power plant. Thus in reality, capacity factor as per explained in Chapter 6 should be applied i.e. afforestation area should become small proportionate to the values of capacity factor.

2. Value of the greenhouse gas emission of diesel oil and thermal is assumed at 778 from Table 8.7-2.

8.8 MITIGATION MEASURES OF THE STUDY COMPONENTS

8.8.1 Mitigation Measures for Mongi-Bulum Hydropower Plant

(1) Natural Environment

a. Since the project site is near the coastal area, and tunnels linking Mongi River and Bulum River should impoundment water for power generation, construction debris should not contaminate the river waters and the coastal waters of Huon Gulf. A designated disposal area where no soil particles can contaminate the waters on the coastal areas must be established before the construction works commence;

b. Borrow areas for construction materials should be sought in the close proximity of the project area. Upon completion of the construction works, areas removed of natural plant should be reinstated by planting indigenous trees;

c. The T/L should be installed generally along the road that partly runs in the mountainous area while most of it has to be installed beside the road along the coast. Same land would have to be cleared in the unstudied natural environment within the mountainous area along the river; hence, the area subject to the T/L should be thoroughly studied in order to assess if further environmental management and mitigation measures should be carried out;

d. As run-of-river weir is constructed across the watercourse, disturbance to the riverside where complete habitat of riparian fauna and flora, water course diversions and soil erosions should be minimized; and

e. Based on Table 8.7-3, afforestation work should be implemented in order to compensate CO_2 equivalent gas emission of the hydropower plant.

(2) Socio-economic Environment

a. The T/L should be installed over a 77 km distance along the road in the coastal area, where it will pass through areas of customary owned land. Negotiations should thus be made with identified ILG existing in each district for the acquisition of land or lease-hold agreements; and

b. Local residents should be employed as non-skilled labor during the construction period in order to provide job opportunities for the local communities.

8.8.2 Mitigation Measures for Ramu 2 Hydropower Development

(1) Natural Environment

a. During the construction period, debris produced from excavation works should be appropriately treated and disposed to the designated site in order to keep the natural environment of the surrounding area as intact as possible;

b. Borrow areas for construction materials should be sought in the close proximity of the project area. Upon completion of the construction works, areas removed of natural plant should be reinstated by planting indigenous trees;

c. Changes of the river water flow regime could cause positive and negative impacts to both the human and natural environments. An appropriate monitoring program for the entire stretch of river should be planned for the lifetime of Ramu2 Hydropower Project in conjunction with Yonki Dam and Ramu1 Hydropower Project. Mitigation measures are further planned as a part of the environmental management plan;

d. As run-of-river weir is constructed across the watercourse, disturbance to the riverside where complete habitat of riparian fauna and flora, water course diversions and soil erosions should be minimized; and

e. Based on Table 8.7-3, afforestation work should be implemented in order to compensate CO_2 equivalent gas emission of the hydropower plant.

(2) Socio-economic Environment

a. Negotiations should thus be made with identified ILG existing in the district for the acquisition of land or lease-hold agreements where power plant, weir, haul road and borrow areas are developed; and

b. Local residents should be employed as non-skilled labor during the construction period in order to provide job opportunities for the local communities.

8.8.3 Mitigation Measures for Kaugel Hydropower Plant

(1) Natural Environment

a. Borrow areas for construction materials should be sought in the close proximity of the project area. Upon completion of the construction works, areas removed of natural plant should be reinstated by planting indigenous trees;

b. The T/L for 260 km to the existing grid would have to be installed through mountainous areas. The T/L construction should cause light but adverse impacts to the natural environment. A detailed study should thus be conducted for the area where the T/L is installed, in addition to the area of the power plant and intake weir for the assessment of further environmental management measures;

c. Power plant is located in the area that appears to be prone to land slide at the time of heavy rain. If determined to construct, slope protection works based on the geo-technical engineering should be implemented or alternative location should be selected;

d. As run-of-river weir is constructed across the watercourse, disturbance to the riverside where complete habitat of riparian fauna and flora, water course diversions and soil erosions should be minimized; and

e. Based on Table 8.7-3, afforestation work should be implemented in order to compensate CO_2 equivalent gas emission of the hydropower plant.

(2) Socio-economic Environment

a. Negotiations should be made with identified ILG existing in the district for the acquisition of land or lease-hold agreements where power plant, weir, haul road and borrow areas are developed;

b. Local residents should be employed as non-skilled labor during the construction period in order to provide job opportunities for the local communities.

8.8.4 Mitigation Measures for Baime Hydropower Plant

There are Upper Baime Hydropower Plant and Lower Baime Hydropower Plant in Bulolo, where PNGFP has built for their own operation of gold mining as well as forest products processing works. It appears that PNGFP's hydropower plants appear to produce surplus electricity in the future. PPL has undertaken to arrange purchasing of the surplus when it is available. Thus, any environmental and socio-economic impact assessment, elaboration of mitigation measures, environmental management and monitoring works are subject to implementation within the framework of the jurisdiction of PNGFP.

8.8.5 Mitigation Measures for Gowar Hydropower Plant

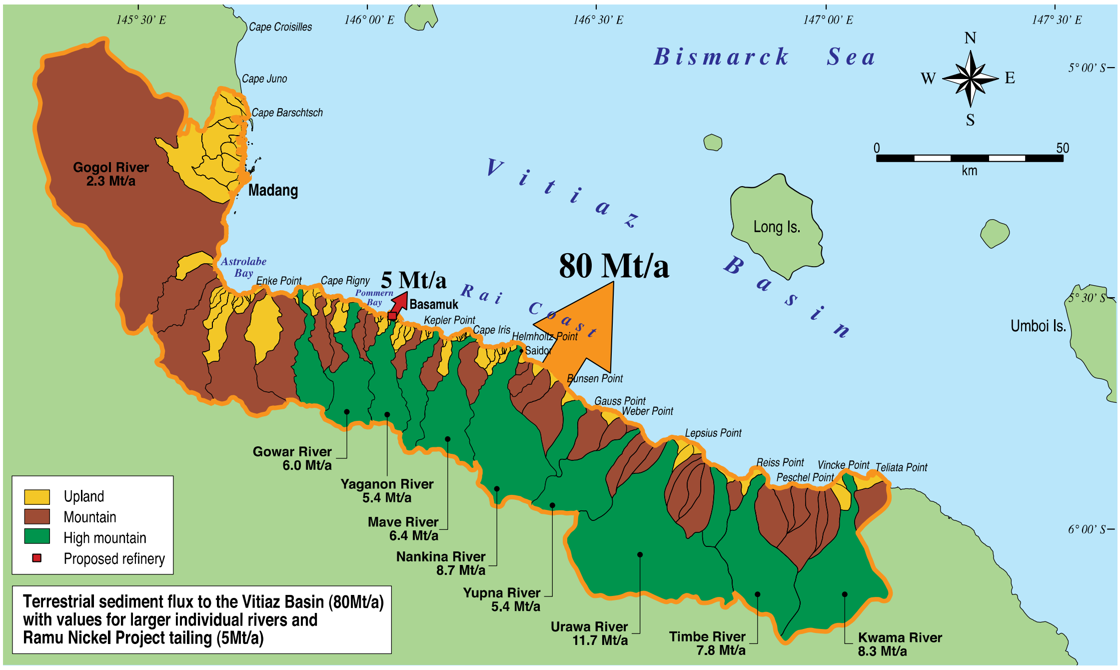
(1) Natural Environment

a. Gowar River originates from the Finisterre Mountains, where discharge of sedimentation is very large as is shown in Fig. 8.8-1. In total volume, 80 million ton/year of sedimentation is drained into Bismarck Sea while Highlands Pacific Co. Ltd. discharge 5 million ton/year of slurry after the extraction of nickel and cobalt.

Among other rivers of the mountains, Gowar River is the western most river draining into Bismarck Sea from the Finisterre Mountains where the volume of sedimentation is 6 million ton/year. Thus the following is noted:

i. Run-of-river type of weir constructed across Gowar River could function as retarding area of sedimentation i.e. advantage to reduce sedimentation drained into Bismarck Sea;

ii. Sedimentation at the weir of Gowar Power Plant may reduce capacity of power generation. Thus, construction of sediment-trap weir in the upstream area is suggested.



Source: Highlands Pacific 2010 Annual Report

Fig. 8.8-1 Sedimentation of Gowar River

b. The T/L for 50 km to the existing grid near Madang would have to be installed on the roadside that runs through coastal areas. In places it crosses over slurry pipe of Highlands Pacific Co. Ltd. In order to avoid any accidents of interfacing works, appropriate protection work for the slurry pipe should be made;

c. Location of the power plant appears to be in the area prone to severe rainfall. Thus extensive slope protection works based on geo-technical study should be carried out;

d. As run-of-river weir is constructed across the watercourse, disturbance to the riverside where complete habitat of riparian fauna and flora, water course diversions and soil erosions should be minimized; and

e. Based on Table 8.7-3, afforestation work should be implemented in order to compensate CO_2 equivalent gas emission of the hydropower plant.

(2) Socio-economic Environment

a. No significant socio-economic impact is envisaged, as local population does not occupy the inundated area by the run-of-river weir. However, the area where power plant and intake for the run-of-river type weir are constructed would be in customary owned land. Details of a group of landowners should be studied during the feasibility study.

b. T/Ls would be installed over 50 km to Madang, where a major grid system exists. There are a number of customary land owners along the road subject to negotiations for land acquisition or lease-hold agreements for the land area of the pylons for T/Ls;

c. Negotiations should be made with identified ILG existing in the district for the acquisition of land or lease-hold agreements where power plant, weir, haul road and borrow areas are developed; and

d. Local residents should be employed as non-skilled labor during the construction period in order to provide job opportunities for the local communities.

8.8.6 Mitigation Measures for Markham Valley Biomass Power Plant

(1) Natural Environment

a. Fast-growing tree species dedicated for tree plantation area of 12,000 ha as primary energy source is a good CO_2 equivalent gas emission achieving carbon neutrality;

b. Depending on the location of power plant, smoke stack could cause adverse effect on the fauna and flora in the near-by area. Thus depending on the use of specification of power plant, there must be stack emissions that do not exceed the emission limits set out in the "Directive 2001/80/EC" of the European Parliament and of the "Council of 23 October 2001". The plant's emission should also meet the standard set out by "Stockholm Convention on Persistent Organic Pollutants";

c. The quality of surface water or groundwater within or leaving the proposed area of power plant should not exceed water quality requirements. Thus storage with water purification system within the power plant should be equipped before any water is discharged from the power plant;

d. Standard mitigation measures of biomass power plant involve safe storage of hazardous substances and piling methods for minimizing the risk of contaminants into the ground. Any other industrial safety of large scale combustion plant should be followed with qualified safety personnel.

(2) Socio-economic Environment

a. Customary landowners have formed an ILG in order to develop businesses related and unrelated to the power plant. Information dissemination during the planning stage is essential for establishing amicable relations with ILG for land acquisition or lease hold agreement of the tree plantation area, power plant and pylons of T/L; and

b. Local residents could be employed as non-skilled labor during the construction period.

8.8.7 Mitigation Measures for Natural Gas Thermal Power Plant

(1) Natural Environment

a. Pipeline Construction Works

Because of the extensive pipeline construction works involved in the project, survey on the right of way in order to avoid sensitive riparian and swamp environment as well as the forest areas should be established.

Soil conditions on the steeply sloped hillside are usually vulnerable if disturbed and slippage should occur during the heavy rain. Thus avoid disturbances to the soil of more than 1 : 2 gradient of slope.

Where the pipeline crosses over watercourse, disturbance to the riverside where complete habitat of riparian fauna and flora, water course diversions and soil erosions should be minimized.

b. Re-vegetation of the Disturbed Ground

The re-establishment and development of a plant cover by either natural or artificial means in the area disturbed by the previous oil exploration and gas exploration should be carried out. Natural re-vegetation, so-called passive re-vegetation without intervention and active re-vegetation with intervention using artificial means, such as ground preparation, fertilization, seeding or seedling planting as well as the use of top soil removed from other construction areas should be carried out.

c. Prevention of Water and Soil Contamination during Operation

A soil contamination management should be implemented for: 1) Fuel handling transport and storage procedures; 2) Materials handling, storage and disposal; 3) Storage and handling of radioactive material if any; 4) Handling of contaminated waste; 5) Diesel storage tanks has to be purpose-built i.e. above ground and within double-walled tanks or containment bunds; 6) Oil spill prevention and response measures has be in place.

d. General Erosion and Sediment Control

An erosion and sediment control measures at watercourse crossings should be carried out by : 1) Reducing stockpile of spoil and soil materials close to waterways i.e. minimum 10 m away from the waterline where practicable; 2) Controlling sediment runoff from stockpiles and cleared areas around watercourses; 3) Limiting erosion and sediment delivery to streams from new quarries; 4) Reducing side-casting of spoil directly into waterways; 5) Grading pipeline ROWs and access way alignments adjacent to streams minimum 10 away from watercourses.

(2) Socio-economic Environment

1) Customary landowners have formed an ILG to develop businesses related and unrelated to the power plant. Information dissemination during the planning stage is essential for establishing amicable relations with ILG for land acquisition or leasehold agreement for the areas of power plant, pipelines and pylons of T/L;

2) Based on the explanations in the Section 8.7.6 and Appendix 8- 5, assessment of the local people, indigenous in every sense should be carried out for the acceptance of the project as a whole as well as to establish rural development scheme in conjunction with the project's socio-economic impact assessment because of the scale of operation, extent of construction works and the impacts caused by the operation and maintenance of the power plant; and

3) Local residents could be employed as non-skilled labor during the construction period. Where there are a number of grievances in terms of landownership, employment for both men and women and compensation for the land area released for the project should all be considered as a matter of the lost mechanism of the indigenous livelihood. Thus thorough social impact study, consequent poverty assessment and indigenous peoples development plan including education and vocational facilities should be carried out in order to lay out a broad community support mechanism. Thereby the standard of living of the local populations raised in conjunction with which the indigenous peoples development plan should achieve the goal of the development of power plant as a matter of social obligations of the company influencing the local communities.

(3) Environmental Impact Statement of PNG-LNG Project

PNG LNG Project has developed extensive natural gas pope line system including underwater pipeline and the shipping plant near POM. During the time natural gas exploration and subsequent development of natural gas plant, PNG LNG plant elaborated environmental impact statement including "Summary of Mitigation and Management Commitments".

Summary of Mitigation and Management Commitments developed by PNG LNG Project is probably the best and very well developed environmental mitigation and management statement ever elaborated in PNG. Because of the scale of project and project finance, such environmental mitigation and management scheme is possible to implement. While it has been developed for the areas concerned with natural gas development project, by all means, in principle it is applicable not only for the PNG LNG project but also applicable to other power generation project. In fact this could be the textbook for the mitigation and management measures of all the development projects that takes place in PNG.

Since natural gas power generation plant would be developed using PNG LNG's gas, for the reference purposes, although it includes a section for marine environment that is not studied as a part of Ramu Grid System, it is shown in Appendix 8-6.

8.8.8 Mitigation Measures for Diesel Generator Power Plants

(1) Natural Environment

Because of the project area is in urban area, mitigation measures for maintaining ambient air quality at the international standard has to be carried out. Thus, the following has to be implemented:

a. Muffler for reducing the noise level of diesel engines; and

b. Diesel engine's combustion process results in significant production of gaseous NOx. Thus exhaust catalytic converter should be equipped unless the system is with selective non-catalytic reduction (SNCR) system.

(2) Socio-economic Environment

There is no explicit adverse effect caused to the general public of urban areas as a result of diesel engine generator installation. However, because of the odor and particle matters that are not possible to suppress with the present technology, newly created power plant should avoid the area in the vicinity of hospitals, clinics, kinder gardens and schools.

Establishing new power plant site within the city limit usually takes place in the area the land has been put into a leasehold area of the national government. Thus establishment of power plant in terms of land acquisition has to be made between PPL and the government. If power plant has to be established in the customary owned land area, the local landowner group has to be identified for negotiation of the land acquisition or lease agreement.

8.8.9 Mitigation Measures for Ramu-Port Moresby Interconnection

(1) Natural Environment

There is no explicit adverse effect caused to the natural environment and general public as a result of interconnection project except for the construction of haul road, which is usually not paved with asphalt. However, depending on the locations, large amount of construction debris are disposed of the area, which has to be designated by the local/central government.

For maintenance purposes, tree and grass cutting activities should take periodically.

(2) Socio-economic Environment

The route of interconnection is known to be scarcely populated while customary land owners should always be identified for negotiation of the right of way. In general, based on the lease agreement of the T/Ls and haul road, use of the land on the leasehold basis of the right of way of the T/L remains generally for 99 years.

8.9 SUGGESTED ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN (EMAP & EMOP)

8.9.1 EMaP and EMoP for Mongi-Bulum Hydropower Plant

(1) Natural Environment

a. Because of the permanent changes of the riparian regime, although visible and drastic changes may not take place immediately after the implementation of the project except for the appearance of power plant, monitoring works on the riparian environment should be carried out for the lifetime of the plant. Interval of monitoring should be at least once a year generally on the fauna and flora, river water regime, slope and soil erosion as well as aquatic life;

b. The T/L installed along the road as well in places that goes through the natural environment should be subject to periodical monitoring. Where the growth of plants causes problems to T/L, vegetation on the right of way is subject to cutting;

c. A designated disposal area where no soil particles can contaminate the river waters as well as the coastal waters must be established before the construction works commence. No disposal of construction debris and solid waste should be allowed in the area other than designated area for disposal; and

d. Borrow areas for construction material should be reinstated to its original conditions with indigenous plants as much as possible.

(2) Socio-economic Environment

a. Monitoring programs should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services. Programs could also monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as Indigenous Population Development Plan (IPDP);

b. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

   i. Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;

   ii. Developing instructional materials for use in the schools in order to educate the local communities on the solar energy industry;

   iii. Supporting community health screenings; and

   iv. Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development.

c. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed; and

d. Grievance redress system has to be established within the framework of the project implementation. PPL's project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs.

8.9.2 EMaP and EMoP for Ramu 2 Hydropower Development

(1) Natural Environment

a. While the project site is in the middle of the narrow gorge of Ramu Valley that runs through Eastern Highlands Province and its mid- to downstream portion runs through the lowland flood plain in Madang Province, there has been RamuI Hydropower Plant and Yonki Dam previously created for power generation.

   The alterations in the construction of the riparian environment attributable to the construction of the Yonki Dam and Ramu1 hydropower plant are summarized as follows:

   i. The area upstream of Ramu River has already been permanently inundated by Yonki Dam;

   ii. The river water is regulated: there is no longer any natural flow from the reservoir to the discharge point of Ramu1 hydropower plant; and

   iii. The flow rate of the river in the downstream area, which has already been regulated by the Ramu1 hydropower plant, should be further regulated by the construction of the Ramu2 Hydropower Plant.

   Because of the river water regime changed by Yonki Dam, Ramu1 and Ramu2 hydropower plant, monitoring riparian environment is subject to periodical monitoring for the lifetime of these hydropower plants. Monitoring works should not limited to but including generally on the fauna and flora, river water regime, slope and soil erosion as well as aquatic life;

b. The T/L installed along the road as well in places that goes through the natural environment should be subject to periodical monitoring. Where the growth of plants causes problems to T/L, vegetation on the right of way is subject to cutting;

c. A designated disposal area where no soil particles can contaminate the river waters as well as the coastal waters must be established before the construction works commence. No disposal of construction debris and solid waste should be allowed in the area other than designated area for disposal; and

d. Borrow areas for construction material should be reinstated to its original conditions with indigenous plants as much as possible.

(2) Socio-economic Environment

a. Monitoring programs should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services. Programs could also monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as Indigenous Population Development Plan;

b. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

   i. Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;

   ii. Developing instructional materials for use in the schools in order to educate the local communities on the solar energy industry;

   iii. Supporting community health screenings; and

   iv. Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

c. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed; and

d. Grievance redress system has to be established within the framework of the project implementation. PPL's project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs.

8.9.3 EMaP and EMoP for Kaugel Hydropower Plant

(1) Natural Environment

a. Because of the permanent changes of the riparian regime of Kaugel River, although drastic changes may not take place immediately after the implementation of the project, monitoring works for the riparian environment generally on the fauna and flora, river water regime, slope and soil erosion as well as aquatic life should be carried out for lifetime of the plant. Interval of monitoring should be carried out for at least once a year;

b. The T/L installed along the road as well in places that goes through the natural environment should be subject to periodical monitoring. Where the growth of plants causes problems to T/L, vegetation on the right of way is subject to cutting;

c. A designated disposal area where no soil particles can contaminate the river waters must be established before the construction works commence. No disposal of construction debris and solid waste should be allowed in the area other than designated area for disposal; and

d. Borrow areas for construction material should be reinstated to its original conditions with plants as much as possible.

(2) Socio-economic Environment

a. Monitoring programs should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services. Programs could also monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as IPDP;

b. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:
   i. Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;
   ii. Developing instructional materials for use in the schools in order to educate the local communities on the solar energy industry;
   iii. Supporting community health screenings; and
   iv. Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

c. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed; and

d. Grievance redress system has to be established within the framework of the project implementation. PPL's project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs.

8.9.4 EMaP and EMoP for Baime Hydropower Plant

There are Upper Baime Hydropower Plant and Lower Baime Hydropower Plant in Bulolo, where PNGFP has built for their own operation of gold mining as well as forest products processing works. It appears that PNGFP's hydropower plants appear to produce surplus electricity in the future. PPL has undertaken to arrange purchasing of the surplus when it is available. Thus, any environmental and socio-economic impact assessment, elaboration of environmental management and monitoring works are all within the framework and jurisdiction of PNGFP.

8.9.5 EMaP and EMoP for Gowar Hydropower Plant

(1) Natural Environment

a. Protection works for the slurry pipeline for Ramu Nickel/Cobalt Project should be carried out prior to commencement of the project. A plan for recovery in the case of accident should be elaborated including sensor system. A stand-by unit of accident recovery tools and materials should also be prepared;

b. Because of the permanent changes of the riparian regime of Kaugel River, although drastic changes may not take place immediately after the implementation of the project, monitoring works for the riparian environment generally on the fauna and flora, river water regime, slope and soil erosion as well as aquatic life should be carried out for lifetime of the plant.

Interval of monitoring should be carried out for at least once a year;

c. The T/L installed along the road as well in places that goes through the natural environment should be subject to periodical monitoring. Where the growth of plants causes problems to T/L, vegetation on the right of way is subject to cutting;

d. A designated disposal area where no soil particles can contaminate the river waters must be established before the construction works commence. No disposal of construction debris and solid waste should be allowed in the area other than designated area for disposal; and

e. Borrow areas for construction material should be reinstated to its original conditions with indigenous plants as much as possible.

(2) Socio-economic Environment

a. Monitoring programs should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services. Programs could also monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as IPDP;

b. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

   i. Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;

   ii. Developing instructional materials for use in the schools in order to educate the local communities on the solar energy industry;

   iii. Supporting community health screenings; and

   iv. Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

c. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed; and

d. Grievance redress system has to be established within the framework of the project implementation. PPL’s project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs.

8.9.6 EMaP and EMoP for Markham Valley Biomass Power Plant

(1) Natural Environment

a. Routine monitoring work for stack emissions that do not exceed the emission limits set out in the “Directive 2001/80/EC” of the European Parliament and of the “Council of 23 October 2001” or equivalent directive should be carried out. Result of the monitoring should also meet the standard set out by “Stockholm Convention on Persistent Organic Pollutants”;

b. The quality of surface water or groundwater should be monitoring periodically and that the result meets water quality requirements of PNG;

c. Monitoring work for the water leaving the power plant should be carried out if exceed water quality requirements of PNG. Monitor the water storage system if that are with water purification system within the power plant before any water is discharged from the power plant; and

d. Monitor the measures of safe storage of hazardous substances and if piling methods for minimizing the risk of contaminants into the ground is carried out throughout the lifetime of the project. Monitoring work should include industrial safety practice of large scale combustion plant and that the qualified safety personnel are permanently stationed throughout the lifetime of the project.

(2) Socio-economic Environment

a. Monitoring programs should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services. Programs could also monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as IPDP.

b. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

    i. Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;

    ii. Developing instructional materials for use in the schools in order to educate the local communities on the solar energy industry;

    iii. Supporting community health screenings; and

    iv. Providing financial support to local libraries for development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

c. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed; and

d. Grievance redress system has to be established within the framework of the project implementation. PPL's project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs.

8.9.7 EMaP and EMoP for Natural Gas Thermal Power Plant

(1) Natural Environment

1) Water Resources

a. Monitoring and maintaining erosion associated with water flow should be implemented until adequate soil stabilization has been achieved in the areas where diversion drains to intercept uncontaminated surface runoff around facilities;

b. Monitoring for and rectifying areas of all problematic erosion at reclaimed watercourse crossings should also be implemented;

c. Routine monitoring works for the watercourses where the power plant's pipelines crossing over should be carried out. If there were any erosion causing problems to the natural environment as well as to the power plant, measures to rectify the situation should be implemented;

d. Groundwater quality, leakages of chemical substance from the plant to the ground contaminating groundwater should be periodically monitored; and

e. Typical water quality criteria is shown in the Schedule 1 of the Environment (Water Quality Criteria) Regulation 2002 of PNG. It is expected that water quality should meet the regulation.

2) Emissions from the Natural Gas Power Plant

In view of the lack of air quality standard in PNG, PNG LNG Project has developed its own air quality criteria. For monitoring of the air quality within the framework of the natural gas power plant, PNG LNG Project's monitoring criteria is applied as per Table 8.9-1.

3) Survey on Fauna and Flora

In view of the extensive construction work for pipelines, survey for notable changes of the fauna and flora should be carried out at least once a year and compare the result with the baseline survey result on the fauna and flora.

Table 8.9-1 Required Monitoring Parameters of Air Quality for LNG Power Plant

Substance	Assessment Criteria (Average)	Project Target (μg/m3)
Sulfur dioxide (SO_2)	10-minute	500
	24-hour	20
Nitrogen dioxide (NO_2)	1-hour	200
	1-year	40
Carbon monoxide (CO)	15-minute	100,000
	30-minute	60,000
	1-hour	30,000
	8-hour	10,000
Hydrogen sulfide (H_2S)		No offensive odour at boundary, less than 5 mg/m^3
Benzene*	1-hour	170
	1-year	4.5
Toluene*	1-hour**	640
	1-year	1,200
Ethylbenzene*	1-hour	2,000
	1-year	200
Xylene*	1-hour	3,700
	1-year	370
p-Xylene*	1-hour	2,080
	1-year	208
PM_{10}	24-hour	150
	1-year	70
$PM_{2.5}$	24-hour	75
	1-year	35
Total suspended particulates (TSP)	24-hour	150 to 230
	1-year	60 to 90

* TNRCC uses effects screening levels (ESLs) to evaluate effects of exposure to these compounds in the air. They are not ambient air standards and, if exceeded, do not necessarily indicate a problem but rather trigger more detailed review.

** Note that the 1-hour ESL is less that the annual ESL for toluene. This is because the 1-hour average criteria is based on odour and the annual criterion on toxicity. Meeting the 1-hour goal would ensure no odour or health impacts.

Source: PNG LNG Project, http://pnglng.com/downloads/eis_chapter30.pdf

(2) Socio-economic Environment

a. Monitoring programs for socio-economics should function as to collect data reflecting economic, fiscal, and social impacts of the development at the local level. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services and educational services;

b. Monitor indicators of social disruption such as a number of crime, alcoholism, drug use, and mental health and the effectiveness of community welfare programs established within the framework of the project as IPDP;

c. Within the framework of IPDP, develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

   i. Establishing vocational training programs for the local workforce to promote development of skills required by the LNG energy industry;

   ii. Developing instructional materials for use in the schools in order to educate the local communities on the LNG energy industry;

iii. Supporting community health screenings and medication; and

iv. Providing financial support to local libraries for development of information repositories on LNG energy, including materials on the hazards and benefits of commercial development.

d. Within the framework of the project, various issues related to compensation, consultation and disclosure, cultural heritage management, employment and training, resettlement action plan, stakeholder engagement, management and development and others should arise. Stringent monitoring works should be carried out if grievances are taken care of and/or management works are implemented as planed;

e. It is imperative to keep in touch periodically with the customary landowners that have formed ILG in each district of the project area including the area along the T/L in order to establish good relationship and hold dialogue with them for which land acquisition or leasehold agreement of land for the project is rightly and appropriately processed;

f. Grievance redress system has to be established within the framework of the project implementation. PPL's project implementation office, a team of officers dedicated for dealing with complaints addressed to the project should be permanently stationed for the purpose of environmental monitoring and management works especially for interfacing with ILGs; and

g. Contents of the Appendix 8- 6, which was developed by PNG LNG Project in terms of the details of mitigation and management of the socio-economic environment as well as the natural environment is generally applicable.

8.9.8 EMaP and EMoP for Diesel Generators

(1) Natural Environment

There is no significant impact caused to the natural environment by diesel generator. However, periodical monitoring of the mufflers and the exhaust catalytic converter if equipped on the power plant should be monitoring periodically unless the system is with SNCR system.

(2) Socio-economic Environment

General complaints of the noise, vibration, odor and smoke emission made from the general public should be monitored and the follow-up action should be implemented in order to maintain operation within the urban areas.

8.9.9 EMaP and EMoP for Ramu-Port Moresby Interconnection

There is no active operation of the interconnection i.e. no significant environmental impact during the operation and maintenance period is identified to take place. However, flood events and landslide should cause significant damages to the T/L. Thus constant patrolling during the rainy season is inevitable on the part of PPL.

8.10 CONCLUSIONS AND RECOMMENDATIONS

8.10.1 Power Industry's Obligation

(1) Development of Forested Areas for Carbon Absorption

The "Paris Agreement" of the COP 21, the 21st United Nations Framework Convention on Climate Change (UNFCCC), is legally binding treaty for which 187 countries in the world commit greenhouse gas emission reduction to 2 Co or less of the global warming by the year 2050. The "Paris Agreement" therefore imposes the end of fossil fuel era while it raises money for the developing countries to achieve the goal.

The GoPNG in its "Papua New Guinea Development Strategic Plan 2010-2030" stated that there is a policy of which 70 % of the total population of PNG should enjoy electricity generated from non-fossil, or minimum fossil fuel. Although PNG's policy is to reduce the cost of fossil fuel for electric power generation, it is by chance matching its policy with the statement of "Paris Agreement".

The GoPNG also states in the "Papua New Guinea Development Strategic Plan 2010-2030" that there is a high potential of hydropower development. Therefore a number of hydropower generation plants are implemented within the framework of the policy. This Master Plant goes along with it. However, hydropower plants alone cannot achieve the target of electricity supply by 2030. Thus other modes of power generation have to be intermixed for the country's power supply system as a whole. It includes LNG power generation system.

Whenever any mode of power generation system is implemented, the GoPNG has an obligation for developing at least small patches of forest area for carbon absorption in order to meet the "Paris Agreement" as is shown in Table 8.7-3.

(2) Indigenous People Development Plan

In 2014, PNG LNG Project has reached its full production and it contributes lift the country's GDP three to four times larger than before. Thus natural gas power plant is planned along with other modes of power generation such as biomass thermal power plant in Markham Valley. On Ramu River, second hydropower plant is ready to implement in order to boost the capacity of power supply by the year 2030 and beyond.

Stable power supply creates employment. It is probably the most important factor of nation building. Unfortunately, the electricity is not enough at present and that it is not covering the entire population of PNG. This is a cause of high poverty rate of PNG. Or the lack of economic development should be blames. It leads to the classic "Chicken and Egg" argument.

Thus, at least, when a large-scale national level of economic development project takes place, it is important to implement "Indigenous Population Development Plan: IPDP". In each district where the power plant is constructed contains indigenous people. It is MDBs including JICA's policy that IPDP has to be implemented with a national level of development project implementation. Because the local area is generally customary owned by the indigenous people of the locality, thorough study on the local society for socio-economic development has to be carried out and the consequent implementation of IPDP. Classic sample of comprehensive IPDP developed by PNG LNG is shown in Appendix 8-6.

8.10.2 Introduction of Decentralized Power Generation System

While hydropower generation of electricity could become a major electricity generation with renewable energy, it is prone to drought. During the ENSO in 2015-2016, electricity supply to POM was somewhat jeopardized because of the lack water in Sirinumu Dam. In the highland area, drought and low temperatures caused crop failure in 2015-2016. If policy on the agriculture activities in PNG does not cater for such natural disaster, invisible skirmishes take place between the local people or between the local tribes in trying to grab resources. Failed rural population then drains into near-by urban areas causing further unrest in the urban centers.

Because of the lack of irrigation system, for instance, ENSO causes crop failure in the tropical countries. PNG is one of them. Provided that solar power system is installed on the roof of each household and PPL purchase a small part of it, each rural household could maintain some sort of steady cash flow i.e. it is a great contribution to eliminate poverty of the rural area, which is somewhere around 38% of the total population of PNG.

Solar power generation is "Decentralized Mode of Power Generation". One of the very few modes of power generation systems that individual household can afford to install. Even in the remote areas of PNG, several thousands local people are using the system. Chamber of Commerce of Madang is trying to spread the solar power generation system as much as possible.

If 500,000 households installed solar power generation system capable for 2 KW, and 1 KW is sold to PPL while the other 1 KW consumed at home, PPL is possible to gain 500 MW of electricity within a fraction of time. While political commitment for "Decentralized Mode of Power Generation" is necessary, because it is not a conventional mode of power generation, effort to realize it could be much smaller than the time spent for study, design and investment made for the "Centralized Power Generation System", which conventional hydropower generation is one of them.

8.10.3 Solar Power Generation System as a Means of Poverty Alleviation

Decentralization of Power Generation using solar power generation should reduce the poverty of PNG. The world trend of power generation, at least in terms of investment is shifting to solar and wind power generation including geo-thermal power generation system. WB and UN are actively involved in financing renewable energy for developing countries. (http//news-room.unfccc.int/lpaa/renewable-energy/the-sids-lighthouses-initiative-small-island-states-strive-for-rapid-shift-to-renewable-energy/).

Any natural disaster caused by ENSO or other causes related to global climate change, economically insecurity of the rural population engage in illegal logging, street vandalism, robbery and any social upheaval. This is a part of "Structural Menace" developing countries has been experiencing for decades. If a country can mobilize resources to support troubled population, no strife should occur. If it was the case, goal of the "Papua New Guinea Development Strategic Plan 2010-2030" could be easily achieved as planned. However, because of the lack of road, electricity and telecommunications as fundamentally necessary social infrastructure for any modern nation, central government find itself not prepared for recovering the national level of emergency once it occurred.

On the other hand, if a household maintains solar power system and a cell phone, which at present people in the rural area go to nearest town for electricity charging every few days, at least telecommunication system in the remote area is maintained with cell phones. What if the cell phone can send money from their home for electricity bill? What if a family member can send money via cell phone from urban area to his/her home in the remote area? They do not have to spend extra day on the queue at the payment counter of PPL. How convenient the system could be. This is a good service provided by telephone company, or PPL can do it.

If such infrastructure investment was implemented, vicious circle of national poverty roles forever: drought-stricken rural areas suffer from drought or flood events, crop failure, small or large skirmishes among indigenous tribes in trying to obtain more land, resources at the time of ENSO induced disaster; Those who failed to win the skirmish should then flow into urban areas changing their life style for which they have to fight against urban unrest, poor urban infrastructure on the limited income; and climate-change-induced national emergency occurs; and if PNG government cannot deal it on time, this country weakens drastically and the structural menace taking over the country in place of peaceful, safe and stabilized economy and society.

8.10.4 Role of Government as Bridging the Investors and Implementers

Decentralization of Power Generation is a contemporary business model of power generation. WB and UN are actively involved in investing the projects using renewable energy for power generation. Thus it is PNG Government role to bridge these world investors and the implementers of IPPs including NGOs for decentralized rural electrification.

If realized, the bridging role of the government should function as a vehicle of eliminating poverty in the rural areas. Thereby poverty-stricken population could enjoy growing level of their own standard of living. Probably this is one of the best ways to achieve the goal of the "Papua New Guinea Development Strategic Plan 2010-2030" while in turn it becomes a mode of great contributor to the "COP 21 Agreement".

Appendix 8-1

Interview Survey of the Stakeholders

Appendix 8-1-1

Selected Key Informants

Province	Organisation / Position	Contact Person	Contact Details
Morobe Province			
	Lae Disrict Development Authority - CEO	Mr Robin Calistus	472 3494
	Lae Chamber of Commerce - President	Allan Mclay	472 2340
	PNGDF Igam Barracks	Lt Col Tavaperry	704 56692
	Unitech - Senior Projects manager	William Pikive	473 4647
	Timber and Forestry Training College - Building and Grounds Manager	Mr Malalok Kikireng	472 4600 / 472 1083 Mobile: 737 03987
	Provincial Program Advisor (PPA)	Francis Japu	473 500 / 472 1783
	Deputy Provincial Program Advisor	Monty Gul	473 500 / 472 1783
	Morobe Council of women - President	Fingkewee Samana	736 91709
Eastern Highlands Province			
	Planning Division		
	University of Goroka - Assistant Director	John Rau	
	Coffee Industry Co-orporation		
	Goroka District	Uturo Ekesae	532 1135
	Wild life Conservation Society		532 3494
	Goroka Town Authority	Harold Abori	532 1999
	Goroka Town Manager	Simo Susuka	532 1999
	Goroka General Hospital	Maryanne Apa	736 31561
Madang Province			
	Madang Provincial Administrator	Daniel Aloi	422 2016
	Madang Urban District Office	Mr Sagem	71115876
	Madang Province Project Mgnt Division	Andrew Hawek	4221446
	Madang Chamber of Commerce President	Kevin Murray	
	RD tuna Canners	Gus Vilarus	423 3144
	RD tuna fishing	Mario Sosioso	422 3031 / 3047
	MST group of companies	Martin Tsang	422 2428
	DWU	Fr Jan Cuzba	422 2937
	MCC - Ramu Nickle Mine	Pang Shaun	422 2888
	Globe Manufacturing	Damit / Roger	700 57774 / 57775
	VSO - Voluntary Service Overseas	Ms Dawn Hoyle	422 1924
	The Nature Conservancy	Magdelene Tara	422 2366
	PNG CCI	Dr Peter Epaina	276 0176
	Country Womens Association	Babani Paul	422 2216
	WWF PNG	Steven Saleu / Philip Iwa	422 1337 /422 1338

Appendix 8-1-2

Interview Record of Stakeholders

Date: Wednesday 17th June 2015
Time Start: 02:20pm **Time End:** **02: 45**pm
Venue: Lae City Authority

Attendees:

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Manfred Sako	Director Lae City Planning Lae City Authority
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 2677 No fax Number +675 7366 1210 No email address.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ There is a demand for power however the supply of power in the city is inconsistent.
2	**How do you see power usage in the City?**	➢ The cost of power is too high for users identified on state land ➢ Settlements identified on customary land located within and outside the Lae city do not have power supply via transmission lines connected to them. ➢ Unless these settlements are upgraded (Process of transition from customary land to state lease) than these service will reach them.
3	**What is your opinion of the cost of power in Lae city?**	➢ Unsure of this as I have been utilising solar power to generate power for usage.
4	**Additional informations**	➢ Apart from the solar power, a K20.00 can provide 5 to 6 litres of fuel for a small (1.4 kva) generator and these can be used for 3 days ➢ For the owners of 'blocks' within the settlements that need PPL supplied power, they will apply to the two authorising bodies for approval before a transmission line is connected to them; *1. Physical Planning Board* *2. Building Board*
5	**Summary**	➢ The demand for power is high but the supply is inconsistent

Date: Wednesday 17th June 2015
Time Start: 02:59pm **Time End:** **03: 30**pm
Venue: Lae Chamber of Commerce Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Allan Mclay	Executive President Lae Chamber of Commerce
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 2340 +675 472 6038 +675 7686 6606 president@lcci.org.pg.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Lae is a good province for investment ➢ However the power supply in the city is inconsistent. ➢ Industries are having difficulties with the current supply of power. For example the 3 fish canneries (Frabelle, IFC and Majestic) are having big power supply issues due to the frequent power disruptions. Its affecting business. ➢ Best option is to support PPL for cheaper sources of power supply
2	**How do you see power usage in the City?**	➢ *There is an Urban Development Plan that caters for the development of the city. With this will be the importance of having consistent power supply.* ➢ *Because of the inconsistent supply of power, some people are using Bio gas or fuel.* ➢ *Biogas involves the burning of quick growing timber. Common along the markham area.*
3	**What is your opinion of the economic growth in the province**	➢ In Markham, cash crop growing is common however recently this is not active due to land issues.
4	**Additional informations**	➢ Lae Chamber of commerce promotes business in Lae. ➢ It is linked to international associations (First for PNG) with Fiji line Chamber of commerce. ➢ Rural electrification is not seen to be effective in Morobe province as yet
5	**Summary**	➢ Lae is a good area for investment however not with the inconsistent supply of power.

Date: Thursday 18th June 2015
Time Start: 08:53am **Time End:** 09: 45am
Venue: Lae Provincial Planner's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Francis Japu	Program Advisor Lae Provincial Physical Planning
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 473 1690 +675 472 4745 +675 725 16610 fjapu@morobe.gov.pg or fjapu@yahoo.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ The population of Lae and Morobe Province is increasing ad the demand for power is also increasing. ➢ However the current power supply in the city is unsatisfactory ➢ Because of this unsatisfactory supply of power, some business have proposed to install and supply their own mini hydro power
2	**How do you see power usage in the City?**	➢ *The provincial government through its physical planning division has a "Growth Centre Concept" and this is used for supporting rural and urban areas.* ➢ *This concept is a guide that gives directions for the development of all areas in Morobe province for the access to electricity.* ➢ *The province has vision to eventually develop these areas in the future especially the northern, eastern and southern parts of Morobe province.* ➢ *Biogas involves the burning of quick growing timber and is found along the Markham area however the provincial government has not committed anything yet.*
3	**What is your opinion of the economic growth in the province**	➢ Industries are having difficulties with the current supply of power. For example the 3 fish canneries (Frabelle, IFC and Majestic) are having big power supply issues due to the frequent power disruptions. Its affecting business. ➢ Previously Lutheran Shipping influenced Morobes economy however with them moving out, it is now a setback for the province. ➢ Other projects are also taking place and with a rapid rate and this is having a big issue with the provincial physical planning. For example the recently upgrade to the lae wharf by IPBC.
4	**Additional informations**	➢ Kabum, Wasu, Finschaphen and Waria Districts have the potential for PPL to develop and have transmission lines put through ➢ PPL Established a site at Finschaphen and are yet to implement any improvements to the site. Still lieing idle. ➢ Will arrange with Markham District Administrator for his District development Plan on the 20th of June 2015 so when travelling to Goroka on the day, we will drop by and pick this development plan ➢ John Orebut Markham District Administrator (722 35070)
5	**Summary**	➢ PPL improvements in Power supply will go along way in supporting the physical planning of the province and also the targets that have been set for the province.

Date: Thursday 18th June 2015
Time Start: 10:10am **Time End:** 10: 25am
Venue: Frabelle's General Managers Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr James Johnson	General Manager (PNG)
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 7663 +675 472 3146 +675 732 62071 James.johnson@frabelle.net

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Power supply is a very big problem. When ever a black out occurs, it affects our machinery and equipments that are reliant on power. So when our machines and instruments break down, it takes 4 to 5 days to repair. ➢ Problems with power outages is commonly a daily thing ➢ There is no system in place by PPL to tell us that there is a switch ➢ It is costing us a lot of money to do repair works to our equipments and instruments. Approximately PGK 200, 000.00 annually. ➢ To support our operations we have 3 x generators however these get broken down due to failure in the switching PPL power and generator power. ➢ We need to have stable power for pumping water.
2	**What is the request to PPL for improvements?**	➢ PPL has to provide a person to concentrate on Markham District Power problems. ➢ Markham district is willing to provide land for PPL staff to be stationed here on site. ➢ Connect Markham District to Gusap substation instead of Lae
3	**Recommendations to PPL**	➢ *General upgrade of wirings, transmission lines and transformers*
4	**Summary**	➢ Power is a big problem for the business and its costing us in repair and maintenance. .

Date: Thursday 18th June 2015
Time Start: 11:23am **Time End:** 11: 35am
Venue: TeleCom College, Executive Director

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Leo Wamo	Executive Director TeleCom College
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 475 7807 +675 475 7346 +675 7688 1000 Leo.Wamo@telikompng.com.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Power supply is a problem. Whenever a black out occurs, it affects our instruments that are reliant on power. ➢ TeleCom College has a huge land area and it plans to develop this in the future. ➢ Current power supply is minimal use. Reason being that students are on holidays. However this will change when they return. ➢ To support our instruments we have 1 x generator. However this is only for the building with the instruments. ➢ Our training equipments are digital and we need reliable power supply. ➢ We need to have stable power for pumping water too.
2	**What is the request to PPL for improvements?**	➢ PPL has to provide stable electricity power to a large consumer like us.
3	**Summary**	➢ Consistent and stable power supply in the future for the sake of our sensitive training instruments. .

Date: Thursday 18th June 2015
Time Start: 02:47pm **Time End:** 03: 43pm
Venue: Planning Director's Office, Morobe Province

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Darren Yorio	Planning Director ADRA
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 7088 +675 472 7638 +675 725 31472 dyorio@adra.org.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Power supply is a problem. Black outs are regular and it's a grave concern. ➢ There is no effective communication from PNG power to Lae users for the power outages. Probably once in a while we get information or read in the daily newspapers. ➢ An uninterrupted power supply will be very much appreciated. ➢ Effects of power outages may have been the cause of buildings been burnt down. For example the Brian Bell Hardware store in Top town of Lae. Another was a near miss in our building but due to quick action and response from our staff this did not eventuate. Full and thorough investigation pointed to the surge in power supply which sparked on deteriorated wirings that nearly led to the building being burnt. ➢ PPL Quality of service is very poor ➢ Probably a cheap means of power supply would be geothermal. ➢ PPL should concentrate on their customer service and also increase their emergency response team for emergencies cause emergences do not only occur during the day only but also during the night as well.
	Your view on rural electrification policy	➢ I speak highly of this policy. Has enabled the delivery of electricity to rural areas ➢ Recommend that the actual work be given to private or independent contractors and also funds to be made readily available
2	**What is the request to PPL for improvements?**	➢ PPL has to provide a person to concentrate on Markham District Power problems. ➢ Markham district is willing to provide land for PPL staff to be stationed here on site. ➢ Connect Markham District to Gusap substation instead of Lae
3	**Summary**	➢ Power supply is a problem. Black outs are regular and it's a grave concern. ➢ An uninterrupted power supply will be very much appreciated

Date: Friday 19th June 2015
Time Start: 09:15am **Time End:** 09: 30am
Venue: Metropolitan Superintendent, Lae

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Ivan Lakatani	Metropolitan Superintendent RPNGC
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 1992 No fax number +675 710 42488 lakaniiven@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Power supply recently has been good. However previously it was a problem. Black outs are a grave concern especially for my facilities. ➢ There has been no report from PPL employees while working on power outage. ➢ An important aspect of the blackouts is that, it will aid prisoners in cells to try and escape and or their friends from outside trying to aid escape. ➢ We have a standby generator however it has broken down due to no maintenance carried out.
2	**What is the request to PPL for improvements?**	➢ Stable supply of electricity is by all means necessary.
3	**Summary**	➢ Power supply is a problem. Blackouts are regular problem and was a grave concern to our operation. ➢ It is crucial that power supply is maintained.

Date: Friday 19th June 2015
Time Start: 10:09am **Time End:** 10: 30am
Venue: Angau Hospital, Facility Managers Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Simon Warne Mr. Eugene Totobu Mr. John Tioti	(AUS AID Consultant – Medical Facility) Facility Manager Project Co-ordinator
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 320 3431 (Simon), +675 479 1004 (Eugene) and +675 472 0061 (John) +675 320 3873 (Simon), +675 472 3015 (Eugene and John) +675 709 21 739 (Simon), +675 707 60809 (Eugene) and +675 7123 6633 (John) simon.warne@teu.org.pg , stot0bu39@gmail.com or jtioti37@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Current supply of power to Angau by PPL is very inconsistent and very poor. ➢ Repair and maintenance of air conditioners cost more than PGK500,000. Reason being that air conditioners play an important part in our medical operation. ➢ An example of our work for instance involves operation in theatres where a constant and steady supply of power is needed. We have only one operational theatre out of the four i.e. three are not operational due to power problems. ➢ Currently Angau is going through redevelopment of the "Facility Development master Plan" where a section of the facility will be removed or demolished and for refurbishment. This is highlighted in yellow in the map attached. The section highlighted in orange is the longterm-planned area where it will not be removed. The purple area is the new housing area. ➢ A new cancer ward is also planned to build on the other side of the road. ➢ Currently there are two generators (500 and 380Kva). These are operational while they are not fully trusted due to constant breakdown. This is a result from the overloading of power when switching is delayed. This is often the case.
2	**What is the request to PPL for improvements?**	➢ Stable supply of electricity is vital for our operation.
3	**Recommendations**	➢ Suggest that a good engineer from PPL in Lae should be arranged in order to handle Angau Hospital power needs reason being that the role of the hospital is to ensure each patient's life should not be jeopardized due to power failure. ➢ PPL needs to effectively communicate to Angau Hospital if there is going to be any planned black outs, or appropriate blackout plan should be laid out and informed to us regularly.
4	**Summary**	➢ Constant poser supply is needed due to the role of the hospital.

Date: Friday 19th June 2015
Time Start: 11:10am **Time End:** 11: 45am
Venue: PNG University of Technology (UNITECH), Administration Conference Room

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Dr. Karl Gena Unitech Power Committee	Chairman Members
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 473 4647 (William) No fax number +675 714 31980 (William) No email address

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ The purpose of UNITEC Power Committee meeting is for project managing the installation of a new generator that will supply uninterrupted power to all 13 departments in the university. ➢ Currently all 13 departments have their own generator. ➢ Unitech pays approximately PGK250,000/month for power bill to PPL. ➢ All the transformers in the campus are very old and will need replacing. As a result of old transformers, electricity voltages fluctuate and contribute to errors in bills paid to PPL. ➢ UNITECH houses a lot of very sensitive teaching and training instruments and these are very sensitive to power reliability. ➢ There are a total of 3,000 plus students that are currently housed in the campus. In addition of another 3,000 for staff and families. Thus campus contains a total population of approximately 6,000. ➢ Under the PNG Vision 2050, the university is to house a total of 20,000 students by the Year 2030. For this matter, the university has employed a consultant taking care of the process of developing a "10 year Master development Plan".
2	**Other information**	➢ There is an increase of economic activities taking place in Morobe province for example – fishing, mining, agriculture etc ➢ UNITECH is not having water supply issues yet so for now it is not an issue. ➢ The university houses an environmental laboratory that can support environmental analysis of samples. ➢ Also the university has an environmental research facility that is currently as a partner for the mining industry.
3	**What is the request to PPL for improvements?**	➢ Present rate of maintenance works of PPL has to be improved as we do not want to get blackout after the expansion of our operation in the near future.
4	**Recommendations**	➢ PPL to Support UNITECH by replacing all the transformers. ➢ PPL current distribution set up for the university is not good. There are two different set up lines. There should be a bypass somewhere that can allow continuation of power even if one area is blacked out.
5	**Summary**	➢ UNITECH needs Power stability for the campus as a whole.

Date: Friday 19th June 2015
Time Start: 1:55pm **Time End:** 2: 35pm
Venue: PNG Forest Research Institute - Dr Cossey's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Dr. Cossey Yosi	Forest Research Scientist
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 472 4188 No fax number +675 707 79646 cyosi@fri.pngfa.gov.pg or cossey.yosi@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**Are you able to assist us with Morobe, Madang and all the Highlands provinces Biodiversity data and information?**	➢ Dr Cossey suggested that we discuss first in details so he can gauge what we need. ➢ He suggested that we search in the net using the key word of " PNG PLANTS" as data are possible to obtain from Sydney University in Australia. ➢ There were some studies previously conducted by UK scientist in Morobe. However the study is done more towards Gabensis and Waria plains than PPL's Ramu System area. ➢ Dr. Cossey will try to search and compile a summary data for us.
2	**What is the request to PPL for improvements?**	➢ Rural electrification in the forested areas should be carried out for those living in the forest.
3	**Contact Information**	➢ Dr Cossey Yosi ➢ Land line number: 472 4188 ➢ Digicel number: 70779646 ➢ Email: cyosi@fripngfa.gov.pg or cossey.yosi@gmail.com

Date: Saturday 20th June 2015
Time Start: 11:38am **Time End:** 11: 55am
Venue: Markham District Administration

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr John Orebut	District Administrator, Markham District
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No landline number No fax number +675 722 35070 No email address

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Lae City?**	➢ Power outage in Markham district is very badly regularized. ➢ We have a 1 x 35kva generator that supplies power to pump water and the office. ➢ There are a total of 600 persons in this village. ➢ Power supplied by PPL is very unreliable. ➢ At times, three months without power supply happened. ➢ Current supply from Lae is the problem. If we are connected to the Gusap sub- station some 20 km away than 150km away of Lae city's sub-station, then we will not have problems. ➢ PPL has an emergency number however they are unreliable at this time.
2	**Other informations**	➢ We will relocate the district station to Umi soon due to threat from the Mangiang River flood problems. It is posing a hazard to this district office.
3	**What is the request to PPL for improvements?**	➢ PPL has to provide a person to concentrate on Markham District Power problems. ➢ Markham district is willing to provide land for PPL staff to be stationed here on site. ➢ Connect Markham District to Gusap substation instead of Lae.
4	**Summary**	➢ Power supply to Markham District is chronically unreliable

Date: Monday 22nd June 2015
Time Start: 09:16am **Time End:** 09: 45am
Venue: Goroka District Development Authority A/CEO's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Andreas Lulue	Acting Chief Executive Office (A/CEO) Goroka District Development Authority
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 1135 No fax Number +675 733 77640 No email address.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Goroka town and the District?**	➢ Supply of power is not reliable. ➢ Recently the supply of power has been somewhat steady. However when rainy season comes between June to September we see a lot of frequent blackouts. ➢ The population of Goroka District is increasing and there will be approximately more than 100,000 people in the near future. ➢ The increase in population in Goroka Town from the migration within Eastern Highlands districts. Population of other highlands provinces are also increasing i.e. demand of the supply of electricity should increase. ➢ The district has 2 x generators. However this is not enough. It plans to purchase another one to support the current generators. ➢ The District has a Five Year Development Plan of "Goroka District Development Plan 2014 – 2017". This document outlines the plan for rural electrification within the district (This document however is the only document in the district and there is no soft copy as well. Therefore the A/CEO is reluctant to supply a copy). ➢ Currently about 65% of the rural electrification scheme completed by District Authority. ➢ To fulfil the 5 Year Development Plan, the District is encouraging all persons within the district to build permanent houses or semi permanent houses in order for PPL to connect power to their houses.
2	**What is your opinion of the economic growth in the province**	➢ The main industry in the District that utilises allot of the power is coffee industries. They have factories in Goroka. Coffee is the only cash crop that generates income for the province. ➢ Other income generating activities are cash crop agriculture. However these do not consume the use of electricity.
3	**Additional informations**	➢ PPL customer service is very poor. The district in year 2014 paid more than PGK 2 million for rural electrification works such as the construction of distribution lines. However PPL has been very slow to implement the plan even after the payment was made. ➢ As a result of the above, for this year (Year 2015), a figure of PGK 500, 000 was held back by the District so that PPL can honour the first agreed payment. What is the use of making payment when the services are going to be delayed for 6 months to one year? This is not a very good customer service of PPL.
4	**Summary**	➢ PPL needs to improve its customer service and also its service of providing reliable power.

Date: Monday 22nd June 2015
Time Start: 10:00am **Time End:** 10: 31am
Venue: University of Goroka (UOG)

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr John Rau Mr Kowesa Tera	Planning and Resource Management , UOG Electrician, UOG
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No Landline number +675 532 2620 +675 706 37440 rauj@uog.ac.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in University of Goroka?**	➢ Supply of power is unreliable due to constant power blackouts ➢ Total population of the university is 2,500 students and another 800 staff and their families that are living on campus. ➢ Power received by campus is not 240volts most times. Normally campus receives about 225 to 237 volts and supply is unstable. As a result, the university bought 5 generators; - 1 x 550 kva to supply offices and dormitories - 1x 250kva to supply library - 165kva to supply midwifery - 2 x 750kva to support the first three generators and cover the residential areas
2	**Additional informations**	➢ PPL has to come into the campus and assess the power infrastructure especially for the 750 kVA before installations and other old infrastructures. This is urgently needed.
3	**Summary**	➢ PPL needs to improve on its customer service and also its service of providing reliable power.

Date: Monday 22nd June 2015
Time Start: 10:40am **Time End:** 11: 47am
Venue: Goroka Urban Area's Local Level Government Manager's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Harold Abori	Town Manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 2649 +675 532 1818 No mobile number gullg@online.net.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Goroka Urban LLG?**	➢ Power supply to Goroka Town is a big issue. For example, at times during peak hours power can go off and it can stay off for more than three to five hours. ➢ Power outages affect our operations as in a day it can take more than five hours off outages. ➢ There are many times when there is not enough power supply to our building and we have to improvise and not use other electrical equipments so that we can use one or two other equipments that use power. ➢ We do not have a back up generator to the building.
2	**Additional informations**	➢ We provide the town water and sewage system services. ➢ Initially before the construction of Yonki Dam, Goroka Town had a small hydro station. This however has been dismantled as it is a very small and old system put up during the colonial period. Its small dam is functioning as a source of water supply. ➢ This old hydro power station is located in North Goroka at a place called "Komiufa".
3	**Summary**	➢ Power supply is a big issue here in Goroka Town.

Date: Monday 22nd June 2015
Time Start: 11:49am **Time End:** 12: 25pm
Venue: Coffee Industry Corporation Administration (CIC)

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Ms Anne Komo	Administration Officer - CIC
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 2466 or +675 532 1266 No fax Number No mobile number No email address.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply to CIC?**	➢ Power supply to CIC and coffee industry in Goroka is a big problem. ➢ Unreliable supply of electricity has led us to purchase a generator to support all our electrical equipment such as laptops, desk computers, servers etc. ➢ Previously when the organisation was small, there was no serious issue with power supply. However when business started to pick up, this has become a serious issue. ➢ We have a station in Aiyura and there was an instance where electric lines to the station had a problem and it took three (3) years before PPL could change it. PPL came in to support us after CIC took the first step to purchase the transformer. This should not bee happening. ➢ When there is a problem in Mt Hagen or Jiwaka, the whole Eastern Highlands including Goroka will have to face the black outs. There must be a separate system where a bypass can be made. ➢ The idea of replacing equipments damaged by power outages is seriously cost to our business.
2	**Summary**	➢ Replacing of items damaged by power outages is very costly. Stable electricity supply should be made.

Date: Monday 22nd June 2015
Time Start: 02:02pm **Time End:** 02: 35pm
Venue: Goroka Institute of Biological Research (IBR)

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Katayo Sagata Mr Enock Kale	Director Goroka IBR Senior Biologist –Goroka IBR
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 3836 (Katayo and Enock) No fax Number +675 716 14731 (Enock) ksagata@pngibr.org or ekale@pngibr.org

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see power supply to CIC?**	➢ Power supply to Goroka Town is a big problem. It is unreliable ➢ As a result, we have bought a 15Kva Generator to support our operation. This is to support all our electrical equipments. For example, laptops, computers, etc. ➢ Hydrothermal power is preferred if power supply system has to be improved while it may cause resettlement issues of local people. ➢ Geothermal has to be explored. On the other hand it is not fully explored to date in order to establish legislations. It also costs a lot of money for exploration, construction and maintenance works.
2	**Additional Information**	➢ Biodiversity Data for the provinces within Ramu System is not easily available information as data of the studies conducted at present have not been compiled. We will look into our database. ➢ Note that the Markham plains have similar biodiversity to the Asian plates. Similarly the highland regions have similar characteristics to the Australian counterparts. This is because after the separation of the tectonic plates these similarities are still obvious.
3	**Summary**	➢ Power supply to Goroka Town is a big problem. It is unreliable ➢ Please send us an email and we will gather the necessary informations.

Date: Tuesday 23rd June 2015
Time Start: 10:00am **Time End:** 10: 47am
Venue: Eastern Highlands Province, Natural Resources Manager's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Frank Wangnapi	EHP Natural Resurces Manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 1233 No fax Number +675 738 39751 fwangnapi@yhoo.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in EHP and Goroka District?**	➢ Power supply is a big problem. Why do we have problems with power supply when our population is very small as compared to some countries. Although other countries have more population, they do not have issues with power supply. Why is it that we are having this problem? ➢ Within the Goroka Town, each business has its own Gensets. ➢ Because of this the provincial government through the national goal of "Green Economy" has embarked on searching for other renewable resources. Such are solar energy, Biogas and hydropower. ➢ Solar energy – The provincial government has funded PGK2.3 million kina for the establishment solar panels to three districts as a pilot project to supply power to the community. These are Daulo, Okapa and Oburawaninara Districts. The feasibility studies were performed by the office of climate change. ➢ A mini Hydro power at Mariwaka located in the Oburawaninara District (This is close to the Yonki Dam). The feasibility study for this was completed by an Australian consultant
2	**Additional informations**	➢ There is a national park in EHP at Mount Gavisaka (Located further to the north of Goroka). It needs a face lift. It has both plants and animals (animals including birds as well). ➢ Another is located at Crater mountains – WMA ➢ Wildlife Conservation society has recently completed a biological assessment for the province and this report will be made available to the provincial government soon. ➢ There is a concern that the development of RAMU II project must also include the land owners and the Provincial Government. This is for benefit sharing.
3	**Summary**	➢ Power supply is a big issue here in Goroka Town and the province. As a result, the Provincial Government has embarked on a green economy strategy to search for renewable energy generating sources.

Date: Tuesday 23rd June 2015
Time Start: 11:00am **Time End:** 11:17am
Venue: Eastern Highlands General Hospital, Project Manager's Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Mathew Mieh	EHP General Hospital Project manager's Office
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No landline number No fax Number +675 791 54869 mathewmieh@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in EHP General Hospital?**	➢ Power supply is a big problem and it is inadequate and unreliable. ➢ The hospital has a genset but this is 30 years old. Same age as the hospital. ➢ The hospital is undergoing refurbishment and it will need more power. With the current supply of power, this is not enough. ➢ Two problems that are currently faced by the hospital are: 1. Power issues 2. Water shortages ➢ For power short and medium term measures, the management has to put out a tender for the purchase of a new genset that can cater for 600KVA. This will be at an approximate cost of about PGK 1million.
2	**Additional Information**	➢ The hospital currently has one operating theatre. It plans to have a separate one for delivery theatre. ➢ The management of the hospital has asked an Australian architectural consulting company to carry out a master plan for the hospital. ➢ Currently the hospital has been classified as a level 3 hospital. In 10 year time, hopefully this hospital becomes a level 7 hospital similar to Port Moresby General Hospital.
3	**Summary**	➢ Power supply is a big issue here in EHP General Hospital. We need to have consistent supply of power due to the nature of our work.

Date: Tuesday 23rd June 2015
Time Start: 11:33am **Time End:** 11:46am
Venue: Monpi Coffee Exports Conference room

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Joseph Nuno	Operations manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 2752 +675 532 1410 +675 7123 8467 jnuno@ecomtrading.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here Monpi Coffee factory?**	➢ Power supply to our factory is definitely a big concern especially for the PPL supplied power. ➢ Currently we experience 3 to 5 hours of no PPL supplied power due to outage ➢ We have frequent blackouts and as a result, we have bought 2 x big generators to support us during the blackouts. This again is costing us allot of money to operate the generators and maintain them. ➢ The same problem with power that we experience is also felt and experienced by other coffee companies.
2	**Additional Information**	➢ We have a system that warms up for drying coffee if the power supplied by PPL is sufficient or we should use the generators if blackout occurs. This utilises an automatic switching system between the PPL supplied power and the generators. ➢ Electric power is the most important source of all our operations especially for the production of export quality coffee to our clients.
3	**Summary**	➢ Power supply to our factory is definitely a big concern especially for the PPL supplied power. ➢ The same problem with power that we experience is also felt and experienced by other coffee companies.

Date: Tuesday 23rd June 2015
Time Start: 1:05pm **Time End:** 2:15pm
Venue: WCS Round Table

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr John Kuange	Assistant Director
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	+675 532 3494 +675 532 3180 No mobile number jkuange@wcs.org

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply to Goroka and the EHP?**	➢ Power generation is stable - current is steady flowing however blackouts are regular. The moment we start having blackouts, there is no stopping to it. It continues like a riffle of waves. ➢ Previously we were notified that blackouts will be experienced. This however is not the case currently. There is no public notice to power blackouts in Goroka. ➢ We as customers and the public think that Yonki dam is not big enough to supply the whole highlands region. ➢ The demand for Power is high due to the increase in population and the increased use of electronic items and equipments.
2	**Are there other options for power generation sources in Goroka and EHP?**	➢ Solar Energy - is an option however the big question is that can it supply the demand for all the 8 highlands provinces. ➢ Hydro Power Stations- There is a small hydro station on the boarder of western highlands and Jiwaka. It is called "Kagul Hydropower". It supplies Western highlands and Jiwaka but is unable to supply all the other highlands provinces. ➢ Yonki Dam - If this is developed than there are few issues to take note of, 1Relocation of people 2. Food Gardens for people will be damaged. The question of soil fertility will be asked. Would the soil be fertile for food gardens in another area? This can be a future problem for both the relocated people against the developer of Yonki dam. 3. Biological impacts will be felt on the land. This covers both animals and plants and vegetation. To determine these, a comprehensive assessment must be done. A rapid assessment can also be performed to assess these. ➢ So again the magnitude of the social and environmental impact of developing hydro power in any area will depend very much on the two following factors; ➢ 1. Site of interest ➢ 2. The scale or magnitude of the hydro power project. ➢ For instance, Yonki Dam has vegetation that is covered with "kunai grass" and the soil is "coronas". The kunai grass is less significant to vegetation impacts.

#	Interviewer Question	Interviewee Response
		➢ Kunai grass is a common vegetation along the Highlands highway and predominantly common in all these 8 highlands provinces. There is not much trees found due to continuous burning. These burning are either for hunting and sometimes out of the "fun " of it. Meaning some people light fires due to " don't care attitude".
3	**What are Wildlife Conservation Society (WCS) Capabilities in terms of service delivery if you were tasked to perform some assessments?**	➢ WCS can perform EIAs for fresh water species for a potential hydro power station. This is to know what organisms are in the riverine system. We need to know what organisms are migratory and which are not. ➢ In PNG there are a few species that are of traditional importance. For example, Fresh water Eels, Fresh water shrimps or prawns. Although these are traditionally hunted, there is no current information whether these are of economical values. From a commercial perspective. ➢ From a mammals perspective, there are bandicoots however the bandicoots found in the highlands are smaller in size as compared to the coastal bandicoots. ➢ WCS can perform a Quick Rapid assessment. These however will not include the migratory patterns. It will only show what organisms are present at a site. ➢ WCS involves students who do research for study. Also wcs has bases in NIP and Manus for marine assessment programs. current assessing Parrots in the highlands and Cuscus in Manus Province ➢ EHP desktop biodiversity report has just been completed for the Eastern Highlands provincial government. These involved literature reviews of biological data. ➢ WWF does not have a detailed map of the PNG animal distribution. ➢ A Rapid assessment can be made by external team members and internal team members ➢ The external team members for that team authority because these external team members come with authority in their own specific field of animal or species speciality. ➢ A good example of these studies is the "hindenback" study in the boarder of PNG Ok Tedi Mining Limited. ➢ Approximate cost of Rapid assessment is between USD 250, 000 and USD 300, 000. Please take note that this is for getting external team members. We need to know the location of the site so we can assess and provide a reasonable quote.
4	**Summary**	➢ Power generation is stable - current is steady flowing however blackouts are regular. The moment we start having blackouts, there is no stopping to it. It continues like a riffle of waves. ➢ WCS can perform EIAs for fresh water species for a potential hydro power station. This is to know what organisms are in the riverine system. We need to know what organisms are migratory and which are not.

Date: Thursday 25th June 2015
Time Start: 09:15am **Time End:** 09: 40am
Venue: Madang Provincial Administrator

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Henry Hantan	Personal Assistant, Provincial Administrator c/o Provincial Office P.O.Box 2139 Madang
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 2016 422 3038 7399 7455 No email address.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Supply of power is not reliable. For the power supply, we have had disruptions for over ten years. ➢ As a result we have 1 x generator with the PPL operations and it supplies the whole town. ➢ Plans for expansion of Ramu Nickel and other commercial projects need more electricity. ➢ Electricity demand is high however the supply is insufficient.
2	**What is your opinion of the potential sources of power generation in the province**	➢ There are potential areas in the province where power can be generated. ➢ 1. Biodiesel - This is a biomass electricity supply with coconuts produce diesel oil. This is still in the planning stage. Project Management Unit knows the details. Biodiesel has multi purposes i.e. it be used for generators, vehicles etc. ➢ 2. Rural Electrification – Poor progress while for instance 4 - 5 km out of town villages need electricity under rural electrification scheme. PPL is to carry out the scheme through funding of the provincial government.
3	**Additional informations**	➢ "Madang Provincial Strategical Development Plans" can be obtained through the Provincial Policy and Planning Division.
4	**Summary**	➢ Supply of power is not reliable. ➢ Power supply - we have had a lot of the disruptions of electricity supply for over ten years.

Date: Friday 26th June 2015
Time Start: 02:10pm **Time End:** **02**: 45pm
Venue: Madang MST group of Companies

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Martin Tsang	M & S Tsang Ltd (CEO), General Manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 2428 422 3016 ➢ No number ➢ tsang@global.net.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province and to your company?**	➢ Power supply is a big problem and it is inadequate, poor and unreliable and I am not happy with the services provided by PNG power Limited. ➢ We have four generators that support my group of companies. We have been using them for months now and it is costing us a lot of money for their operational costs. ➢ Also we are paying too much for PNG Power supplied electricity power. It is like every year the bill is growing by PGK 50, 000.00. ➢ We are over charged for the power supplied to my house. This is my private house. Prior to the installation of the easy pay meter we were paying PGK 800 every month. After the installation of different power meter we are paying PGK 4,000 every month. I have spoken to Madang PPL and they said if I don't want it then they can disconnect the power. This again leaves me no choice so I have been paying that much. ➢ The power supplied by PPL is inconsistent and it has spikes and this again causes allot of damages to the electrical equipments. It is costing us allot in repairs and replacing these equipments.
2	**Summary**	➢ I am not happy with the services provided by PNG Power Limited.

Date: Thursday 25th June 2015
Time Start: 09:45am **Time End:** 10: 30am
Venue: Madang Provincial Project Management Unit Office

Attendance:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Boga Figa	Manager Madang Project Management Unit
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 1446 No facsimile number 7341 8275 bogafiga@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Power supply is bad and insufficient in Madang. ➢ PPL has not notified any of the public for blackouts or explained the cause of blackout. ➢ We need cheaper and alternative sources of power sources. ➢ APEC 2018 meeting will require a large amount of power and 10MW is planned for standby.
2	**What is your opinion of the potential sources of power generation in the province**	➢ Rural Electrification Program that the Department of National Planning has been embarked on. ➢ Biodiesel at Karkar Island is known at present that it is capable to produce 600,000 lit. per annum. It helps to run generators as soon as it is completed. ➢ PPL is to put up a grid on Karkar island. In 2 or 3 years it is to produce 6 million litres. With this project, 80% Carbon footprint of the province could be reduced. A consultant completed a draft report. ➢ Geothermal plant on Karkar Island has a great potential but the question is when it begins. ➢ 3. There are two active volcanoes in the province: 1) At Manam Island; and 2) Karkar Island. Currently there is no political drive to the option of using geothermal energy. A company from Iceland 3-4 years ago carried out an assessment. However implementation of geothermal power generation is under the co-ordination of the central government and there is no progress to date. ➢ Prospective Sources of electricity would be: 1) USINO Bundi's Hydro Power station which is best located in the mountainous area and have continuous rainfall and rivers. As it is, Districts should provide and propose for their own specific needs. Hopefully it is the districts that are in charge of their power generation sources for rural electrification.
3	**Additional informations**	➢ Economic Potentials in Madang is relatively large. Ramu Sugar Agriculture, Ramu Nickel, Yanderra Mine for gold, copper, and nickel that are in total needs of 150MW. The cost of their electricity supply depends on their own generators and diesel fuel. Thus it becomes a costly operation. Currently there is no capacity to meet electricity needs. Let alone in the future.

#	Interviewer Question	Interviewee Response
		➢ For the Pacific Maritime Industrial Zone (PMIZ), approximately 10 factories will be established. ➢ There is a greater need for an additional environmental impact assessment for the Ramu River's sedimentation. This appears to have been occurring after the completion of Yonki Hydro power project.
4	**Summary**	➢ PPL has to implement appropriate customer services ➢ We need a cheaper and a more alternative source of power generating source.

Date: Thursday 25th June 2015
Time Start: 09:45am **Time End:** 10: 30am
Venue: Madang Chamber of Commerce and Industry

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Kevin Murray	Madang Chamber of Commerce and Industry
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No Number No Number No Number kmurray@globalnet.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Power supply is a problem here in the town. ➢ In Walium power pylons were washed away in the heavy rainfall. ➢ Power lines will need to be relocated to the toe of the mountains. This is located between Walium station and Sausi in the Usino Bundi District. ➢ Normally this takes a total of 3 to 6 months to rectify and it has impacts to the supply of power to the town and clients ➢ In the rainy season that is between December and May, we get frequent blackouts. We have generators that can support us but these are not at full capacity.
2	**What is your opinion of the potential sources of power generation in the province**	➢ Potential areas of power generation are as follows: ➢ 1. South Ambenob for natural gas. There are 2 potential sites for natural gas while at present 1 drilling site is under exploration. PNG Heritage O1il is in charge of the exploration. ➢ Prospective Customers are: - Marengo or Yandra Mining that will need the power - Ramu Nickle want replace their own generators of 84KW at Basamuk - Up coming Provincial Maritime Industrial Zone will be in need of large power supply ➢ 2. Geothermal Potential at Karkar Island - Karkar Island has 600MW potential according to the result of exploration carried out by Icelend's consultant. ➢ 3. Solar power generation is prospective. However the security issues have to be solved. There is no industrial scale use of solar power but more of personal use. Chamber of Commerce as an organization is trying to spread a solar power package for home use so as to be able to see TV, light up the house, charging cell phones and use computers. ➢ 4. Hydro power – There must be potential at "Gowa River"
3	**Summary**	➢ We would appreciate it if full capacity is received here at Madang Town. Load shedding should reach full 24 hours of capacity.

Date: Thursday 25th June 2015
Time Start: 09:45am **Time End:** 10: 30am
Venue: Madang Maritime College

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Captain Dabung Kiong Terence Sisu	Principal Finance Manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 2615 or 422 2922 422 3113 7023 6112 (Mr Sisu) or 7267 4145(Mr Kiong) tsisu@pngmc.ac.pg or dkiong@pngmc.ac.pg.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ 2 or 3 years ago, power supply to the college was ok. There was no problem. However when the establishment of a copra mill factory down the road we started to face problems in power shortages and blackouts. ➢ PPL needs to act as we addressed the problem. If they have approved the factory to receive power then why are we facing this problem? ➢ We do have our back up generator. However this was bought before the establishment of the copra factory. As a result of severe shortages of electricity, our generator cannot support all of our facilities and equipment. ➢ We currently have a brand new building and we intend to relocate to this new setup and the demand for power to this new setup is high. ➢ We currently have blackouts 3 or 4 times a day and the backup generator works to its maximum capacity. This is dangerous for the generator as we may burn it out.
2	**Additional informations**	➢ This is the only college in PNG and the Pacific Islands for maritime technology since it was enacted in 1976. There is no other institution that teach what we teach in the country and the Pacific islands. ➢ PPL must realise that power supplied to training institutions and medical facilities must be steady and consistent. ➢ We have very sensitive equipments for training and have faced damages to them. The estimated costs associated with repairing these are approximately PGK 500,000. ➢ We have a total of 500 students per annum.
3	**Summary**	➢ Capacity of the electricity in Madang is very low to cater for industry and a large consumers like collages, universities and hospitals.

Date: Thursday 25th June 2015
Time Start: 01:15pm **Time End:** 1: 59pm
Venue: WWF Pacific, Madang

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	➢ Ms Rebecca Samuel	➢ Marine Officer , WWF Pacific - PNG office
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 1337 or 422 1338 No number No number No email address.

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Divine Word University (DWU) supplies our office's electrical needs. So all power demand questions my be answered by DWU. ➢ From a power need perspective, we face power shortages when we travel to remote and rural areas for training programmes. There is no power supply in the rural areas were we work. Thus we occasionally use our small generator.
2	**Additional informations**	➢ This is our country office. Headquarters is in Fiji ➢ We perform biological programs and involve researches and projects. ➢ We are more focused in Marine Assessments ➢ Studies have showed that Madang lagoon is over-fished. ➢ We also do mangrove rehabilitation funded by the office of Climate Change. ➢ NFA is another organisation that we work closely with for IFAD implementation.
3	**Summary**	➢ Consistent electricity supply to urban and rural areas should be ascertained.

Date: Thursday 25th June 2015
Time Start: 2:45pm **Time End:** 3: 11pm
Venue: Madang Binatang Research Centre

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Bradley Gewa	Researcher
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No number No number 793 99892 bgewa@binatang.org.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Power supply to Madang and our facility is unreliable. ➢ As a result of the unreliable supply of power, we have 2 x generators to support reliable and consistent supply of power for our operation.
3	**Any other additional informations**	➢ Our research extends to Chimbu and Madang Province. ➢ We have a total of 40 personnel. ➢ 25 permanent staff of which 10% are expatriates and the rest are PNG nationals. ➢ 20 are locals to assist us with field work.
4	**Summary**	➢ Power supply should become reliable source of energy for our operation.

Date: Thursday 25th June 2015
Time Start: 09:45am **Time End:** 10: 30am
Venue: Madang Provincial Policy and Planning Office

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field Trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	➢ 1. Chris Torot ➢ 2. Mr David Turik	➢ Natural Extended Functions and Provincial Monitoring Co-ordination Unit. ➢ Planning Branch
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 2016 / 422 2896 422 3038 714 13223 (Chris) and 729 07101(David) christorot@gmail.com and davesontango@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang Province?**	➢ Power supply in town is a problem. Plenty of blackouts and a lot of generators are getting damaged. ➢ PPL has to hold "Consistent Dialogue" between with the Provincial Government in order to rectify the situateion. ➢ The maximum capacity of the town's backup generator is 10MW. However it is giving 4MW power supply to the town at present. ➢ There is currently a plan for acquiring 2 additional generators. ➢ There is a large number of economic developments in the province. Pacific Maritime International Zone (PMIZ) needs 12MW to operate and a town of 80,000 people resettling from active volcano island in the north has to be developed. ➢ Because of these economic activities in Madang, demand of electricity is high and supply is insufficient at present.
2	**What is your opinion of the potential sources of power generation in the province**	➢ There is a committee for rural electrification in the province. ➢ For long-term purposes, PPL carried out scoping for electrification of all the villages of the province. For short term therefore individuals need to provide their own generators if electricity is needed. ➢ Previously PPL had officers at district level. Now no engineering staff is in town. The planning and policy division aims to bring back PPL to the province. The provincial administration is planning to realize the arrangements ➢ Potential Sources of energy for Madang District and Madang Province are; - Simbai - Mini Hydro (Not in operation currently). Another potential area for Hydro power development is at the North Coast, Dimar. This has a potential to produce 28MW. A local engineering company did a preliminary assessment. A detailed assessment is needed with further funding. - Solar power generation is another option. - Biodiesel production project at Karkar Island is seriously planned. - Geothermal at Karkar Island is also a prospective project. Iceland's consultant has conducted an initial study. It can produce 600MW of power. Currently a feasibility assessment is conducted. Current

#	Interviewer Question	Interviewee Response
		opinion at the central government level is that it is not an optimistic option for the province. There is no legislation laid out yet in terms of ownership, schedule of legislation, etc. Cost of further engineering study and implementation is also a question. ➢ Another project that will need power supply will be the Manam Island's resettlement project. There must be sufficient electricity for 8000 people. ➢ An International meeting of the APEC in the Year 2018 will be held in Madang. PPL has to develop appropriate electricity supply system.
3	**Any other additional informations**	➢ There is currently a Provincial/District Development Plan and it is still in draft work. This will be published soon and will be made known to all stakeholders. ➢ Previously there were appropriate government services carried out by the districts. However after the "Provincial/Local Level Government Reform", all political powers including electricity supply was taken away from the local government and given back to the service providers such as PNG Power for electricity supply, Dept of Public Works for road works, etc. Since then, infrastructure development works began stagnated.
4	**Summary**	➢ "Consistent Dialogue" between PPL and the Provincial Government in terms of electricity supply improvement.

Date: Friday 26th June 2015
Time Start: 09:55am **Time End:** 10: 25am
Venue: Madang RD Tuna Canners

Attendees:

Meeting Structure	Name	Position/ Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	➢ Mr Augustus Philip P. Villarus ➢ Mr Clyde Ricshirl J. Genturo	➢ Electrical and Maintenance Division Manager ➢ Electrical and Maintenance Division Supervisor
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	No number No number ➢ +675 736 14 309 (Augustus) and ➢ +675 702 47 908 (Clyde) ➢ appvillarus@rd-png.com.pg ➢ cgenturo@rd-png.com.pg

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in RD tuna factory?**	➢ We are a manufacturing company and produce tuna fish products to Europe. ➢ We have all kind of electrical equipments that support our production such as air conditioner, food processing plants, motors, etc. ➢ We currently have a 1.2MW Generator that supports our operation. We do not use PNG Power's electricity. ➢ Although there is an Automatic Voltage Regulator installed for the factory's equipment, we still experience fluctuations of the power that is supplied by PNG Power. Electric surge after blackout can reach a maximum of 530 volts. As a result we have stopped using the PPL's power and have been using the generator since April 2015. ➢ As a company we intend to expanding the operation and the demand of power will be increased. We have experienced a lot of damages on our equipments as a result of the fluctuations by the PPL supplied power. ➢ Our operation is 17 years old and the cost of damage repairs and replacements have been more than PGK 1 million.
2	**Additional informations**	➢ Our operation is depending on stable power. The power supplied by PPL is not helping us. We would like to go back to the PPL supplied power but we are yet to see stable and consistent power supply. ➢ We have spoken to Madang PPL. However their response has been very slow.
3	**Summary**	➢ No prospective electric use of PPL is unknown unless reliable electricity supply resumed.

Date: Friday 26th June 2015
Time Start: 10:35am **Time End:** 10: 45am
Venue: Madang General Hospital, Facility Manager's Office

Attendees:

Meeting Structure	Name	Position/Organisation
Interviewers	Mr Shusuke Minato	Environment Field trip - Team Leader
	Mr Serpico Liliome	Environment team member
Interviewee (Interviewed)	Mr Benjamin Marin	Madang General Hospital Facility Manager
Interviewee Contact Details	Landline No. Fascimile No. Mobile No. Email :	422 2022 ext:843 No number ➢ +675 712 65149 ➢ benmarin57@gmail.com

Contents of the Meeting:

#	Interviewer Question	Interviewee Response
1	**How do you see Power Supply here in Madang General Hospital?**	➢ Power supply is a big problem and it is inadequate and poor ➢ The hospital has a generator but this is very old. Approximately the same age as the hospital. ➢ The hospital is undergoing major refurbishment and it will need more power after the renovation. Current supply of power is nor enough for the future operation. ➢ Damages to the hospital electrical equipment has been costly and we lost more than PGK 1million. ➢ The hospital currently has one operating theatre. It plans to have a separate one for the future. ➢ We work for the life of patients and it is frustrating to see a life being lost due to power failure.
2	**Summary**	➢ Power supply is a big issue here in Madang General Hospital. ➢ There must be consistent supply of power due to the nature of our work.

Appendix 8-2

Tree's Carbon Sequestration

Trees' Carbon Sequestration

The first step in determining how much carbon a single tree sequesters is to convert carbon to carbon dioxide (CO_2) or carbon dioxide equivalent (CO_2e). The common conversion of the carbon to CO_2 used in such calculations is as follows:

1 ton of carbon = 3.666 tons of CO_2

Where: Carbon dioxide (44) divided by the atomic mass of carbon (12).

It is estimated that 1 ha of trees contains 125.5 metric tons of carbon. Thus:

125.5 metric tons of carbon per ha of forest X 3.666 tons of CO_2 = 460.2 metric tons of CO_2 per ha of forest.

In general, the average tree planting project includes 1,112 trees per ha, which leaves us with a final calculation:

460,200 kg of CO_2/1,112 trees per ha = 413,849 g of CO_2 sequestered per tree planted

We assume an age of 55 years when estimating the carbon sequestration and storage of a tree.

The details of the U.S. Forest Service in terms of average carbon stored in trees of 58.8 tons per acre are used and converted to 125.5 tons/ha.

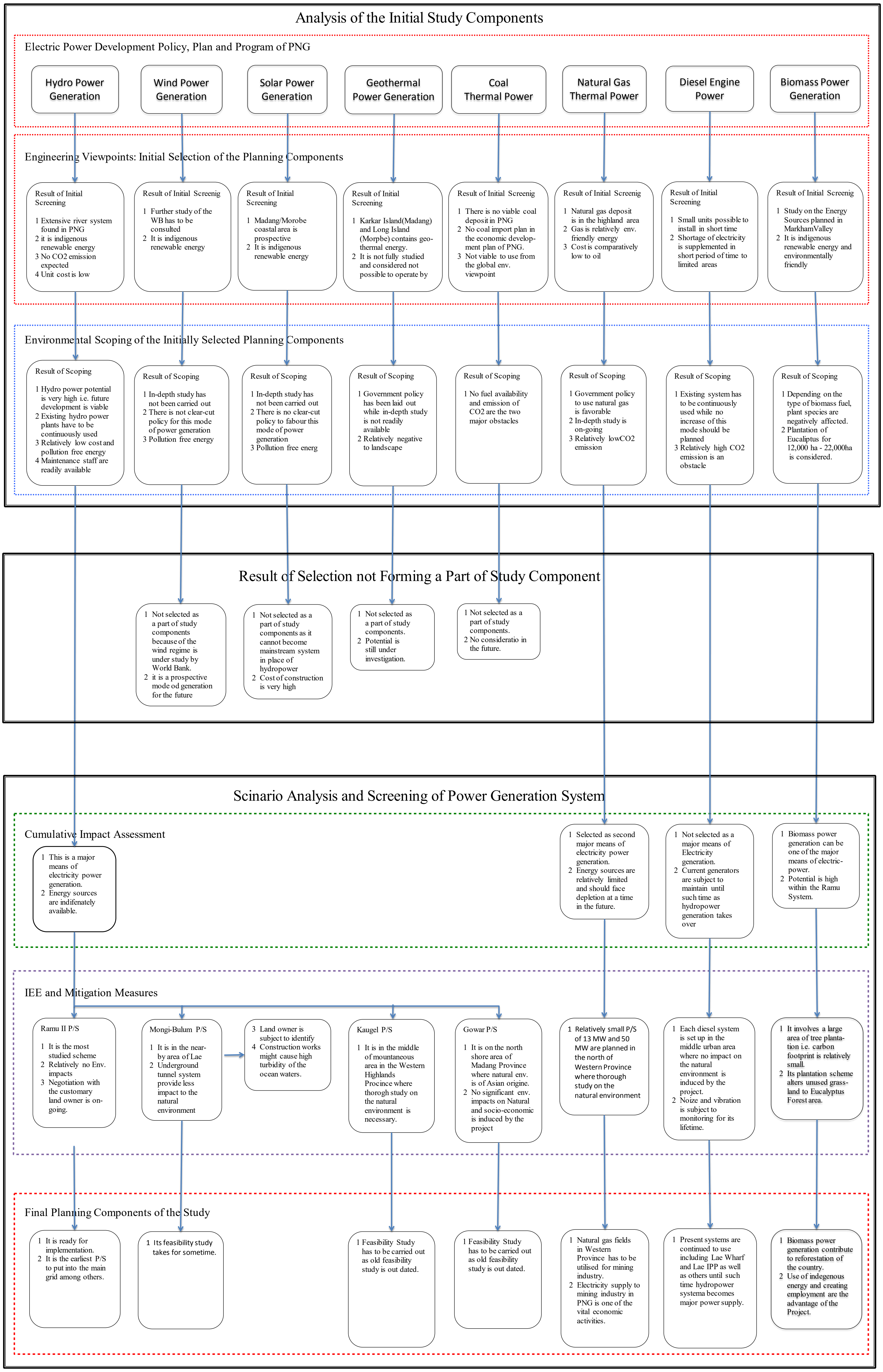
Sources:
1) United States Department of Agriculture, Forest Service, Methods for Calculating Forest Ecosystem and Harvest Carbon with Standard Estimates for United States Forest Types, 2006, http://www.treesearch.fs.fed.us/pubs/22954.

2) United States Department of Agriculture, Forest Service, Carbon Storage and Accumulation in United States Forest Ecosystems, 1992, http://www.nrs.fs.fed.us/pubs/gtr/gtr_wo059.pdf.

Appendix 8-3

Flow Chart Analysis of the Major Project Components

Procedure of the Framework of Strategic Environmental Assessment (SEA): Ramu System Power Development Master Plan



Appendix 8-4

PPL Training College Rehabilitation Plan

PPL TRAINING COLLEGE UPGRADING PLAN: A Funding Proposal submitted to Japan International Cooperation Agency

PPL.
P.O. BOX 1105, Boroko, NCD
(675) 324 3200
(675) 325 0072
11/19/2015

Project Summary

Title of the Project Proposal

"Purchase of Training Equipment's and maintenance of existing technical workshops"

Project Location

PPL Training College - Hohola

Originating/Commissioning Organization

PPL

Address and Contacts

PPL
Organization and Development Team
P.O BOX 1105, Boroko, NCD
Papua New Guinea
Ph: 324 3192
Email: akavanamur@pngpower.com.pg

Project Description and Rationale

Background:

PPL is the sole electricity provider in PNG. It has been legislated by the National GoPNG under individual licenses (generation, transmission, distribution and retail) to operate as the state's entity.

The generation of electricity is mainly through hydro, thermal and gas. The hydro plants are Rouna in POM, Yonki in Eastern Highlands, Pauanda in Mt Hagen and Warangoi in East New Britain. All other centres in PNG are thermal generated. Only recently the GoPNG purchase gas turbine machines that will be using gas from the LNG plant and have them installed at Port Moresby and Lae.

PPL is challenged by the National Government to deliver electricity to PNG as per the Vision 2050 indicators. By 2050, the government expects that there will be 100% access to electricity by PNG.

PPL is regulated by the Electricity Act 2002 and IPBC Act. The company holds 100% shareholding of the government through IPBC.

PPL employs around 1500 plus employees who are working in PPL centres in the country. 80% of these employees make up the technical workforce whilst 20% is the administration and management team.

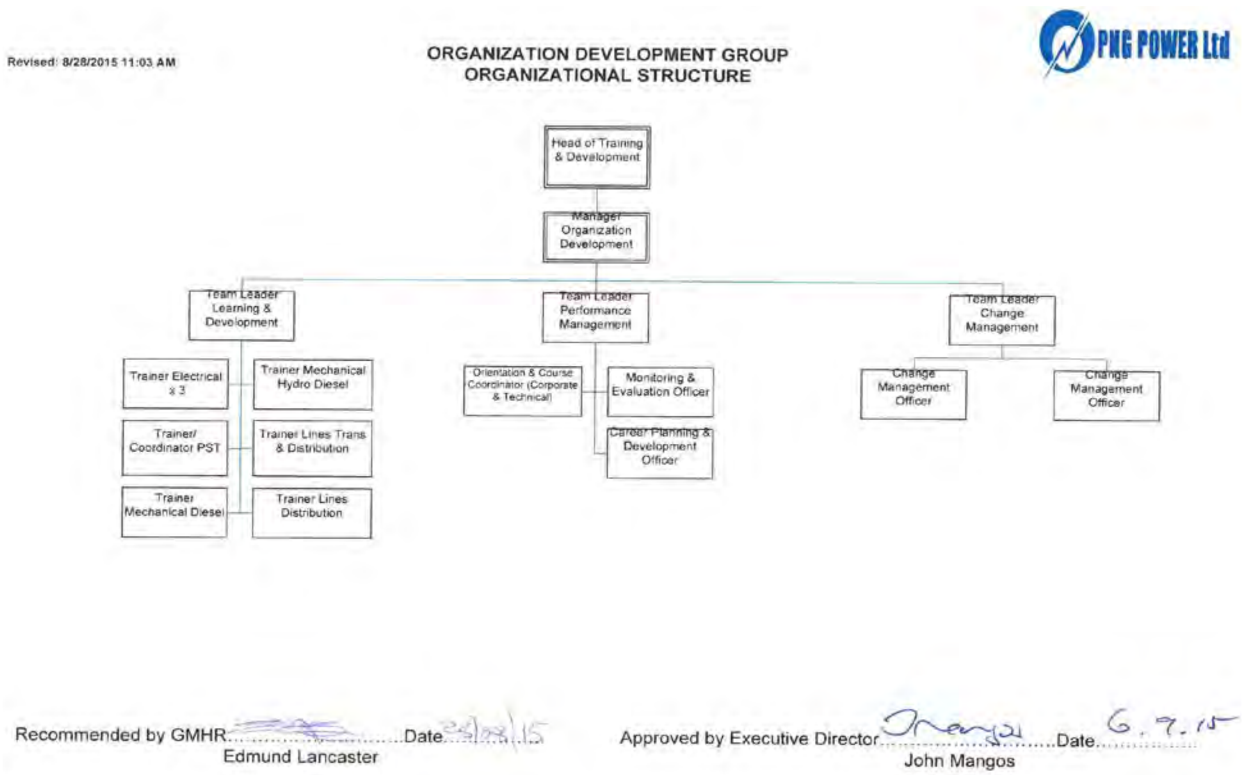
The company also has a training college that supports the organization in terms of training employees through its apprenticeship, traineeship and graduate development programs. The college relies on funding by the company to run its operations.

PPL Human Resources Organization Development Structure

The PPL Training College falls under the Organization Development Group Structure. The Head of Training and Development reports to General Manager Human Resource. The 18 employees who make up the training and development team in PPL total team structure is 18 employees. There are three (3) teams under the organization development group.

Learning and Development Team are in charge of delivering all technical training to PPL apprentices, trainees and trade assistants. The workshop facilities and equipment's come under the team leader learning and development responsibility.

Performance Management and Change Management Teams offer administration and management support in terms of employee performance management, performance appraisal and guiding new change initiatives within the organization.



Baseline Analysis

The PPL Training College was once referred to as the ELCOM Training College. The college was built purposely to offer training to the company's employees in the areas of technical and administration.

The college has played a very significant role in terms of developing the company's employees so they contribute back to PPL's operations. PPL falls within the energy sector industry and is the only sole provider of electricity in the country. It has the licenses for electricity generation, transmission, distribution and retail in PNG.

The PPL Training College has that extra bigger role to develop its employees' so that they can be competently deployed into the main 4 areas of the company (generation, transmission, distribution and retail)

At current, the college has two setups; this is the main administration block where classrooms and an IT lab is located and the workshop area where there are five technical workshops.

The five (5) technical workshops are in great need of repair at the moment plus having equipment's that will enable trainers to train trainees. The five workshops are for lines, diesel fitting, machine fitting, power station operation and electrical.

The college is registered with the PNG National Training Council and is also recognised by PNG Nation Apprenticeship Trade Testing Board. The college offers technical training in the following areas;

- Electrical Mechanic
- Power Station Operation/Technician
- Machine Fitting and Machinist

- Diesel Fitting
- Lines Mechanic
- Electrical Inspector
- Cable Jointing
- Low voltage
- High Voltage

The need for electricity in PNG is increasing every day due to new projects, businesses and houses built. Hence, training of PPL employees need to be current and of high quality to help the company continuously grow and update its electricity infrastructure.

Equipment's for each trade and a bigger workshop facility is a need for the training college at the moment given minimum funding comes every year to keep the college up to industry standards every year.

Problem Identification and Implication on Stakeholders

The problem has been identified as the lack of proper equipment's and maintenance of training workshops that is affecting the effective delivery of trade courses and programs to trade professionals, assistants, apprentices and trainees at the PNG Power Training College. PPL is regulated by the Electricity Act 2002 to generate, transmit, distribute and retail electricity in PNG. To support the company deliver key electricity projects in the country, it developed a college now known as the PNG Power Training College. Over the years, the college have lost its training potential especially in terms of delivering world class training in the areas of lines, diesel fitting, power station operation, machine fitting, electrical and welding.

Company in 2015 has embarked on recruiting 50 new technical apprentices, 8 trainee electrical inspectors, 50 trainees and 20 university graduates. This exercise is undertaken as part of filling in skill gap that will become available should the again workforce exit in the next five (5) years.
The workshops used for the various trainings are in dire need of maintenance, and during rainy seasons, water floods the interior of the workshops putting machines at danger of being destroyed by the weather elements. Most of the equipment's that are in the workshops now are not functioning, especially lathe machines, there is no Power Station simulators working in the XXX (PSO) workshops, lines training yard don't have cherry pickers that trainees can use as part of training. The dilemma that the college is facing is a direct impact on the performance of employees or the trainees that we train at the college. Hence, projects and operations can be at risk if employees and trainees are not trained on how to use machines and how to maintain them.

Most projects in terms of delivering electricity to PNG is funded by government and donors and the college has an important role in ensuring that the investment made in projects are useful in terms of getting employees skilled and certified.

Swot Analysis Matrix of PPL Training College

STRENGTHS

- PNG Power Training College is located in the heart of the city where there is easy access for students to travel to and from.
- PPL training college has a big land mass for future development of the college.
- PNG Power Training College has the brand name that impact on the enrolment of students each year.
- PNG Power Training College is registered with National Apprenticeship Trade Testing Board (NATTB) and is also recognised by the National Training Counsel (NTC) to operate as a Technical Training College in PNG.
- PPL has offered almost all the technical training programs in the college.
- PPL being the monopoly in the electricity industry, PPL has advantage over other technical institutions in offering technical trades such as; Power Station Operator/ Technician; Lines Distribution and Lines Transmission Trainings.
- PPL has qualified Technical Trainers who are known for offering the best training.
- PPL will be the leading technical institution in the national tally of producing the best and qualified technical officers each year.

WEAKNESS

- PPL Training College lacks classrooms to run all trade trainings concurrently to meet the excessive demand from companies and outside student body.
- PPL Training College lacks workshops for practical assessments for students and PPL workforce.
- PPL Training College lacks training equipment and materials for all technical trades.
- Over the years PPL Training College had lacked funding from the company to develop the college.

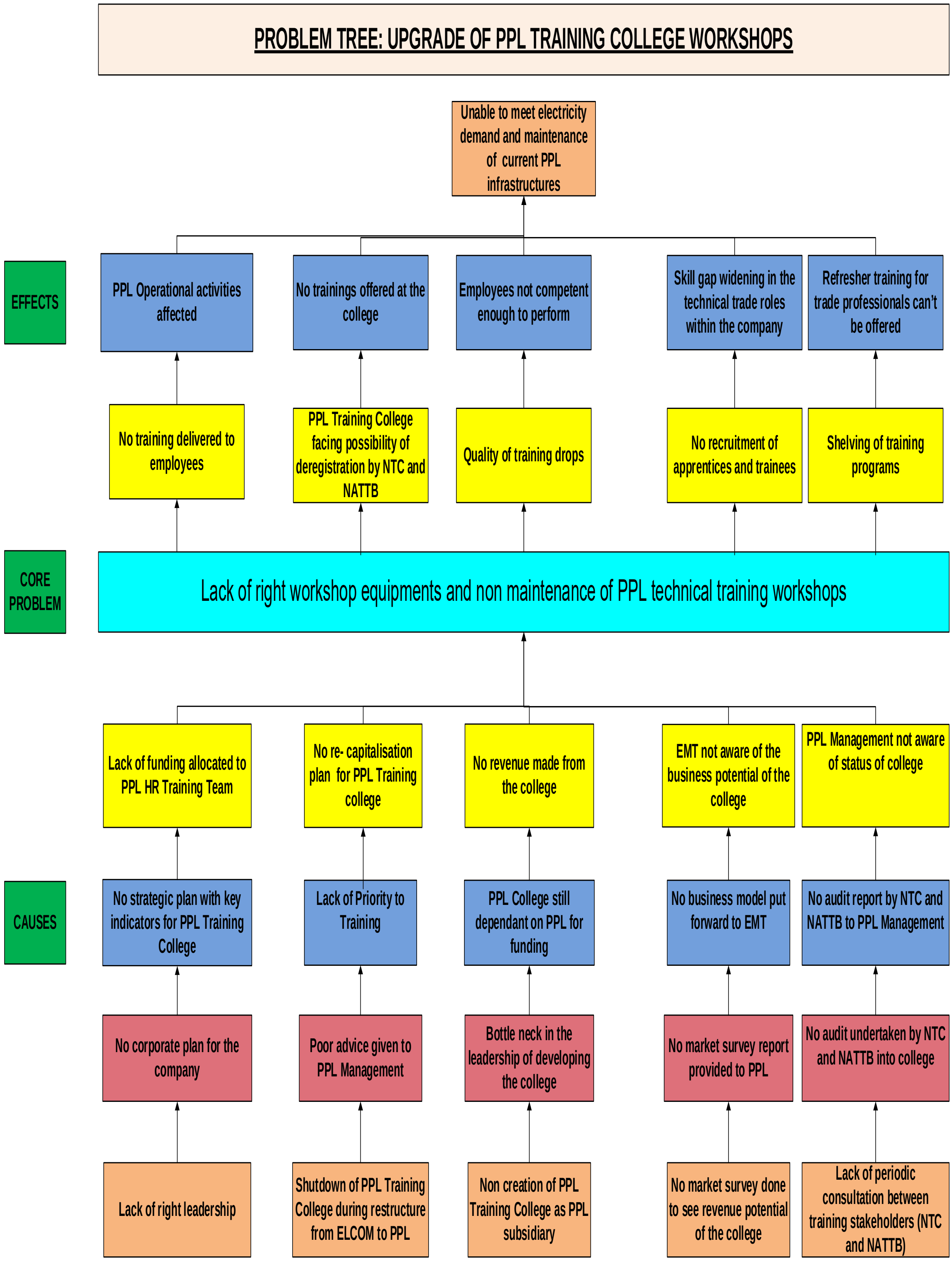
OPPORTUNITIES

- PPL training college to develop from a service providing institution to a more profit making entity.
- There is opportunity for PPL to affiliate with the international training providers to deliver trainings at an international standard for PPL employees outside student body.
- There is opportunity for PPL training college to set up branches in the country to provide training for our citizens and hence maximise the profit margin.
- There is opportunity for PPL to take the lead in providing technical training in PNG and other Pacific Islands.

THREATS

- Deregulation of electricity market can open opportunity for other training providers to compete with PPL Training college
- Deregistration of the college if PPL does not keep it up to standards that meet NTC and NATTB requirements.

Problem Tree



Objective Tree

Logical Frame Matrix

Project Description	Indicators	Source of Verification	Assumptions
Overall Objective:			
To develop skill level of trade personnel's; meet electricity demand and maintenance of PPL infrastructures.	100 employees trained every month in technical related programs/courses Skill level of trade employees increase Less complaints from EMT on lack of training	Training statistics submitted to EMT by Organizational Development Team every month Certification update in Chris 21 system EMT monthly reports	
Purpose:			
Purchase of equipment's and construction of a new multi Technical Training Workshop	New multi training workshop built in 2017 New equipment's commissioned in the workshop Regular trainings in all workshops every month	Receipts of equipment's purchased and recorded in monthly financial report Building plan of new multi workshop Demolition of old workshops	*Proposal is approved by Donor and PPL Management* *PNG NTC and PNG NATTB approval*
Result 1: Funding available through PPL Management & Donors			
Develop Strategic Plan for PPL Training College	Funding allocated in 2016 for PPL Training Workshop upgrade and purchase of equipment's by PPL and donor Strategic plan for PPL Training College approved by EMT and board	Proposal funding approved by PPL and donor Board paper approval	*Donors and management agree with proposal submitted* *No changes to enabling acts (electricity act 2002) governing PPL*
Result 2: Recapitalisation plan for PPL Training College in place			
PPL Management priority given to training	Approval of the 2016 Capex budget New equipment's for each trade workshop purchased in 2016/2017 New multi workshop facility housing all trades is built in 2016/2017	Approved copy of 2016 Capex Budget Commissioning of new multi workshop and equipment's	*Management realises the potential in developing the college workshops* *Proposal approval and funding from Management and donor*

Project Description	Indicators	Source of Verification	Assumptions
Result 3: Revenue is made from college operations			
PPL Training College operates and competes with other training providers in PNG	License to operate as subsidiary granted in 2017 100% revenue generated from college into college account to maintain operations	PPL Board management approval paper giving college mandate to operate as subsidiary	*Government through Kumul Holding agrees to the concept of operating training college as subsidiary of PPL* *Government does deregulate electricity market sooner*
Result 4: EMT aware of business potential of the college			
EMT and board's approval of training college business model	Business Model approved by EMT and board by 2016	Copy of economic viability proposal of the college approved by both EMT and board.	*No regular changes in PPL board and Management*
Result 5: Implementation of training regulators audit recommendation			
Audit report from NTC and NATTB provide to PPL Management	Audit reports provided to PPL Management by April 2016 Implementation of 30% of recommendations by end of year 2016.	Audit recommendation reports from NTC and NATTB	*NTC and NATTB actually carrying out audit into PPL college facilities and processes*
Activities For Each Result 1 :			
1.1 Develop a corporate plan for PPL		1.2 Provide effective leadership and management of PPL	
Activities For Each Result 2 :			
2.1 Competent advise provided to PPL Management on how to operate the college		2.2 Restructure PPL Training College setup	
Activities For Each Result 3 :			
3.1 Elimination of bureaucratic processes and systems in the development of the college		3.2 Creation of PPL training College as a PPL subsidiary	
Activities For Each Result 3 :			
4.1 Prepare market survey report of PPL training College potential to Board and Management		4.2 Carry out market survey on revenue potential of college	
Activities For Each Result 3 :			
5.1 Have NTC and NATTTB carry out Audit into PPL College		5.2 Have regular meetings with NATTB and NTC on training college matters	

Project Overall Duration

PPL anticipates that JICA does not fund project proposals immediately but will use the initial proposal document to analyse and make a decision. Below is a timeline depicting the expected activities that will happen before and after the proposal is approved by JICA.

Time Line	Details
2015	Submission of Proposal for JICA Funding
2016	JICA consideration
January 2017	Expecting funding to be given by JICA
February 2017	Advertisement of Tenders
March 2017	Screening of Tenders
April – June 2017	Maintenance of workshops
July – August 2017	Purchase of Equipment’s
September 2017	Commissioning of workshops and equipment’s
October 2017	End of project – wrap up

Project Overall Cost and Implementations

The total funding requested from Japanese International Cooperation Agency for both workshop renovations and equipment’s is K17, 870,000.00 (equivalent to US$5,560,714).

Details	Cost (Kina)
Machine Fitting Workshop Maintenance	1,050,000.00
Diesel Fitting Workshop Maintenance	1,200,000.00
Lines Workshop Maintenance	1,160,000.00
Electrical Workshop Maintenance	1,090,000.00
Power Station Workshop Maintenance	1,170,000.00
Erection of New Welding Workshop	1,230,000.00

The structures in the machine fitting workshop are rusting away due to corrosion and will need total replacement as well as the roofing irons. This workshop will attract more financial assistance than the others.

A new Welding workshop is also needed so that trainees and apprentices can be trained in different types of welding. The previous welding shop was torn down this year (2015) and this will greatly affect the delivery of training in this trade area.

Details	Cost (Kina)
Diesel Workshop Equipment	1,030,000.00
Machine Fitting Workshop Equipment	2,500,000.00
Lines Workshop Equipment	1,130,000.00
Electrical Workshop Equipment	1,400,000.00
Power Station Workshop Equipment	1,270,000.00
Welding Shop Equipment	1,340,000.00

Workshop Building Plan

We initially intended to seek funding to build a new multi complex workshop that will house all workshops, classrooms, and offices in one building. However, we have realised that this will affect the delivery of training to the new apprentices and trainees that PPL has just recruited. Hence, though we have attached the copy of the new multi complex building, this is for long term planning purposes only. For now, our focus will be on re-habilitating the existing workshop facilities first.

Appendix 8-5

Poverty Analysis and Indigenous Peoples Development Plan

1 Poverty Assessment

1.1 General Concept of Poverty Assessment

Poverty Assessment is a process of assessing and managing the impacts of a project, plan, program or policy on people. It can be defined as the process of predicting, evaluating, reflecting and managing the intended and unintended consequences on the human environment in relation to interventions such as policies, plans, programs, projects and other social activities. Along with these interventions, social change processes take place so as to create a more sustainable biophysical and human environment, or complete opposite depending on how the situation is managed or mismanaged by the project proponent.

The important features of this definition are that:

a. Poverty Assessment includes adaptive management of impacts, projects and policies as well as prediction, mitigation and monitoring i.e. it is necessary to implement at the planning level of the project;

b. It is implicit that social and biophysical impacts and the human and biophysical environments are interconnected in the rural society of PNG; and

c. The overall purpose of all impact assessment is to bring about a more sustainable primitive world, and those issues of social sustainability and ecological sustainability need to be considered as an integral part of the rural life.

1.2 General Concept of Poverty Assessment

Poverty Assessment is also understood to be an overarching framework that embodies all human impacts including aesthetic impacts of landscape analysis, archaeological and heritage impacts, community impacts, religious and cultural impacts, demographic impacts, development impacts, economic and fiscal impacts, gender assessment, health impacts, indigenous rights, infrastructural impacts, institutional impacts, political impacts of human rights, central and local area's governance, psychological impacts, resource issues such as access and ownership of resources, tourism impacts, and other impacts on societies. Process of Poverty Assessment begins with the following:

a. People‘s ways of life – how they live, work, play and interact with one another on a day-to- day basis;

b. Their culture – shared beliefs, customs, values and language or dialect;

c. Their community – its cohesion, stability, character, services and facilities;

d. Their environment – the quality of the air and water people use; the availability and quality of the food they eat; the level of hazard or risk, dust and noise they are exposed to; the adequacy of sanitation, their physical safety, and their access to and control over resources;

e. Their health and well-being – where health is defined as ―a complete state of mental, physical and social well-being, not merely the absence of disease or infirmity‖, and is applied to individuals and to the society in which they live; and finally;

f. Their fears and aspirations – their perceptions about their safety, their fears about the future of their community, and their aspirations for their future and the future of their children.

1.3 Sampling for Poverty Assessment

Poverty Assessment has to be carried out on a sample basis for the target community. The recommended sample size is 10-20% of the total households in the target community. In case the community is large with a high density of population, the sample size could be 5-10%.

Poverty Assessment will provide data on the basic characteristics of the likely affected population, such as the family size, religion, occupation, educational level, vulnerable groups etc., current issues, political and civic institutions, social structures, gender analysis and indigenous people, cultural tradition and attitudes and perception of people towards the project.

Poverty assessment should also identify specific social constraints, establish prospects for a participatory framework to enhance local land ownership and define social and institutional arrangements.

The process of the implementation of poverty assessment will enable the identification of social development issues for in depth analysis planning level of the project as follows:

1) Reconnaissance - Rapid appraisal

   Rapid appraisal or the rural area subject to assessment is the first contact with the community in order to get familiar with the project area and its inhabitants. This will likely be the first time the community gets to know about the project. A visit with a group of assessment personnel is made to the proposed project area in order to collect the required information.

   First, a brief introduction about the team and the project will have to be made and then, the information is collected that will include the number of households, population of the area, social groups present in the area, housing pattern and occupational pattern. The information has to be collected from reliable sources such as the local leaders or the residents of that particular area.

2) Tools and Sampling

   Based on the rapid appraisal above, a sample questionnaire is prepared that covers all the social, cultural and economic aspects of the particular project area. Once the sample questionnaire is prepared, a pre testing has to be carried out under which the sample questionnaire is filled by a few people. The purpose of the pre testing is to see if the local people understand the terms and language used in the questionnaire, as well as to see whether any additions or deletions are necessary in the sample questionnaire.

   After completion of the pre testing, the questionnaire has to be finalized and the sample for the study is decided. Usually, the recommended sample size is 10-20% of the total households in the target community for the feasibility study. People from all social categories are included in the sample.

   A team of poverty assessment has to be identified and trained for conducting the sampling. It is very important that the team members understand the socio-cultural issues and are well trained to conduct the assessment. The team is made aware about the findings of the rapid appraisal.

3) Method of Sampling

   The trained team members cover 10 - 20% of the total target community’s population. The study is conducted with the help of various techniques such as household survey, participatory rural appraisal, focus group discussion, stakeholder analysis, economic focus survey and institutional mapping.

4) Data Analysis

After the completion of the study, the data are analyzed. Quantitative and qualitative data analysis has to be performed. Quantitative data will represent the information collected on an individual basis through the questionnaire and qualitative data will represent the information collected through the focus group discussions, participatory rural appraisal and consultation with the various stakeholders. In these exercises, a number of peoples are involved so as to provide the general opinion prevalent to the community.

For data compilation, two software packages are available: one is Microsoft Excel and another one is Statistical Package for Social Sciences (SPSS). SPSS is among the most widely used programs for statistical analysis in social science. Market researchers, health researchers, survey companies, government, education researchers, and others use the software. SPSS can be used in a more user-friendly manner where cross tabulation can be done. SPSS is also helpful in doing the comparison between the pre and post status of the project area. Microsoft Excel creates and manipulates spreadsheets, which are very helpful in manipulating and analyzing data.

5) Report Preparation

Outlining is a necessary preliminary step to report writing. It involves the planning needed to prepare a clear report that is logically organized, concise, and easy to read. The outlining stage is a natural progression from the analysis and sorting stage. In the outlining stage, attention is drawn to how these results should be presented.

The revised outline should contain descriptive headings of each significant part of the report. The information should be transmitted clearly and concisely. With a logically organized outline and the necessary illustrations already prepared, the rough draft should be prepared and here the writing style becomes important.

2 Indigenous Population Development Plan (IPDP)

2.1 Concept of IPDP

In general, almost all the rural population PNG is considered as indigenous. Thus IPDP seeks to ensure that indigenous people and communities are well informed, consulted and mobilized in order to participate in the project preparation. The framework is intended to guide selection and preparation of projects that impacts on indigenous people are identified. It is necessary to ensure better distribution of the project benefits achieved while it promotes development of the indigenous peoples in the project areas. The framework has to be prepared in accordance with ADB's procedures for sector loans as presented in ADB's Policy on Indigenous Peoples (IP, 1998). General format is as follows:

1) Project Introduction

Provide detailed description of the project, its components and scope.

2) Indigenous/Tribal Groups

Provide details of socio economic details of IP population in the project location.

3) IPDP Policy Framework

The need for a full IPDP will depend on the nature and magnitude of the project impacts and sensitivity of issues. The need for IPDP is established on the basis of the following criteria set out in ADB‘s Policy on IP, to determine if project impacts are significant:

a. Adverse impacts on customary rights of use and access to land & natural resources;

b. Negative impacts on socio-economic status and cultural identity;

c. Impacts on health, education, livelihood and social security status; and

d. Any other impacts that may alter or undermine indigenous knowledge and customary institutions.

The IPDP will ensure that project affected peoples will eventually become well off with the project. This IPDP will also aim to identify measures towards satisfying the needs and developmental aspirations of the local populations.

If, the impacts on the local populations are insignificant, then specific actions in favor of the indigenous people will need to be integrated in other program of socio-economic development plan. This would ensure appropriate mitigations and benefits for the indigenous people.

Based on both PNG constitutional and developmental strategies and ADB‘s policy on indigenous people, the objectives of an IPDP is as follows:

a. When impacts are insignificant as fewer than 100 people affected, a full IPDP is not required but impacts and mitigation measures can be dealt with through other socio-economic program;

b. Impacts are considered to be significant‘ when more than 100 people are affected by the Project thereby requiring a separate IPDP;

c. Ensure IP inclusion in the entire process of planning, implementation and monitoring of the project;

d. Provide a baseline data of the IP groups in the area to receive adequate development focus and attention.

2.2 Procedure for Preparing an IPDP

In order to prepare an IPDP the following steps is undertaken:

a. Based on the social assessment, establish baseline data on the IP community affected by the project;

b. If the impacts are considered significant as defined above, prepare an IPDP based on ADB‘s Policy on Indigenous People (1998); and

c. As enumerated above, the main features of the IPDP will comprise of a preliminary screening process, followed by a social impact assessment in order to determine the degree and nature of impact of each project, and an action plan is developed if warranted.

2.3 Screening

The project proponent and its consultants responsible for project preparation and implementation should visit all the settlements related to the project areas. Public meetings should be so arranged in the selected communities. The project proponent and its consultants should provide them information about the project. During this visit, undertake a screening of the local communities with the help of the community leaders and local authorities. The screening should cover the following aspects:

a. Name(s) of the community group(s) in the area;

b. Total number of tribal community groups in the area;

c. Percentage of tribal community population to that of total area/locality population;

d. Number and percentage of tribal community households along the zone of influence of the proposed project.

2.4 Social Impact Assessment (SIA)

SIA will gather relevant information on demographic data; social, cultural and economic situation; and social, cultural and economic impacts – positive and negative on the tribal communities in the project area. Information is gathered from separate group meetings within the tribal community, including tribal leaders; group of tribal men and women, especially those who live in the zone of influence of the proposed project under the Project.

Discussions should focus on the positive and negative impacts of the project, pros and cons of the implementation of the project as well as the recommendations on the design of the project. Based on the discussions, develop an action plan with the tribal community leaders. If the SIA indicates that the potential impact of the proposed project is significantly adverse threatening the cultural practices and their source of livelihood, consider other design options in order to minimize such adverse impacts.

2.5 Elaboration of Indigenous Populations Development Plan

IPDP should consist of a number of activities including mitigation measures of potentially negative impacts. Modification of project design is usually the best way of mitigation measures.

Where there is land acquisition in tribal communities, the project should ensure that their rights are not violated and that they are compensated for the use of any part of their land in a manner that is culturally acceptable to them. The compensation is in keeping with Entitlement Matrix as provided in the Resettlement Framework of the Project. The IPDP should include:

a. Baseline data;
b. Land tenure information;
c. List of the people of local participation;
d. Technical/engineering contents of d mitigation measures;
e. Institutional arrangement;
f. Implementation schedule;
g. Monitoring and evaluation; and
h. Cost estimation and financing plan

2.6 Specific Action Plan

If the impacts of the project are not significant, the project proponent should prepare a specific action to address issues of the rural communities. A specific action plan should include a community action plan where the indigenous peoples live with non-indigenous peoples in the same project area. The main objective of specific action plan is to address developmental needs of tribal community and households and ensure their socio-cultural ethnicity remains unaffected.

2.7 Mitigation Measures

The mitigation measures is described either in IPDP or Specific Action Plan. The main objective is to ensure all affected indigenous households are provided with assistance, which would help them to improve their living standards without exposing their communities to disintegration. As vulnerable groups, they are entitled to receive special assistance not only to restore and improve their income and livelihood, but also to maintain their distinct cultural identity

2.8 Consultation & Disclosure

The groups affected by the project should be consulted with during the preparation of IPDP. They should be informed of the mitigation measures and their views should reflect in finalizing the plan. The Plan is translated into the tribal language and made available to the affected people before implementation. The disclosure should be made in a manner acceptable to the levels of literacy of the affected peoples.

The tribal institutions and local organizations in the affected area should also be involved in implementation of IPDP and in resolving any disputes that may arise.

2.9 Institutional Framework and Budget

The EA will have the primary responsibility for the preparation of IPDP. Project proponent should also prepare a detailed budget taking into account all the activities associated with the formulation and implementation of IPDP or a number of IPDP.

Each IPDP will have its own budget and will form an integral part of the overall project cost. The responsibility of financing, implementation and monitoring of the IPDP will rest with the project proponent. A local NGO, church institutions and others with the relevant experience should be hired in order to assist project proponent in planning and implementation of IPDP.

2.10 Monitoring and Evaluation

Project proponent should set up an internal monitoring system in order to monitor the implementation of IPDP. Monitoring indicators should be established at the time of IPDP preparation. Reporting/monitoring formats are also prepared for both internal and external monitoring at the time of the preparation of IPDP. In addition, an external independent monitoring agency has to be assigned.

Appendix 8-6

Summary of the Impact Mitigation and Environmental Management Commitments developed by PNG LNG Project

Table 29.1 LNG Facilities mitigation and management commitments

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M1	Establish and enforce project-wide quarantine management procedures as part of the ecology, natural habitat and biodiversity plan.	Construction Operations	Operator Contractor
M2	Establish and enforce pest and weed management procedures for the LNG Facilities site as part of the ecology, natural habitat and biodiversity plan.	Construction Operations	Operator Contractor
M3	Where practicable locate perimeter fence and other facilities to the landward side of the mudflats and wetlands.	Construction	Operator Contractor
M4	As far as practicable, clearing of riparian vegetation should be limited to the width required to safely accommodate roads, and watercourse crossings.	Construction	Operator Contractor
M5	Limit ground disturbance and vegetation clearing for LNG Facilities site, camps, lay down areas to the area within the perimeter fence (plus working buffer zone).	Construction Operations	Operator Contractor
M6	Prohibit works from exceeding the design disturbance width and enforce boundaries through use of security fencing.	Construction	Operator Contractor
M7	Where practicable revegetate promptly areas no longer required for construction or support services (e.g., the areas set aside for future LNG trains).	Construction Operations	Operator Contractor
M8	During operations, prohibit staff from disturbing migratory species and associated habitats, especially along perimeter fence adjacent to mudflat habitat.	Operations	Operator
M9	Prohibit disturbance/harassment of wildlife, hunting of fauna, gathering of plants or bush foods, collection of firewood or possession of wildlife products by project workers or contractors while working, travelling in project vehicles, and residing in project field accommodation. Implement appropriate inductions and education to encourage staff to comply with regulations.	Construction Operations	Operator Contractor
M10	Limit machinery and vehicle movements to defined works areas and designated project roads. Note that anywhere within the perimeter fence will be accessible during construction.	Construction Operations	Operator Contractor
M11	Develop a reclamation management plan, which would include as a priority the regeneration of natural vegetation communities, wetland substrates and savanna as close to natural levels as possible through seed collection and/or use of topsoil as a seed resource.	Construction	Operator Contractor
M12	Where practicable strip and salvage topsoil. Where salvaged, protect topsoil from loss or degradation. Use topsoil in reclamation management plan.	Construction	Operator Contractor

Table 29.1 LNG Facilities mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M13	Conduct a preclearance survey for sandalwood and other listed species and develop management plan in the unlikely event of discovering listed species.	Construction	Operator Contractor
M14	Where tree removal is necessary for road construction, limit damage to surrounding habitats by felling trees away from existing stands where practicable taking into account the value and safety of the areas into which the trees are being felled.	Construction	Operator Contractor
M15	Limit the scraping of standing tree trunks by machinery as far as practicable.	Construction	Operator Contractor
M16	Use appropriately qualified ecologist to inspect trees prior to felling in order to locate any *Pharotis imogene* colonies. If located, use controlled felling methods to allow the colony to relocate.	Construction	Operator Contractor
M17	Use cleared vegetation where practicable for dust control and revegetation.	Construction	Operator Contractor
M18	Where practicable, disturbed areas will be returned to former landforms and vegetation of exposed areas will occur as soon as practicable once construction activities are completed in any particular location. Areas prone to erosion will receive particular attention.	Construction Operations	Operator Contractor
M19	All watercourse crossings, diversions and culverts will be designed to accommodate expected streamflows. Similarly, the drainage system within the LNG Facilities site will be designed to minimise changes to flow regimes and sediment transport of existing creeks including any works on the North Vaihua River tributaries and Karulla Creek.	Construction	Operator Contractor
M20	Conduct community consultation regarding fishing, mud crab and mangrove wood collection and how the project will minimise impacts to these activities.	Construction Operations	Operator
M21	Conduct community consultation regarding burning in the vicinity of the LNG Facilities site.	Operations	Operator
M22	At new or improved road crossings, maintain connectivity of wet season flow in watercourses, avoiding the creation of high-velocity 'chutes' or step-down cascades in order to enable fish migration.	Construction	Operator Contractor
M23	Establish and enforce a sediment and erosion control management plan that limits the mobilisation and dispersion of sediment into freshwater and estuarine environments particularly in relation to site preparation earthworks watercourse diversions, site drainage design and road crossings.	Construction	Operator Contractor
M24	Use silt curtains and other industry good practice management controls as appropriate when working in mangroves, particularly near the seaward extent.	Construction	Operator Contractor

Table 29.1 LNG Facilities mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M25	Vehicles and machinery maintained to a high level of safety with respect to leaks. Drivers will be appropriately trained and have the required driving licence.	Construction Operations	Contractor
M26	Fuel, lubricating oils and chemicals will be stored in appropriately designed and sized designated areas that have impervious liners and/or bunds as appropriate.	Construction Operations	Operator Contractor
M27	Establish a spill response plan appropriate to the project phase and include staff training at induction to inform workers of their responsibilities under the plan.	Construction Operations	Operator Contractor
M28	Develop and implement an acid sulfate soil management plan within the proposed water management plan.	Construction Operations	Operator Contractor
M29	The waste and wastewater management approach for the LNG Facilities site as described in this EIS is to be used for the preparation of the relevant management plans.	Construction Operations	Operator Contractor
M30	Suitable containment provided for all parts of the plant area where hazardous or dangerous goods are stored or used.	Construction Operations	Operator Contractor
M31	Install a groundwater monitoring network within the LNG Facilities site and on the downstream hydraulic gradient side of potentially contaminating/impacting activities (e.g., the landfill site).	Construction Operations	Operator
M32	Place spoil into low, rounded stockpiles to limit erosion and dust effects of soil and spoil.	Construction Operations	Operator Contractor
M33	Construction vehicles and equipment will be maintained in order to limit emissions.	Construction Operations	Operator Contractor
M34	During construction, spray unsealed project construction roads (not using saline water) when required and limit speed of traffic.	Construction	Contractor
M35	Establish blasting procedures within a noise management plan (for both the terrestrial and marine environments) considering ANZECC guidelines, or similar and in consultation with local communities.	Construction	Operator Contractor
M36	Establish and enforce speed limit for project traffic on all roads. Liaise with government agencies and local villages with regard to general road safety and traffic regulation.	Construction Operations	Operator Contractor
M37	Undertake measures in planning and design to limit flare and venting as much as practicable, including a 'smokeless' flare design that would apply to normal operation.	Operations	Operator
M38	Locate facility components according to safe constructability and operations.	Construction	Operator

Table 29.1 LNG Facilities mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M39	Excepting LNG facilities, utilities and other process areas, use materials for camps, administration buildings, warehouses and other non-process areas that are visually compatible with the surrounding landscape where practicable.	Operations	Operator
M40	Respond to community views regarding visual effects if raised through general ongoing public consultation during construction and operation.	Construction	Operator
M41	Where practicable, utilise treatments for the reduction of light spill into the marine environment to reduce visibility of the site from Ihidi Island where turtles may be nesting. Reduce lighting on jetty when not loading while meeting navigation and security guidelines.	Construction Operations	Operator Contractor
M42	Develop an air emissions management plan (including dust) for the LNG Facilities site including project roads.	Construction Operations	Operator Contractor
M43	Use low NOx turbines in the LNG Plant.	Operations	Operator
M44	Where practicable, use low sulfur diesel for equipment and machinery during construction of the LNG Facilities site.	Construction	Operator Contractor
M45	Stabilise exposed areas susceptible to wind erosion during site earthworks using industry good practice measures such as water, agglomerating agents, temporary grass/hydromulch or mulch where appropriate.	Construction	Operator Contractor
M46	Collect and dispose of BTEX emissions through thermal destruction or industry best practice from all significant sources.	Operations	Operator
M47	Regularly inspect and maintain valves, pipes and tanks, etc., to reduce fugitive VOC emissions.	Operations	Operator
M48	Waste heat recovery units will utilise heat from the exhaust from the aero-derivative turbines driving the two propane refrigeration compressors to provide the main source of heat to the hot-oil system.	Operations	Operator
M49	Turbine generators will use dry, low-emissions technology to maintain NO_X and CO concentrations at less than 25 ppm.	Operations	Operator

Table 29.2 Upstream mitigation and management commitments

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M50	Prohibit transportation of live animals, plants or seeds to the Juha or Hides Ridge areas.	X	X	X	Construction Operations	Operator Contractor
M51	At Hides Ridge, hydrotest water sourced off the ridge will be discharged into the same watershed as its source to prevent cross-contamination with live organisms from another catchment.		X		Construction	Contractor
M52	Establish a weed, exotic pest and pathogen plan as part of the proposed ecology, natural habitat and biodiversity management plan.	X	X	X	Construction	Operator
M53	Establish procedures to prohibit PNG LNG Project workers or contractors from establishing any gardens or introducing or transporting any plants, seeds or animals within the project area (including the translocation of fish species).	X	X	X	Construction Operations	Operator Contractor
M54	Establish and enforce a project-wide quarantine management protocols as part of the ecology, natural habitat and biodiversity management plan.	X	X	X	Construction Operations	Operator Contractor
M55	Establish a project-specific safety plan to perform risk assessments for various activities including excavations.		X		Construction	Operator
M56	Where safe and practicable, patrol open trench to rescue and record fauna that fall into the open pipeline trench.		X		Construction	Operator Contractor
M57	Prohibit disturbance/harassment of wildlife, hunting of fauna, gathering of plants or bush foods, or possession of wildlife products by project workers or contractors while working, travelling in project vehicles, and residing in project field accommodation.	X	X	X	Construction Operations	Operator Contractor
M58	Implement appropriate inductions to encourage staff to comply with hunting and collecting regulations.	X	X	X	Construction Operations	Operator Contractor
M59	Contractor to control speed limits on project unsealed roads and pipeline ROWs via posted speed limit signs, where practicable, and keep vehicles to marked trafficable areas to prevent injury to fauna.	X	X		Construction	Operator

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M60	If fire hazard exists, pushed vegetation can be left to rot at forest edge rather than burnt.		X	X	Construction	Operator Contractor
M61	Develop and implement a bush and forest fire management plan for the construction and operations phases of the project.	X	X	X	Construction Operations	Operator
M62	The conservation activities of environmental non-government organisations in the project area will be encouraged.	X	X	X	Operations	Operator
M63	Encourage conservation education in villages in the project area.	X	X	X	Operations	Operator
M64	Clearing of riparian vegetation will be limited to the width required to safely accommodate pipeline ROWs and access ways and watercourse crossings. Also, the number of watercourse crossings will be reduced, to the extent practicable, to limit riparian soil erosion and sediment delivery to watercourses.	X	X		Construction	Operator Contractor
M65	ROWs and roadways will be located within or adjacent to existing disturbed areas where practicable.	X	X		Construction	Operator Contractor
M66	Wellpads will be designed and located to reduce the extent of vegetation clearing and earthworks by limiting to the extent practicable, the size of the wellpads.	X			Construction	Operator Contractor
M67	No quarries beyond cut to be established on the Hides Ridge where practicable.	X	X		Construction	Operator Contractor
M68	Minimise the number of quarries developed by: – Using previously worked (old) quarries, where practicable. – Using limestone generated by construction activities for road base material.	X	X	X	Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M69	Road base and foundation aggregate material sourced from in-country quarries not developed by the project will be in accordance with the requirements of Land and Community Affairs guidelines and procedures, that provides controls for the amount of gravel extracted from quarries.	X	X	X	Construction	Operator Contractor
M70	No construction camps allowed on Hides Ridges beyond Hides Wellpad A (with the exception of drilling camps).	X	X		Construction	Operator Contractor
M71	If a temporary drilling camp is necessary on Hides Ridge there should be only one and it is to be located near Hides Wellpad D and to be used by successive drilling campaigns.	X			Construction	Operator Contractor
M72	Promote use of timber felled during wellpad, pipeline, ROW, roadways and facility site clearing for project uses to the extent practicable.	X	X	X	Construction	Operator Contractor
M73	Industry good practice for construction camps will also apply to management of environmental effects from temporary fly camps and pioneer camps.	X	X	X	Construction	Operator Contractor
M74	Where practicable, land clearing will utilise techniques that preserve the rootstock of removed vegetation in the ground. Cleared vegetation will be spread back on to the rehabilitated ROW and access ways as mulch, where practicable.		X		Construction	Operator Contractor
M75	The extent of clearing and earthworks along the ROW will be limited and the time for which surfaces are exposed prior to natural revegetation will be reduced to the extent practicable.		X	X	Construction Operations	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M76	The standard ROW width for the project is 30 m and following construction the ROW will be allowed to naturally regenerate except for 15 m, to allow for a gap in the canopy for aerial surveillance of the pipeline. If there is a requirement to exceed the ROW design width, the contractor shall seek approval through a formal procedure from the operator.		X		Construction	Operator Contractor
M77	The design criteria for ROW width on Hides Ridge is 18 m. During operations the ROW will be allowed to regenerate except for a 10-m-wide access road required for ongoing drilling and maintenance access to the wellpads on the ridge.	X	X		Construction Operations	Operator Contractor
M78	Where trees are to be felled by hand, use directional felling for trees > 50 cm dbh so they land in natural slots between standing trees or along the axis of tracks to reduce damage to the remaining forest.		X		Construction	Operator Contractor
M79	Reduce scraping by machinery of standing tree trunks adjacent to, or off, the ROW.		X		Construction	Operator Contractor
M80	No herbicides to be used unless for the eradication of a serious invasive environmental weed.	X	X	X	Construction Operations	Operator Contractor
M81	No machinery will leave the ROW or access ways to unnecessarily clear additional forest.		X		Construction	Operator Contractor
M82	On Hides Ridge and between Hides Ridge and Juha, align the route to bypass potentially high-value conservation swamps that might provide juvenile nursery habitat or swamps in sinkholes <50 m deep where practicable. At sites where this is impractical, reduce sidecast into these high-value habitats.		X		Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M83	Locate the temporary Juha drilling camp within the footprint of the Juha Production Facility.	X			Design Phase 4	Operator
M84	Locate the temporary Angore drilling camp within the footprint of the Hides Gas Conditioning Plant.	X			Design Phase 2	Operator
M85	Provide protection for stream heads in the Baia River area and elsewhere in the upstream project area above 1,800 m, to reduce erosion material entering the watercourse.		X		Construction	Operator Contractor
M86	If practical and safe, retain trees over 1 m dbh at camp locations.	X	X	X	Construction	Operator Contractor
M87	Establish procedures to prohibit PNG LNG Project workers or contractors disturbing bird-of-paradise and bowerbird display grounds or trees identified next to the ROW. Conduct a preclearance survey to identify such sites.		X		Construction	Operator Contractor
M88	All new project road sections constructed for logistics transfer between Kopi and the Hides Gas Conditioning Plant will have controlled access for project use only following completion of construction.		X		Operations	Operator
M89	All pipeline ROWs and roadways between the Omati River Landfall and the Kopi deviation will be made impassable at the end of project construction, and those on Hides Ridge will be made impassable at the end of the project.	X	X		Operations	Operator
M90	Control access to Hides Ridge and Juha on the Juha and Hides Ridge access ways to the west of Hides Wellpad A and implement a permit system for vehicle access for the lifetime of project.	X	X	X	Construction Operations	Operator

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M91	Establish pipeline security procedures, including procedures for heavy logging trucks on road sections where the pipeline is buried.		X		Operations	Operator
M92	Prohibit disposal of any waste into forest, streams or sinkholes.	X	X	X	Construction Operations	Operator Contractor
M93	Dispose of drilling fluids, drilling cuttings and other drilling materials in an appropriate manner away from Hides Ridge.	X			Construction	Operator Contractor
M94	Dispose of wastes from ROWs and access ways construction activities (not spoil) and camps (including the drilling camp) away from Hides Ridge.	X	X		Construction	Operator Contractor
M95	Establish waste management procedures to control and appropriately manage all non-biodegradable materials.	X	X	X	Construction Operations	Operator Contractor
M96	Manage sewage in an appropriate manner to limit environmental contamination.	X	X	X	Construction Operations	Operator Contractor
M97	Incinerate organic waste and bury at specified sites, as required.	X	X	X	Construction Operations	Operator
M98	Where employed, high-temperature incinerator waste will be controlled through the project environmental management plan.			X	Construction Operations	Operator
M99	Prohibit washdown or fuel handling near or in streams.	X	X	X	Construction	Operator
M100	Establish appropriate fuel handling transport and storage procedures in the environmental management plans.	X	X	X	Construction Operations	Operator
M101	Establish appropriate materials handling, storage and disposal in the environmental management plans.	X	X	X	Construction Operations	Operator

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M102	Establish appropriate storage and handling of radioactive material in the environmental management plans.	X		X	Construction Operations	Operator
M103	Establish appropriate waste handling procedures in the environmental management plans that will: ▪ Comply with the relevant and applicable parts of the IFC Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental Waste Management (IFC, 2007k). ▪ Comply with the relevant and applicable parts of the IFC Environmental, Health, and Safety Guidelines – Waste Management Facilities (IFC, 2007l). ▪ Meet the intent of the emission limits in US EPA 40 CFR Part 60, Standard of Performance for New Stationary Sources (NSPS), including Subpart AAAA, Standards of Performance for Small Municipal Waste Combustion Units, or Subpart CCCC, Standards of Performance for Commercial and Industrial Solid Waste Incineration Units (EPA US, 2008), as applicable.	X	X	X	Construction Operations	Operator
M104	Direct lights at facilities to eliminate shine into surrounding forest, where security allows.	X	X	X	Construction Operations	Operator Contractor
M105	Conduct a preclearance survey of pinnacles along the ROW and access ways for caves to determine presence of bat colonies, and where colonies are located in proximity to the ROW and access ways, establish procedures to reduce disturbance, where practicable. Potential quarry sites should not be located near caves with colonies containing protected bat species.	X	X	X	Construction	Operator

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M106	Investigate the potential Bulmer's fruit-bat colony near Angore and design and implement a management plan should a colony be found near Angore or elsewhere in the project area.	X	X	X	Construction Operations	Operator
M107	Establish cave management protocols for worker and contractor inductions, to prohibit unnecessary disturbance of bat colonies by project workers.	X	X	X	Construction Operations	Operator
M108	Consider restricting access to caves with bats and prohibit unnecessary disturbance by project workers.	X	X	X	Construction Operations	Operator Contractor
M109	Limit or control (where practicable) blasting within 100 m of known colonies of cave bats.	X	X	X	Construction	Operator Contractor
M110	Conduct: grade 1 bat surveys, where practicable, prior to construction in areas likely to be inhabited by bats; grade 2 bat surveys in areas where blasting is contemplated; and grade 3 bat surveys where required (after checking with the local community for presence of bat caves near the route) to limit disturbance.	X	X	X	Construction	Operator Contractor
M111	Control vehicle speed via posted speed limit signs on project unsealed roads and pipeline ROWs (when required) and keep vehicles to marked trafficable areas.	X	X		Construction Operations	Operator
M112	The number of special vehicle parks will be reduced, and placed in areas of existing disturbance, where practicable.		X		Construction	Operator Contractor
M113	Develop an approved chain of custody for timber sourced for the project.	X	X	X	Construction	Operator Contractor
M114	Review of the reduced emissions from deforestation and degradation mechanism as a means of limiting potential indirect forest degradation and deforestation along the ROW warrants consideration.		X		Operations	Operator

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M115	Develop a management plant to reduce impacts on pandanus swamp forest. Design ROW and roadways to allow adequate surface and subsurface flows.		X		Construction	Operator Contractor
M116	Develop management procedures to reduce impacts on *Nothofagus* forest and the spread of dieback as part of the ecology, natural habitat and biodiversity management plan. Design to allow adequate surface and subsurface flows and avoid redirection of stream flows where practicable.		X		Construction	Operator Contractor
M117	Implement vehicle washdown facilities. Ban the import of exotic species, including seed into the project area.	X	X	X	Construction Operations	Operator Contractor
M118	Establish weed and exotic pest control management measures that identify foreign and invasive weed and exotic pest threats and appropriate control measures as part of the ecology, natural habitat and biodiversity management plan.	X	X	X	Construction Operations	Operator Contractor
M119	Develop a reclamation management plan that will include measures to assist revegetation in areas found to be slow to revegetate naturally.	X	X		Construction	Operator Contractor
M120	Areas requiring active revegetation will be identified: ▪ On Hides Ridge. ▪ In areas between Idauwi and Homa, in particular unstable volcanic terrains.	X	X		Construction	Operator Contractor
M121	Where practicable, soil, mulch and discarded vegetation debris (including natural seed stock) will be spread on reclaimed or rehabilitated disturbed land surfaces to facilitate natural revegetation.	X	X	X	Construction	Operator Contractor
M122	Where practicable, topsoil will be conserved in designated topsoil stockpile areas at facility construction sites for later reuse.			X	Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M123	Salvage topsoil for rehabilitation of slopes, where practicable.	X	X	X	Construction	Operator Contractor
M124	Where salvaged, reduce damage to topsoil and mulch with sterile medium to protect seed resource.	X	X	X	Construction	Operator Contractor
M125	Drilling fluids and additives to be sourced from reputable suppliers.	X			Construction	Operator Contractor
M126	Well development waters will be captured within mud pits and make-up water pits or similar. Where warranted, alternative methods of disposal can be implemented, e.g., via reinjection.	X			Construction	Contractor
M127	Wastewater streams associated with drilling, such as water-based, non-toxic whole drilling fluids and completion drilling fluids, will be discharged in accordance with permit requirements.	X			Construction	Operator Contractor
M128	Combustible wastes will be incinerated at project-specified sites.	X	X	X	Construction Operations	Operator Contractor
M129	Effluents treated to appropriate standard and disposed of to combined outfall. For example stormwater and oily wastes treated in corrugated-plate interceptor facility to appropriate standard prior to disposal in retention pond. In addition, sufficient time is allowed for sediment and solids to settle within the pond prior to final offsite discharge in accordance with the environment (waste discharge) permit.			X	Operations	Operator
M130	Diesel storage system will be purpose-built, above ground and within double-walled tanks or containment bunds. Hydrocarbon spill prevention and response procedures will be detailed in the spill response plan.	X	X	X	Construction Operations	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M131	MEG slop storage tanks will be purpose-built full-containment tanks and bunded. Hydrocarbon spill prevention and response procedures will be detailed in the spill response plan.			X	Operations	Operator
M132	Biological, pharmaceutical and medical wastes will be treated and disposed of using appropriate technologies that will be detailed in the environmental management plan.	X	X	X	Construction Operations	Operator Contractor
M133	Sewage treatment plants will be operated in accordance with the manufacturer's specifications and will comply with the conditions for discharge quality (including disinfection) specified in the environment (waste discharge) permit.	X	X	X	Construction Operations	Operator Contractor
M134	All water and wastewater discharges will be treated to comply with conditions for discharge quality specified in the relevant environment (water discharge) permits.	X	X	X	Construction Operations	Operator Contractor
M135	All bunded open drain areas at facility sites will be concreted, kerbed and sloped to drain catchpits. The catchpits will feed to interception pits for separation of oil and water. The de-oiled water will be transferred to retention ponds for treatment as appropriate prior to disposal in accordance with the environment (waste discharge) permit. Waste oil that is collected from the interception pits and other facility sumps will be recycled by reinjection into the condensate being sent to the Kutubu Central Processing Facility where practicable.			X	Operations	Operator Contractor
M136	Non-equipment areas at plant facilities will be graded and sloped to allow uncontaminated storm water to drain naturally via the stormwater drains prior to routing offsite.			X	Operations	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M137	Water taken from watercourses or groundwater will meet environment (water extraction) permit conditions.	X	X	X	Construction Operations	Operator Contractor
M138	Where practicable, trees felled into watercourses will be removed and used for revegetation works.		X		Construction	Operator Contractor
M139	Where practical, stabilise cleared banks to provide a suitable habitat for recolonisation.		X		Construction	Contractor
M140	Where practicable, the pipeline ROWs and access ways alignment approaches to watercourses will be kept as close to right angles as possible to limit disturbances to the banks of watercourses.		X		Construction	Operator Contractor
M141	Conduct fine-scale routing of the ROWs and access ways to reduce traversing particularly erosive soils on steep slopes and to limit the number of pipeline crossings of clear-water streams, sinkholes, off-channel waterbodies and other karst terrain, where practicable.		X		Construction	Operator Contractor
M142	Where a watercourse crossing is considered too large and fast-flowing for the use of conventional open-cut trenching methods, horizontal directional drilling may be used to install the pipeline.		X		Construction	Operator Contractor
M143	Horizontal direction drilling sites on either side of a watercourse will be re-contoured, graded and rehabilitated after pipe installations are completed to reduce soil erosion and fugitive sediment.		X		Construction	Operator Contractor
M144	For watercourse crossings at which horizontal directional drilling techniques are used, a drilling fluids and cuttings management system, including drill cuttings settlement and slurry containment pits, will be implemented.		X		Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M145	As part of the water management plan develop hydrotest disposal management procedures that includes adherence to guidelines and measures as follows: • Disposal of hydrotest waters in accordance with industry good practice engineering codes for system gauging, hydrotesting and disposal, and discharges will be required to meet the prescribed quality criteria for ambient water (see Table 18.15) as part of the relevant environmental (waste discharge) permit conditions. • Measures to hold and treat hydrotest wastewater where necessary prior to release so the quality meets the requirements of the relevant environment (water discharge) permit. • Predischarge sampling and analysis of hydrotest water to check that quality complies with the conditions attached to the relevant environment (water discharge) permit. • If the wastewater is to be discharged to land for infiltration, the outflow energies will be dissipated (e.g., via sprinkler or T-bar arrangements) to prevent possible problematic soil erosion.		X		Construction	Operator Contractor
M146	Fuel, lubricating oils and chemicals will be stored in appropriately sized designated areas that have impervious liners and bunds, or are in double-hulled tanks. This includes temporary fuel stores along the ROW and access ways.	X	X	X	Construction Operations	Operator Contractor
M147	Procedures for vehicle/equipment refuelling will be implemented to prevent spillages, and appropriate spill containment equipment will be available at refuelling sites and construction sites. All drivers will be appropriately trained in emergency spill response procedures.	X	X	X	Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M148	Vehicles and machinery are to be maintained to a high level of safety with respect to leaks. Drivers will be appropriately trained and have the required driving licence.	X	X	X	Construction Operation	Operator Contractor
M149	Operations sites will be designed to intercept potentially contaminated water.	X	X	X	Operations	Operator
M150	The washing of equipment, vehicles or machinery near or within watercourses will be prohibited.	X	X	X	Construction	Operator Contractor
M151	An appropriate number of staff will be trained in the handling of emergency response and spill scenarios.	X	X	X	Construction Operations	Operator Contractor
M152	Conduct post-construction inspections along the upgraded ROW and roadway within the catchment of Lake Kutubu including: • Checking for problematic erosion areas and implementing remedial works as appropriate. • Inspecting ditches and culverts and removing accumulated debris, where required. • Reviewing feedback from water quality monitoring for advance warning of deteriorated water quality due to increased suspended sediment loading.		X		Construction Operations	Operator Contractor
M153	The duration of construction activities at watercourse crossings will be as short as practicable.		X		Construction	Construction Operator
M154	The construction of bridges, abutments and in-river bridge supports (where needed) will take into account the hydraulics of the watercourse in their design to consider stability and flow disruptions.		X		Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M155	Incorporate erosion and sediment control procedures into the water management plan for all construction-related activities to: • Implement industry good practice erosion and sediment control measures at watercourse crossings, as necessary. • Reduce stockpiling spoil and topsoil materials close to waterways (i.e., maintaining a minimum of 10 m from the waterline), where practicable. • Control sediment runoff from stockpiles and cleared areas around watercourses. • Implement sediment control measures downstream of sidecast material where safe and practicable. • Limit erosion and sediment delivery to streams from new quarries. • Prohibit sidecasting material directly into waterways where practicable. • Grade pipeline ROW and access ways alignments adjacent to streams away from watercourses. • Monitor and maintain erosion and sediment control measures until adequate soil stabilisation has been achieved. • Install diversion drains to intercept uncontaminated surface runoff around facilities and away from construction areas. • Install sediment control structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses. • Monitor for and rectify areas of problematic erosion at reclaimed watercourse crossings.	X	X	X	Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M156	Fine-scale routing will be implemented during FEED and detailed design to mitigate impacts from sidecasting in steep terrain areas and to reduce traversing areas prone to mass failure by: • Examining the separation of the pipeline ROWs and roadways or access tracks to reduce sidecasting where practicable. • Using fine particle size organic matting or lattice framework or similar in karst areas to trap organic matter across sidecast where safe and practicable. • Implementing sediment control measures downstream of sidecast material where safe and practicable.		X		Construction	Operator Contractor
M157	Perform terrain evaluation/mapping to identify past landform instabilities (i.e., landslides).		X		Construction	Operator Contractor
M158	River/stream crossings will be limited in areas of high, unstable banks.		X		Construction	Operator Contractor
M159	A surface water and stormwater management plan will be implemented.	X	X	X	Construction Operations	Operator Contractor
M160	Watercourse crossing construction management plans will be incorporated into the water management plan to address the sensitivities of crossings on an individual watercourse basis. Plans will consider, where relevant: • Watercourse diversions requirements. • Disturbance limits. • Equipment limitations.	X	X	X	Construction	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M160 (cont'd)	• Erosion control measures. • Fine-scale routing at crossing sites to limit disturbance of particularly large and established riparian vegetation and complex bank habitat structure. • Delay of clearing of banks for temporary vehicle crossing until the need for the crossing is imminent, where practicable.					
M161	Design the modified and new wharfs at Kopi Shore Base to parallel the existing frontage of the Kikori River and to take account of channel hydraulics and other hydrodynamic characteristics of the lower Kikori River that may affect the long-term stability of the river frontage.		X	X	Construction Operations	Operator
M162	The construction and rehabilitation of the ROW in the Omati River swamp area will be managed to maintain natural hydrologic flows and connectivity in the surrounding area. Monitoring of vegetation condition in the vicinity of the ROW will be conducted to assess the need for post construction remedial works in this area. The scope of the monitoring program will be developed in the environmental management plan.		X		Construction Operations	Operator Contractor
M164	A water quality baseline monitoring plan will be developed for the Hides Gas Conditioning Plant and Juha Production Facility. The plan will be implemented as part of the project's water management plan.			X	Construction Operations	Operator Contractor
M165	Post-rehabilitation monitoring of vegetation will be undertaken in swamp areas between Kopi and the Omati River to determine whether additional remediation is necessary to maintain hydraulic flows in the area of project works.		X		Operations	Operator
M166	Water and sediment quality of streams draining the Juha Production Facility will undergo further baseline characterisation prior to construction.			X	Construction Phase 4	Operator Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M167	Design the facility to reduce routine flaring and venting of associated gas.	X		X	Operations	Operator
M168	At the Hides Gas Conditioning Plant waste heat from the exhaust of the pipeline compressor gas turbines will be used to provide heat to the thermal fluid-based hot oil system.			X	Operations	Operator
M169	With the exception of drilling activities, limit construction works at night time where practicable to meet agreed project noise criteria.		X	X	Construction	Operator Contractor
M170	Where practical, noise mitigation measures (including consultation with local citizens) will be implemented at drilling sites to minimise the noise level as much as possible.	X			Construction	Operator Contractor
M171	Adhere to specific criteria for construction and operations that are aligned to the intent of the IFC and WHO Guidelines on Environmental Noise Management 5A boundary noise limit of 55 dBA L_{eq} during the day period and 45 dBA L_{eq} during the night from noise sourced from the construction and operation of the facilities will apply to protect the amenity of landowners. A property fence line will be constructed around the facilities to coincide with the calculated nighttime noise limit of 45 dBA L_{eq}. Current receptors that are within the perimeter fence location will be resettled as appropriate.	X		X	Operations	Operator
M172	Select construction plant and equipment based on industry good practice and OHS standards and document requirements in the environmental management plans.	X	X	X	Construction	Operator Contractor
M173	Noise suppression devices on construction vehicles and equipment will be maintained.	X	X	X	Construction Operations	Contractor

Table 29.2 Upstream mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Project Component			Relevant Phase	Responsible Party
		Drilling	Pipeline and Logistics	Facilities		
M174	Where high intensity noise from construction activities may affect local villagers and/or sensitive locations (i.e., school), the affected parties will be notified of the intended work and its duration.	X	X	X	Construction Operations	Operator Contractor
M175	Establish a noise management plan considering ANZECC guidelines, or similar and in consultation with local communities.	X	X	X	Construction	Operator Contractor
M176	Diesel-powered equipment will be regularly serviced and low-sulfur diesel fuel will be used where practicable.	X	X	X	Construction Operations	Operator Contractor
M177	Fixed and mobile equipment (i.e., generators required for welding) will be located sensitively with respect to local people.	X	X	X	Construction	Operator Contractor
M178	Speed limits will be controlled via posted speed limit signs on project unsealed roads and pipeline ROWs (when required) and vehicles kept to marked trafficable areas which will be maintained in a damp and compacted condition (when required) to enhance safety and minimise dust emissions.	X	X	X	Construction	Operator Contractor
M179	BTEX emissions will be disposed by thermal destruction or industry good practice.			X	Operations	Operator
M180	Low-NOx emissions equipment will be fitted on the turbine generators and gas compressors.			X	Operations	Operator
M181	High-temperature incinerator wastes will be controlled through the project environmental management plan.		X	X	Construction Operations	Operator
M182	Site-specific security measures will be considered and appropriately applied at excavation sites. These measures will include security (watchmen), active dewatering, provision of a physical barrier, community awareness programs and signage as appropriate.		X	X	Construction	Operator Contractor

Table 29.3 Marine mitigation and management commitments

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M183	Notify local communities, particularly inhabitants of fishing camps adjacent to the Omati River Landfall, with respect to offshore construction activities and the associated dangers of approaching vessels too closely.	Construction	Operator Contractor
M184	Limit interfering with, or restricting local fishers' access to, fishing camps during construction activities in the Omati River as far as practicable.	Construction	Operator Contractor
M185	Notify local communities about project barge traffic and the associated dangers of approaching vessels too closely.	Construction	Operator Contractor
M186	Undertake sedimentation and geomorphologic characterisation studies of the Omati River to collect baseline data of the portion of the riverbed in which the proposed LNG Project Gas Pipeline will be laid so that any future changes can be compared to pre-construction conditions.	Construction Operations	Operator Contractor
M187	In order to discharge marine hydrotest water, the project will require an environment (waste discharge) permit from the department of Environment and Conservation. The project will comply with the requirements of the permit when discharging.	Construction	Operator Contractor
M188	The storage, use and handling of all hazardous chemicals, materials and wastes on project vessels will be in accordance with IMO MARPOL (1973/1978) requirements. Appropriate spill response procedures and training for workers will be implemented.	Construction	Operator Contractor
M189	A marine fauna observation procedure will be implemented, requiring all observations and encounters with marine mammals (such as whales and dugongs) and turtles to be documented in an observation log. In the event of any close approach (e.g., within 500 m) by marine mammals, the vessel crew will be alerted.	Construction	Operator Contractor
M190	Fine-scale routing (using bathymetry and geotechnical data) of offshore pipeline to: • Avoid coral reefs and reduce the extent of sea grass beds traversed. • Limit activities that cause most disturbance to seabed (i.e., trenching and anchor deployment). • Reduce the placement of anchors and/or anchor chains on sensitive habitat (e.g., the shallow areas south of Caution Bay).	Construction	Operator Contractor
M191	Bury pipeline 2 to 3 m below the seabed in water depths less than 15 m LAT in Caution Bay.	Construction	Operator Contractor
M192	Request commercial vessels to remain outside a safe buffer zone around the pipeline installation vessels and the anchor cables (if used).	Construction	Operator Contractor

Table 29.3 Marine mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M193	Barge transport will be managed to control wake and prevent incidents with small boats.	Construction Operations	Operator Contractor
M194	The LNG Project Gas Pipeline will be buried in the bed of the Omati River to protect the pipeline and limit potential causes of interruptions to natural bed sediment transport processes.	Construction	Operator Contractor
M195	Vessel decks will not be illuminated at night more than is necessary for safe operations.	Construction Operations	Operator Contractor
M196	An oxygen scavenger and a biocide will be added to the hydrotest water to control marine organisms present in the water and the hydrotest water will, if necessary, be filtered prior to filling and emptying the pipeline to remove most solid material.	Construction	Operator Contractor
M197	The offshore pipeline route will be aligned to cross the LNG tanker shipping channel at an angle as perpendicular as practicable to the channel and the pipeline will be buried (or covered with rocks) through the shipping channel.	Construction	Operator Contractor
M198	Advise prawn trawl operators and National Fishing Authority prior to construction.	Construction	Operator Contractor
M199	Engineering techniques will be used in the design of the pipeline to reduce potential for entanglement including: • Span reduction methods. • Active burial (trenching or grout bag support) in parts of the Omati River and Caution Bay where required.	Construction Operations	Operator Contractor
M200	Provide as-laid location of pipeline to PNG Hydrographer's Office.	Operations	Operator
M201	Develop a procedure for the evaluation and payment of compensation for any loss of fishing gear through consultation with relevant parties.	Construction Operations	Operator
M202	Implement an awareness program to educate local fishers about the dangers of dynamite fishing in proximity to high-pressure gas pipelines and LNG marine facilities in Caution Bay.	Operations	Operator
M203	Notify local communities with respect to offshore construction activities and the associated dangers of approaching vessels too closely. Implement marine traffic and navigation procedures relevant to the area and document in the project environmental management plans.	Construction	Operator Contractor
M204	Minimise sediment release resulting from construction of the Materials Offloading Facility.	Construction	Operator Contractor
M205	Design marine outfall to ensure adequate dispersion of desalination brine to comply with environment (waste discharge) permit conditions.	Construction	Operator Contractor

Table 29.3 Marine mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M206	Consider discharging wastewater and brine in the same vicinity to assist with salinity dilutions.	Construction Operations	Operator Contractor
M207	Validation baseline monitoring of sedimentation will be undertaken during construction and will be similar in scope to that undertaken for the EIS characterisation baseline or expanded as required.	Construction Operations	Operator Contractor
M208	Limit marine habitat disturbance and mangrove clearing for Materials Offloading Facility/Jetty construction to the area within the perimeter fence (plus working buffer zone). Prohibit works from exceeding the design disturbance width and enforce boundaries through use of markers/tape and worker awareness.	Construction	Operator Contractor
M209	Establish an offshore spill response plan appropriate to the project phase and include staff training at induction to inform workers of their responsibilities under the plan.	Construction Operations	Operator Contractor
M210	Implement marine waste management (discharges to sea) procedures as part of the waste management plan complying with MARPOL standards and international port policies and procedures.	Construction Operations	Operator Contractor
M211	Adhere to Environment Australia (Commonwealth) guidelines or other similar industry good practice with respect to dredging and disposal of dredged material.	Construction Operations	Operator Contractor
M212	Employ a soft start for piling activities during the construction of the jetty to allow any marine fauna in the vicinity the opportunity to move away.	Construction	Operator Contractor
M213	Conduct a preblasting clearance survey (e.g., for turtles).	Construction	Operator Contractor
M214	Model dispersion characteristics of hydrotest water that will be discharged in Caution Bay prior to discharge.	Construction	Operator Contractor
M215	Measures to minimise sediment release resulting from construction of the earthen causeway will include setting a lower limit of particle size for material used for LNG Jetty/Materials Offloading Facility causeway construction and/or use of a geotextile lining or similar industry good practise to minimise the release of fine sediment into the water column.	Construction	Operator Contractor
M216	Silt curtains and/or other industry good practice management controls will be used to restrict the spread of sediment released during construction of the combined LNG Jetty/Materials Offloading Facility earthen causeway, particularly when working in mangroves, or adjacent to the reef and seagrass areas.	Construction	Operator Contractor
M217	Selection of dredging equipment (cutter, suction/hopper, etc.) by the contractor will be appropriate to the depths and material types to be dredged and to minimise the creation of plumes.	Construction	Operator Contractor

Table 29.3 Marine mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
M218	Disposal of the dredge spoil will be undertaken off the continental shelf presenting minimal risk of impact to the outer barrier reef. Locations for disposal will be selected based on hydrodynamic modelling to ensure no spoil settles on outer reef site.	Construction	Operator Contractor
M219	Treated effluent will be sent to retention pond(s) for polishing prior to discharge into Caution Bay in accordance with the required environment (waste discharge) permit conditions.	Operations	Operator Contractor
M220	Where practicable, light spill into the marine environment during construction and operation will be managed by shielding to reduce visibility of the LNG Facilities (including the marine facilities) from Idihi Island.	Construction Operations	Operator Contractor
M221	Compensation for loss of either access to and/or marine resources as a result of marine facilities exclusion zones will be managed through consultation with relevant communities to determine details of how compensation measures will be implemented.	Construction Operations	Operator
M222	A project-wide quarantine management plan will follow International Maritime Organization requirements and industry good practice with respect to ballast water discharge and hull cleaning to prevent the introduction of pest species.	Construction Operations	Operator Contractor
M223	Maintain existing alongshore sediment transport patterns in the vicinity of the Vaihua River mouth.	Construction Operations	Operator

Table 29.4 Cultural heritage mitigation and management commitments

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Project-wide Measures			
M224	Conduct preconstruction surveys (including consultation with relevant project area landowners), by systematically recording and mapping cultural heritage sites in all project footprint areas. The surveys will inform the cultural heritage management plan that will be developed for the project (see M230).	Construction	Operator Contractor
M225	Undertake additional preconstruction surveys (including consultation with relevant project area landowners), in any additional impact areas that could not be surveyed for the EIS.	Construction	Operator Contractor

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Project-wide Measures (cont'd)			
M226	Consult and liaise with the PNG National Museum and Art Gallery as required for preconstruction surveys. Appropriately qualified professional archaeologists will supervise all preconstruction surveys. Liaison with the National Cultural Commission (NCC) will be through the PNG National Museum and Art Gallery as appropriate.	Construction	Operator Contractor
M227	Detail in the cultural heritage management plan the appropriate management measures for each site, once the preconstruction surveys are complete, the ROW has been cut and all cultural sites are identified.	Construction	Operator Contractor
M228	Consult local communities and cultural heritage specialists, to identify oral tradition sites during preconstruction surveys, and before obtaining their consent for the damage or destruction of cultural heritage sites.	Construction	Operator Contractor
M229	Conduct further research of appropriate archives as part of site preconstruction works, where relevant and required.	Construction	Operator Contractor
M230	Develop and implement a cultural heritage management plan (see Chapter 30, Environmental, Management, Monitoring and Reporting) in consultation with the PNG National Museum and Art Gallery, archaeologists and cultural heritage specialists.	Construction Operations	Operator Contractor
M231	Salvage, where required, highly significant sites specified in the cultural heritage management plan that may be destroyed by project activities.	Construction	Operator Contractor
M232	Engage appropriately qualified archaeologists and/or cultural heritage–trained personnel to coordinate and direct salvage activities. Salvage activities will be supported by the University of Papua New Guinea and will be in consultation with the PNG National Museum and Art Gallery, as required. Minimum qualification levels will be detailed in the cultural heritage management plan.	Construction	Operator Contractor
M233	Avoid significant sites during design and construction of pipelines and project facilities, as specified in the cultural heritage management plan.	Construction	Operator Contractor
M234	Develop management procedures for the recording and subsequent reburial of any human remains that may be unearthed during project site clearance salvage works and later, as part of project construction earthworks. This procedure will be prepared in consultation with the PNG National Museum and Art Gallery and representatives of the local communities. The procedure will be detailed in the cultural heritage management plan.	Construction	Operator Contractor

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Specific Measures for the LNG and Marine Facilities Cultural Environment			
M235	Develop and implement a cultural awareness program before early works and over the duration of project construction activities. The cultural heritage management plan will detail this program.	Construction Operations	Operator Contractor
M236	Develop monitoring programs and protocols for salvage (including artefact acquisitions) in consultation with the PNG National Museum and Art Gallery. The cultural heritage management plan will detail these programs and protocols.	Construction	Operator Contractor
M237	Develop protocols for timely and regular consultation with community representatives on matters concerning the management of those cultural heritage sites that will be impacted by project activities. The protocols will be developed in consultation with the local communities and the PNG National Museum and Art Gallery. The cultural heritage management plan will list these protocols.	Construction	Operator Contractor
M238	Engage appropriately qualified archaeologists or cultural heritage–trained personnel to monitor construction activities, and to ensure that any previously unknown sites are treated appropriately and according to measures and protocols detailed in the cultural heritage management plan.	Construction	Operator Contractor
M239	Periodically monitor cultural sites within the vicinity of pipelines and facilities (but which may not necessarily lie within the project footprint), to ensure that project personnel are not disturbing sites outside the area of disturbance.	Construction Operations	Operator Contractor
M240	Mark known offshore cultural sites on nautical charts and add a GIS reference on site construction plans for avoidance where practicable.	Construction	Operator Contractor
M241	Detail in the cultural heritage management plan the project personnel engaged to manage cultural heritage matters associated with the construction and operations stages of the project.	Construction Operations	Operator Contractor
M242	Consider whether it is feasible, practical and safe to train a cultural heritage officer to sample dredge spoil for the purpose of investigating the presence of submerged prehistoric artefacts in Caution Bay. The decision will be taken in consultation with the PNG National Museum and Art Gallery, and if the decision is affirmative, then the training program will be detailed in the cultural heritage management plan.	Construction	Operator

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Specific Measures for the LNG and Marine Facilities Cultural Environment (cont'd)			
M243	Liaise with a marine archaeologist to review the detailed side-scan sonar data obtained for areas to be developed offshore of Caution Bay. Management and/or future survey of any credible anomalies of cultural heritage origin will be detailed in the cultural heritage management plan, including avoidance where practicable. The project will liaise with PNG, Australian and international agencies involved in the recording and reporting of WWII war graves and artefacts as appropriate.	Construction	Operator
M244	Limit the movement of employees and contractors to within the site security fence and designated traffic and transport routes or locations outside of the LNG Facilities site. Employees will be prohibited from visiting local areas or villages around the site. These mitigation measures will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPs.	Construction	Operator
M245	Avoid sites identified outside the project area of development including Buria (CB10), Aemakara, Dirora, Darebo (CB11), Dori Hill (CB12), Daeroto, the four sites associated with Edai Siabo's first lagatoi story (CB6, CB7, CB8, ASM) and the three sunken lagatoi sites (CB16, CB17 and CB18). Measures to avoid these sites and to mitigate indirect and cumulative impacts will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPs.	Construction	Operator
M246	Engage a social anthropologist to record the Koita and Motu place names and their oral traditions within the LNG Facilities site lease boundary, which includes land immediately surrounding the site security fence area. This survey will be undertaken in consultation with relevant local communities.	Construction	Operator
M247	Cross-check the ARE, ARB and ARJ sites against previous sites formally recorded on the PNG National Museum and Art Gallery/University of PNG registers, i.e., sites AAIP, AAIO and AAIQ respectively. This cross-check will be undertaken as part of future site archaeology salvage and management, which will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPs.	Construction	Operator

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Specific Measures for the LNG and Marine Facilities Cultural Environment (cont'd)			
M248	Ensure that the ancient village of Konekaru (CB1, JD1, JD2, JD3, JD5, ML3, including the beach area; SC4) will be avoided by major site earthworks. Minor disturbance may occur during construction of the low-level post-and-wire fence around the lease perimeter boundary. Mitigation measures M228, M237 and M238 will be undertaken and will be managed in accordance with the cultural heritage management plan.	Construction	Operator
M249	Avoid the ancestral oral tradition sites including Davage, Taubarau, Ava Garau and the associated archaeological sites, as per M233. These sites are located more than 1.5 km south of the LNG Facility exclusion fence near Boera and are of the highest level of cultural heritage significance.	Construction	Operator
M250	Avoid the significant ancestral oral tradition sites of Buria (CB10), Aemakara, Dirora, Darebo (CB11), Dori Hill (CB12) and Daeroto located outside the LNG Facilities site security fence. Mitigation measures will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPs.	Construction	Operator
M251	Identify on site plans and create buffer zones to avoid, where practicable, the cultural heritage sites: • CB6, which lies well outside the project footprint, but will need to be identified on nautical charts for avoidance by shipping activities, as per M240. • CB7, which lies between the site security and site perimeter fence boundaries. • CB16, CB17, CB18, CB8 and ASM. Mitigation measures for each of these sites will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPs.	Construction	Operator
M252	Follow mitigation measures M231 and M232 for the SC3 and SC5 complex of sites, located within the LNG Facilities site security fence. The program to salvage and record sites will be detailed in the cultural heritage management plan.	Construction	Operator

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Specific Measures for the Upstream Cultural Environment			
M253	Ensure that major earthworks avoid the SC1 and SC4 sites, and the northern section of the ancient village site complex known as Aemakara. Minor disturbances may occur in these areas during construction of the low-level wire-and-post fence around the lease perimeter boundary. Construction will follow mitigation measures M228 and M238 and any sites discovered will be managed in accordance with mitigation measures detailed in the cultural heritage management plan, which will include measures to protect sites through cultural awareness training (as per M235) and movement restrictions for project personnel and contractors (as per M244). No excavation or salvage is proposed in these areas.	Construction	Operator
M254	Follow mitigation measures M228, M231, M232 and M238 for sites that are located within the site security fence boundary. The program to salvage and record sites will be detailed in the cultural heritage management plan.	Construction	Operator
M255	Liaise with the communities of the project area and various government agencies as appropriate to investigate and agree to strategic community programs.	Construction	Operator
M256	Revisit the P-39 aircraft crash site (CB4) and the cultural pipe bridge structure site (CB3) during the preconstruction survey. These heritage sites lie outside the project site security fence area but inside the site lease boundary area. Management measures will be detailed in the cultural heritage management plan.	Construction	Operator
M257	Avoid the aircraft crash site at Lea Lea (CB21), located outside the project area of development. Cultural awareness training, as per M235, implemented as part of the cultural heritage management plan, will prevent project personnel and contractors from visiting the site. There will be no further survey work of this site by the project.	Construction	Operator
M258	Indicate on site construction maps, and avoid, where practicable, the general area of known lagatoi wreck sites CB16, CB17 and CB18. If sunken lagatoi remains are discovered during site construction activities, works will stop and remains will be managed and protected as appropriate in consultation with the PNG National Museum and Art Gallery.	Construction	Operator
M259	Consider the Boera battery (CB30) when developing mitigation measure M235.	Construction	Operator

Table 29.4 Cultural heritage mitigation and management commitments (cont'd)

Mitigation Item Number	Mitigation Measure	Relevant Phase	Responsible Party
Specific Measures for the Upstream Cultural Environment			
M260	Include in the cultural heritage management plan management measures for the extent of Lake Kutubu (with particular attention to the avoidance of rock art sites and ossuaries; sites LK001-037, 056-063).	Construction	Operator
M261	Identify on site plans and create buffer zones to avoid, where practicable: • The two ossuary sites LK040 and LK041, which are located 1.4 km and 700 m southeast of the pipeline respectively, and include one of the largest ossuaries in the region. • The myth site Sisibuitono (LK043), which is located approximately 2.7 km southeast of the pipeline. • The Mount Ru complex, which is located approximately 10 km east of the LNG Project Gas Pipeline and west of Kopi Shore Base, and is associated with travels of the spirits of the dead. • The small hill at Helipad 14 (KG125), located 8 km east of the pipeline. • The area located 10 km east of the proposed pipeline, between Utiti Creek in the north, the Kikori River western bank in the east, and an area 500 m to the south and to the west of the existing Kopi base camp. • The major ritual lake Iba Mabuli (HD011) and the associated ritual sites (HD037, HD009, HD010 and HD012), all located about 1km north of the pipeline. • The Datore gebeanda ritual site (HD016), located about 2 km north of the pipeline. • The ritual site HD017, located about 4 km north of the pipeline. • The cultural sites at the north boundary of the Tipuripu HGCP Alternative Site, including sites HD225, HD209 and HD211. Mitigation measures for each of the sites will be detailed in the cultural heritage management plan and implemented through the project early works and construction EMPS.	Construction	Operator
M262	Conduct a cultural heritage assessment on limestone hills before quarrying, to determine whether the hills are culturally significant. The assessment will be undertaken in consultation with locals and the PNG National Museum and Art Gallery.	Construction	Operator

CHAPTER 9

LONG-TERM INVESTMENT PLAN AND LONG RUN MARGINAL COST STUDY

CHAPTER 9 LONG-TERM INVESTMENT PLAN AND LONG RUN MARGINAL COST STUDY

9.1 FINANCIAL STATUS OF PPL

9.1.1 Financial Statement

(1) Balance Sheet

The balance sheets for the six-year period from 2009 to 2016 are shown in Table 9.1-1. The table is supplemented with the current ratios and capital-to-asset ratios as calculated by the study team. The balance shrunk in 2014, mostly attributable to resolution of deferred income tax, partly checked by increase in non-current assets and share capital. The current ratios remained inadequately low for the period. As they normally should exceed 100%, it implies that PPL had trouble servicing its debts. The own equity ratios, conversely, were sufficient, having declined slightly but regained in 2014.

Table 9.1-1 PPL's Balance Sheet

	2009 K'000	2010 K'000	2011 K'000	2012 K'000	2013 K'000	2014 K'000
ASSETS						
Non-Current Assets						
Property, plant and equipment	860,403	983,809	1,049,621	1,107,673	1,233,982	1,366,375
Deferred income tax assets	21,483	19,021	115,579	112,760	140,690	(161,004)
	881,886	1,002,830	1,165,200	1,220,433	1,374,672	1,205,371
Current Assets						
Cash and cash equivalents	786	797	1,232	2,439	1,134	10,758
Funds held in trust for rural electrification	27,580	22,535	33,300	62,240	58,338	24,854
Trade and other receivables	74,144	122,794	106,964	139,268	141,564	100,565
Inventories	42,490	37,927	39,590	32,834	39,096	38,471
	145,000	184,053	181,086	236,781	240,131	174,647
TOTAL ASSETS	**1,026,886**	**1,186,883**	**1,346,286**	**1,457,214**	**1,614,803**	**1,380,019**
EQUITY						
Share capital	151,464	151,465	151,464	151,464	151,465	230,666
Property, plant and equipment-revaluation reserve	157,793	157,793	157,793	157,793	157,793	155,087
Retained earnings	258,765	295,396	306,069	356,240	390,322	325,095
TOTAL EQUITY	**568,022**	**604,654**	**615,326**	**665,497**	**699,580**	**710,847**
LIABILITIES						
Non-Current Liabilities						
Employee provisions	37,701	30,077	36,033	31,036	27,115	54,209
External borrowing	176,492	252,712	-	282,835	273,985	241,311
Deferred income tax liability	50,394	50,092	151,999	169,864	221,454	79,811
	264,587	332,881	188,032	483,735	522,554	375,331
Current Liabilities						
Trade and other payables	112,192	121,918	208,192	247,265	301,916	217,739
Bank over draft	11,095	21,555	49,258	16,480	34,363	-
Income tax payable	47,860	59,381	6,386	6,386	5,696	25,117
Employee provisions	4,624	5,874	6,776	9,853	5,968	8,140
Other provisions	1,440	1,440	1,440	3,471	3,471	6,457
External borrowing	17,066	39,180	270,876	24,527	41,255	36,388
	194,277	249,348	542,928	307,982	392,669	293,841
TOTAL LIABILITIES	**458,864**	**582,229**	**730,960**	**791,717**	**915,223**	**669,172**
TOTAL EQUITY AND LIABILITIES	**1,026,886**	**1,186,883**	**1,346,286**	**1,457,214**	**1,614,803**	**1,380,019**
Current Ratio	75%	74%	33%	77%	61%	59%
Capital-to-Asset Ratio	55%	51%	46%	46%	43%	52%

(2) Profit and Loss

The profit and loss for the period 2009 to 2014 from the PPL's financial statements are summarized in Table 9.1-2 The table is supplemented with the Return on Equity indices calculated by the study team.

Income from electricity sales has been steadily increasing. For the period from 2011 to 2013, the annual growth rate for sales remained above 10%. But in 2014 the growth slowed down. However, both operating expenses and finance cost in particular have climbed, likewise the profitability index, while the Return on Equity showed no improvement. Sudden increase in operation cost was seen in 2014, which comes mostly from fuel and operating lease expenses.

Table 9.1-2 PPL's Profit and Loss

	2009 K'000	**2010 K'000**	**2011 K'000**	**2012 K'000**	**2013 K'000**	**2014 K'000**
Operating Income						
Electricity sales	499,688	529,601	622,450	718,584	803,471	817,418
Other operating income	4,573	5,473	5,387	12,687	22,940	17,820
	504,261	**535,074**	**627,837**	**731,271**	**826,411**	**835,238**
Operating Expenses						
Operations and maintenance (Direct expenses)	267,833	340,837	426,209	460,612	528,539	647,504
Overhead expenses (Indirect expenses)	101,915	136,338	106,898	115,873	147,978	138,194
Depreciation	30,248	35,174	49,545	54,589	58,548	59,754
	399,996	**512,349**	**582,652**	**631,074**	**735,065**	**845,452**
Operating Profit/Loss	104,265	22,725	45,185	100,197	91,346	(10,214)
Non-operating income	3,637	3,014	781	2,748	0	0
Net finance cost	(6,379)	(13,878)	(28,610)	(32,087)	(32,919)	(35,072)
Profit before income tax	101,523	11,861	17,356	70,858	58,427	(45,286)
Income Tax	30,052	2,921	4,847	20,684	18,099	18,263
Profit after Income Tax	71,471	8,940	12,509	50,175	40,328	(63,549)
Return on Equity	12.6%	1.5%	2.0%	7.5%	5.8%	(8.9%)

(3) Cash Flow

The cash flow for the same period from the PPL's financial statements is summarized in Table 9.1-3.

Investment activities declined once in 2011 and 2012, but returned to the 2009-2010 level in 2013 at about 20% of income. However, the repayment and interest obligation increased significantly for 2012 and 2013. Without rural electrification funds, the cash balance remained in the red throughout the period.

There was a remarkable movement in investing activities, both in disposal and purchase in 2014. Also in 2014, there was a capital input from the government which kept the net cash flow positive.

The financial statement for 2014 points out that, considering the investment program necessary to sustain the company's operation, "there is a need for significant new funding."

Table 9.1-3 PPL's Cash Flow

	2009 K'000	2010 K'000	2011 K'000	2012 K'000	2013 K'000	2014 K'000
CASH FLOW FROM OPERATING ACTIVITIES						
Receipts from customers	555,532	490,808	685,619	801,967	1,099,568	909,670
Cash paid to suppliers and employees	(400,175)	(429,567)	(586,326)	(661,598)	(939,434)	(653,258)
Net cash generated from operating activities	**155,357**	**61,241**	**99,293**	**140,369**	**160,134**	**256,412**
CASH FLOW FROM INVESTING ACTIVITIES						
Proceeds on disposal of property, plant and equipment	0	0			209	600,977
Purchases of property, plant and equipment	(171,884)	(157,869)	(78,367)	(106,303)	(162,274)	(798,233)
Net cash used in investing activities	**(171,884)**	**(157,869)**	**(78,367)**	**(106,303)**	**(162,065)**	**(197,256)**
CASH FLOW FROM FINANCING ACTIVITIES						
Proceeds from borrowing	53,173	116,608	438	66,919	57,478	14,397
Borrowing repayments	(14,164)	(21,656)	(22,377)	(26,294)	(69,916)	(61,700)
Interest paid	(6,379)	(13,818)	(28,960)	(32,087)	(32,919)	(35,072)
Rural electrification funds received	5,815			20,000	24,203	-
Dividends paid					(5)	-
Increase in Government Equity						79,200
Net cash generated from financing activities	**38,445**	**81,134**	**(50,899)**	**28,538**	**(21,159)**	**(3,175)**
Net Increase/(decrease) in cash, cash equivalents and bank overdraft	**21,918**	**(15,494)**	**(29,973)**	**62,604**	**(23,090)**	**55,981**
Cash, cash equivalents and bank overdraft at the start of the year	(4,647)	17,271	15,247	(14,726)	48,199	(18,950)
CASH AND CASH EQUIVALENTS						
Cash at bank and on hand	475	483	915	1,797	810	1,072
Funds held in trust for rural electrification	27,580	22,535	33,300	62,240	58,338	24,854
Short term, highly liquid deposit	311	314	317	321	324	327
Bank overdraft	(11,095)	(21,555)	(49,258)	(16,480)	(34,363)	10,778
CASH (DEFICIT) / BALANCE	**17,271**	**1,777**	**(14,726)**	**47,878**	**25,109**	**37,031**
Less Restricted cash						
Funds held in trust for rural electrification	(27,580)	(22,535)	(33,300)	(62,240)	(58,338)	(24,854)
NET CASH (DEFICIT)	**(10,309)**	**(20,758)**	**(48,026)**	**(14,362)**	**(33,229)**	**12,177**

9.1.2 Electricity Tariff and Sales of PPL

(1) Electricity Tariff

PPL is an entity licensed under the Electricity Industry Act to generate, transmit, distribute and sell electricity in PNG, which is regulated by the ICCC, under the ICCC Act 2002. The electricity tariff is determined based on the Electricity Regulatory Contract (ERC) concluded between ICCC and PPL under the ICCC Act every five years. The current contract is valid for the period from January 2013 to December 2017.

ERC stipulates matters such as the following:
- Electricity tariff (for customer categories, price caps, regional tariffs, adjustments, etc.)
- Mid-term evaluation report on expenses and demand forecasts,
- Service standards (reliability standards, service provision dates, etc.)
- Procurement process
- Mid-term review (expenditure, demand forecast), etc.

Customers are categorized by types and payment methods, as in the table below:

Table 9.1-4 Customer Categorization

Domestic Customer	Credit	Easipay
General Supply Customer (demand less than 200kVA)	Credit	Easipay
Industrial Customer (demand 200kVA or more)	Credit	
Public Lighting Customers	Credit	
wholesale network customer		

Where "Credit" means payment by installed energy meter and "Easipay" by the prepaid method.

As for tariffs, the following are stipulated in ERC:

1) The tariff system is capped with a value called the “Maximum Weighted Average Price” (MWAP), which is predetermined every year: the MWAP for all customer categories and service delivery areas shall not exceed MWAP,

2) Tariff adjustment to cover fuel price variation is allowed quarterly, subject to the approval of the Regulator (ICCC),

3) Tariff adjustment for commodity price variation in domestic, Australian and USA markets is allowed bi-annually, subject to the approval of the Regulator,

4) Cost variation due to Force Majeure events, changes in the tax system and water access costs can be passed on via the tariffs, subject to the approval of the Regulator,

5) Tariff differences (ratios) between customer categories in any service areas shall be within ±1.5% of the predetermined “Price Relativity Ratios” and no other discriminative pricing to any customers is allowed. For major customers, with loads exceeding 10MW, the prices shall be set separately, but based on the cost of serving individual customers,

6) PPL must be capable of implementing different prices for customers in different service areas, no later than 1 January, 2015. This requirement must be met, even if the capability is not used. Moreover, the Regulator may choose to direct PPL to vary its prices between service areas.

The tariff level for a year is discussed between the Regulator and PPL during the period November-December of the preceding year, in accordance with the rules set out in ERC. However in reality, the PPL tariff system is more inflexible than it seems: after January 2013, when the current ERC was signed, there was only a single fuel price adjustment, implemented in the second quarter of 2013.

The variation in prices between service areas mentioned in 6) above is one of the interesting features in ERC. The costs of providing electricity in the Ramu System and other service areas must differ significantly, since the power is mostly generated by hydro plants in the Ramu System and thermal plants elsewhere. There must be significant cross-subsidy between areas under PPL's national operation. If this regional variation in tariffs is implemented, it would relieve PPL from the financial burden of the cross-subsidy. The shortcoming of this option, namely the potential rise in tariffs for remote areas, could be handled separately, via more direct, explicit subsidy system.

Change in tariffs for customer categories are shown in the table below; the regional variation in tariffs had not been introduced as of September 2015.

Table 9.1-5 Recent Changes of Electricity Tariff

TARIFF CATEGORY	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Domestic Customers (Credit)	49.36	51.83	58.51	66.56	64.69	71.10	81.47	84.75	84.75	84.75
Domestic Customers (Easipay)	41.17	43.23	48.11	54.73	53.19	58.46	66.99	69.68	69.68	69.68
General Supply Customers (Credit)	62.90	63.53	68.14	77.51	75.34	82.81	94.89	98.71	98.71	98.71
General Supply Customers (Easipay)	61.36	61.97	66.45	75.61	73.49	80.77	92.55	96.27	96.27	96.27
Industrial Customers (Credit Meters)	35.64	38.13	43.70	49.71	48.32	53.11	60.86	63.31	63.31	63.31
Public Lighting Customers	62.90	63.53	68.14	77.51	75.34	82.81	94.89	98.71	98.71	98.71

Unit: toea/kWh

In addition to the above, the domestic (Credit) category has a low-priced rate for the first 30kWh every month (toea 49.87 per kWh, for 2013 onward). Domestic and general supply categories are also subject to a minimum monthly charge, while the demand charge (Kina 77.12 per month, for 2013 onward) is payable by industrial customers. Many public lighting customers are charged fixed rates for a year, instead of rate-based charges.

Aside from the usage charges shown in the above table, ERC stipulates fees such as for a new connection, temporary supply connection, reconnection and metering tests, etc. The new connection fee is K 48.0 for 2013 onward.

There is another customer category called "Special Category" for major customers such as mining operations and sugar industries, tariffs for which are set separately as shown in the table below. Tariffs for mining operations in particular are set at about half those of other categories. These low tariffs for major customers are in line with pricing policy described in ERC, which reflects the cost of providing power for customers, but the actual process of determining tariffs for these special customers has not been disclosed or regulated by the ICCC. However, they also have a price adjustment mechanism based on price indices prescribed in the power selling agreements, which resemble those for other customer categories.

Table 9.1-6 Electricity Tariffs of Special Customers

Special Category	2008	2009	2010	2011	2012	2013	2014
Ramu Sugar	35.00	35.00	35.00	35.00	53.00	53.00	53.00
Mining	30.00	30.00	30.00	30.00 40.26	32.00 41.52	32.00 41.52	32.00 41.52

Unit: toea/kWh

(2) Power Sales in the Ramu System

The following figure shows comparisons of power sold by PPL in POM and Ramu Systems and the rest. Ramu System has taken up about 35% of national power sales throughout the period shown. In 2012 and 2013, sales in POM and Ramu Systems soared, which was attributable to the increase in sales for the special category (specifically mining operations).

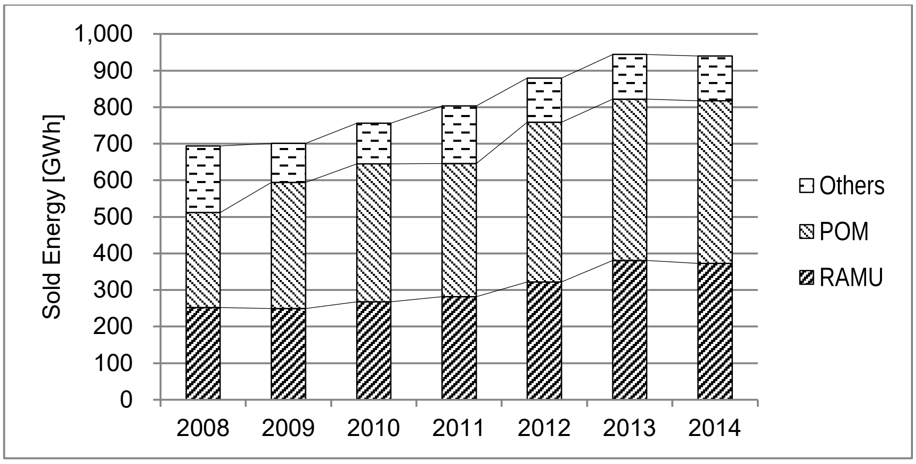


Fig. 9.1-1 Sold Energy of Recent Years

The proportions of sales by customer category in the Ramu System are compared with the same on a national level in the following figure. Ramu System has a larger "special category" of sales than the national level due to customers such as Ramu Sugar. It also shows a higher proportion in the industrial category, reflecting the industrial characteristics of the Lae area.

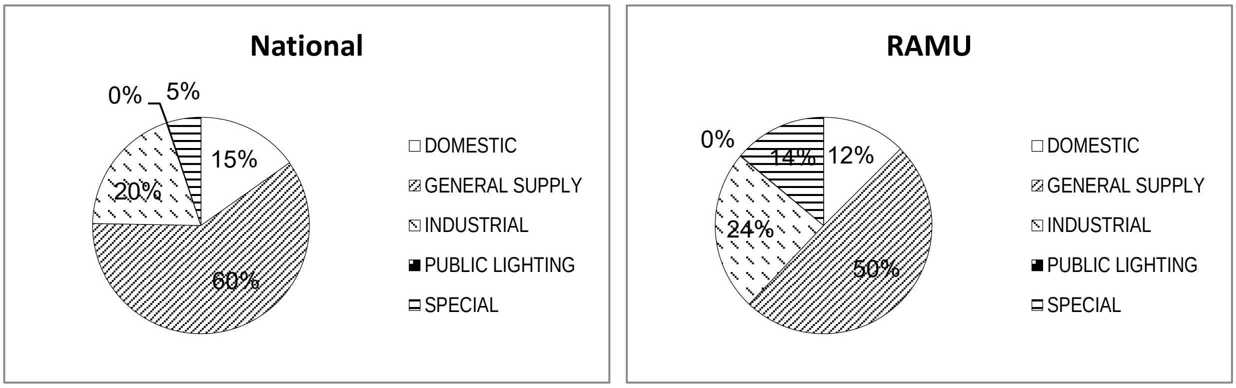


Fig. 9.1-2 Customer Proportion of Electricity Sales in National and Ramu System Levels [2014]

The next figure shows the change in energy sales by customer category in the Ramu System over a seven-year period. In 2012, sales in the industrial category soared and there has also been a marked increase in the special category since 2011.

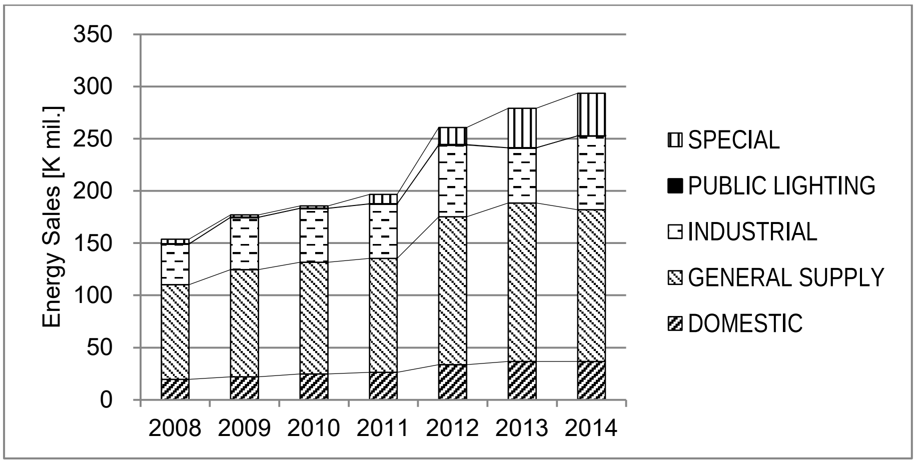
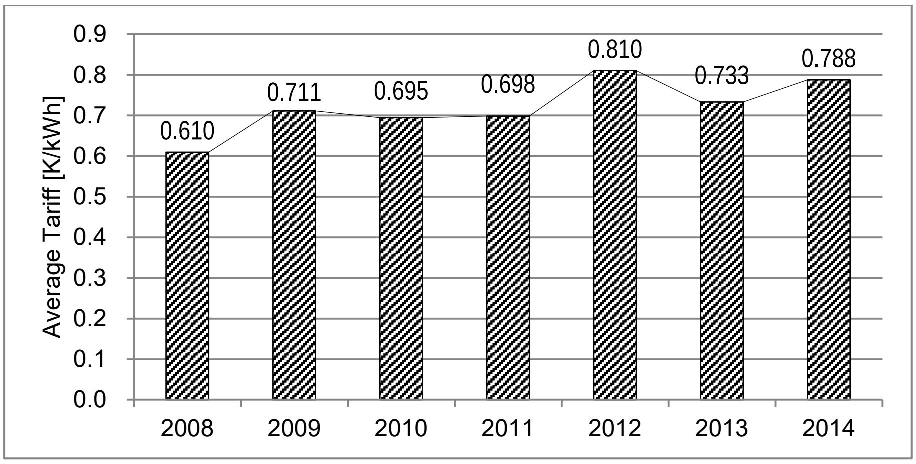


Fig. 9.1-3 Energy Sold in the Ramu System by Customer Category

The effective average tariffs (weighted average tariff) of Ramu System, which were calculated with sales divided by energy sold, are shown in the following figure. In this calculation, sales from demand charges were included in the industrial category. If the demand charge was removed, the average price for 2014 was toea 73.2 per kWh, equivalent to approximately US¢ 30 per kWh. Compared with the average tariff in many Asian countries, namely US¢ 10, the tariff level in PNG can be considered relatively high.



Unit: K/kWh

Fig. 9.1-4 Effective Average Tariff in the Ramu System

After comparing the energy generated and sold, the energy loss in the Ramu System was calculated at 23.6%, which far exceeds the desirable level under international standards. However, considering the vastly dispersed population in the service areas under the Ramu System, the loss ratio may be inherently high.

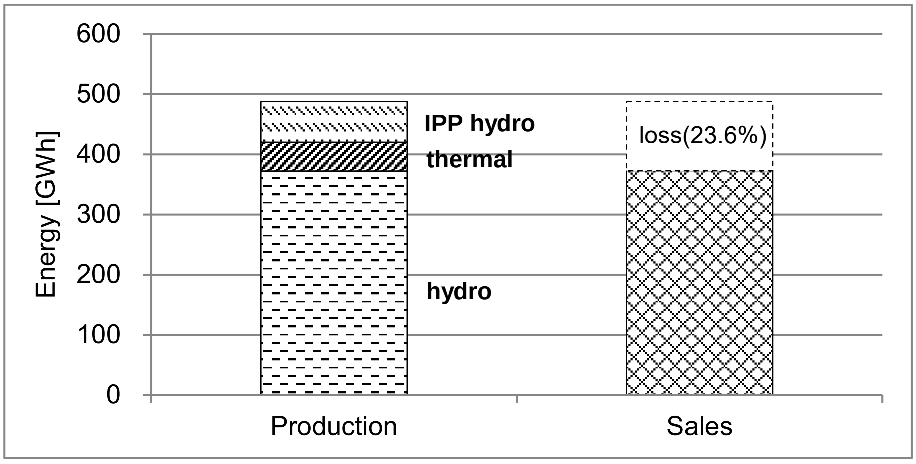


Fig. 9.1-5 Comparison between Generated and Sold Energy in the Ramu System [2014]

9.1.3 Expenditure and Unit Cost

(1) Expenditure

To analyze operational costs in the Ramu System, the JICA Study Team requested detailed records of expenditure in the Ramu Systems, which were provided by PPL by sections (operation units) and expenditure categories.

The sections under Ramu System were grouped into five by function as shown in the table below.

Table 9.1-7 Section Grouped by Function

Function	Section
Generation Hydro	SECTION=523 (GENERATION-PAUNDA POWER STATION)
	SECTION=528 (GENERATION-RAMU POWER STATION)
	SECTION=534 (GENERATION-RAMU1 POWER STATION)
	SECTION=535 (GENERATION-RAMU1 POWER STATION(YTOD))
Generation Diesel	SECTION=521 (GENERATION-TARAKA POWER STATION)
	SECTION=522 (GENERATION-MADANG POWER STATION)
	SECTION=586 (GENERATION - WABAG POWERSTATION (T))
	SECTION=587 (GENERATION - GOROKA POWERSTATION (T))
	SECTION=588 (GENERATION - KUNDIAWA POWERSTATION (T))
	SECTION=589 (GENERATION - MENDI POWERSTATION (T))
	SECTION=590 (GENERATION - TARI POWERSTATION (T))
	SECTION=599 (GENERATION-MILFORD POWER STATION (T))
Transmission	SECTION=512 (TRANSMISSION & DISTRIBUTION-RAMU(North))
Distribution	SECTION=610 (DISTRIBUTION-WABAG)
	SECTION=620 (DISTRIBUTION-LAE)
	SECTION=622 (DISTRIBUTION-WAU/BULOLO)
	SECTION=623 (DISTRIBUTION-MADANG)
	SECTION=624 (DISTRIBUTION-WALIUM)
	SECTION=630 (DISTRIBUTION-YONKI)
	SECTION=631 (DISTRIBUTION-GUSAP)
	SECTION=632 (DISTRIBUTION-GOROKA)
	SECTION=633 (DISTRIBUTION-KUNDIAWA)
	SECTION=634 (DISTRIBUTION-MT.HAGEN)
	SECTION=635 (DISTRIBUTION-KAINANTU)
	SECTION=636 (DISTRIBUTION-MENDI)
	SECTION=637 (DISTRIBUTION-IALIBU)
	SECTION=638 (DISTRIBUTION - TARI)
	SECTION=639 (DISTRIBUTION - MINJ/BANZ)
Customer Services	SECTION=862 (CUSTOMER SERVICES-LAE)
	SECTION=863 (CUSTOMER SERVICES-MT-HAGEN)
	SECTION=864 (CUSTOMER SERVICES-MADANG)
	SECTION=865 (CUSTOMER SERVICES-WALIUM)
	SECTION=866 (CUSTOMER SERVICES-WABAG)
	SECTION=867 (CUSTOMER SERVICES-GOROKA)
	SECTION=868 (CUSTOMER SERVICES-KUNDIAWA)
	SECTION=869 (CUSTOMER SERVICES-KAINANTU)
	SECTION=870 (CUSTOMER SERVICES-YOKNI)
	SECTION=871 (CUSTOMER SERVICES-GUSAP)
	SECTION=872 (CUSTOMER SERVICES-MENDI)
	SECTION=873 (CUSTOMER SERVICES-IALIBU)
	SECTION=874 (CUSTOMER SERVICES-TARI)
	SECTION=875 (CUSTOMER SERVICES-MINZ/BANZ)
	SECTION=882 (CUSTOMER SERVICES-WAU)
Regional Office	SECTION=561 (REGIONAL OFFICE-NEW GUINEA MAINLAND-WABAG)
	SECTION=562 (REGIONAL OFFICE-NEW GUINEA MAINLAND-LAE)
	SECTION=563 (REGIONAL OFFICE-NEW GUINEA MAINLAND-MADANG)
	SECTION=564 (REGIONAL OFFICE-NEW GUINEA MAINLAND-GOROKA)
	SECTION=565 (REGIONAL OFFICE-NEW GUINEA MAINLAND-KUNDIAWA)
	SECTION=566 (REGIONAL OFFICE-NEW GUINEA MAINLAND-MT.HGN-Banz)
	SECTION=567 (REGIONAL OFFICE-NEW GUINEA MAINLAND-MT.KAINANTU)
	SECTION=568 (REGIONAL OFFICE-NEW GUINEA MAINLAND-YONKI)
	SECTION=569 (REGIONAL OFFICE-NEW GUINEA MAINLAND-MENDI-Ialibu)
	SECTION=570 (REGIONAL OFFICE-NEW GUINEA MAINLAND-IALIBU)
	SECTION=571 (REGIONAL OFFICE-NEW GUINEA MAINLAND-MINJ)
	SECTION=577 (REGIONAL OFFICE-NEW GUINEA MAINLAND-WAU)
	SECTION=578 (REGIONAL OFFICE-NEW GUINEA MAINLAND-GUSAP)
	SECTION=579 (REGIONAL OFFICE-NEW GUINEA MAINLAND-TARI)

The expenditure was recorded for each section under various categories since 2014. The following table shows the general categories used in the records:

Table 9.1-8 General Expense Categories in the Records

OPERATING EXPENSES	General Expenses
	Direct Personnel Expenses
	Other Personnel Expenses
	Stores Issues
	Fuel Costs
	Direct Purchases Consumables
	Depreciation Expenses
NON-OPERATING EXPENSES	Non-Operating Expenses

The total expenses in the Ramu System for 2014 were calculated at K 112,087,931. The expenditure was recalculated and summed up for each function shown in Table 9.1-7. The results are shown in the following figure:

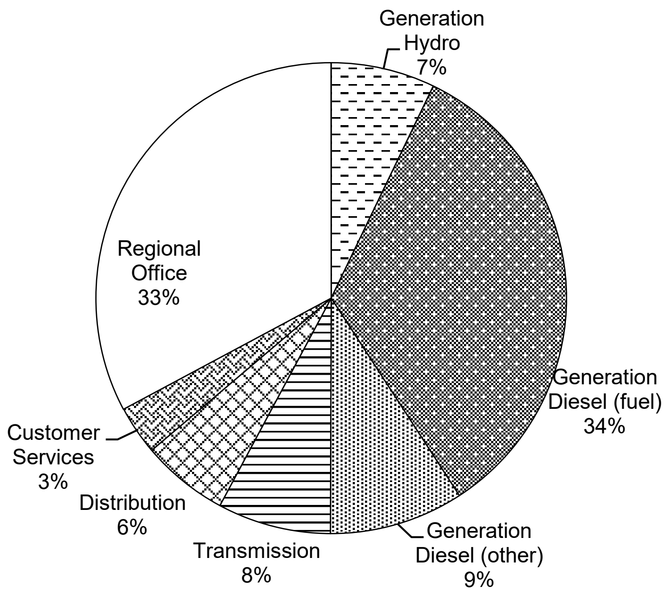


Fig. 9.1-6 Proportion of Expenditure by Function in the Ramu System [2014]

Further analyses were made of expenditure records to define the unit rates of functions to be used in the Long-run Marginal Cost (LRMC) analysis

(2) Analyses of Unit Cost

Generation - Hydro

The expenditure records of sections falling under the "Generation Hydro" function in Table 9.1-7 were analyzed and unit costs to operate and maintain hydro power stations in the Ramu System were estimated. Although hydropower stations generally have no significant variable cost categories, they operate diesel gen-sets with energy used internally as they start and stop generation. Accordingly, the fuel and lubricant costs incurred were used to define the variable cost of hydropower stations. Other expenditure was divided by the total capacity (derated) of hydropower stations in the Ramu System. Analyses revealed the following unit costs for operating and maintaining hydropower in the Ramu System:

Generation Hydro Variable Cost	K 0.0039 per kWh
Generation Hydro Fixed Cost	K 98.1 per kW·year

<u>Generation – Thermal (diesel)</u>

The variable and fixed unit cost of operation and maintenance of thermal (diesel) generation in the Ramu System were estimated. The expenditure categories used in the variable cost were fuel and lubricant and others for fixed cost. No distinction was made among different power stations in the Ramu System.

Generation thermal (diesel) Variable Cost	K0.7968 per kWh
Generation thermal (diesel) Fixed Cost	K260.7 per kW·year

For the variable cost, an alternative estimation was conducted to ensure accurate estimation: the fuel cost was calculated as the fuel consumption multiplied by the fuel prices at each power station; the data obtained from different sources. Consequently, the fuel cost of generation was estimated at K 0.7894 per kWh. Adding the lubricant cost of 5% meant the alternative variable cost was obtained as K 0.7933 per kWh, which was very close to the original estimation. Taking the mean of two estimations, the variable cost of diesel generation was reevaluated as shown below:

Generation thermal (diesel) Variable Cost	K 0.795 per kWh

The variable cost of diesel generation is strongly affected by crude oil prices in the international market. The estimation above refers to the 12-month period of 2014, during which a significant decline in crude oil prices was observed in the third quarter and PPL's fuel procurement prices also fell. A comparative study was conducted to evaluate the effect of international oil prices on PPL's fuel procurement prices.

As an index for the international crude oil price, the Europe Brent Spot Price FOB was used, which was compared with PPL's procurement prices at centers in the Ramu System areas (Lae, Taraka, Madang, etc.). The latter were converted to US dollars per liter unit, using monthly exchange rate records published by the Bank of PNG.

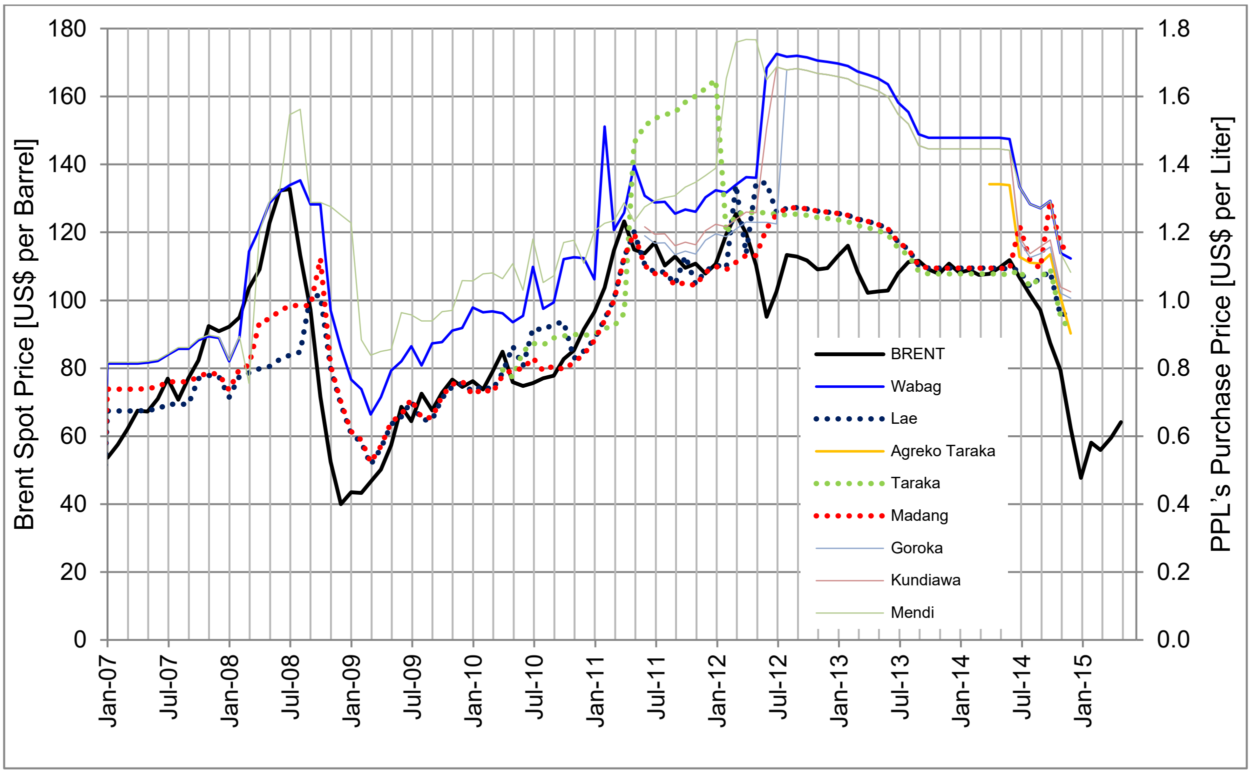
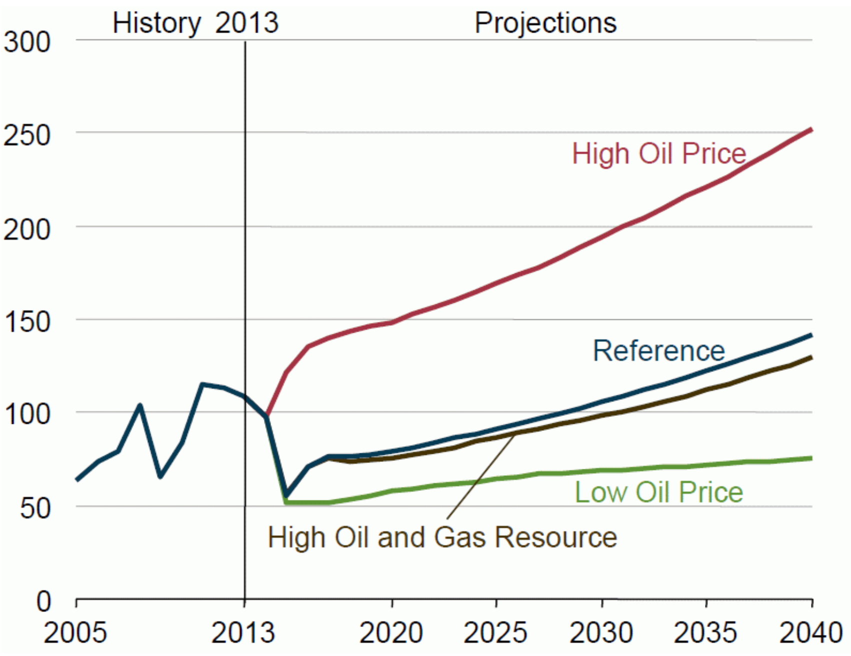


Fig. 9.1-7 Comparison of Crude Oil Price and PPL's Procurement Prices in the Ramu System

The variation in PPL's procurement prices almost precisely follows that of Brent prices. Although it is difficult to forecast future prices; LRMC analysis requires the assumption of future oil prices and resulting generation costs in future.

The following figure is a projection of crude oil prices for the period up to 2040 by US EIA (The Annual Energy Outlook 2015 published in April 2015). The reference value in the figure is drawn upward from US$ 50 per barrel in 2015 to US$ 75 level in a few years, followed by a slow increase to US$ 100 per barrel level in 2030. The estimation of the variable costs discussed above were based on actual expenditure records in 2014, where the average European Brent price was US$ 99 per barrel. Therefore, the EIA's projection draws the future price of crude oil in an increase from the current level of US$ 50 per barrel back to the 2014 level in 2030.



Source: U.S. Energy Information Administration

Fig. 9.1-8 Projection of Oil Price until 2040 by USEIA

In the planning, crude oil price was assumed to rise from US$ 50 per barrel in 2016 at an annual increase rate 5% which results in 2030 price to be US$ 99 per barrel.

This assumption affects the unit price used in the planning. Unit diesel variable cost estimated using 2014 actual cost was K 0.795 per kWh, as mentioned in the previous page. In 2014, average crude oil price was US$ 99 per barrel. Therefore, the estimated 2016 variable cost for diesel was calculated at K 0.4015 per kWh, to be increased at a rate of 5% p.a.

<u>Generation – Thermal (gas turbine)</u>

Before the estimation of unit generation cost at gas turbine power plant, the price of natural gas had to be assumed. Using a preceding case in PNG, a gas price applicable in Ramu System could be calculated at 11.75% of JaCC. Then we had to assume future JaCC. Monthly JaCC was compared with Europe Brent Spot Price FOB for six years, from March 2009 to March 2015, which is shown in the figure below. In the figure, it is evident that the two variables were correlated, and their relationship is expressed in a regression curve;

JaCC = Brent Spot Price x 1.015

Future crude oil price assumed as above, together with this formulae, we now could assume future JaCC price and future natural gas price, as well.

For 2016 when the assumed crude oil price is US$ 50 per barrel, the natural gas price is calculated at US$ 5.96 per MMBTU. Using this price and the energy efficiency of gas turbine plant assumed at 30% and own consumption rate 3%, the variable cost for natural gas-fired gas turbine is estimated at:

Generation thermal (gas turbine) Variable Cost K 0.352 per kWh

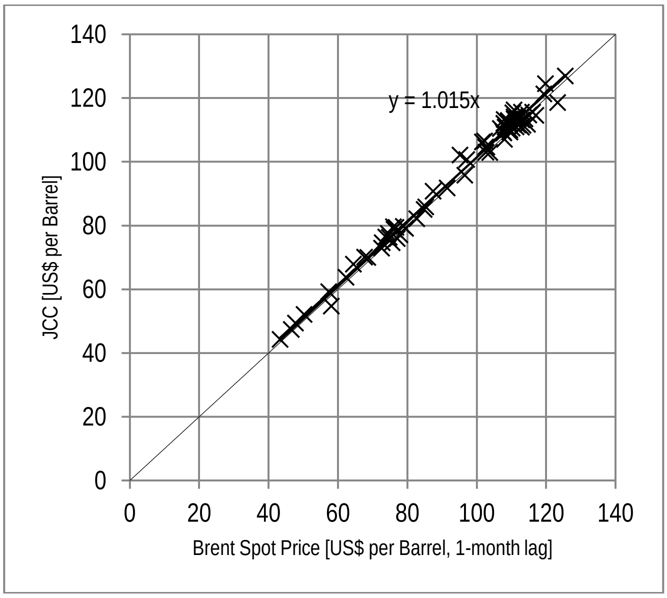


Fig. 9.1-9 Comparison of Brent Oil Price and JaCC

The fixed cost of operation and maintenance of gas turbine was assumed at 6% of investment cost per year, K150 per kW·yr, regardless of the type of fuel used.

<u>Generation – Biomass</u>

Variable and fixed cost for biomass generation was estimated at;

Generation Biomass Variable Cost	K 0.265 per kWh
Generation Biomass Fixed Cost	K 696.4 per kW·year

<u>Transmission</u>

The operation and maintenance costs for T/Ls were estimated for the fixed cost alone: all the expenditure recorded under the transmission function in Table 9.1-7 was assumed related to the operation and maintenance of T/Ls in the Ramu System, the total of which was divided by the total length of the T/Ls. As there are two different voltage classes in the Ramu System transmission, no distinction was made among these classes and their total transmission length was used to obtain the following unit cost:

Transmission Fixed Cost	K 11,443 per km

<u>Substation</u>

The unit cost of operating and maintaining substations was determined for the fixed part only, as for the case for transmission, based on all expenses under the distribution function in Table 9.1-7 divided by the total of distribution transformers in the system, which was 474 MVA. The estimated value was:

Substation Fixed Cost	K 14,120per MVA

<u>Other costs</u>

As shown in Fig. 9.1-610, about a third of expenditure in the Ramu System operation went on clerical works in customer services and regional offices, the costs of which will not increase at the same rate as electricity sales. If the future increase in these sales is small, these costs may remain the same. However, for the planning period up to 2030, electricity demand is projected to double, even if excluding incidental growth in sales due to special categories, e.g. for mining operations. It would be desirable if the clerical costs were to remain unchanged, but some increase may be unavoidable with the quantity of service doubling in the fifteen year period, as shown in the following figure:

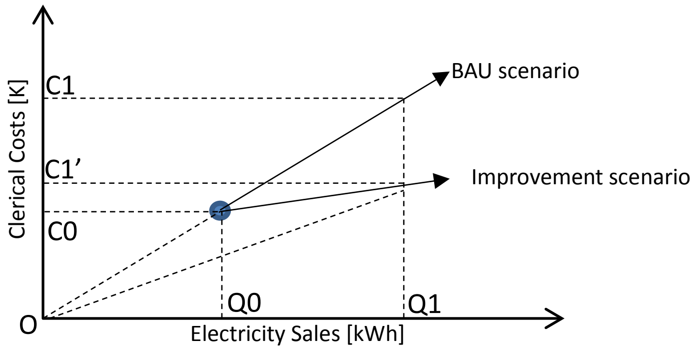


Fig. 9.1-10 Concept of Diminishing Clerical Costs

The present sales and clerical costs are at point (Q0, C0), the unit cost of which is defined by OC_0/OQ_0 K/kWh. If the clerical cost increased at the same rate as sales along the Business As Usual (BAU) scenario in the figure, the unit cost would remain the same, for OC_1/OQ_1 K/kWh is the same as OC_0/OQ_0 K/kWh. If the clerical cost increased at a lower rate than sales along the improvement scenario in the figure, the unit cost would become OC_1'/OQ_1 K/kWh, which is smaller than the original OC_0/OQ_0 K/kWh and the difference would rise further with increasing sales.

Using 2014 records, the unit operation costs for customer services and regional offices were as follows:

Unit cost of customer services	K 0.0102 per kWh
Unit cost of regional offices	K 0.0987 per kWh

In the analysis of LRMC, it would be unrealistic to completely ignore increases in these clerical costs at all. However, using the same unit costs on an unchanged basis may lead to inefficient planning. For the purpose of planning here, it was assumed that for a unit increase of demand (per kWh) from 2014 level demand, 50% of the clerical cost mentioned above would apply, that is K 0.05445 per kWh.

9.1.4 Assumed Investment Cost

Investment costs for power development were assumed. The current policy sets out that investment to develop power plants will be made by private entities in forms such as IPP. In this study, however, the investments required and their costs are evaluated from a wide power sector perspective and no distinction is made between PPL's own investment and that of third parties.

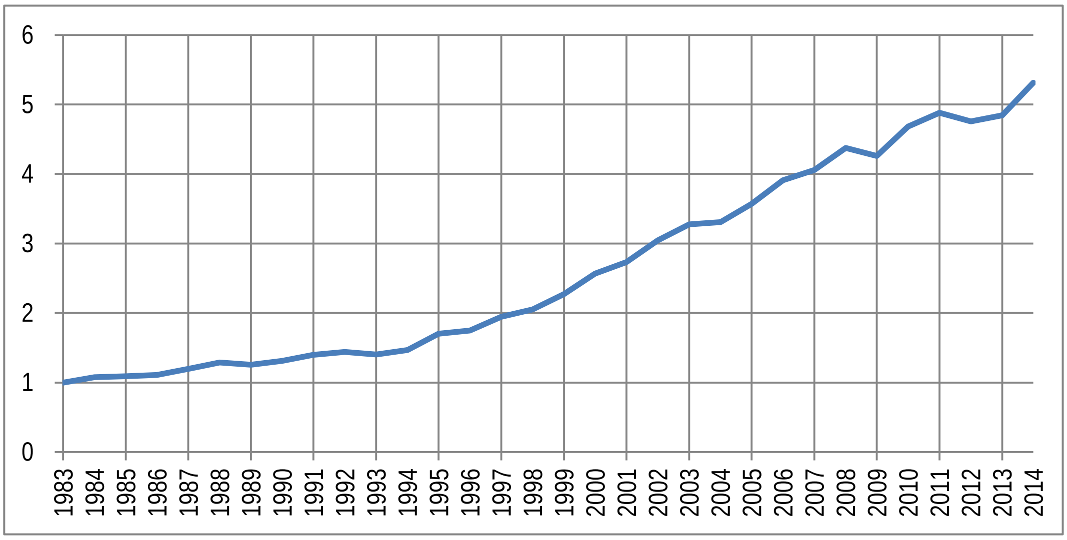
(1) Hydropower

As discussed previously, five hydro candidates were taken up in this study, namely, Baime, Ramu2, Kaugel, Mongi-Bulum and Gowar. The investment costs for these hydro projects were assumed based on cost estimations conducted in the previous studies. All the values were converted to 2014 values using GDP deflators.

Table 9.1-9 Assumed Hydro Projects and Their Investment Costs

Name	Capacity MW	Annual Energy GWh	Capacity Factor	Construction cost [K million]	Time of estimate	cost as of 2014 [K mil]	unit cost used in planning K per kW
Baime	10	70.1	80.0%	22.5	2014?	22.5	2,250
Ramu2	180	1,340.0	85.0%	1,031.0	2006	1,371.2	7,618
Kaugel	84	345.6	47.0%	81.9	1979	409.7	4,877
Mongi-Bulum	116	875.9	86.2%	2,496.3	2014	2,496.3	21,519
Gowar	54	298.0	63.0%	45.0	1980	225.0	4,167

For Kaugel and Gowar, the previous FSs were performed in and around 1980 and the GDP deflators applied were as large as 500%. For Ramu2, the FS study conducted in 2006 assumes a project generation capacity of 240 MW, which may lead to a significant margin of error in the estimation.



Source: ADB Key Indicators

Fig. 9.1-11 GDP Deflator

(2) Thermal (Diesel)

For thermal (diesel) power plant candidate in the planning, there is only one project identified, that is Munum.

The unit investment cost was assumed to be K2,750 per kW of capacity.

(3) Thermal (Gas Turbine)

For thermal (gas turbine) power plants in the planning, the locations were not specified.

The unit investment cost was assumed at K2,500 per kW of capacity.

(4) Renewable Energy

Among available renewable energy sources in Ramu System, only biomass with plantation was considered in the power development plan.

The investment cost of biomass plant was assumed at K10,000 per kW, equivalent to US$4,000 per kW.

9.2 LONG TERM INVESTMENT PLAN

9.2.1 Framework of Analysis

Current power sector policy of PNG prescribes that an investment in power plant development should be left to initiative of private entities. Also, a discussion on a privatization and vertical disintegration of power supply services is under way. However, this study takes a perspective of an integrated power supply industry, without distinction of PPL as a retailer and other private companies as IPPs. This is partly because the power supply industry perspective can eliminate a complication (or exclusiveness) of PPA setting and its implication on power development plan. Also, it is because the power development plan is not a subject of PPL alone, whether it would remain a sole power supply company or be privatized to become a power retailer, but a concern of PNG economy and population in general.

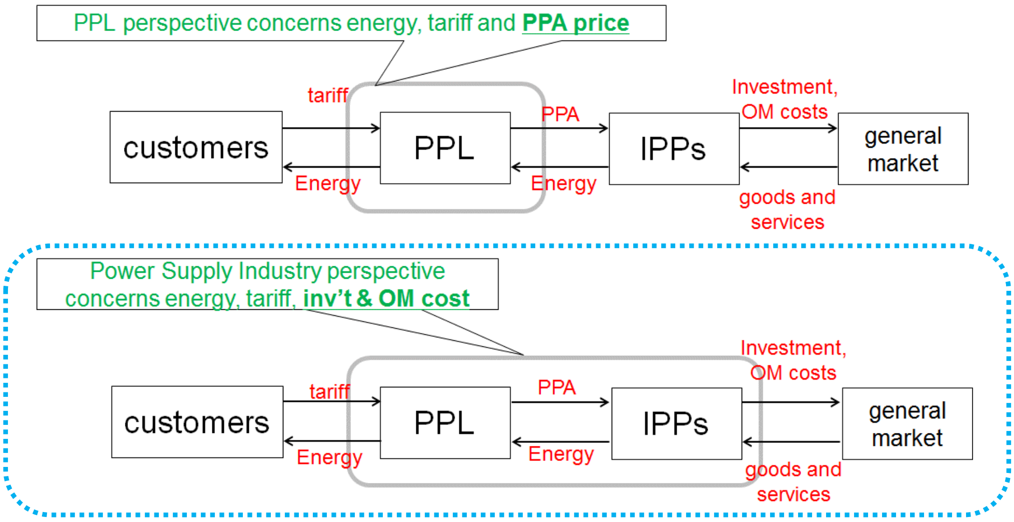


Fig. 9.2-1 Framework of Analysis

Taking this position, this section "9.2 Long Term Investment Plan" and the next "9.3 ANALYSIS OF LONG-RUN MARGINAL COST" deal the power generation and transmission/distribution altogether. However, wherever possible, the costs for these two major functions are shown separately, providing insight to implication of privatization/disintegration of power supply industry.

9.2.2 Long Term Investment Plan

On the basis of Power Generation Development Plan and Power System Development Plan discussed in Chapter 6 and 7, respectively, a long term investment plan for each scenario, namely, Base Case, High Demand and Alternative Scenario, was developed.

For each case, Power Generation Development Plan expressed in capacity [MW] was tabulated, where the capacity of each power plant is shown in actual, or "derated" in other word, figure. A chart of resulting Long Term Investment Plan follows each table, where the investment fund requirement, or capital expenditure schedule, for each year for both power stations and T/Ls is presented.

Capital expenditure schedule for a hydro project was distributed over a construction period. Typically, for Ramu2 hydro project, the distribution was assumed as in the figure below.

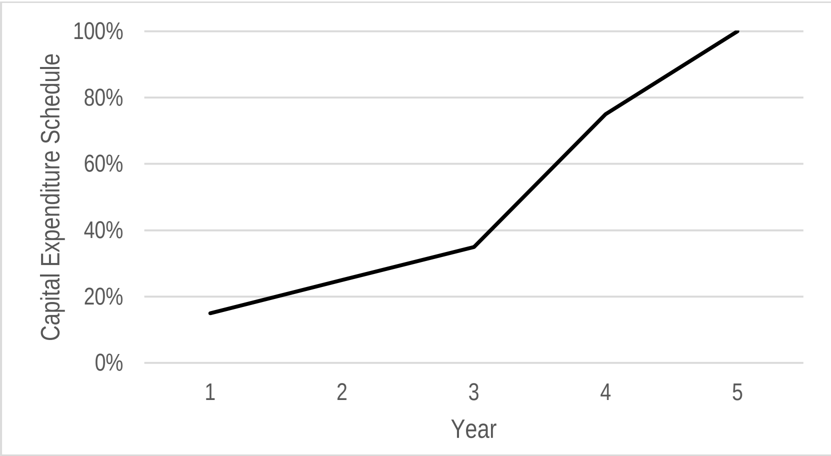
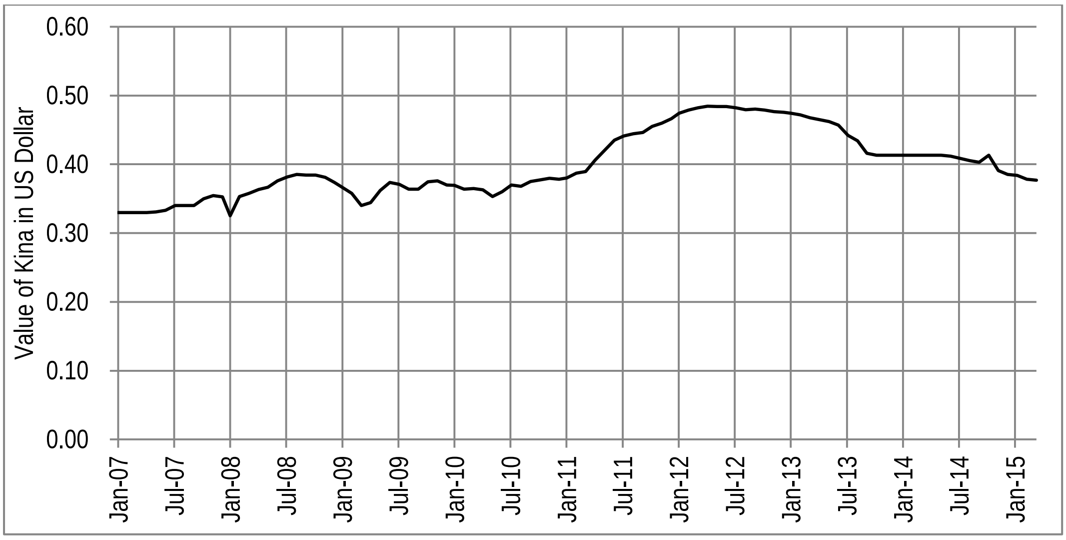


Fig. 9.2-2 Capital Expenditure Schedule for Ramu 2 Hydro Project

All the numbers shown here were converted from PNG Kina values in the previous section to US Dollar, at an exchange rate;

Kina 1.0 = US$ 0.40

The records of exchange rate of Kina against US Dollar for the last eight years are shown in the figure below.



Source: Bank of Papua New Guinea

Fig. 9.2-3 Exchange Rate

Table 9.2-1 Power Generation Development Plan for Base Case Scenario [MW]

	existing capacity	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EXISTING POWER PLANT																
Hydro																
Ramu1	45.0	5				25										
Pauanda	1.0	5			4											
YTOD	6.0			12												
Baiune	8.0															
Diesel																
Milford	15.9					-14.5										
Taraka	7.0															
Taraka Aggreko	9.6										-9.6					
Madang	11.6					-4										
Mendi	1.0															
Wabag	2.1										-1					
Goroka	2.7															
Kundiawa	1.2															
Lae GT	26.0															
POWER PLANT TO BE CONSTRUCTED																
Hydro																
Baime				8												
Ramu2							120	60								
Kaugel											56					
Mongi/Bulum													60			
Gowar																
Diesel																
Munum			30													
Natural Gas																
Highland GT						20				20			20			
Natural Gas GT																
Biomass																
Markham Valley					15											
Capacity additional		10	30	20	19	26.5	120	60	0	20	45.4	0	80	0	0	0
Hydro		10	0	20	4	25	120	60	0	0	56	0	60	0	0	0
diesel		0	30	0	0	-18.5	0	0	0	0	-10.6	0	0	0	0	0
Natural gas		0	0	0	0	20	0	0	0	20	0	0	20	0	0	0
Biomass		0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
Capacity Total	137	147	177	197	216	243	363	423	423	443	488	488	568	568	568	568
Hydro	60	70	70	90	94	119	239	299	299	299	355	355	415	415	415	415
Diesel	77	77	107	107	107	89	89	89	89	89	78	78	78	78	78	78
Natural gas	0	0	0	0	0	20	20	20	20	40	40	40	60	60	60	60
biomass	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15

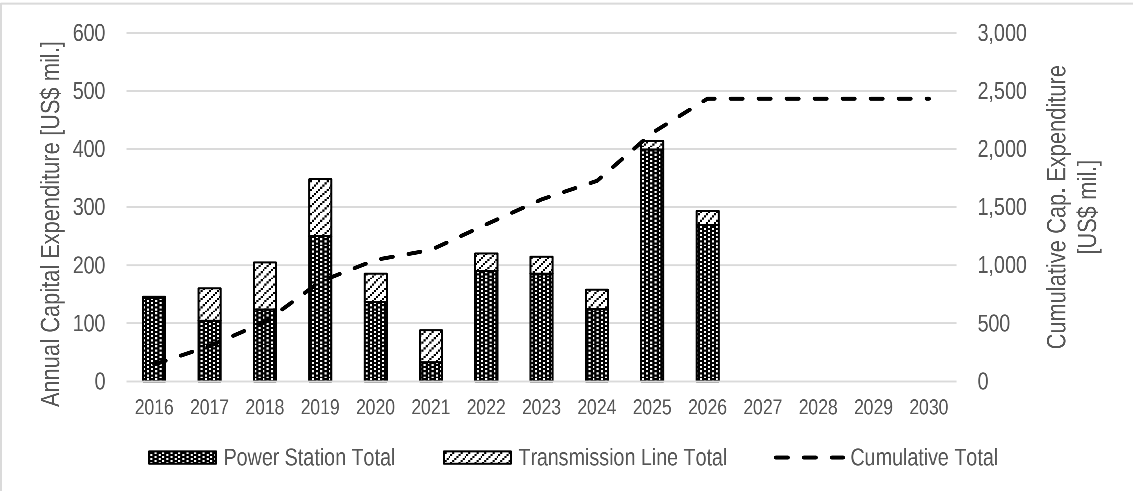


Fig. 9.2-4 Long Term Investment Plan for Base Case Scenario

Table 9.2-2 Power Generation Development Plan for High Demand Scenario [MW]

	existing capacity	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EXISTING POWER PLANT																
Hydro																
Ramu1	45.0	5				25										
Pauanda	1.0	5			4											
YTOD	6.0			12												
Baiune	8.0															
Diesel																
Milford	15.9					-14.5										
Taraka	7.0															
Taraka Aggreko	9.6										-9.6					
Madang	11.6					-4										
Mendi	1.0															
Wabag	2.1										-1					
Goroka	2.7															
Kundiawa	1.2															
Lae GT	26.0															
POWER PLANT TO BE CONSTRUCTED																
Hydro																
Baime				8												
Ramu2							180									
Kaugel											56					
Mongi/Bulum											60					
Gowar											44					
Diesel																
Munum			30													
Natural Gas																
Highland GT						20				20			20			
Natural Gas GT						90					60			30		30
Biomass																
Markham Valley			15			15										
Capacity additional		10	45	20	4	131.5	180	0	0	20	209.4	0	20	30	0	30
Hydro		10	0	20	4	25	180	0	0	0	160	0	0	0	0	0
diesel		0	30	0	0	-18.5	0	0	0	0	-10.6	0	0	0	0	0
Natural gas		0	0	0	0	110	0	0	0	20	60	0	20	30	0	30
Biomass		0	15	0	0	15	0	0	0	0	0	0	0	0	0	0
Capacity Total	137	147	192	212	216	348	528	528	528	548	757	757	777	807	807	837
Hydro	60	70	70	90	94	119	299	299	299	299	459	459	459	459	459	459
Diesel	77	77	107	107	107	89	89	89	89	89	78	78	78	78	78	78
Natural gas	0	0	0	0	0	110	110	110	110	130	190	190	210	240	240	270
biomass	0	0	15	15	15	30	30	30	30	30	30	30	30	30	30	30

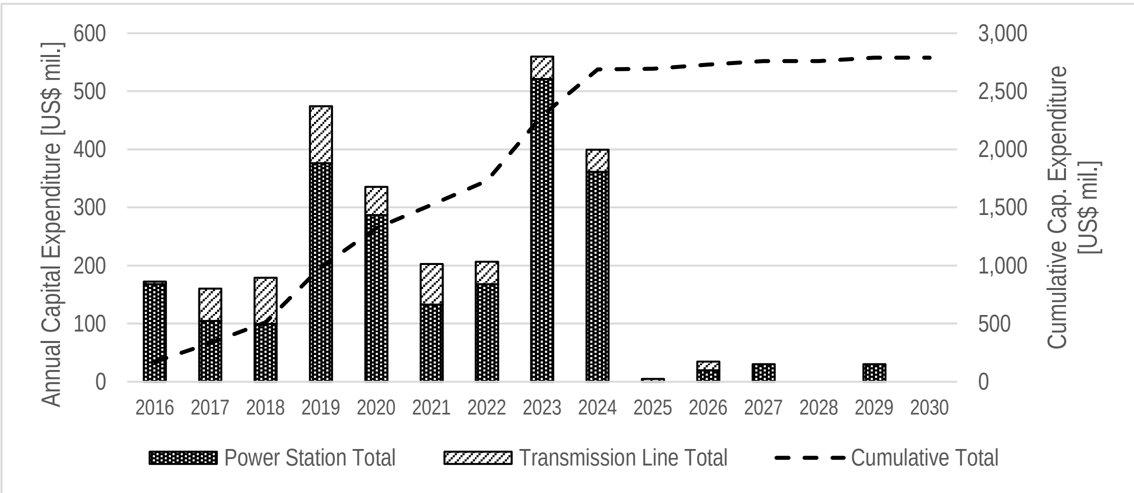


Fig. 9.2-5 Long Term Investment Plan for High Demand Scenario

Table 9.2-3 Power Generation Development Plan for Alternative Scenario [MW]

	existing capacity	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EXISTING POWER PLANT																
Hydro																
Ramu1	45.0	5				25										
Pauanda	1.0	5			4											
YTOD	6.0			12												
Baiune	8.0															
Diesel																
Milford	15.9					-14.5										
Taraka	7.0															
Taraka Aggreko	9.6										-9.6					
Madang	11.6					-4										
Mendi	1.0															
Wabag	2.1										-1					
Goroka	2.7															
Kundiawa	1.2															
Lae GT	26.0															
POWER PLANT TO BE CONSTRUCTED																
Hydro																
Baime				8												
Ramu2							180									
Kaugel											56					
Mongi/Bulum																
Gowar											44					
Diesel																
Munum			30													
Natural Gas																
Highland GT						20				20			20			
Natural Gas GT						90					105	15		15	30	15
Biomass																
Markham Valley			15			15										
Capacity additional		10	45	20	4	131.5	180	0	0	20	194.4	15	20	15	30	15
Hydro		10	0	20	4	25	180	0	0	0	100	0	0	0	0	0
diesel		0	30	0	0	-18.5	0	0	0	0	-10.6	0	0	0	0	0
Natural gas		0	0	0	0	110	0	0	0	20	105	15	20	15	30	15
Biomass		0	15	0	0	15	0	0	0	0	0	0	0	0	0	0
Capacity Total	137	147	192	212	216	348	528	528	528	548	742	757	777	792	822	837
Hydro	60	70	70	90	94	119	299	299	299	299	399	399	399	399	399	399
Diesel	77	77	107	107	107	89	89	89	89	89	78	78	78	78	78	78
Natural gas	0	0	0	0	0	110	110	110	110	130	235	250	270	285	315	330
biomass	0	0	15	15	15	30	30	30	30	30	30	30	30	30	30	30

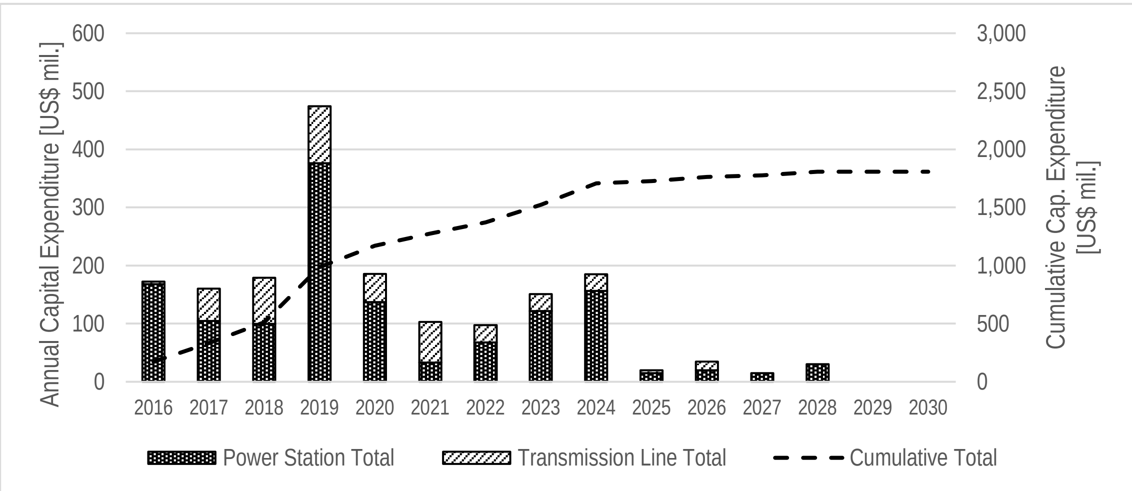


Fig. 9.2-6 Long Term Investment Plan for Alternative Scenario

Table 9.2-4 Long Term Investment Plan for Base Case Scenario

	Project Name		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1. Power Stations																	
1.1 hydro																	
	Ramu1 Rehab.	plus 30MW	0	16	27	11	0	0	0	0	0	0	0	0	0	0	0
	Pauanda Rehab	plus 9MW	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0
	YTOD Rehab.	plus 32MW	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0
	Baime	10MW	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ramu2	180MW	82	55	55	219	137	0	0	0	0	0	0	0	0	0	0
	Kaugel	84MW	0	0	0	0	0	33	41	66	25	0	0	0	0	0	0
	Mongi/Bulum	116MW	0	0	0	0	0	0	150	100	100	399	250	0	0	0	0
	Gower	54MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2 Diesel																	
	Munum	30MW	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3 Natural Gas																	
	Highland GT	20MW x 3	0	0	0	20	0	0	0	20	0	0	20	0	0	0	0
	Natural Gas GT	15MW x 0															
1.4 Biomass																	
	Markham Valley Biomass 1st	15MW x 1	12	12	36	0	0	0	0	0	0	0	0	0	0	0	0
Total Power Generation Development Cost			144	105	124	250	137	33	191	185	124	399	270	0	0	0	0
2. Power System																	
	Lae area transmission system reinforcement		0	0	0	10	10	10	0	0	3	3	3	0	0	0	0
	Madang area transmission system reinforcement		0	0	0	9	9	9	0	0	2	2	2	0	0	0	0
	Transmission system reinforcement as Ramu2 development		0	6	31	31	25	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Mongi development		0	0	0	0	0	0	0	0	9	9	9	0	0	0	0
	Transmission system reinforcement as Gowar development																
	Transmission system reinforcement as Highland area development		0	48	48	48	0	10	30	30	20	0	0	0	0	0	0
	Transmission system reinforcement as Munum development		2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Markham development		0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Baime development		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Substation reinforcement in Highland area		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Reactive power compensation facility		0	0	0	0	0	25	0	0	0	0	10	0	0	0	0
Total Power System Development Cost			2	56	81	98	48	55	30	30	34	14	24	0	0	0	0
GRAND TOTAL			146	160	205	348	186	88	220	215	158	414	294	0	0	0	0

Unit: million US Dollar

Table 9.2-5 Long Term Investment Plan for High Demand Scenario

	Project Name		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1. PowerStations																	
1.1 hydro																	
	Ramu1 Rehab.	plus 30MW	0	16	27	11	0	0	0	0	0	0	0	0	0	0	0
	Pauanda Rehab	plus 9MW	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0
	YTOD Rehab.	plus 32MW	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0
	Baime	10MW	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ramu2	180MW	82	55	55	219	137	0	0	0	0	0	0	0	0	0	0
	Kaugel	84MW	0	0	0	0	0	33	41	66	25	0	0	0	0	0	0
	Mongi/Bulum	116MW	0	0	0	0	150	100	100	399	250	0	0	0	0	0	0
	Gower	54MW	0	0	0	0	0	0	27	36	27	0	0	0	0	0	0
1.2 Diesel		30MW															
	Munum	30MW	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3 NaturalGas																	
	Highland GT	20MW x 3	0	0	0	20	0	0	0	20	0	0	20	0	0	0	0
	Natural Gas GT	15MW x 14	0	0	0	90	0	0	0	0	60	0	0	30	0	30	0
1.4 Biomass																	
	Markham Valley Biomass 1st and 2nd	15MW x 2	36	12	12	36	0	0	0	0	0	0	0	0	0	0	0
Total Power Generation Development Cost			168	105	100	376	287	133	168	521	361	0	20	30	0	30	0
2. Power System																	
	Lae area transmission system reinforcement		0	0	0	10	10	10	0	0	3	3	3	0	0	0	0
	Madang area transmission system reinforcement		0	0	0	9	9	9	0	0	2	2	2	0	0	0	0
	Transmission system reinforcement as Ramu2 development		0	6	31	31	25	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Mongi development		0	0	0	0	0	0	9	9	9	0	0	0	0	0	0
	Transmission system reinforcement as Gowar development		0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
	Transmission system reinforcement as Highland area development		0	48	48	48	0	10	30	30	20	0	0	0	0	0	0
	Transmission system reinforcement as Munum development		2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Markham development		2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Baime development		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Substation reinforcement in Highland area		0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	Reactive power compensation facility		0	0	0	0	0	40	0	0	0	0	10	0	0	0	0
Total Power System Development Cost			4	56	79	98	48	70	39	39	38	5	15	0	0	0	0
GRAND TOTAL			172	160	179	474	335	203	207	560	399	5	35	30	0	30	0

Unit: million US Dollar

Table 9.2-6 Long Term Investment Plan for Alternative Scenario

	Project Name		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1. PowerStations																	
1.1 hydro																	
	Ramu1 Rehab.	plus 30MW	0	16	27	11	0	0	0	0	0	0	0	0	0	0	0
	Pauanda Rehab	plus 9MW	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0
	YTOD Rehab.	plus 32MW	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0
	Baime	10MW	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ramu2	180MW	82	55	55	219	137	0	0	0	0	0	0	0	0	0	0
	Kaugel	84MW	0	0	0	0	0	33	41	66	25	0	0	0	0	0	0
	Mongi/Bulum	116MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gower	54MW	0	0	0	0	0	0	27	36	27	0	0	0	0	0	0
1.2 Diesel																	
	Munum	30MW	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3 NaturalGas																	
	Highland GT	20MW x 3	0	0	0	20	0	0	0	20	0	0	20	0	0	0	0
	Natural Gas GT	15MW x 17	0	0	0	90	0	0	0	0	105	15	0	15	30	0	0
1.4 Biomass																	
	Markham Valley Biomass 1st and 2nd	15MW x 2	36	12	12	36	0	0	0	0	0	0	0	0	0	0	0
Total Power Generation Development Cost			168	105	100	376	137	33	68	122	157	15	20	15	30	0	0
2. Power System																	
	Lae area transmission system reinforcement		0	0	0	10	10	10	0	0	3	3	3	0	0	0	0
	Madang area transmission system reinforcement		0	0	0	9	9	9	0	0	2	2	2	0	0	0	0
	Transmission system reinforcement as Ramu2 development		0	6	31	31	25	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Mongi development		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Gowar development		0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
	Transmission system reinforcement as Highland area development		0	48	48	48	0	10	30	30	20	0	0	0	0	0	0
	Transmission system reinforcement as Munum development		2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Markham development		2	0	0	0	2	0	0	0	0	0	0	0	0	0	0
	Transmission system reinforcement as Baime development		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Substation reinforcement in Highland area		0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	Reactive power compensation facility		0	0	0	0	0	40	0	0	0	0	10	0	0	0	0
Total Power System Development Cost			4	56	79	98	48	70	30	30	29	5	15	0	0	0	0
TOTAL			172	160	179	474	186	103	98	151	185	20	35	15	30	0	0

Unit: million US Dollar

9.3 ANALYSIS OF LONG-RUN MARGINAL COST

9.3.1 Various Pricing Methods

There are several principles for setting price of supplying public services;

(i) recovery of full-cost of supply, that is, taking average-cost,
(ii) emphasis on economic efficiency, that is, taking long-run marginal cost (LRMC,)
(iii) generating extra fund for ongoing and/or future investments,
(iv) achievement of income redistribution for social equity, etc.

We cannot simply say which principle is good or best. The choice is a policy decision, depending on the conditions of societies and economies to which the service is provided and the intention of decision maker on how to serve them.

Here, the use of LRMC may require some explanation. Marginal cost (MC) is a slope of a supply cost curve, which is a relationship between quantity of service provided and the total cost of provision. And long-run marginal cost is a slope of a cost curve where there is no fixed elements of input. In the case of power supply business, all physical assets such as power plants and T/Ls, substations etc., are assumed variable elements of input in LRMC. LRMC can be larger or lower than the average cost of supply. Therefore, taking LRMC as a price of service does not guarantee that the costs of service provision are recovered. Still, LRMC is an important indicator in price setting because[1];

"Economic theory suggests that efficient allocation of resources is achieved when price equals the marginal cost of supplying the service; that is, the increment to the total system cost of producing and delivering an additional unit of output under specified circumstances."

For reference, average electricity tariff in major Asian countries in 2014 are shown in the table below.

Table 9.3-1 Average Electricity Tariff in Major Asian Countries

	Domestic	Commercial	Industrial	Public Lighting	Agriculture	TOTAL
TNB, Malaysia	8.94	12.86	9.78	6.67	12.35	10.62
PLN, Indonesia	6.03	9.27	6.78	7.72	6.95	7.36
Taipower, Taiwan	8.54	10.28	8.07	3.89		8.64
EGAT, Thailand	12.74	11.81			10.69	12.36
CLP, Hong Kong						15.16
Meralco, Philippines	23.30	20.60	16.38	2.44		20.14
TEPCO, Japan	23.17	24.86				25.18
KEPCO, Korea	9.90	9.08	7.53	7.94	3.64	8.03
Singapore Power	16.45	15.06	14.23			16.28

Unit: in US Cent, Source: Performance and Statistical Information on Electricity Supply Industry in Malaysia, Energy Commission

In this section, an estimation of long-run marginal cost (LRMC) of electricity supply in the power development plan is discussed.

1 Financial Management and Analysis of Projects, July 2005, Asian Development Bank, edited and rearranged by the Study Team

9.3.2 Estimation of Long-Run Marginal Cost

(1) Method of Estimation

A method used here was "average incremental cost method", an approximation method of estimating LRMC. A process of derivation of LRMC is shown in the flowchart below.

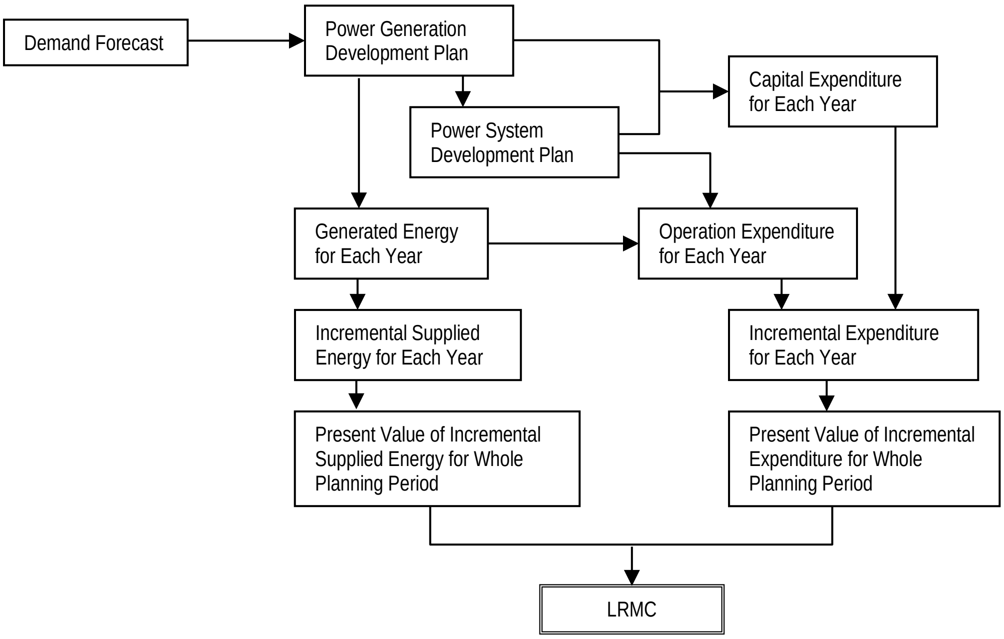


Fig. 9.3-1 Derivation Process of LRMC

(2) Supplied Energy and Cost of Energy Supply

Supplied energy (demand) and total cost of energy supply for three cases are shown in the figure below. Supplied energy is the summation of energy generated at power stations less energy loss in transmission and distribution. Energy supply cost include such cost elements as;

- Capital expenditure for power stations and power system development
- Operation expenditure for power stations (fixed OM cost and variable OM cost including fuel cost), transmission OM cost, distribution OM cost, clerical cost within Ramu system.

Note that head office overhead cost is not included.

Energy loss is assumed to decrease gradually during the planning period, from 22% in 2016 to 15% in 2030.

Unit costs used in the estimation were those explained in the previous section 9.1.

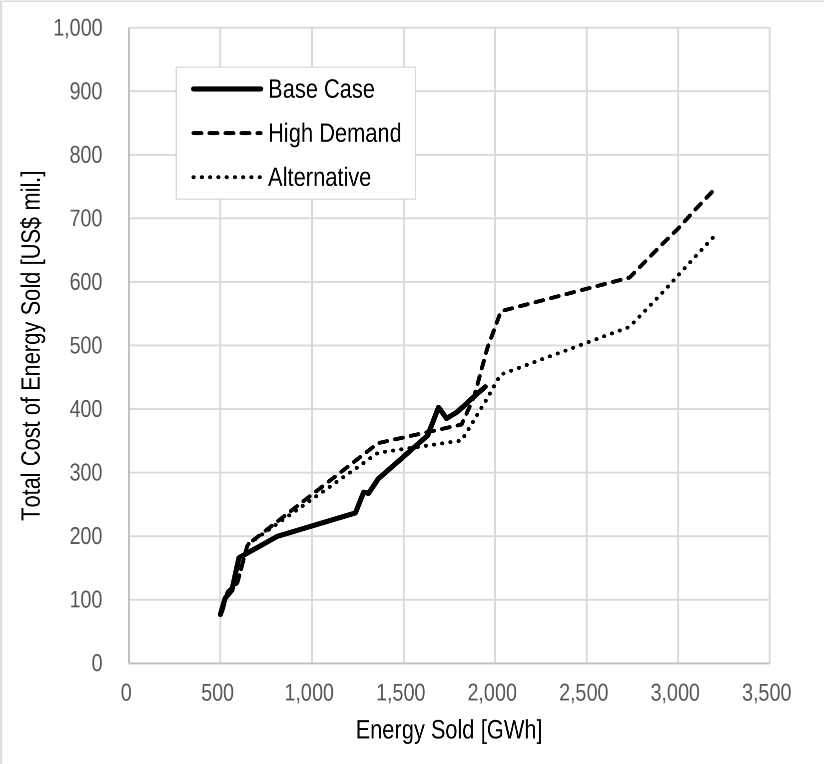


Fig. 9.3-2 Energy Supplied and Total Cost of Energy Supply in Three Cases

(2) Estimated LRMC

All the numbers used in the estimation of LRMC for Base Case, High Demand and Alternative Scenario are presented in Table 9.3-3, Table 9.3-4, and Table 9.3-5, respectively. In the estimation, the capital expenditures (investment costs) of each year were levelized using the interest rate 9.0% p.a. and maturity period of loans 25 years.

Result of estimation is summarized in the table below.

Table 9.3-2 Estimated LRMC for Three Power Development Scenario

	unit	Scenario		
		Base Case	High Demand	Alternative
PV of Incremental Demand	GWh	689	1,291	1,291
PV of Incremental Cost	US$ mil.	182	335	295
LRMC	US$/kWh	0.264	0.259	0.229
	K/kWh	0.660	0.648	0.572

Note: PV= present value

Table 9.3-3 Estimation of Long Run Marginal Cost for Base Case Scenario

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Demand (Generation End)	GWh	641	669	712	757	1,015	1,540	1,586	1,611	1,665	1,985	2,047	2,087	2,145	2,233	2,303
Demand (Energy Sold)	GWh	500	525	562	601	811	1,237	1,281	1,309	1,361	1,632	1,692	1,735	1,793	1,877	1,947
Installed Capacity	MW															
	hydro	115.5	115.5	124.5	124.5	124.5	244.5	304.5	304.5	304.5	394.5	394.5	510.5	510.5	510.5	510.5
	diesel	97.0	127.0	127.0	127.0	97.6	97.6	97.6	97.6	97.6	83.2	83.2	83.2	83.2	83.2	83.2
	natural gas	0.0	0.0	0.0	0.0	20.0	20.0	20.0	20.0	40.0	40.0	40.0	60.0	60.0	60.0	60.0
	biomass	0.0	0.0	0.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Energy Generated	GWh															
	hydro	508	508	611	611	771	1,211	1,211	1,431	1,431	1,621	1,621	1,831	1,831	1,831	1,831
	diesel	133	161	101	106	116	136	136	74	53	74	95	53	53	95	115
	natural gas					36	83	129	33	71	180	221	93	151	197	247
	biomass				40	92	110	110	73	110	110	110	110	110	110	110
Levelized Investment Cost	USD mil.	14.9	31.2	52.1	87.5	106.4	115.4	137.8	159.7	175.8	217.9	247.8	247.8	247.8	247.8	247.8
OM cost Fixed (capacity cost)	USD mil.															
	hydro	4.5	4.5	4.9	4.9	4.9	9.6	11.9	11.9	11.9	15.5	15.5	20.0	20.0	20.0	20.0
	diesel	10.1	13.2	13.2	13.2	10.2	10.2	10.2	10.2	10.2	8.7	8.7	8.7	8.7	8.7	8.7
	natural gas	0.0	0.0	0.0	0.0	1.2	1.2	1.2	1.2	2.3	2.3	2.3	3.5	3.5	3.5	3.5
	biomass	0.0	0.0	0.0	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
total OM Fixed Cost		14.6	17.8	18.1	22.3	20.4	25.1	27.5	27.5	28.6	30.7	30.7	36.4	36.4	36.4	36.4
OM Cost Variable	USD mil.															
	Hydro	0.8	0.8	1.0	1.0	1.2	1.9	1.9	2.2	2.2	2.5	2.5	2.9	2.9	2.9	2.9
	Diesel	21.4	27.2	17.9	19.7	22.6	27.9	29.3	16.7	12.6	18.4	24.9	14.6	15.3	28.8	36.6
	natural gas	0.0	0.0	0.0	0.0	3.1	7.4	12.1	3.2	7.3	19.5	25.2	11.1	19.0	26.0	34.2
	biomass	0.0	0.0	0.0	4.2	9.8	11.7	11.7	7.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
total OM Variable Cost		22.2	27.9	18.8	24.9	36.7	48.8	54.9	29.9	33.8	52.2	64.2	40.2	48.8	69.3	85.3
Transmission Line OM cost	USD mil.	3.5	3.5	3.5	6.2	6.6	6.8	7.2	7.6	7.9	8.1	8.2	8.2	8.2	8.2	8.2
Substation OM cost	USD mil.	2.7	2.7	2.7	3.9	4.3	5.7	5.9	6.1	6.3	6.4	6.9	6.9	6.9	6.9	6.9
Customer Service and Regional Office	USD mil.	19.0	19.5	20.4	21.2	25.8	35.1	36.0	36.6	37.8	43.7	45.0	45.9	47.2	49.0	50.5
Total Cost	USD mil.	76.8	102.6	115.6	166.1	200.1	236.9	269.3	267.4	290.3	358.9	402.8	385.4	395.2	417.6	435.1
Discounted Incremental Demand and Cost																
Demand	GWh		22.29	29.55	27.80	133.20	242.00	22.47	12.54	20.86	97.66	19.48	12.31	14.95	19.25	14.24
Cost	USD mil.		23.03	10.31	35.96	21.64	20.88	16.41	-0.87	9.24	24.75	14.13	-4.99	2.52	5.12	3.59

Table 9.3-4 Estimation of Long Run Marginal Cost for High Demand Scenario

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Demand (Generation End)	GWh	652	687	750	815	1,704	2,261	2,333	2,408	2,486	3,327	3,411	3,499	3,590	3,686	3,785
Demand (Energy Sold)	GWh	509	539	592	647	1,361	1,816	1,885	1,957	2,032	2,735	2,820	2,909	3,001	3,099	3,200
Installed Capacity	MW															
	hydro	115.5	115.5	124.5	124.5	124.5	304.5	304.5	304.5	304.5	554.5	554.5	554.5	554.5	554.5	554.5
	diesel	97.0	127.0	127.0	127.0	97.6	97.6	97.6	97.6	97.6	83.2	83.2	83.2	83.2	83.2	83.2
	natural gas	0.0	0.0	0.0	0.0	110.0	110.0	110.0	110.0	130.0	190.0	205.0	225.0	255.0	285.0	315.0
	biomass	0.0	15.0	15.0	15.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Energy Generated	GWh															
	hydro	508	508	611	611	771	1,431	1,431	1,431	1,431	2,001	2,001	2,001	2,001	2,001	2,001
	diesel	144	179	139	115	442	376	448	474	474	384	384	384	384	384	384
	natural gas					271	234	234	283	361	722	806	894	985	1,081	1,180
	biomass				89	220	220	220	220	220	220	220	220	220	220	220
Levelized Investment Cost	USD mil.	17.5	33.9	52.1	100.4	134.5	155.1	176.2	233.2	273.8	274.3	277.8	280.9	280.9	284.0	284.0
OM cost Fixed (capacity cost)	USD mil.															
	hydro	4.5	4.5	4.9	4.9	4.9	11.9	11.9	11.9	11.9	21.8	21.8	21.8	21.8	21.8	21.8
	diesel	10.1	13.2	13.2	13.2	10.2	10.2	10.2	10.2	10.2	8.7	8.7	8.7	8.7	8.7	8.7
	natural gas	0.0	0.0	0.0	0.0	6.4	6.4	6.4	6.4	7.6	11.1	12.0	13.2	14.9	16.7	18.4
	biomass	0.0	4.2	4.2	4.2	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
total OM Fixed Cost		14.6	22.0	22.3	22.3	29.9	36.9	36.9	36.9	38.1	49.9	50.8	52.0	53.7	55.5	57.2
OM Cost Variable	USD mil.															
	Hydro	0.8	0.8	1.0	1.0	1.2	2.2	2.2	2.2	2.2	3.1	3.1	3.1	3.1	3.1	3.1
	Diesel	23.1	30.2	24.6	21.4	86.3	77.1	96.4	107.1	112.5	95.7	100.5	105.5	110.8	116.3	122.1
	natural gas	0.0	0.0	0.0	0.0	23.0	20.9	21.9	27.8	37.3	78.3	91.8	106.9	123.7	142.5	163.4
	biomass	0.0	0.0	0.0	9.4	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3
total OM Variable Cost		23.9	31.0	25.6	31.8	133.8	123.5	143.9	160.5	175.3	200.4	218.7	238.8	260.9	285.3	311.9
Transmission Line OM cost	USD mil.	3.5	3.5	3.5	6.2	6.6	6.8	7.3	7.8	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Substation OM cost	USD mil.	2.7	2.7	2.7	3.9	4.3	5.9	6.0	6.2	6.5	6.6	6.9	6.9	6.9	6.9	6.9
Customer Service and Regional Office	USD mil.	19.2	19.9	21.0	22.2	37.8	47.7	49.2	50.7	52.4	67.7	69.5	71.5	73.5	75.6	77.8
Total Cost	USD mil.	81.5	112.8	127.1	186.8	346.8	375.9	419.5	495.4	554.3	607.1	632.0	658.3	684.1	715.4	746.0
Discounted Incremental Demand and Cost																
Demand	GWh		27.24	42.20	39.23	453.64	258.41	34.82	32.50	30.29	253.47	27.36	25.61	23.72	22.33	20.64
Cost	USD mil.		28.00	11.41	42.46	101.71	16.51	22.10	34.31	23.78	19.06	8.02	7.56	6.63	7.18	6.26

Table 9.3-5 Estimation of Long Run Marginal Cost for Alternative Scenario

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Demand (Generation End)	GWh	652	687	750	815	1,704	2,261	2,333	2,408	2,485	3,327	3,411	3,498	3,590	3,685	3,785
Demand (Energy Sold)	GWh	509	539	592	647	1,361	1,816	1,885	1,957	2,031	2,735	2,820	2,908	3,001	3,098	3,200
Installed Capacity	MW															
	hydro	115.5	115.5	124.5	124.5	124.5	304.5	304.5	304.5	304.5	438.5	438.5	438.5	438.5	438.5	438.5
	diesel	97.0	127.0	127.0	127.0	97.6	97.6	97.6	97.6	97.6	83.2	83.2	83.2	83.2	83.2	83.2
	natural gas	0.0	0.0	0.0	0.0	110.0	110.0	110.0	110.0	130.0	235.0	250.0	270.0	285.0	315.0	330.0
	biomass	0.0	15.0	15.0	15.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Energy Generated	GWh															
	hydro	508	508	611	611	771	1,431	1,431	1,431	1,431	1,791	1,791	1,791	1,791	1,791	1,791
	diesel	144	179	139	115	442	376	448	474	474	384	384	384	384	384	384
	natural gas					271	234	234	283	360	932	1,016	1,103	1,195	1,290	1,390
	biomass				89	220	220	220	220	220	220	220	220	220	220	220
Levelized Investment Cost	USD mil.	17.5	33.9	52.1	100.4	119.2	129.7	139.7	155.0	173.9	175.9	179.5	181.0	184.0	184.0	184.0
OM cost Fixed (capacity cost)	USD mil.															
	hydro	4.5	4.5	4.9	4.9	4.9	11.9	11.9	11.9	11.9	17.2	17.2	17.2	17.2	17.2	17.2
	diesel	10.1	13.2	13.2	13.2	10.2	10.2	10.2	10.2	10.2	8.7	8.7	8.7	8.7	8.7	8.7
	natural gas	0.0	0.0	0.0	0.0	6.4	6.4	6.4	6.4	7.6	13.8	14.6	15.8	16.7	18.4	19.3
	biomass	0.0	4.2	4.2	4.2	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
total OM Fixed Cost		14.6	22.0	22.3	22.3	29.9	36.9	36.9	36.9	38.1	48.0	48.9	50.0	50.9	52.7	53.6
OM Cost Variable	USD mil.															
	Hydro	0.8	0.8	1.0	1.0	1.2	2.2	2.2	2.2	2.2	2.8	2.8	2.8	2.8	2.8	2.8
	Diesel	23.1	30.2	24.6	21.4	86.3	77.1	96.4	107.1	112.5	95.7	100.5	105.5	110.8	116.3	122.1
	natural gas	0.0	0.0	0.0	0.0	23.0	20.9	21.9	27.8	37.2	101.1	115.7	131.9	150.1	170.1	192.4
	biomass	0.0	0.0	0.0	9.4	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3	23.3
total OM Variable Cost		23.9	31.0	25.6	31.8	133.8	123.5	143.9	160.5	175.2	222.9	242.3	263.5	286.9	312.5	340.7
Transmission Line OM cost	USD mil.	3.5	3.5	3.5	6.2	6.6	6.8	7.3	7.8	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Substation OM cost	USD mil.	2.7	2.7	2.7	3.9	4.3	5.9	6.0	6.2	6.5	6.6	6.9	6.9	6.9	6.9	6.9
Customer Service and Regional Office	USD mil.	19.2	19.9	21.0	22.2	37.8	47.7	49.2	50.7	52.4	67.7	69.5	71.5	73.5	75.6	77.8
Total Cost	USD mil.	81.5	112.8	127.1	186.8	331.6	350.5	383.0	417.2	454.2	529.2	555.3	581.1	610.5	641.5	672.7
Discounted Incremental Demand and Cost																
Demand	GWh		27.24	42.20	39.23	453.64	258.41	34.82	32.50	29.96	253.77	27.36	25.37	23.93	22.14	20.82
Cost	USD mil.		28.00	11.41	42.46	92.02	10.74	16.47	15.49	14.93	27.06	8.39	7.43	7.54	7.09	6.40

9.3.3 Discussion on Pricing

Estimation of LRMC for Ramu System resulted in the value US¢ 26 to 30 per kWh (64 to 74 toea per kWh). This is lower than the average tariff of Ramu System in 2014 (Fig. 9.1-4). US¢ 26 per kWh would be, if adopted as an average tariff, rather high compared with those of major Asian countries. One of the reasons is rapid increase of capacity and required capital expenditure in short period of time to meet the demand of emerging large customers. Also, general high prices of goods and services in PNG and the remoteness of Ramu System and relating generation/transmission facilities distribution must contribute.

It is difficult to discuss the adequacy of tariff level on the basis of LRMC obtained for Ramu System only. We should first note that LRMC is a reference level of tariff which does not take into account the cost-recovery of electricity supply business. Also, the estimation of LRMC did not include power supplied and cost incurred in other power systems. In Ramu System, proportion of hydro in generation capacity and actual generated energy is larger than in other systems and the cost structure there can be different from those in other systems. In particular, in those systems utilizing diesel generation only, the difference can be significant. Ramu System is very different from others in that it is geographically spread over the sparsely distributed demand, and that it has much larger proportion of Special Category customers. Current universal tariff system of PPL regulated by ERC is more or less full-cost recovery basis of PPL as a whole, to which marginal cost obtained for Ramu System alone is not necessarily close. Also, under the universal tariff system across the country, there must be cross-subsidy in place between the systems.

The assumption of future crude oil price affects the level of estimated LRMC. The actual expenditure records used in cost analysis of Ramu System were that for 2014, where the average crude oil price in the world market was US$ 99 per barrel. In the LRMC estimation, crude oil price was assumed at US$ 50 per barrel for 2016, appreciating at 5 % p.a. to reach US$ 99 in 2030. However, as of the time of this reporting, January 2016, crude oil price just fell below US$ 30, which makes any projection of future oil price completely uncountable. High Demand and Alternative scenarios share the same demand but differ in hydro/thermal generation capacity proportion, resulting in larger fuel-related cost element in Alternative Scenario. Therefore, assuming higher crude oil price for the planning would increase the LRMC of Alternative Scenario more.

Different tariffs for customer categories can be one of discussion points. The tariff for “Special Category” customers is set at about a half of other categories. It is reasonable to set a lower price for large customers as large customers receive power at very high voltage without causing additional cost for sub-stations and distribution to PPL. However, in the estimation of LRMC it was revealed that the investment cost and O&M cost for generation and power system take up about 90% of total cost in any scenarios, leaving small portion to distribution and customer services costs. Tariff settings that intends to provide favorable conditions to particular industry to develop regional economy and that aims at realizing efficient resource allocations in the economy through the use of LRMC are based on different policy objectives.

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