Independent State of Papua New Guinea
PNG Power Limited

2nd Preparatory Survey on The Project for Reinforcement of Ramu Transmission System in Independent State of Papua New Guinea

FINAL REPORT

MARCH 2012

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.
Sojitz Research Institute, Ltd.
Mitsubishi Research Institute, Inc.
Mitsui Consultants Co., Ltd.

EXECUTIVE SUMMARY

1. Objective

The main objective of this survey is to conduct a feasibility study for the project for the reinforcement of the 132 kV transmission line between Ramu 1 hydropower station and Taraka substation through Erap substation (the Project) to enhance the power supply reliability and stability of the Ramu grid.

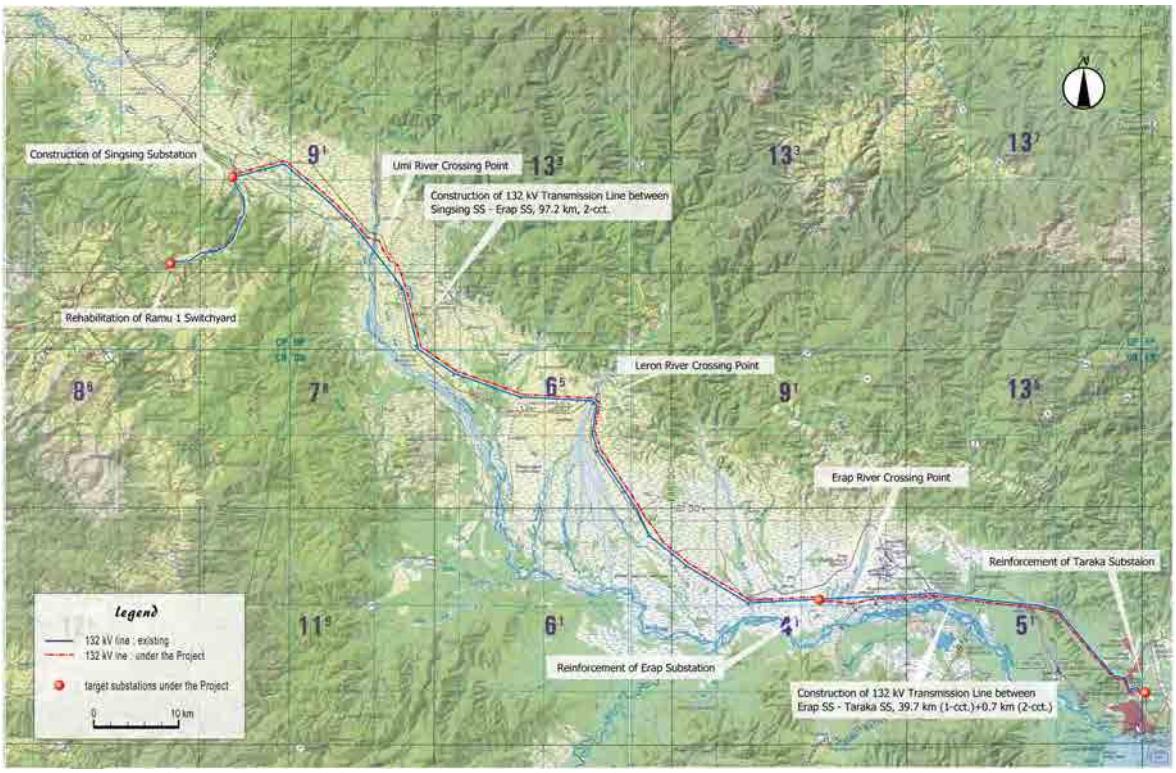
The main objectives of the Project are as follows:

1) to reinforce the efficiency of the Ramu grid, which is considered to lead directly towards the stabilization of electric power supply and economic development of Lae, and
2) to increase opportunities for reliable and stable electrical connections in the neighbouring communities of the project sites.

In addition, implementation of the Project is urgently needed not only for reinforcement of the Ramu grid, but also for securing the power supply reliability to Lae, where remarkable economic development is taking place, and ensuring the power supply capability for rapidly increasing mining demand.

2. Scope of the Project

1) Transmission line components
   i) 132 kV double-circuit overhead transmission line from Taraka substation to Taraka Junction, 0.7 km, and 132 kV single-circuit overhead transmission line from Taraka Junction to Erap substation, 39.7 km
   ii) 132 kV double-circuit overhead transmission line between Erap substation and new Singsing substation, 97.2 km
2) Substation components
   i) Rehabilitation of Ramu 1 switchyard
   ii) Construction of Singsing substation including one unit of 132/33 kV 10 MVA main power transformer and six 132 kV transmission line bays
   iii) Augmentation of Erap substation including additional two units of 132/66/33 kV 10 MVA main power transformers and three transmission line bays
   iv) Rehabilitation of Taraka substation with three alternative plans including additional one 132 kV transmission line bay



(Prepared by the Survey Team)

Figure 1 Scope of the Project

3. Project Costs

Table 1 summarizes the total costs for the Project.

Table 1 Total Project Costs

Items	FC (US$)	LC (US$)	Total (US$)	Total (PGK eq.)	Total (JPY eq)
1. Transmission Line Component	17,033,600.00	17,611,400.00	34,645,000.00	79,433,300.00	2,805,898,000
2. Substation Component					
2.1 Plan-A	16,700,600.00	8,678,300.00	25,378,900.00	58,188,500.00	2,055,437,000
2.2 Plan-B	18,683,900.00	9,020,200.00	27,704,100.00	63,519,600.00	2,243,755,000
2.3 Plan-C	21,010,200.00	9,185,700.00	30,195,900.00	69,232,700.00	2,445,566,000
3. Land & ROW Compensation	-	931,320.00	931,320.00	2,135,400.00	75,427,000
4. Consulting Fee	3,233,400.00	1,788,400.00	5,021,800.00	11,513,900.00	406,715,000
5. Contingency (8% of 1+2)					
5.1 Contingency Plan-A	2,698,700.00	2,103,200.00	4,801,900.00	11,009,700.00	388,906,000
5.2 Contingency Plan-B	2,857,400.00	2,130,500.00	4,987,900.00	11,436,200.00	403,970,000
5.3 Contingency Plan-C	3,043,500.00	2,143,800.00	5,187,300.00	11,893,400.00	420,119,000
Grand Total (Plan-A)	39,666,300.00	31,112,620.00	70,778,920.00	162,280,800.00	5,732,383,000
Grand Total (Plan-B)	41,808,300.00	31,481,820.00	73,290,120.00	168,038,400.00	5,935,765,000
Grand Total (Plan-C)	44,320,700.00	31,660,620.00	75,981,320.00	174,208,700.00	6,153,725,000

(Prepared by the Survey Team)

4. Project Evaluation

The result of economic internal rate of return (EIRR) and financial internal rate of return (FIRR) calculations, and sensitivity analysis considering the case of +30 % cost, are shown in Table 2.

Table 2 Sensitivity Analysis

Alternatives	EIRR (%) base case	EIRR (%) +30% cost	FIRR (%) base case	FIRR (%) +30% cost
Plan-A	26.74	22.15	19.58	15.95
Plan-B	27.03	22.32	19.54	15.87
Plan-C	27.23	22.45	19.61	15.92

(Prepared by the Survey Team)

From the result, enough economic and financial benefits are expected from each plan based on the state of the national economy and the type of managerial finance of PPL, even if construction costs are increased by 30%.

5. Environmental and Social Considerations

1) Environmental Assessment

The project category has been officially confirmed as Level 2B by the DEC. Therefore, PPL is now preparing for the permit application according to the procedure for Level 2B project and targeting to submit the application by March 2012. The local communities in the project area depend their livelihood on the rich natural resources of the area, as well as seasonal climate change which may cause the impacts to the project facilities. Hence, it is important to consider minimizing such impacts by adopting adequate mitigation measures and conducting regular monitoring process.

2) Land Issues

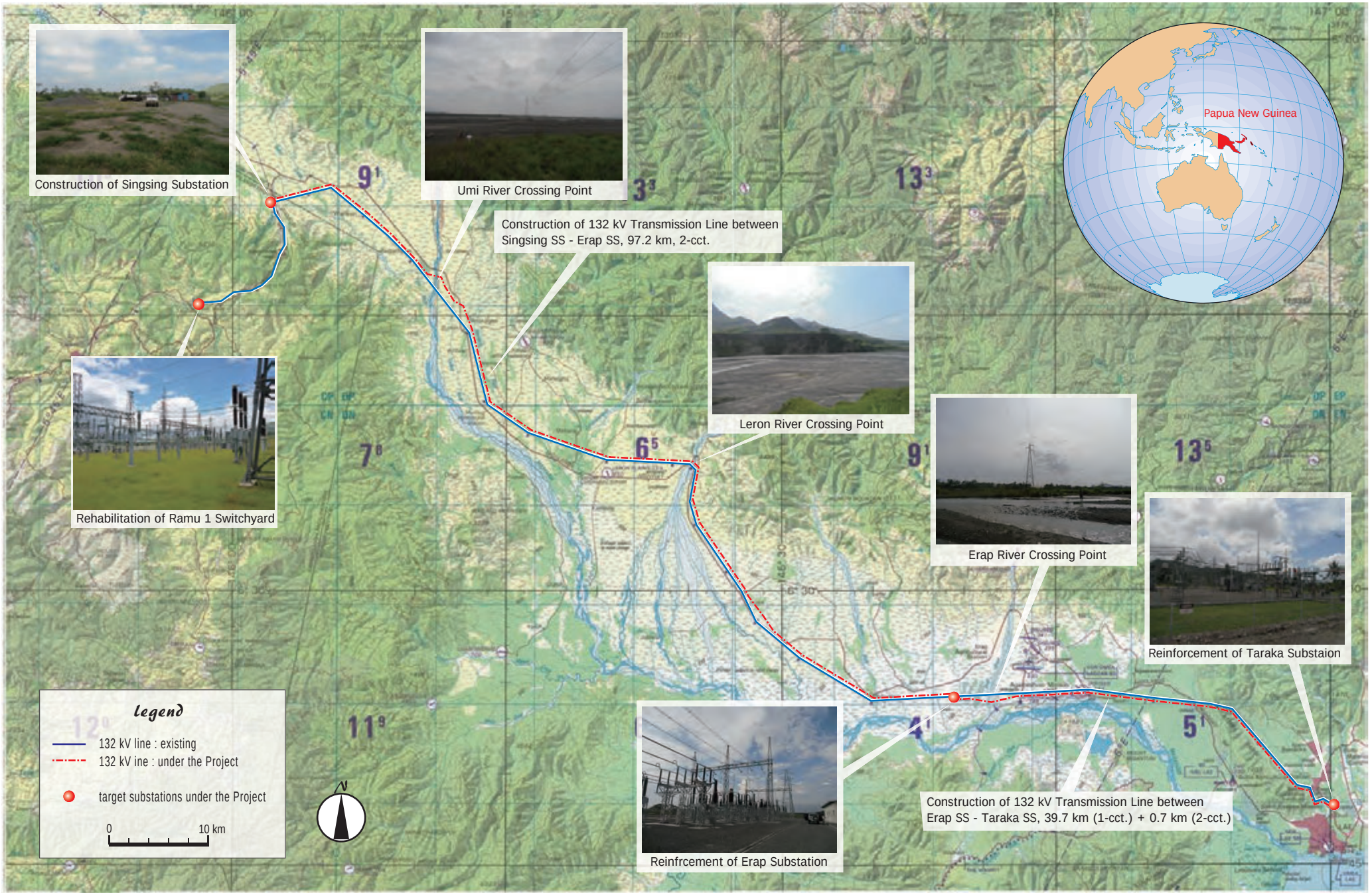
The design of the Project took consideration of avoidance and minimization of involuntary resettlement, land acquisition and loss of livelihood. Therefore, involuntary resettlement and relocation of structures are not expected. It has been noted that the Project requires (i) acquiring approximately 0.46 ha of land for the extension of Erap substation, (ii) obtaining agreements for land release for tower bases and transmission line easement, and (iii) compensation for damaged crops and trees.

The land areas around existing Erap substation is state-owned and will be acquired through negotiation with its current landowner. For the land for tower bases and transmission line easement, landowners will be provided compensation for the release of such land and all damages and detriments that may be caused, in particular, damages to economic crops and trees.

6. Recommendation

The Survey Team has studied three alternative rehabilitation plans for Taraka substation. As a result of economic and financial evaluation, Plan C shows highest EIRR/FIRR values among the plans as shown in Table 2. In addition, Plan C also has advantages from viewpoints of reliable power supply and ease of O&M.

Therefore, it is strongly recommended that the Project is to be implemented with Plan C, considering the importance and actual situation of Taraka substation.



Project Location Map

FINAL REPORT

for

2nd Preparatory Survey

on

the Project for Reinforcement of Ramu Transmission System

in

Independent State of Papua New Guinea

CONTENTS

ATTACHMENTS

TABLES

FIGURES

Abbreviations

AC	:	Aluminum Covered (ground-wires)
ACSR	:	Aluminum Conductor Steel Reinforced
ADB	:	Asian Development Bank
AIS	:	Air Insulated Switchgear
ANSI	:	American National Standards Institute
AS	:	Australian Standards
BS	:	British Standards
BSC	:	Breaker Switched Capacitors
CIF	:	Cost Insurance Freight
CPI	:	Consumer Price Index
CT	:	Current Transformer
CVT	:	Capacitor Voltage Transformer
DEC	:	Department of Environment and Conservation
DL	:	Distribution Line
DLPP	:	Department of Land and Physical Planning
DIN	:	Deutsche Industrie Norm
DNPM	:	Department of National Planning and Monitoring
DPEne	:	Department of Petroleum and Energy
DPEnt	:	Department of Public Enterprises
DS	:	Disconnector
EDS	:	Everyday Stress
EIA	:	Environmental Impact Assessment
EIP	:	Electricity Industry Policy
EIRR	:	Economic Internal Rate of Return
EMC	:	Electricity Management Committee
EMP	:	Environmental Management Plan
EP	:	Energy Policy
ES	:	Earthing Switch
ESAA	:	Electricity Supply Association of Australia
ETF	:	Electricity Trust Fund
EU	:	European Union
EXIM	:	Export and Import (Bank of China)
FC	:	Foreign Currency
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GCB	:	Gas Circuit Breaker
GDP	:	Gross Domestic Product
GDP 2025	:	Generation Development Plan 2025
GEF	:	Global Environment Facility
GIS	:	Gas Insulated Switchgear
GoPNG	:	Government of Papua New Guinea
GPS	:	Global Positioning System
HPS	:	Hydropower Station
HV	:	High Voltage
ICCC	:	Independent Consumer and Competition Commission
IDA	:	International Development Association
IEC	:	International Electrotechnical Commission
IEE	:	Initial Environmental Examination

IEEE	:	Institute of Electrical and Electronics Engineers
IPP	:	Independent Power Producer
ITU	:	International Telecommunication Union
IUCN	:	International Union for the Conservation of Nature and Natural
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standards
JPY	:	Japanese Yen
LC	:	Local Currency
LBS	:	Load Break Switch
LDC	:	Load Dispatching Center
NG	:	Liquefied Natural Gas
LRMC	:	Long Run Marginal Cost
LV	:	Low Voltage (400 V in PNG)
MFF	:	Multi-tranche Financing Facility
MTDP	:	Medium Term Development Plan
MV	:	Medium Voltage (22 kV and 11 kV in PNG)
NEC	:	National Executive Council
NPC	:	National Planning Committee
NPV	:	Net Present Value
NZS	:	New Zealand Standards
O&M	:	Operation and Maintenance
OCB	:	Oil insulated Circuit Breaker
ODA	:	Official Development Assistance
ODF	:	Optic-fibre Distribution Frame
OLTC	:	On-Load Tap Changer
ONAN	:	Oil Natural circulation Air Natural cooling
ONAF	:	Oil Natural circulation Air Forced cooling
OPGW	:	Optical Ground Wire
PABX	:	Private Automatic Branch Exchange
PAP	:	Project Affected Person
PGDP	:	Power Grid Development Project
PGK	:	Papua New Guinea Kina
PLC	:	Power Line Carrier
PMU	:	Project Management Unit
PNG	:	Papua New Guinea
PNGDSP	:	Papua New Guinea Development Strategic Plan 2010-2030
PNGS	:	Papua New Guinea Standard
PPA	:	Power Purchase Agreement
PPL	:	PNG Power Limited
REP	:	Rural Electrification Policy
RTU	:	Remote Terminal Unit
RUS	:	Rated Ultimate Strength
SA	:	Surge Arrester
SF6	:	Sulphur Hexafluoride
SIA	:	Social Impact Assessment
SB	:	Splicing Box
SCADA	:	System Control and Data Acquisition
SCF	:	Standard Conversion Factor
SS	:	Substation
STM	:	Synchronous Transport Module

SwS	:	Switching Station
SVG	:	Static Var Generator
TA	:	Technical Assistance
TDDP	:	Transmission and Distribution Development Plan
TEIP	:	Town Electrification Investment Program
TL	:	Transmission Line
UNFCCC	:	United Nations Framework Convention on Climate Change
UNDP	:	United Nations Development Program
USD	:	United States Dollar
UTS	:	Ultimate Tensile Strength
WB	:	World Bank

Exchange Rate

1 PNG Kina = 35.324 Japanese Yen

1 US dollar = 80.99 Japanese Yen

1 Euro = 116.55 Japanese Yen

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background and Objective

According to the Baseline Data Collection Survey of Power Sector in Papua New Guinea (PNG), which was conducted by the Japan International Cooperation Agency (JICA) from April to May, 2010, the Ramu transmission system (grid) had difficulties with having stable and continuous power supply, because it did not meet the N-1 criteria for the assessment of power supply reliability. Moreover, the Ramu grid did not have a single-phase auto-reclosing system of circuit breakers to minimize line-outage time caused by single-line-to-ground faults. Therefore, reinforcement of the Ramu grid was urgently needed.

In order to conduct further studies about the Ramu grid, JICA, in consultation with the Government of Japan, decided to dispatch the survey team to PNG for the 1st Preparatory Survey on Electric Power Sector: the Project for Reinforcement of Ramu Transmission System in PNG from February to March, 2011. The team held discussions with the officials of the PNG side, and conducted a field survey. As a result of the survey, both the PNG side and the team had confirmed the scope and implementing arrangement of the 2nd Preparatory Survey (the 2nd Survey).

The main objective of the 2nd Survey is to conduct a feasibility study for the project for the reinforcement of the 132 kV transmission line between Ramu 1 hydropower station and Taraka substation through Erap substation (the Project) to enhance the power supply reliability and stability of the Ramu grid.

The main objectives of the Project are as follows:

1) to reinforce the efficiency of the Ramu grid, which is considered to lead directly towards the stabilization of electric power supply and economic development of Lae, and
2) to increase opportunities for reliable and stable electrical connections in the neighbouring communities of the project sites.

The abovementioned objectives conform to the power sector development policy of the Government of Papua New Guinea (GoPNG) which will be described in Chapter 2.

1.2 Scope of the 2nd Survey

The scope of the 2nd Survey includes the following:

1) Study on the current situation of the power sector
   - to confirm the electricity industrial policy of the GoPNG,
   - to study the institutional and organizational structures of the power sector,
   - to study the current situation of power supply and demand for the entire Ramu grid,
   - to analyze the current situation of power supply and demand in Ramu 1 – Erap – Taraka 132 kV transmission line in detail,
   - to assess PNG Power Limited's (PPL's) financial condition, and
   - to confirm the flow of funds from the donor agencies to PPL.

2) Review of the development plan of Ramu grid
   - to review development plans for power generation and transmission network of the Ramu grid, and
   - to review future power demand forecast considering mines and other industrial demands.

3) Study of the current condition of existing power facilities
   - to confirm the design and specifications of the existing Ramu 1–Erap–Taraka 132 kV transmission line, Ramu 1 switchyard, and Erap and Taraka substations.

4) Environmental and social considerations
   - to confirm the legal and institutional framework of the environmental and social considerations including land issues,
   - to conduct a study which complies with JICA Guidelines for Environmental and Social Considerations, and
   - to support the PPL in obtaining the necessary permits including environmental impact assessment (EIA) and land issues.

5) Feasibility study
   - to confirm the institutional and organizational structures for project implementation,
   - to conduct power flow analysis considering the review of future demands,
   - to design the project outline,
   - to conduct geographical and topographical survey necessary for the basic design,
   - to conduct the basic design of the planned transmission line and relevant facilities,
   - to prepare the implementation schedule,
   - to estimate the project cost,
   - to analyze the economic and financial availability by calculating the economic internal rate of return (EIRR) and financial internal rate of return (FIRR),
   - to analyze the project risk, and
   - to recommend appropriate indicators to assess the project output.

1.3 Survey Schedule

The whole survey period is expected to last for about five months from October 2011 to February 2012. The first field survey in PNG was conducted from October 26 to December 1, 2011 and the second field survey was conducted from January 7 to 26, 2012

The following reports were submitted during the survey period:

1) Inception Report end of October 2011
2) Interim Report end of November 2011
3) Draft Final Report middle of February 2012
4) Final Report middle of March 2012

1.4 Survey Team

The Survey Team is organized from the association of Nippon Koei Co., Ltd. (NK), Sojitz Research Institute, Ltd. (SRI), Mitsubishi Research Institute Inc. (MRI) and Mitsui Consultants Co., Ltd. (MC).

The following team members carried out the 2nd Survey with the assistance of counterpart personnel from PPL.

Table 1.4-1 Survey Team

	name	position	firm
1.	Junichi FUKUNAGA	Leader / Power System Planner	NK
2.	Hiroyuki MORITA	Transmission Line Engineer-1	NK
3.	Tokio MORI	Transmission Line Engineer-2	NK
4.	Fukiyoshi KOREZAWA	Substation Engineer	NK
5.	Masaharu FUJISHIMA	Hydrology and Civil Engineer	MC
6.	Akiko NISHINOMIYA	Environmental and Social Consideration-1	SRI
7.	Kyoko HARADA	Environmental and Social Consideration-2	SRI
8.	Shota INOUE	Economist	MRI
9.	Kazumasa YAZAWA	GIS Expert / Coordinator	NK

Note: NK: Nippon Koei Co., Ltd.
SRI: Sojitz Research Institute, Ltd.
MRI: Mitsubishi Research Institute, Inc.
MC: Mitsui Consultants Co., Ltd.

1.5 Concerned Personnel

During the survey period, the Survey Team attended meetings and discussions with several concerned personnel listed in Attachment-1.

CHAPTER 2

POWER SECTOR

CHAPTER 2 POWER SECTOR

2.1 Long and Medium-term National Strategic Plans

(1) Papua New Guinea Vision 2050

In December 2007, the National Executive Council (NEC) of the GoPNG, on advice from the National Planning Committee (NPC), made a decision to develop a framework for a long-term strategy, entitled "Papua New Guinea Vision 2050" that should map out the future direction for the country and reflect the aspirations of the people of PNG. The Vision 2050 offers a holistic approach to PNG's development on a 40-year target period from 2010 to 2050. The 'ideal' of the Vision 2050 is that the significant revenue projections from the mining, gas and oil projects are efficiently managed so that PNG develops and builds a solid and sustainable economic foundation.

The Vision 2050 is defined by the following seven strategic focus areas, which are referred to as the key pillars:

1) Human capital development, gender, youth and people empowerment
2) Wealth creation
3) Institutional development and service delivery
4) Security and international relations
5) Environmental sustainability and climate change
6) Spiritual, cultural and community development
7) Strategic planning integration and control

As for the national goals of power sector development, the following statements are projected to form the basis of socioeconomic growth under the Vision 2050.

> *1.17.7.3.4: Increase the availability of rural electrification from 15 % to 100 % of the population.*
>
> *1.17.9.9: Provide 100 % power generation from renewable energy sources.*

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

In March 2010, the Department of National Planning and Monitoring (DNPM) of the GoPNG issued the "Papua New Guinea Development Strategic Plan 2010-2030 (PNGDSP)", which aims to transform PNG from a low-income to a middle income country by 2030. To achieve this, the GoPNG plans to quadruple its Gross Domestic Product (GDP), sustain an economic growth of 8 % per annum, create over two million jobs, reduce crime by 55 %, and open up

20 % of customary land to commercial uses. The PNGDSP sets a broad framework of targets, and strategies in order to achieve the objectives of the Vision 2050. Under the PNGDSP, all sector policies, plans and strategies are to be re-aligned to the PNGDSP.

As for the power sector development policy, the PNGDSP set a goal as "*All households have access to a reliable and affordable energy supply, and sufficient power is generated and distributed to meet future energy requirements and demands*".

The PNGDSP sets the key strategic areas for power sector development by 2030 as follows:

1) Over 70% of households and all business sectors must have access to reliable, affordable, modern and clean energy sources;
2) Power generation capacities from gas, hydro and other renewable energy sources are to be 390 MW, 1,020 MW and 500 MW, respectively;
3) Power generation capacities from diesel and coal are to be less than 40 MW and 30 MW, respectively;
4) All major towns and cities are to be connected to the national grid which will feed off an electricity super-corridor; and
5) Most households must have access to "Easipay (prepaid power)".

(3) Papua New Guinea Medium Term Development Plan 2011-2015

The Medium Term Development Plan 2011-2015 (MTDP) is a 5-year development plan which provides a clear and accountable plan for investment. It sets the sector strategies, targets, deliverables and their projected estimated cost of implementation. The MTDP aims for the PNGDSP to have tangible results. It also takes into account the lessons and experiences learned from the past MTDP, 2005-2010. The plan outlines the specific players who will be responsible for achieving the key deliverables. It strengthens the national government's ability to monitor and evaluate investments over the coming years during the life of the PNGDSP 2010–2030.

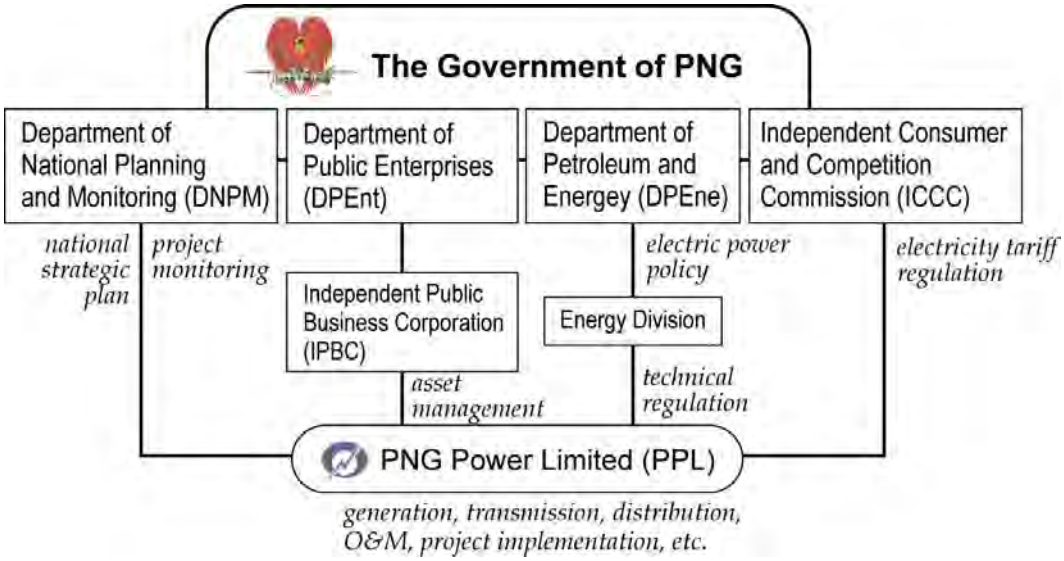
The MTDP for the power sector focuses on increasing access to electricity for all households in the country. Electricity will be provided to rural aid centres and schools by using renewable energy such as solar, wind and micro-hydro. Diesel will also be used but only as an interim measure while renewable sources are being developed. The MTDP also tries to address the establishment of clear and specific frameworks for utilizing gas energies in electricity generation. New investments from private sectors in the photovoltaic technology retail market in the country are also expected during the period of the MTDP.

The MTDP also mentioned that a feasibility study will be undertaken to develop a national grid, which interconnects the major regional grids, namely Rouna, Ramu and Gazelle.

While this study is in progress, rehabilitation/reinforcement works will be undertaken by the PPL on the existing regional grids to improve the current supply of electricity. Rehabilitation will be carried out first on the Port Moresby Rouna grid since it is the national capital where much of the energy demands originates. The second will be on the Ramu grid since it is the second largest city, and the last will be on the Gazelle grid.

2.2 Power Sector Structures and Policies

Figure 2.2-1 shows the outline of PNG's power sector.



(Prepared by the Survey Team)

Figure 2.2-1 PNG Power Sector

1) Department of National Planning and Monitoring

The roles of DNPM include leading, planning, coordinating and facilitating the appropriate national and international initiatives that address and promote the equitable and sustainable development of PNG. The DNPM acts as the key central agency advising GoPNG on matters relating to strategic development, development policy, development planning and programming, foreign aid coordination and management, and monitoring and evaluation of national development projects and programmes.

2) Department of Public Enterprises

The Independent Public Business Corporation (IPBC) is under the supervision of the Department of Public Enterprises (DPEnt) of the GoPNG. The IPBC was established under the law of IPBC promulgated in 2002 in accordance with the privatization policy of the GoPNG. The IPBC is responsible for the management of its assets and for its privatization if it is appropriate.

3) Department of Petroleum and Energy

The Department of Petroleum and Energy (DPEne) of the GoPNG was established in

order to promote and regulate the development of petroleum and other sources of energy for the long-term benefits of the state in a way which is ethical, socially responsible and environmentally sound. The DPEne comprises two core technical divisions, namely the Petroleum Division and the Energy Division, with two distinct but related sets of functions.

To achieve the long-term goals of the national strategic plan, the Energy Division has studied three fundamental policies for power sector development such as the Draft Electricity Industry Policy (EIP), the Draft Energy Policy (EP) and the Draft Rural Electrification Policy (REP) since 2008.

The main issues brought to the forefront in the EIP (August 2009) include the following:

a) Promotion of competition and development of an enabling third-party access regime;
b) An emphasis on rural electrification such as the following:
   - Setting of long-term electrification targets,
   - Establishment of an Electricity Trust Fund (ETF) for rural electrification purposes to be funded by the GoPNG, and
   - A policy of country-wide uniform electric power tariffs for the PNG Power Limited (PPL);
c) Strengthening of the regulatory regime, with a role provided to the present regulator (the Independent Consumer and Competition Commission, ICCC) of developing regulations for third-party access, as well as a commitment to price cap regulation;
d) Formation of an Electricity Management Committee (EMC) to oversee implementation of the EIP, and manage the rural electrification public tendering process.

A number of issues and concerns regarding the EIP have been raised after it has circulated among stakeholders, of which the main ones are as follows:

a) Continued policy of providing subsidies to the power sector,
b) Exclusivity provisions granted to PPL in the policy, and
c) Accessibility to the grid by third parties.

4) Independent Consumer and Competition Commission

The primary role of the ICCC is to promote competition and fair trading, protect the rights and interests of consumers in the market place, and regulate the prices and standards of certain goods and services specified by the GoPNG such as rice, flour, canned fish, water and sewerage services, petrol, etc. The ICCC also regulates certain state-owned entities to avoid the risk of having monopolies in the provision of

public utilities such as in the electricity, telecommunications, ports and harbours, postal services, etc. These entities are regulated through a regulatory contract which sets out the conditions for future price paths tied to service standards. Furthermore, for each industry under which they operate, there is specific legislation and the ICCC is empowered in that legislation as the regulator and licensing authority.

As for the electric power sector, the ICCC is responsible for review, adjustments and regulations of the electric power tariff.

5) PNG Power Limited

The PPL has a concession/permission to exclusively manage the generation, transmission, and distribution of electricity for the capital city of Port Moresby and the towns in the 19 provinces. The PPL is an electric power utility of which the equity is held by the GoPNG where the IPBC holds 100% share of its stocks. The PPL collects the electric tariff in accordance with the tariff system approved by the ICCC.

2.3 PNG Power Limited

2.3.1 Outline

The total installed generation capacity in PNG owned by the PPL and private companies was 582 MW in 2010, of which 230 MW (39.5%) comes from hydropower, 217 MW (37.3%) from diesel, 82 MW (14.1%) from gas-fired, and 53 MW (9.1%) from geothermal. Among this, the PPL owns and operates a total of 168 MW from hydropower plants and 148 MW from thermal power plants in total including diesel and gas-fired plants. In addition, there are many generating plants that are owned and operated by private mining companies, sugar factories, manufacturers and industries for their own use and/or stand-by. The total capacity of the private plants is estimated at about 270 MW. Due to the unreliability of the power supply, urban areas have considerable self-generation and backup generation capacity, which are not only expensive but also inefficient. Large industrial users, particularly mining sites, also operate off-grid self-generation.

There are three major grid systems of the PPL in Port Moresby, Ramu (including Lae, Madang and the Highlands) and Gazelle in East New Britain that have hydropower plants with capacities of more than 10 MW, and high voltage transmission lines such as 132 kV and 66 kV. Electric power supply to the other regional centres that are not connected to these power grids rely on diesel power plants through medium-voltage distribution lines of 33 kV, 22 kV and/or 11 kV, and low-voltage lines. There is at present no national interconnected grid system due mainly to PNG's topography as well as the vast distances between various towns and/or load centres. Figure 2.3-1 shows the present PPL’s national network.

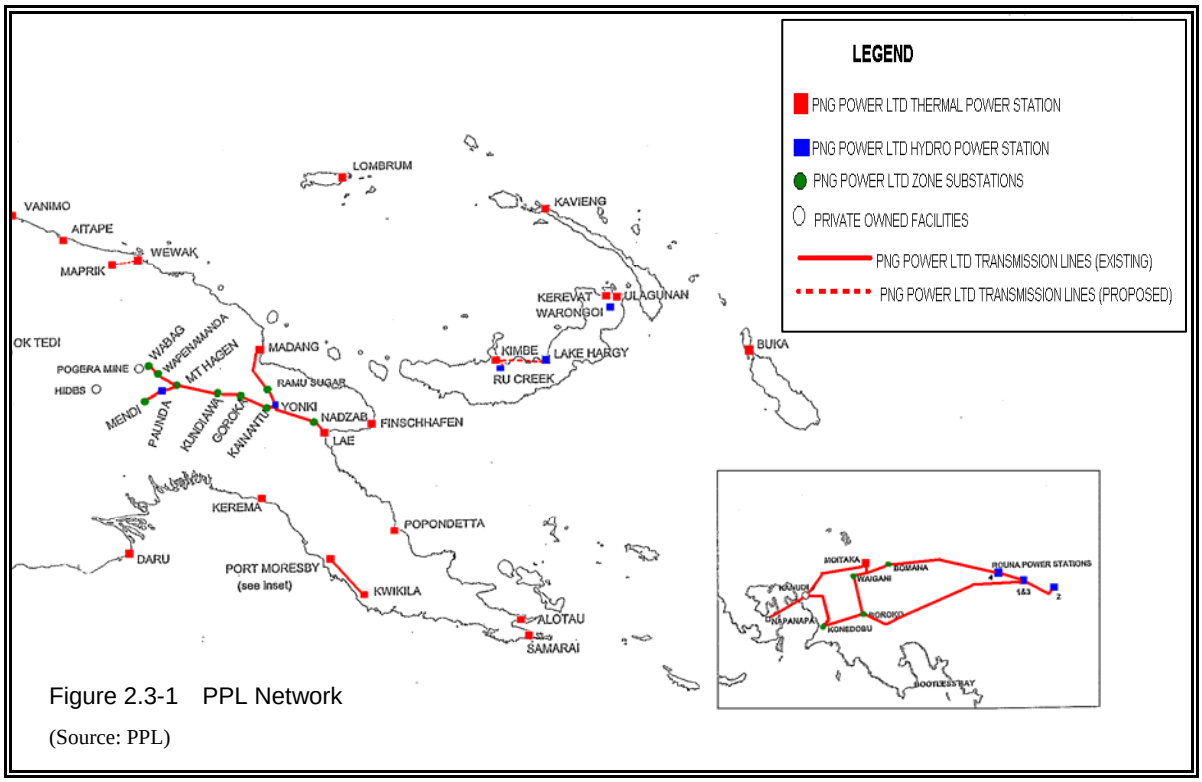
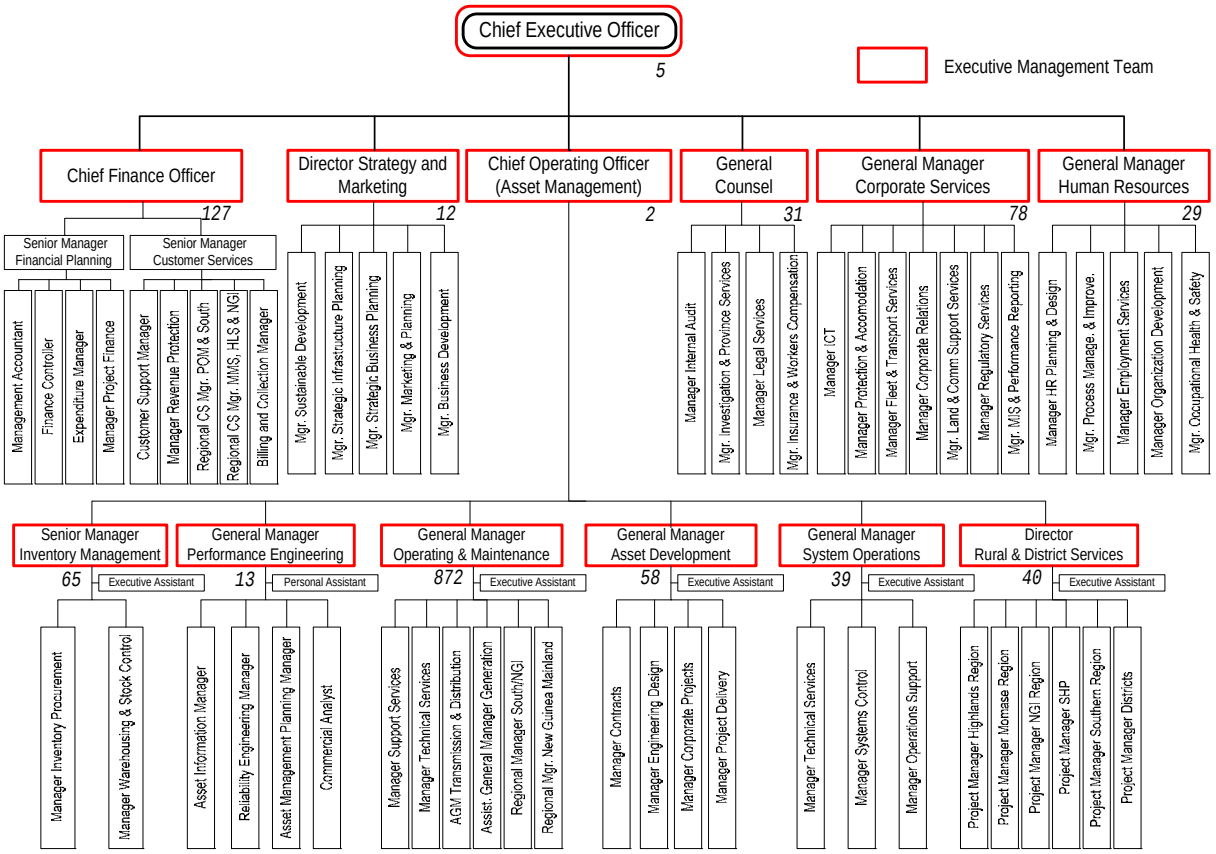


Figure 2.3-1 PPL Network

(Source: PPL)

2.3.2 Organization

Figure 2.3-2 shows the PPL's organizational structure as of November 2011.



(Source: PPL Human Resources) Note: Numbers under the business units show number of employees as of October 7, 2011.

Figure 2.3-2 PPL Organization

There are six business units under the Chief Executive Officer such as the Finance Office, Strategy and Marketing, Operating Office, General Counsel, Corporate Services, and Human Resources. Under the Chief Operating Officer, there are six divisions which include Inventory Management, Performance Engineering, Operating & Maintenance, Asset Development, System Operations, and Rural & District Services. Heads of these business units and divisions make up the Executive Management Team of the PPL. The total number of employees of PPL was 1,371 as of October 7, 2011.

The Corporate Projects team under the Asset Development division is to be responsible for the implementation of the Project. The Transmission and Distribution team under the Operation and Maintenance division is to be responsible for the operations and maintenance of the transmission lines and substations after the completion of the Project.

2.3.3 Financial Status

Unlike other developing countries dependent on thermal power, the pace of tariff reform by the PPL has been impressive in recent years, with the tariff level increasing at an average annual rate of 9.9% in real terms from 2002 to 2011. With the increase in tariff as well as the increase in the number of consumers, sales revenue increased by 9.3% per annum from 2002 to 2011. Rate of return on net fixed assets after depreciation in 2007 was 8.7% which was comparatively well above the average of electric power companies in other countries. Fundamental indicators of the PPL financial situation are shown in Table 2.3-1.

Table 2.3-1 Actual Cash Flows and Forecast (unit: million PGK)

	2010	2011
Sources	188.9	232.0
Internal cash generation		
- Gross Internal Cash Generation	72.3	108.3
Other		
- Total other sources	116.6	123.7
Applications	208.0	248.8
Capital		
- Total capital	157.9	229.6
Debt repayment		
- Total debt Service	35.5	47.7
Other		
- Total other	14.6	-28.5
Balance		
- Cash increase/decrease for year	-19.1	-16.8
- Opening balance	0.0	-19.1
- Closing balance	-19.1	-35.9

(Source: PPL)

The borrowing situation of the PPL is also comparatively sound. The PPL entered into a multi-option revolving credit facility with a consortium of banks (Bank of South Pacific Limited Domestic Facility) for a total amount of 331 million PGK as credit line, and the result of total

drawn down was 155 million PGK in 2008. The Bank of South Pacific Limited is a lead manager and lending rate is 8.45% per annum (interest rate: 1.00%). Total borrowing of the PPL is shown in Table 2.3-2.

Table 2.3-2 PPL Borrowing (unit: thousand PGK)

	2008	2007
Current		
Bank South Pacific Limited –Domestic Facility	17,574	3,499
Bank Overdraft	32,615	13,582
Total secured current borrowings	50,189	17,081
Non-current		
Bank South Pacific Limited-Domestic Facility	137,540	117,797
Total secured-non current borrowings	187,729	134,878

(Source: PPL)

Nevertheless, it would be worth noting that PPL's long-term attempts at strengthening its financial status could be undermined by the three factors of cost structures listed below:

1) Some of the tariffs and rates are regulated and determined by government law (Independent Consumer and Competition Commission Act 2002). At present, the tariff is determined in accordance to the consumer price index (CPI). Still, there remains a political difficulty which may hinder the full recovery of their cost in case of inflation.
2) The International Price Index of oil is increasing, which is a major operation expense for the PPL. Direct fuel costs have increased by 65% in 2008 compared to their costs in 2007.
3) Shortage of electricity supply by the PPL is now remedied by purchasing from several independent power producers (IPPs). In addition, most of the IPPs get their power source from thermal power, especially diesel. It means there is a risk of increase in operation cost in case there is an increase in the international price index of oil.

Moreover, it is highly possible that risks 2) and 3) will occur simultaneously. The history of electricity tariff increase, and the past and forecast revenue estimated by the PPL are shown in Tables 2.3-3 and 2.3-4, respectively.

Table 2.3-3 History of Electricity Tariff Increase

Year	Average Tariff (Toea/kWh)	Tariff Increase
2002	36.19	13.50%
2003	40.72	12.50%
2004	44.42	9.10%
2005	49.87	12.25%
2006	56.20	12.71%
2007	57.64	2.56%
2008	62.92	9.16%
2009	71.57	13.75%
2010	69.57	-2.80%
2011	76.46	9.91%

(Source: PPL)

Table 2.3-4 Revenue and Earnings Indicator (unit: million PGK)

	2006	2007	2008	2009	2010	2011f	2012f	2013f	2014f	2015f
Operating Income	371	397	439	504	535	620	793	992	1,171	1,377
EBITDA*	69	89	44	138	79	82	124	175	304	458
Net Profit before Tax	44	56	8	102	31	34	53	93	179	321
Net Profit %	11.9%	14.1%	1.8%	20.2%	5.8%	5.5%	6.7%	11.7%	15.3%	23.3%

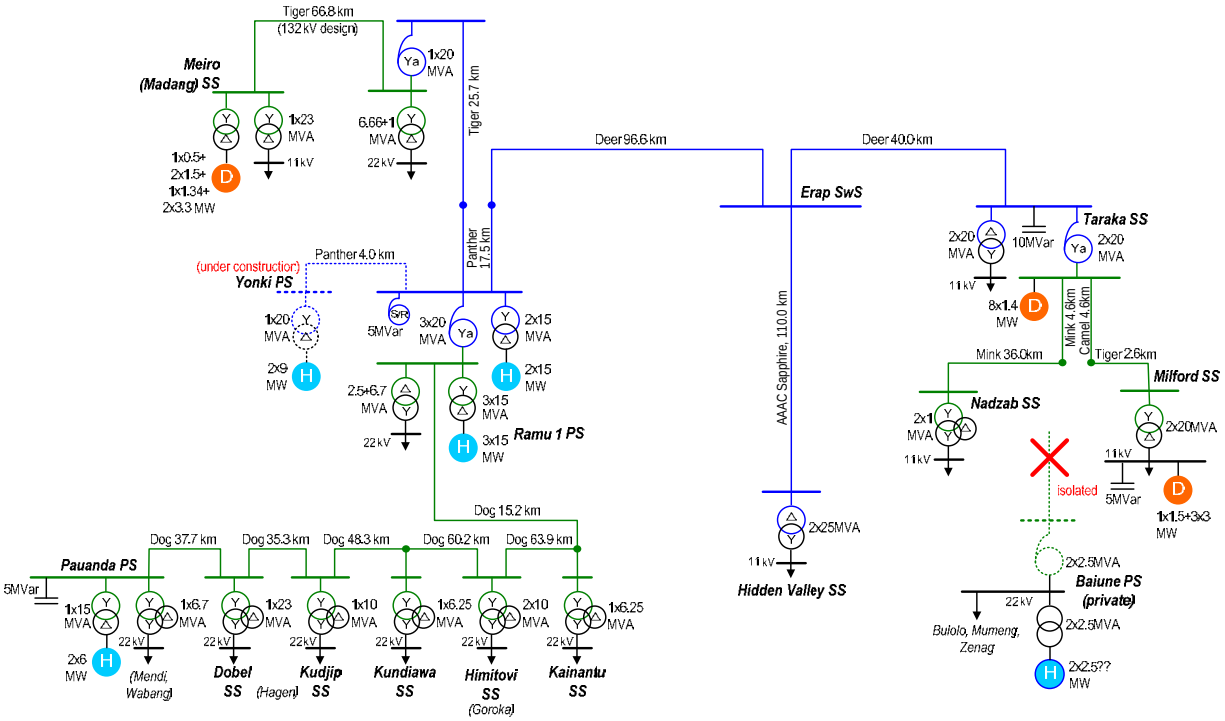
Note*: Earnings before interest, tax, depreciation and amortization.

(Source: PPL)

2.4 Development Plans of Ramu Grid

2.4.1 Ramu Grid

Figure 2.4-1 shows system diagram of the existing Ramu grid as of November 2011.



(Prepared by the Survey Team)

Figure 2.4-1 Existing Ramu Grid

The Ramu grid supplies electric power to nine supply centres such as Lae (Morobe), Madang (Madang), Goroka (Eastern Highlands), Kainantu (Eastern Highlands), Mount Hagen (Western Highlands), Kundiawa (Chimbu), Yonki (Eastern Highlands), Mendi (Southern Highlands) and Wabag/Wapennamanda (Enga).

Major power sources of the Ramu grid are hydropower stations (HPS) located at Ramu 1 (5x15 MW) and Pauanda (2x6 MW), and diesel generators located at Taraka, Milford, Meiro (Madang), Mendi and Wabag which supply supplementary power during power shortage and/or transmission line outage periods. Yonki Toe HPS (2x9 MW) is now under

construction and is set to be commissioned in the middle of 2012.

Table 2.4-1 shows a list of existing generating plants owned by the PPL in the Ramu grid as of November 2011.

Table 2.4-1 Existing Generating Plants in Ramu Grid

no.	name	type	units	installed unit capacity (MW)	total capacity (MW)	firm capacity (MW)	commissioning year
1	Ramu 1	hydro	3	15.00	45.0	33.00	1976
		hydro	2	15.00	30.0	24.00	1990
2	Panand11	hydro	2	6.00	12.0	5.00	1983
3	Taraka	diesel	8	1.40	11.2	9.00	2009
4	Milford	diesel	2	0.70	1.40	0.50	1959
		diesel	3	3.00	9.00	-	1971/79
		diesel	6	3.00	18.00	10.00	-
		diesel	1	1.50	1.50	1.20	2009
5	Meiro	diesel	1	0.50	0.50	0.40	1959
	(Madang)	diesel	2	1.50	3.00	1.20	1971/72
		diesel	1	1.34	1.34	5.40	1968
		diesel	2	3.30	6.60	0.50	1980/2008
6	Mendi	diesel	2	0.25	0.50	0.40	1975
		diesel	1	0.30	0.30	0.20	-
7	Wabag	diesel	1	0.30	0.30	0.30	-
		diesel	1	0.23	0.23	0.23	-
		diesel	1	0.63	0.63	0.62	-
				Total	141.50	91.95	

(Source: PPL)

As shown in Figure 2.4-1, the Ramu grid is a simple radial network with single-circuit 132 kV and 66 kV transmission lines extended from the switchyard of Ramu 1 HPS to Lae (Morobe), Madang and Highland areas. Any of the transmission lines in the Ramu grid does not satisfy the N-1 criteria for assessing the supply reliability of the transmission network.

The 132-kV transmission line between Erap switching station (SwS) and Hidden Valley substation (SS) was commissioned in December 2010 as the newest section in the Ramu grid. The transmission line between Gusap SS and Meiro SS is designed for 132 kV operation, but is currently operated at 66 kV.

Tables 2.4-2 and 2.4-3 show the lists of existing transmission lines and substations in the Ramu grid, respectively.

Table 2.4-2 Existing Transmission Lines in Ramu Grid

no.	sections		voltage	line id	length	number of	conductors
	from	to	(kV)		(km)	circuit	
1	Ramu 1 HPS	Singsing point	132	601	17.5	1	ACSR Panther
2	Ramu 1 HPS	Singsing point	132	602	17.5	1	ACSR Panther
3	Singsing point	Erap SwS	132	601	96.9	1	ACSR Deer
4	Singsing point	Gusap SS	132	602	25.7	1	ACSR Tiger
5	Erap SwS	Taraka SS	132	601/2	40.0	1	ACSR Deer
6	Erap SwS	Hidden Valley SS	132	603	110.0	1	AAAC Sapphire
7	Gusap SS	Meiro SS	66 (132)*	605	66.8	1	ACSR Tiger*
8	Taraka SS	Milford T1	66	509/1	4.6	1	ACSR Camel
9	Milford T	Milford SS	66	509/2	2.6	1	ACSR Tiger
10	Taraka SS	Milford T1	66	508/1	4.6	1	ACSR Mink
11	Milford T2	Nadzab SS	66	508/2	36.0	1	ACSR Mink
12	Ramu 1 HPS	Kainantu T	66	506/1	15.2	1	ACSR Dog
13	Kainantu T	Kainantu SS	66	506/2	4.0	1	ACSR Dog
14	Kainantu T	Himitovi SS	66	506/3	63.9	1	ACSR Dog
15	Himitovi SS	Kundiawa T	66	507/1	60.2	1	ACSR Dog
16	Kundiawa T	Kundiawa SS	66	507/2	4.0	1	ACSR Dog
17	Kundiawa T	Kudjip SS	66	514	48.3	1	ACSR Dog
18	Kudjip SS	Dobel SS	66	515	35.3	1	ACSR Dog
19	Dobel SS	Pauanda HPS	66	510	37.7	1	ACSR Dog

Note*: 132 kV design transmission line

(Source: PPL)

Table 2.4-3 Existing Substations/Switching Stations in Ramu Grid

no.	name	voltage ratios			number of units	unit capacity (MVA)	total capacity (MVA)	TR windings
1	Taraka SS	132	11		2	20.00	40.00	Dyn11
		132	66		1	20.00	20.00	YNa0
		132	66		1	20.00	20.00	YNa0d11
		66	11		1	10.00	10.00	Dyn11
2	Hidden Valley SS	132	11		2	25.00	50.00	Dyn11
3	Ramu 1 HPS	132	66		3	20.00	60.00	Yyn0
		66	22		1	2.50	2.50	Dyn11
		66	22		1	6.70	6.70	Dyn11
4	Erap SwS	132			-	-	-	-
5	Gusap SS	132	66		1	20.00	20.00	YNa0
		66	22	11	1	6.66	6.66	YNyn0d11
		66	22	11	1	1.00	1.00	YNyn0d11
6	Meiro SS	66	11		1	23.00	23.00	YNyn0d11
7	Milford SS	66	11		2	20.00	40.00	Ynd11
8	Nadzab SS	66	22	11	2	1.00	2.00	Dyn11
9	Kainantu SS	66	22	11	1	6.25	6.25	YNyn0d11
10	Himitovi SS	66	22	11	2	10.00	20.00	YNyn0d11
11	Kundiawa SS	66	22	11	1	6.25	6.25	YNyn0d11
12	Kudjip SS	66	22	11	1	10.00	10.00	YNyn0d11
13	Dobel SS	66	22	11	1	23.00	23.00	YNyn0d11
14	Pauanda HPS	66	22	11	1	6.70	6.70	YNyn0d11

Note: Step-up transformers for generating units are not included in the above list.

(Source: PPL)

The 132 kV transmission line between Ramu 1 – Erap – Taraka is the most important section as it is the backbone of the Ramu grid in supplying bulk electric power to Lae, the largest demand centre. However, since the Ramu 1 – Taraka line does not apply a single-phase

auto-reclosing system to minimize line outage time due to single-line-to-ground faults, it is judged that stable and continuous power supply over the lines seems difficult.

2.4.2 Generation Development Plan

The Infrastructure Planning Team of the PPL prepared the long-term Generation Development Plan 2011-2025 (GDP 2025) in May 2011. This plan presents generation development needs and options for all centres currently served by the PPL including the Port Moresby, Ramu and Gazelle grids. Based on the expected load growths and generally old assets, two main methods are applied to planning. These are: i) loss of load modelling and ii) least cost analysis.

As for the development plan for the Ramu grid, the GDP 2025 mentioned the following:

1) To meet reliability criteria in a cost-efficient way, the preferred development path is to increase the operating performance of the existing hydro assets. However, in the short term, rehabilitation of new underperforming diesel generators would be required to make up for the unreliable performance of Ramu 1 HPS.
2) Some of the existing diesel generators are already old and with poor reliability, and thus they have to be replaced early in the planning period. There is a need for a new power station in Lae to accommodate the replacement of Milford generation and augment the capacity over time.
3) An additional 20 MW of low-cost generation can be absorbed (at 50% capacity factor) within the next five years, and another 25-35 MW towards the end of the planning period.
4) There are some planned industrial developments in Lae and Madang that may add significant loads. The exact timing and scope of these developments are still unclear and has not been included in the loss of load modelling.

The GDP 2025 summarized and recommended the following:

1) Refurbish, maintain or replace existing diesel generators at Taraka, Milford, and Madang,
2) Refurbish Ramu 1 in 2012,
3) Add at least 5 MW every second year from 2016 onwards until major new generation sources are to be commissioned; and
4) Develop major low cost generation sources in the latter parts of the planning period.

Table 2.4-4 summarizes the development options for the Ramu grid from 2011 to 2025.

Table 2.4-4 Development Options for Ramu Grid

timing	required capacity	0ptions	key objectives	production costs (PGK/kWh)
2011-2016	20-30 MW	Upgrade of Ramu 1	Maintain reliability Reduce average unit cost of production	0.25
		Refurbish existing non operating diesel generators		0.74-1.20
		Additional diesel generators (medium speed)		0.76-1.23
2017-2024	20 MW*	Ramu 2 supply (240 MW)	Maintain reliability	0.30
		Mongi/Bulum hydro scheme (60-90 MW)	Reduce average unit cost of production	0.30
		Kaugel hydro scheme		0.30

Note: *depending on supporting mining loads

(Source: Generation Development Plan 2011-2025, PPL)

The abovementioned generation development plans are to be considered for the power flow calculations to be discussed in Chapter 4.

2.4.3 Transmission System Development Plan

The Infrastructure Planning Team of the PPL prepared a long-term transmission system development plan named “High-Level Transmission and Distribution Development Plans, Port Moresby, Ramu, and Lae, 2011 to 2025 (TDDP 2025)” in August 2011 to identify the key augmentations and upgrades required in the transmission and distribution systems in Port Moresby, Ramu, and Lae.

Regarding the development for the Ramu grid, the TDDP 2025 mentions that there are some prioritized upgrades/constructions that are required within the planning period as shown in Table 2.4-5.

Table 2.4-5 Transmission and Distribution Development Plan for Ramu Grid

priority	projects	timing	comments
1	602 line - improve bypasses from Gusap to Meiro	2010/11	completed
2	Taraka – install 10 MVA STATCOM	2011	under construction
3	Pauanda – upgrade capacitor bank to 5 MVA	2012	
4	601 Ramu to Singsing – construct Singsing switchyard	2012/13	under JICA FS
5	510 line-redundancy using 22 kV line from Pauanda to Dobel	2011/12	Arrangement and operating model to be assessed by networks business unit in 2012
6	602 line – 132 kV operating voltage from Gusap to Meiro	2014-2016	Detailed study to be completed in 2012

(Source: High Level Transmission and Distribution Development Plans, Port Moresby, Ramu and Lae, 2011 to 2025, PPL)

In addition to the abovementioned plans, the following projects are indicative prioritizations of optional transmission upgrades:

1) Singsing to Erap – second 132 kV line
2) Erap to Taraka – second 132 kV line or 2 x 66 kV Erap to Milford

3) Ramu to Goroka – complete second line
4) Goroka to Hagen – second line
5) Singsing to Meiro – second line
6) Ramu to Pauanda – change operating voltage to 132 kV
7) Ramu to Port Moresby system interconnection

These projects are not considered financial and/or economically viable during the planning stage (unless there are major changes in loads/generation). However, the highest priority projects can be completed if low-cost financing is available from donor agencies such as the World Bank, JICA, and Asian Development Bank (ADB).

The TDDP 2025 also mentions transmission and distribution reinforcement plans for Lae, the largest load centre in the Ramu grid. Significant load growth is expected in the Malahang/Singawa industrial area in Lae and a new substation is required to cater to these loads. The preferred distribution voltage at Singawa SS is 22 kV with a medium-term aim of converting all of Lae to the same voltage. Table 2.4-6 summarizes the plan for Lae.

Table 2.4-6 Transmission and Distribution Development Plans for Lae

no.	projects	timing
1	Build new substation at Singawa	2011/12/13
2	Complete detailed study of conversion to 22 kV distribution voltage in Lae	2011/12
3	Build 132 KV transmission line Taraka – Singawa	2012/13
4	Build 66 kV transmission line Singawa – Milford	2014
5	Augment (and covert to 22 kV) Taraka and Milford substations as required	2015-

(Source: High Level Transmission and Distribution Development Plans, Port Moresby, Ramu and Lae, 2011 to 2025, PPL)

The abovementioned transmission system development plans for the Ramu grid and Lae are to be considered for the power flow calculations to be discussed in Chapter 4.

2.5 Other Donors' Assistance to PPL

In this section, the activities of other international organizations with regards to transmission and distribution projects are discussed. In the case of the PPL, current projects are funded by a single international organization only, which is the ADB, as follows:

1) ADB, Port Moresby Power Grid Development Project 2 (PGDP2)

   PGDP2 is a program to provide loans to financial institutions in upgrading and extending the transmission and distribution grid in Port Moresby, thereby improving the reliability and quality of power supply, improving the energy efficiency of power delivery, and enabling delivery of essential power to rapidly expanding areas in Port Moresby. PGDP2 includes the two purposes as enumerated below:

   i) Upgrading to support the additional load

ii) Extending to supply new industrial and residential areas

The project is especially for LNG Plants as well as the continued growth in the mining sector and the associated industries. The project is scheduled to be approved in June 2012, and the total amount of loan is US$ 80 million.

2) ADB, Town Electrification Investment Program (TEIP Tranche I)

The project is a multi-tranche financing facility (MFF) with two tranches to be implemented over a six-year period. The loan was approved on December 2010 and expected to be completed by December 2013. Each tranche is comprised of a number of sub-projects, including construction of renewable energy generation projects such as hydropower plants, and transmission systems. Projects under TEIP Tranche I include the following:

i) Kimbe to Bialla Interconnection - West New Britain Province,
ii) Divune Hydropower Plant - Northern Province, and
iii) Ramazon Hydropower Plant - Autonomous Region of Bougainville.

The DPEne is the executing agency and the PPL is the implementing agency. The project financing for TEIP Tranche 1 is estimated at US$ 57.3 million, of which US$ 16.40 million and US$ 40.90 million will be provided by the Asian Development Fund and Ordinary Capital Resources. The Loan has a principal repayment period of 20 years, and interest rate is the sum of LIBOR and 0.60%.

3) ADB, Town Electrification Investment Program (TEIP Tranche II)

The project is scheduled to be implemented by January 2013, with physical completion by December 2016. The scope of the project is currently undetermined. The PPL estimates its project cost at US$ 100 million. However, the full amount will not be required as there are internally generated loans available at reasonable levels during those years.

CHAPTER 3

CURRENT SITUATION OF THE PROJECT SITE

CHAPTER 3 CURRENT SITUATION OF THE PROJECT SITE

3.1 General

The new transmission line, with a distance of approximately 136 km, is planned to run along the Markham River and the existing 132 kV transmission line between Lae in the eastern area of New Guinea Island and Wankun in the Eastern Highlands, where the Highlands Highway from Lae meets the Ramu Highway.

The Survey Team visited the transmission line sites several times in November 2011, including related substations (SS) and power station sites. The route of the new transmission line will connect Taraka SS in Lae and the proposed new Singsing SS in Wankun, and its altitude range is estimated to be between 55 m and 501 m.

There is existing 132 kV single-circuit transmission line mostly running in parallel with the Markham River together with the Highlands Highway. For ease of access and maintenance, the route of the proposed new line will also run in parallel with the existing line. According to the PPL, there is enough space for the new transmission line in both the northern and southern sides of the existing line. The new line will mostly run through farms, banana plantations, coconuts plantations, and coffee plantations. There seems to be no serious environmental effects caused by the construction.

The PPL's numbering of the existing 132 kV line towers is made from the Taraka (Lae) side. All the description of the line route in this chapter will be made from the Taraka SS side to the new Singsing SS side.

3.2 132 kV Transmission Lines

3.2.1 Taraka – Erap Section

The slack span at the outdoor switchyard in Taraka SS is terminated on the anchors buried in the ground without any gantry structures. In the design of the new transmission line, such termination is to be avoided as much as possible because of its short clearance from the live conductors even though it is a technically allowed value.

After starting from Taraka SS, the existing line goes through a relatively congested residential area. Unfortunately, because of the unstable security during the site survey, the Survey Team was not allowed to go into this area. From satellite photographs, it can be seen that the existing line passes through this residential area for about 3 km. Then, the

existing line goes into the small hills called Atzera Range. This hilly range is a jungle of broad-leaved plants in such a way that the trace of tree clearing is distinct in satellite photographs. The limited space beside the Highlands Highway is occupied by the existing 66 kV transmission line and the 11 kV distribution line, and thus the construction of the new 132 kV transmission line in the upper hill is technically a good choice.

Approximately 14 km from Taraka SS, the existing line goes out from the jungle and crosses the Highlands Highway. After the crossing, the existing line runs through a flat terrain which consists of banana, coconut, and coffee plantations, and empty flat fields. Construction of the new line in the said flat fields seems easy. The numbers of houses to be encountered also look limited.


End of Jungle Terrain


Plantations

Approximately 33 km away from Taraka SS, the existing line crosses the Erap River. According to the local people who guided the Survey Team, the river water covers the top of the existing tower foundation during the rainy season. Although the tower numbers at the river crossing point could not be confirmed because the number plates attached to the existing towers are broken, it looks like this river crossing is made by tower Nos. 82 and 83. The PPL's tower schedule (table of tower types, span lengths, and foundations) shows that those two towers are equipped with pile foundations. Pile foundations are considered for the new line over this river crossing to ensure high reliability.


Tower for Erap River Crossing


Tower for Erap Rover Crossing

After the Erap River crossing, terrain vegetation changes drastically. Most of the existing line routes pass through stock farms. Broad-leaved plants are located far away from the

line and even the plantations can rarely be seen. However, the burnt field around the existing line may be utilized for plantations in the future.


Stock Farm Terrain

Erap SS is located 7 km away from the Erap River crossing. Since Erap SS is in the middle of the wide stock farm terrain, there is no difficulty in tapping into the substation by means of slack span.


Tower No.92

According to PPL's tower schedule, the approximate line length of the existing transmission line from Taraka SS to Erap SS is 40 km. The existing tower numbers started from No. 1 at the Taraka side and ended up with No. 92 in front of Erap SS.

3.2.2 Erap – Singsing Section

The existing line starts from Erap SS and again runs through the long stock farm terrain. The Survey Team measured the height of the bottom conductor above the Highlands Highway using an optical distance meter. The height of the conductor is 8.0 m with a 1.3 m allowance for the required 6.7 m. The tensioning condition of the existing conductor seems generally appropriate.

The existing line crosses the Leron River at a point 35 km from Erap SS. This river has a very wide river bed. There is no artificial dike or embankment so that erosion of the natural riverbank may happen in the future. From the number plates on the towers, this river crossing is made by tower Nos. 181 and 182. PPL's tower schedule for the existing line shows a span length of 1,643 ft (501 m), which is very long. There is no record of employing pile foundations or any other remarks.


Leron River Crossing


Leron River Crossing

After the Leron River crossing, the existing line again runs through the stock farm terrain.

The line again crosses the Umi River at a point 70 km from Erap SS. This river also has a wide river bed and its river banks do not have any artificial protection. In the middle of the river bed, one tower is erected with a bent pile foundation. Hence, the foundation is designed to withstand the river flow. However, there is no record of the pile foundation or any other remarks in PPL's tower schedule.


Bank of Markham River


Bent Pile Foundation

The existing line keeps running in the stock farm terrain. At about 26 km after the Umi River, the line reaches the prospective location of Singsing SS, where the double circuits of 132 kV existing lines from Ramu 1 HPS separates into two directions. One of them goes to Taraka SS via Erap SS, and the other goes to Gusap SS.


Separation to Erap and Gusap


Ramu 1 Direction from Singsing

At the location of Singsing SS, the existing line has the 90° cross-arm tower No. 303. The distance from the Erap SS up to tower No. 303 is approximately 96 km while the total distance from Taraka SS is approximately 136 km.

3.2.3 Singsing – Ramu 1 Section

Construction of the new transmission line in this section is not included in the scope of the Project. However, the situation of the existing line is discussed hereunder for reference.

From Singsing SS's location towards Ramu 1 HPS, the terrain vegetation becomes a combination of bush and broad-leaved plants. The road from Singsing SS's location climbs up to an altitude of approximately 1,300 m at Ramu 1 HPS from 500 m. The road towards Western Highland Province branching from Highlands Highway is a winding road and the

existing line goes along this road up to Ramu 1 HPS. The existing line consists of two parallel single-circuit lines in this section.

At Ramu 1 HPS, the existing line ends with tower No. 341.

3.3 Substations

The Survey Team visited the candidate SS sites to check the actual conditions of the equipment, and look for relevant concerns and issues about the equipment and the site.

3.3.1 Ramu 1 Switchyard

(1) Site Conditions

The existing 132/66 kV Ramu 1 switchyard is a part of Ramu 1 HPS located in Kainantu District of Eastern Highland Province, which is about 150 km away from Lae in the west-northwestern direction.


Ramu 1 switchyard


Erap line bay

There are seven 132 kV bays including two transmission line bays for Erap (#601) and Gusap (#602), three 66/132 kV auto-transformer bays, and two step-up transformer bays for generator units. There are nine 66 kV bays including one transmission line bay for Kainantu (#506), three 66/132 kV auto-transformer bays, two 132/22 kV distribution transformer bays, and three step-up transformer bays for generator units. Although the 66 kV switchyard utilizes the “main and transfer” busbar system, the 132 kV switchyard uses the single busbar system.

(2) Issues

The Survey Team found the following issues on Ramu 1 switchyard through the field survey and interview with operators.

1) 132 kV outdoor switchyard
   i) Surge arresters (SA) are not installed in the Erap and Gusap line bays.
   ii) Insulation oil leaks from the capacitor voltage transformer (CVT) of the Erap line bay.
   iii) Gas circuit breaker (GCB) of the Erap line bay is single/three phase operation type and short-circuit current capacity of the GCB is 16 kA.

2) Control room

i) Currently, distance relay is used as the main protection for transmission lines of Erap and Gusap, but there are no back-up protections. Distance relay (21B) for Gusap line is an old-fashioned mechanical-type relay. Directional over-current/directional over-current grounding protection relays are not used for the lines.

ii) Although optical ground wires (OPGW) have already been installed on both Erap and Gusap lines, they are used only for transfer trips and not for an internal telephone system between stations, which is uses the power line carrier (PLC) system.

iii) 110 V DC power supply system including chargers and cells seems deteriorated and has no supply capacity for future extension.

iv) Although the 48 V DC power supply system equipped with the PLC system was installed about two years ago, the system does not apply the double charging system and the capacity is not suitable for future extension of the communication system.

v) There is no space for the new 110 V and 48 V DC battery systems in the existing control building.

3.3.2 Singsing Substation

The planned 132/33 kV Singsing SS site is located at Latitude 6° 08' 45.57'' South and Longitude 146° 02' 21.27'' West in Kainantu District of Eastern Highland Province, which is about 130 km away from Lae in the west-northwestern direction.

As shown in Figure 3.3-1, the candidate substation site is located along the highway between Lae and Yonki and estimated to have an area of approximately 13,150 m^2 considering the planned substation scale.

The PPL have to acquire the land for the substation premises. There is no household in the premises.


Planned substation site

(Prepared by the Survey Team based on Google Earth Pro)

Figure 3.3-1 Singsing Substation Location

3.3.3 Erap Substation

(1) Site Conditions

The existing 132 kV Erap SS is located in Markham Valley of Morobe Province, which is about 40 km away from Lae in the west-northwestern direction. Erap SS is one of the newest substations in the Ramu grid, commissioned in December 2010.

There are three 132 kV transmission line bays in the switchyard including one each for Ramu 1 switchyard, Taraka SS and Hidden Valley SS. The "one-and-a-half circuit breaker" busbar scheme is applied to the existing 132 kV switchyard.

Land space for the additional installation of three 132 kV bays is available in the existing 132 kV switchyard.


Erap substation


Extension Area

(2) Issues

The Survey Team found the following issues on Erap SS through the field survey and interview with operators.

1) 132 kV outdoor switchyard
   i) Although land space for the additional three 132 kV bays is available in the existing switchyard, three 132 kV transmission line bays, two 132 kV transformer bay, two units of 132/66/33 kV main transformers, two 66 kV transformer bay, and a 66 kV single busbar are planned to be installed in Erap SS under the Project as described in Chapter 6. Extension of SS land space is needed.
   ii) Since land level of the existing switchyard is elevated 1,300 mm from the neighbouring ground level, the land to be extended shall be elevated up to the same level.

2) Control room
   i) Currently, distance relay is utilized as the main protection for transmission lines of Ramu 1 and Taraka, but there are no backup protections. Directional over-current/ directional over-current grounding protection relays are not used for the lines.
   ii) Although OPGWs has already been installed on the Ramu 1, Taraka and Hidden Valley lines, they are used only for transfer trips and not for an internal telephone system between stations, which uses the PLC system.
   iii) Although the 48 V DC power supply system equipped with PLC system was installed about two years ago, the system does not use the double charging system and the capacity is not suitable for future extension of the communication system.
   iv) There is no spare space for the installation of the planned 33 kV switchgear cubicles in the control building.
   v) Power source of the SS is supplied from the existing 11 kV distribution line.

3.3.4 Taraka Substation

(1) Site Conditions

The existing 132/66/11 kV Taraka SS is located in the northwestern suburb of Lae in Morobe Province. Taraka SS is one of the most important substations in the Ramu grid to supply bulk electric power to Lae and was commissioned in the early 1970s.


Taraka substation

There are one 132 kV transmission line bay for Erap SS, two 66 kV transmission line bays for Milford and

Nadzab, and nine 11 kV distribution feeders in Taraka SS. There are two units of 132/66 kV 20 MVA auto-transformers and two units of 132/11 kV 20 MVA main transformers in Taraka SS. Single busbar system is applied for both the 132 kV and 66 kV switchyards. The 132 kV 10 MVar static var generator (SVG) was undergoing installation as of November 2011.


Single busbar and TR bays

Since land space for the installation of an additional one 132 kV transmission bay is available, extension of substation premises is not needed. However, upgrading the 132 kV single busbar system into a double busbar system or a one-and-a-half circuit breaker busbar system is very difficult due to the limitation of the 132 kV switchyard and difficulty of land extension.

(2) Issues

The Survey Team found the following issues on Taraka SS through the field survey and interview with operators.

1) 132/66 kV outdoor switchyard
   i) 132 kV SAs are not installed in the existing Erap line bay.
   ii) Two units of 132 kV CVTs are connected to the 132 kV single busbar to measure the bus voltage and for synchro-checking purposes. However, since the secondary sides of the CVTs are delta connection, they are not suitable for over-voltage ground fault protection.
   iii) 132 kV GCBs and current transformers (CT) are not installed on the primary side of four units of 132 kV main transformers.
   iv) 66 kV SAs are not installed in the Milford and Nadzab line bays.
   v) Insulation oil leakages from the following equipment are observed:
      - 66 kV voltage transformers (VT), CTs and oil insulated circuit breakers (OCBs) of the Milford line bay
      - 66 kV CTs and OCBs of the Nadzab line bay
      - 66 kV CTs and OCBs of secondary side of 132/66 kV auto-transformers

2) Control room
   i) 11 kV switchgear cubicles have burned down during a fire. Currently, 11 kV feeders are operating with the temporary overhead distribution line.
   ii) Currently, distance relay is utilized as the main protection for transmission line of Erap, but there are no backup protections. Directional over-current/directional over-current grounding protection relays are not used for the line.

iii) Although OPGW has already been installed on the existing Erap line, it is used only for transfer trips and not for an internal telephone system between stations, which uses the PLC system.

iv) 110 V DC power supply system including chargers and cells seems deteriorated and has no supply capacity for future extension.

3.4 Distribution Network in Lae

Lae is the largest load centre in the Ramu grid. Two substations, namely Taraka and Milford, and a total of eleven 11 KV feeders are currently serving the city. The Survey Team visited Lae to check the current situation of the distribution network and found issues through the site investigations and interview with the PPL officials.

(1) Substations

Figure 3.4-1 shows the location of substation sites in Lae including the existing Taraka and Milford SSs and the planned Singawa SS.

(Prepared by the Survey Team based on Google Earth Pro)

Figure 3.4-1 Substation Sites in Lae

Table 3.4-1 summarizes the existing transformer capacities with peak load, saturation factors and whether or not they meet the N-1 criteria.

Table 3.4-1 Existing Substations in Lae

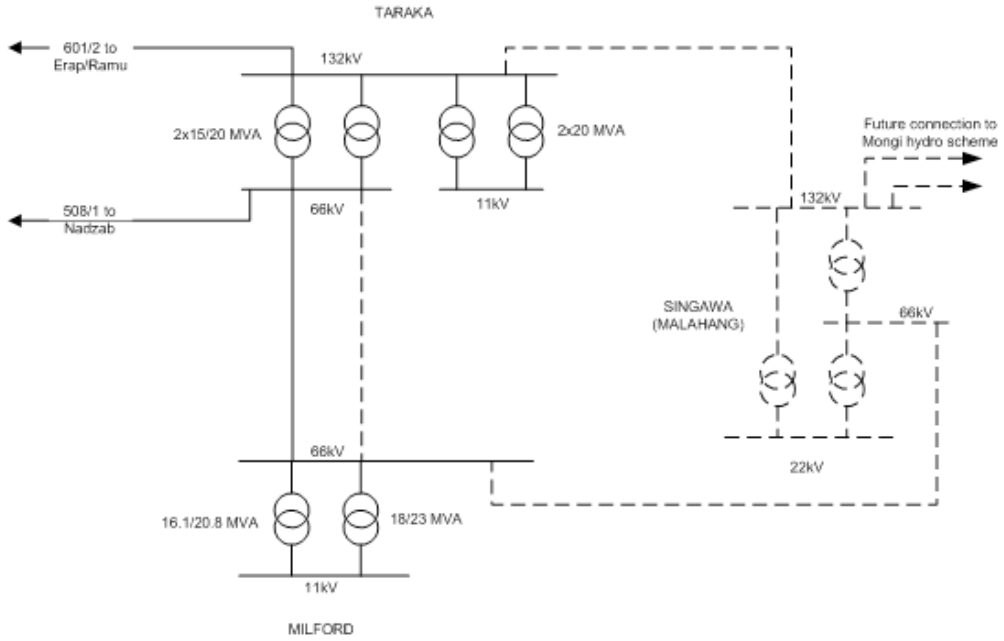
Substation	Transformer Capacity	Peak Load 2010	% Saturated	N-1 criteria
Milford	1 x 23 MVA 66/11 kV 1 x 20 MVA 66/11 kV	31.6 MVA	73%	No
Taraka	2 x 20 MVA 66/11 kV	14.7 MVA	36.5%	Yes

(Source: High Level Transmission and Distribution Infrastructure Development Plan, PPL)

Milford SS is highly-loaded and does not satisfy the N-1 criteria. Therefore, loads from this SS should be diverted to Taraka as well as to the new Singawa SS, which is planned by the PPL.

1) Singawa substation

Figure 3.4-2 shows the future plan of transmission/distribution network in Lae.



(Source: High Level Transmission and Distribution Infrastructure Development Plan, PPL)

Figure 3.4-2 Future Network Plan in Lae

Singawa SS will be required to meet the industrial demands in Malahang/Singawa area, which is forecasted to have a significant load growth. Singawa SS is planned to be connected with the 132 kV 1-cct transmission line with Taraka and 66 kV 1-cct transmission line with Milford. The distribution voltage from Singawa SS is planned as 22 kV, which is a part of the medium-term aim of converting all of Lae to the same voltage.

2) Taraka and Milford substations

The PPL gives a higher priority to improving the security of supply in Lae from the existing SSs before the construction of Singawa SS and the upgrading of distribution voltage from 11 kV to 22 kV. By rearranging open points on the existing 11 kV feeders and additional 66 kV transmission lines between Taraka and Milford, the N-1 criteria

can be achieved.

Initially, 5 MVA loads of Milford SS should be shifted to Taraka SS, although Taraka SS can only keep saturation below 50%. The additional 66 kV transmission line and appropriate sectionalizing of 11 kV feeders would allow both SSs to meet the N-1 criteria despite being loaded beyond 50%.

In the long term, with the existing diesel generators moving from Milford and Taraka to Singawa, there will be adequate space to develop the older SSs with additional and/or larger transformers. This will ensure that the N-1 criteria can be achieved in a cost effective way.

(2) 66 kV Transmission Lines from Taraka Substation

There are two 66 kV transmission lines from Taraka SS to Milford and Nadzab SSs. Some parts of the transmission lines are supported by steel poles. Through the site visit, the Survey Team found the following issues on the 66 kV transmission lines, especially for the steel pole-supported sections:

1) Improper clearance between live lines and steel poles as shown in the right photograph,
2) Broken suspension and tension insulators,
3) Very sharp angles between the steel poles, and
4) Improper clearance between conductors and the ground.

It is easy to assume that the above issues sometimes cause single-line-to-ground faults. Appropriate countermeasures have to be taken, and regular inspections and maintenance are needed to ensure the reliability of power supply.

(3) Distribution feeders

The key issues at the distribution level in Lae are as follows:

1) Switching restrictions
   i) Increases in loads along feeders are causing difficulty with switching. Switching points need to be re-positioned with respect to the current loads, to allow for load switching and transfers.
   ii) Isolators rated at 100 A have been burnt out and are now bypassed/bridged through which limits the ability to switch and transfer loads.

2) Conductor/feeder capacity constraints
   Low capacity conductors namely Apple (6/1/3.00, 42 mm^2), Banana (6/1/3.75, 66 mm^2),

Cherry (6/4.75, 7/1.60, 106 mm^2) and Grape (30/7/2.50, 147 mm^2) are still in use. These provide weak points on the feeder and restrict the full utilization of the standard Saturn conductor (37/3.00, 260 mm^2).

(4) Other Issues

1) Nadzab substation

Nadzab SS, which is 40 km away from Lae and is connected to Taraka SS, supplies electric power mainly to Nadzab airport and its surrounding area. The existing main transformer directory in Nadzab SS connects with the 66 kV transmission line from Taraka SS without a busbar.

It is difficult to control and protect the SS under such situations. The PPL plans to install a main transformer in the existing Erap switching station, which is located close to the airport, in order to improve the situation and to supply electric power to the airport and the surrounding area through the new 22 kV distribution lines from Erap SS.

2) Illegal connections

According to the PPL in Lae, there are illegal connections that are stealing electric power from the low-voltage distribution line. It is easy to steal electric power by hanging a hook on a bare conductor of the low-voltage line, but it is difficult to discover it.

3) Lightning during the rainy season

Lightning happens frequently during the rainy season (from January to March) and sometimes strikes transmission/distribution lines. Thus, appropriate countermeasures such as installation of shield wires and SAs are needed.

(5) Recommendations

Among the above mentioned issues of distribution network in Lae, to improve the power supply situations, it is recommended to implement the following projects urgently.

1) Construction of new Singawa substation to share the loads on Taraka and Milford substations
2) Reconstruction of steal-pole supported 66 kV transmission lines to tower supported ones to secure the safety and to avoid ground faults
3) Replacement of small-sized conductors of 11 kV distribution lines to standard Saturn conductor and to remove constraint on the network utilization
4) Additional installation of load-break switches and/or disconnecting switches on the existing 11 kV lines to avoid the switching restrictions

CHAPTER 4

POWER FLOW CALCULATIONS

CHAPTER 4 POWER FLOW CALCULATIONS

4.1 General

The objective of the power flow calculations is to validate the status of the future Ramu grid, especially for 132 kV transmission lines from Ramu 1 HPS to Taraka SS through Singsing SS and Erap SS, in formulating the transmission system development plan. The active and reactive power flows on transmission lines, and voltages and phase angles at each bus in power stations and substations/switching stations are to be simulated in the calculations.

The PPL has provided all necessary information and data required for the calculations including the line constants, transformer capacities, generating and load conditions, static capacitors and shunt reactors, etc. The PPL has also provided long-term generation and transmission development plans (Clause 2.4). They also provided an energy and power demand forecasts from 2011 to 2025 (to be reviewed in Clause 4.2).

The Survey Team has built future network models suitable for the calculations in 2015, target commissioning year of the Project, 2020, and 2025 based on the provided network data, development plans and demand forecast.

The Survey Team has carried out the power flow calculations using "PSS/E^{TM} version 33" software with the following procedure;

1) Confirming power supply/demand balance based on the peak demand forecast of each substation and generation development plans.
2) Setting system planning criteria for screening the calculation results.
3) Making preliminary network models based on the existing system configurations and network development plans.
4) Calculating preliminary network models and screening of the results with the system planning criteria.
5) Adding network elements such as transmission lines, transformers, static capacitors, etc., and recalculating until results satisfying the criteria are obtained.

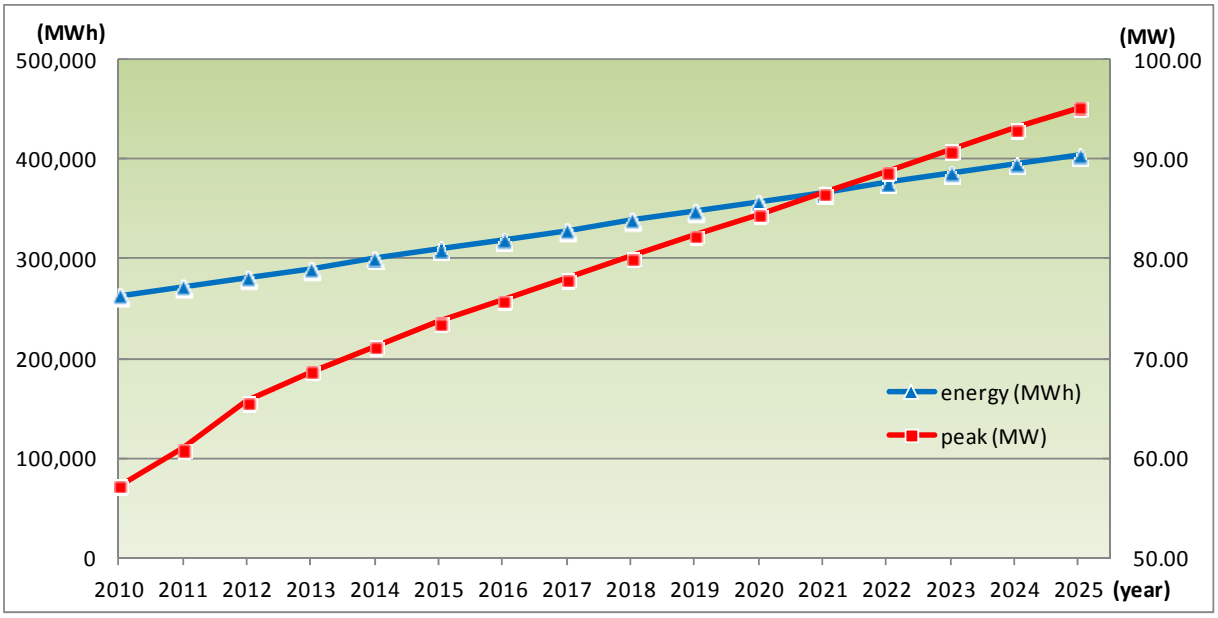
4.2 Review of Demand Forecast

4.2.1 PPL's Demand Forecast

The Strategic Infrastructure Planning of the PPL forecasts an energy and peak demand of 11

supply centres in the Ramu grid, based on the trends of previous sales records since 1993. The PPL's energy and peak demand forecasts includes energy production forecasts, considering the average energy losses, and adjusted accordingly to GDP trends. Accounted as well are future additional specific commercial and industrial demands, such as sugar factory and LNG projects.

The Survey Team has received the latest PPL's demand forecasts from 2011 to 2025 for review. Figure 4.2-1 summarizes the PPL's energy and peak demand forecasts while Tables 4.2-1 and 4.2-2 show the details.



(Source: PPL Strategic Infrastructure Planning)

Figure 4.2-1 PPL's Energy and Power Demand Forecasts

Table 4.2-1 PPL's Energy Demand Forecast for Ramu Grid

	record	forecast															(MWh)
Centres	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
1 Goroka	18,940	18,999	19,058	19,118	19,177	19,236	19,295	19,354	19,414	19,473	19,532	19,591	19,650	19,710	19,769	19,828	
2 Gusap	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	5,662	
3 Hagen	29,841	30,019	30,196	30,374	30,552	30,730	30,907	31,085	31,263	31,441	31,618	31,796	31,974	32,151	32,329	32,507	
4 Kainantu	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	4,165	
5 Kundiawa	4,438	4,443	4,449	4,454	4,460	4,465	4,471	4,476	4,481	4,487	4,492	4,498	4,503	4,509	4,514	4,520	
6 Lae	145,305	154,674	162,841	171,008	179,175	187,342	195,509	203,676	211,843	220,010	228,177	236,344	244,511	252,678	260,844	269,011	
7 Madang	39,865	40,884	41,902	42,921	43,940	44,958	45,977	46,996	48,014	49,033	50,052	51,070	52,089	53,107	54,126	55,145	
8 Mendi	3,817	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,008	4,009	
9 Mumeng (Zenag)	5,439	5,539	5,639	5,739	5,839	5,939	6,039	6,139	6,239	6,339	6,439	6,539	6,639	6,739	6,839	6,939	
10 Wabag	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803	
11 Yonki	2,857	2,000	1,500	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	
Ramu Grid Toral	263,132	273,196	282,224	291,304	300,832	310,360	319,888	329,416	338,944	348,472	358,000	367,528	377,056	386,584	396,112	405,641	
growth rate		3.8%	3.3%	3.2%	3.3%	3.2%	3.1%	3.0%	2.9%	2.8%	2.7%	2.7%	2.6%	2.5%	2.5%	2.4%	

(Source: PPL Strategic Infrastructure Planning)

Table 4.2-2 PPL's Peak Demand Forecast for Ramu Grid

	record	forecast															(MW)
	Centres	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1	Goroka	4.50	4.51	4.53	4.54	4.56	4.57	4.59	4.60	4.61	4.63	4.64	4.66	4.67	4.69	4.70	4.71
2	Gusap	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
3	Hagen	5.20	5.23	5.26	5.29	5.32	5.36	5.39	5.42	5.45	5.48	5.51	5.54	5.57	5.60	5.64	5.67
4	Kainantu	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
5	Kundiawa	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.22	1.23
6	Lae	33.00	35.72	38.83	40.69	42.55	44.40	46.26	48.11	49.97	51.82	53.68	55.53	57.39	59.24	61.10	62.95
7	Madang	8.90	9.95	11.47	12.61	13.26	13.74	14.07	14.30	14.52	14.75	14.98	15.21	15.43	15.66	15.89	16.12
8	Mendi	0.93	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
9	Mumeng (Zenag)	0.74	0.76	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.87	0.88	0.89	0.91	0.92	0.93	0.95
10	Wabag	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
11	Yonki	0.30	0.21	0.16	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	Ramu Grid Toral	57.24	61.03	65.68	68.68	71.25	73.65	75.89	78.04	80.18	82.32	84.47	86.61	88.76	90.90	93.05	95.19
	growth rate		6.6%	7.6%	4.6%	3.7%	3.4%	3.0%	2.8%	2.7%	2.7%	2.6%	2.5%	2.5%	2.4%	2.4%	2.3%

(Source: PPL Strategic Infrastructure Planning)

The PPL's demand forecast seems reasonable at 2.9 % annual average growth rate. However, the PPL's demand forecasts did not include the following: new mining demand, Hidden Valley Gold Mine, and planned mining demand such as Kurumbukari and Wafi Gold Mines. From the results of the discussions with the PPL, the following mining demands are to be included in the forecast considering the high possibility of realizing this demand.

1) Morobe Gold - Hidden Valley Gold Mine: 18.0 MW from 2011
2) Ramu Nickel - Kurumbukari Mine: 16.2 MW from 2014
3) Wafi Gold Mine: 10 MW from 2012, 30 – 50 MW in 2015 (to be connected to the Ramu grid), 100 MW in 2017 and 200 MW in 2024

4.2.2 Demand Forecast for Substations

The PPL's demand forecasts were simulated for each supply centre but not for each substation. Substation forecasts are needed for power flow calculations. As a result of discussion with the PPL considering the actual distribution network, each supply centre's demand had been assigned with the existing substations as follows:

1) Goroka: Himitovi SS 100 %
2) Gusap: Gusap SS 100 %
3) Hagen: Dobel SS 50 % and Kudjip SS 50 %
4) Kainantu: Kainantu SS 100 %
5) Kundiawa: Kundiawa SS 100 %
6) Lae: Taraka SS 40 % and Milford SS 60 % from 2011-2014
   Taraka SS 28 %, Milford SS 42 % and new Singawa SS 30 % from 2015-2025
7) Mumeng (Zenag) ex. Nadzab: 100 % Erap SS (from 2015)
8) Madang: Meiro SS 100 %
9) Mendi: Pauanda HPS 100 %
10) Wabag: Pauanda HPS 100 %

11) Yonki: Ramu 1 HPS 100 %

In addition, the PPL plans to install distribution transformer in Singsing SS for new residential demands from 2015 under the Project. The initial demand of Singsing SS is estimated at 1.0 MW with a 5 % annual increase rate.

Table 4.2-3 shows the peak demand forecast for substations:

Table 4.2-3 Peak Demand Forecast for Substations

		record	forecast														(MW)
Substations	TR capa (MVA)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Himitovi SS	2x10	4.50	4.51	4.53	4.54	4.56	4.57	4.59	4.60	4.61	4.63	4.64	4.66	4.67	4.69	4.70	4.71
			0.32%	0.32%	0.32%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.30%
Gusap SS	1x10	1.20	1.80	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
			50.01%	13.90%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Dobel SS	1x10	2.60	2.62	2.63	2.65	2.66	2.68	2.69	2.71	2.72	2.74	2.76	2.77	2.79	2.80	2.82	2.83
			0.60%	0.60%	0.59%	0.59%	0.59%	0.58%	0.58%	0.57%	0.57%	0.57%	0.57%	0.56%	0.56%	0.56%	0.55%
Kudjip SS	1x10	2.60	2.62	2.63	2.65	2.66	2.68	2.69	2.71	2.72	2.74	2.76	2.77	2.79	2.80	2.82	2.83
			0.60%	0.60%	0.59%	0.59%	0.59%	0.58%	0.58%	0.57%	0.57%	0.57%	0.57%	0.56%	0.56%	0.56%	0.55%
Kainantu SS	1x6.25	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
			0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Kundiawa SS	1x6.25	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.22	1.23
			0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%	0.14%
Taraka SS	2x20	13.20	14.29	15.53	16.28	17.02	12.43	12.95	13.47	13.99	14.51	15.03	15.55	16.07	16.59	17.11	17.63
			8.24%	8.72%	4.78%	4.56%	-26.95%	4.18%	4.01%	3.86%	3.71%	3.58%	3.46%	3.34%	3.23%	3.13%	3.04%
Milford SS	2x20	19.80	21.43	23.30	24.41	25.53	18.65	19.43	20.21	20.99	21.76	22.54	23.32	24.10	24.88	25.66	26.44
			8.24%	8.72%	4.78%	4.56%	-26.95%	4.18%	4.01%	3.86%	3.71%	3.58%	3.46%	3.34%	3.23%	3.13%	3.04%
Singawa SS	2x20						13.32	13.88	14.43	14.99	15.55	16.10	16.66	17.22	17.77	18.33	18.89
	from 2016, to be shared 30% loads of Taraka & Milford								4.01%	3.86%	3.71%	3.58%	3.46%	3.34%	3.23%	3.13%	3.04%
Erap SS (2015)	1x10	0.74	0.76	0.77	0.78	0.80	0.81	0.82	0.84	0.85	0.87	0.88	0.89	0.91	0.92	0.93	0.95
			1.85%	1.82%	1.79%	1.76%	1.73%	1.70%	1.67%	1.65%	1.62%	1.59%	1.57%	1.54%	1.52%	1.50%	1.48%
Meilo SS	2x20	8.90	9.95	11.47	12.61	13.26	13.74	14.07	14.30	14.52	14.75	14.98	15.21	15.43	15.66	15.89	16.12
			11.81%	15.31%	9.89%	5.14%	3.67%	2.36%	1.62%	1.59%	1.57%	1.54%	1.52%	1.50%	1.48%	1.45%	1.43%
Paunda HPS	1x6.7	1.49	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.55	1.55	1.55	1.55
(Mendi+Wabang)			3.15%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
Ramu 1 HPS	2.5+6.7	0.30	0.21	0.16	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
			-29.98%	-24.96%	-29.80%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%	0.10%
Hiddne Valley SS	2x25		18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
				0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Kurumbukari Mine	1x20					16.20	16.20	16.20	16.20	16.20	16.20	16.20	16.20	16.20	16.20	16.20	16.20
							0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Wafi Gold SS	4x50			(10.00)	(15.00)	(20.00)	50.00	65.00	90.00	115.00	130.00	145.00	160.00	175.00	190.00	200.00	200.00
								30.00%	38.46%	27.78%	13.04%	11.54%	10.34%	9.38%	8.57%	5.26%	0.00%
Singsing SS	1x10						1.00	1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48	1.55	1.63
								5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Ramu Grid Toral		57.24	79.62	74.52	72.53	86.29	159.70	176.99	204.18	231.38	248.59	265.79	283.00	300.21	317.43	329.65	331.87
growth rate			39.1%	-6.4%	-2.7%	19.0%	85.1%	10.8%	15.4%	13.3%	7.4%	6.9%	6.5%	6.1%	5.7%	3.8%	0.7%

Note: Cells in yellow mean new substation demand.

(Prepared by the Survey Team based on the PPL's demand forecast)

4.2.3 Power Supply and Demand Balances

The Survey Team checked the supply-demand balance of the Ramu grid from 2011 to 2025 based on the demand forecast as shown in Table 4.2-3 and the following assumptions for the new hydropower stations, which were described in Clause 2.4.2.

1) Yonki Toe HPS (2x9 MW) is to be commissioned in 2012
2) Ramu 2 HPS (4 x 60 MW) is to be commissioned in 2018

3) Mongi HPS (2 x 30 MW) is to be commissioned in 2017

Table 4.2-4 shows the supply-demand balance of the Ramu grid from 2011 to 2025.

Table 4.2-4 Supply-demand Balance of Ramu Grid

(MW)

plants	installed capa (MVA)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Hydropower Plants																
1 Ramu 1 #1	16.70	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
2 Ramu 1 #2	16.70	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
3 Ramu 1 #3	16.70	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
4 Ramu 1 #4	18.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
5 Ramu 1 #5	18.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
6 Paunda #1	7.50	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
7 Paunda #2	7.50	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
8 Yonki #1	10.00		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
9 Yonki #2	10.00		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
10 Ramu 2 #1	66.00								60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
11 Ramu 2 #2	66.00								60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
12 Ramu 2 #3	66.00								60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
13 Ramu 2 #4	66.00								60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
14 Mongi #1	30.00							30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
15 Mongi #2	30.00							30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
hydro total		87.00	105.00	105.00	105.00	105.00	105.00	165.00	405.00	405.00	405.00	405.00	405.00	405.00	405.00	405.00
Diesel Plants																
1 Taraka #1	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
2 Taraka #2	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
3 Taraka #3	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
4 Taraka #4	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
5 Taraka #5	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
6 Taraka #6	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
7 Taraka #7	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
8 Taraka #8	1.80	1.40	1.40	1.40	1.40	1.40	1.40	disposition or relocation			-	-	-	-	-	-
9 Milford #1	3.50	3.00	3.00	3.00	3.00	3.00	3.00	disposition or relocation			-	-	-	-	-	-
10 Milford #2	3.50	3.00	3.00	3.00	3.00	3.00	3.00	disposition or relocation			-	-	-	-	-	-
11 Milford #3	3.50	3.00	3.00	3.00	3.00	3.00	3.00	disposition or relocation			-	-	-	-	-	-
12 Milford #4	1.90	1.00	1.00	1.00	1.00	1.00	1.00	disposition or relocation			-	-	-	-	-	-
13 Madang #1	0.60	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
14 Madang #2	4.10	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
15 Madang #3	4.10	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
16 Madang #4	1.90	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
17 Madang #5	1.90	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
18 Madang #6	1.90	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
additional diesels (temporally location)																
Singawa						30.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
diesel total		32.64	32.64	32.64	32.64	62.64	82.64	61.44	61.44	61.44	61.44	61.44	61.44	61.44	61.44	61.44
Generation Total		119.64	137.64	137.64	137.64	167.64	187.64	226.44	466.44	466.44	466.44	466.44	466.44	466.44	466.44	466.44
Demand Forecast		79.62	74.52	72.53	86.29	159.70	176.99	204.18	231.38	248.59	265.79	283.00	300.21	317.43	329.65	331.87
Supply-demand Balance		40.02	63.12	65.11	51.35	7.94	10.65	22.26	235.06	217.85	200.65	183.44	166.23	149.01	136.79	134.57

(Prepared by the Survey Team)

As shown in the table above, the supply-demand balances in 2015 and 2016 are very severe status because of new mining demand of Wafi Gold. To solve this severe status, new diesel generators with 30 – 50 MW capacity have to be installed temporarily at new Singawa SS, which the PPL plans to construct in Lae.

The PPL also plans to dispose or relocate existing diesel generators in Taraka and Milford at the appropriate time. Such plans can be executed after the commissioning of Mongi HPS (2 x 30 MW) in 2017 and Ramu 2 HPS (4 x 60 MW) in 2018.

4.3 Conditions for Power Flow Calculations

(1) System Planning Criteria

The technical criteria for transmission network planning are described below. The transmission network is designed so as not to interrupt power supply to domestic demand in Ramu grid and to keep the system voltage at an appropriate level.

1) Power Flow

Under normal operating conditions, the loading of transmission lines shall not exceed the thermal ratings calculated at the maximum operating temperature of 75 °C as shown in Table 4.3-2 (attached at the end of this chapter). In case of a single circuit fault for the interval with more than double circuits, the power flow of remaining facilities must be within the rated capacity (N-1 criteria).

Under normal operating conditions, the loading of transformers shall not exceed the rated capacity of transformers allowed by the available mode of cooling. Under N-1 contingency conditions, a short period (one hour) of overloading up to 120% rated capacity is allowed.

2) System Voltage

Bus voltage for power stations/substations must be in the range from 95 % to 105 % at normal operating conditions and in the range from 90% to 110 % at N-1 condition.

(2) Preliminary System Configurations

To confirm the power flow on the new 132 kV transmission lines to be constructed under the Project, the Survey Team will carry out power flow calculations for the Ramu grid for the 2015, 2020 and 2025 cases, with the following network developments.

1) 2015 Case: 2011-2015 developments

- Yonki Toe HPS (2 x 9 MW) in 2012 and 132 kV transmission line between Yonki Toe HPS and Ramu 1 HPS 4.0 km, 1-cct.
- Upgrade of operating voltage from 66 kV to 132 kV transmission lines between Gusap SS and Meiro SS with installation of 132/22 kV transformers (2x20 MVA) in Meiro SS by 2014
- Kurumbukari Mine SS (1x20 MW) and 132 kV transmission lines between Meiro SS and Kurumbukari Mine SS 30 km, 1-cct. in 2014
- 132 kV transmission lines between Singsing SS and Erap SS (96.6 km, 2-cct), and between Erap SS and Taraka SS (40.0 km, 1-cct) with construction/augmentation of concerned substations under the Project in 2015
- 66 kV transmission line between Erap SS to Nadzab junction, 5.0 km, 1-cct. in 2015

- Singawa SS in Lae (132/66 kV TR 2x20 MVA, 132/22 kV TR 2x20 MVA and 66/) and 132 kV transmission line 5.2 km, 1-cct. and 66 kV transmission line 5.5 km, 1-cct. between Taraka SS to Singawa SS in 2015
- Wafi Gold SS (initially 2 x 60 MVA) with 132 kV transmission line between Erap SS and Wafi Gold SS 37.0 km, 2-cct with double ACSR Goat[1] conductors in 2015.
- Diesel generators 3 x 10 MW in Singawa SS (temporary) to satisfy the supply and demand balance in 2015

2) 2020 Case: 2016-2020 developments
   - Mongi HPS (2 x 30 MW) and 132 kV transmission line between Mongi HPS and Singawa SS 45.0 km, 2-cct. with ACSR Panther[1] conductor in 2017
   - Ramu 2 HPS (4 x 60 MW) with 132 kV transmission line between Ramu 2 HPS and Singsing SS 18.0 km, 2-cct. with double ACSR Goat[1] conductors in 2018
   - Wafi Gold SS (additional 2 x 60 MVA, 4 x 60 MVA in total) in 2018

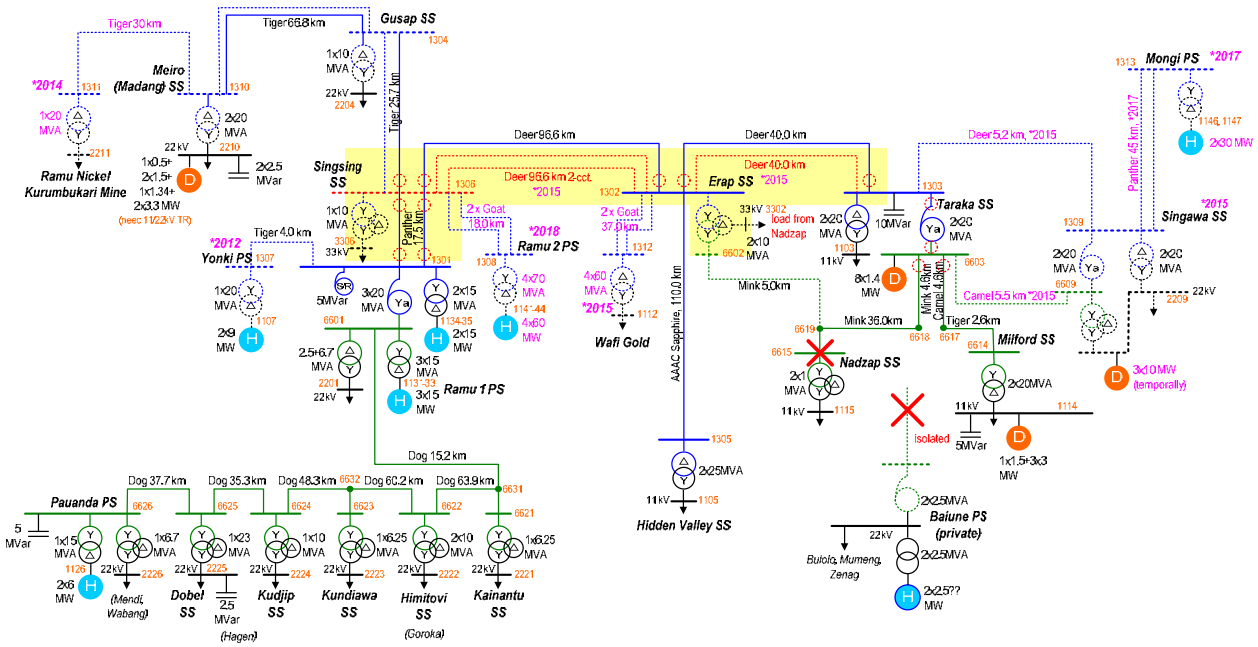
3) 2025 Case: 2021-2025 developments
   - 2nd circuit of 132 kV transmission line between Singsing SS and Gusap SS 25.7 km, 1-cct.
   - 2nd circuit of 132 kV transmission line between Gusap SS and Meiro SS 66.8 km, 1-cct.

As for the Project, construction of Singsing SS under the Project is necessary to ensure the system reliability. Singsing SS is planned to be constructed on both Ramu 1 HPS – Erap SS and Ramu 1 HPS – Gusap SS 132 kV single-circuit lines. As a result, Ramu 1 – Singsing section is to be double-circuit line and satisfy the N-1 criteria.

In addition, as a result of preliminary examination and discussion with PPL based on the demand forecast, additional double-circuit line is needed for Singsing SS – Erap SS section, even TDDP 2025 mentioned that additional single-circuit is needed for this section as descried in Sub-clause 2.4.3.

Figure 4.3-1 shows the preliminary system configurations of the Ramu grid for power flow calculations.

[1] Conductor sizes are tentatively set to meet the N-1 criteria.



(Prepared by the Survey Team)

Figure 4.3-1 Preliminary System Configurations

(3) System Parameters

The following tables attached to the end of this chapter show the parameters applied for power flow calculations by PSS/E.

Table 4.3-1 Node List
Table 4.3-2 Generating Units
Table 4.3-3 Transmission Lines
Table 4.3-4 Transformers

4.4 Result of Power Flow Calculations

4.4.1 2015 Case

Figure 4.4-1 (attached at the end of this chapter) shows the result of the power flow calculation for the 2015 system. As shown in the figure, there is no serious problem in the load flow on the Ramu grid under normal operating conditions.

The points to be noted are summarized below:

1) Voltage levels for all 132 kV, 66 kV and medium voltages busbars are maintained within ±5% of rated voltage.

2) It is observed that all transmission lines operate with load flows less than 70% of thermal rating under the normal operation conditions.

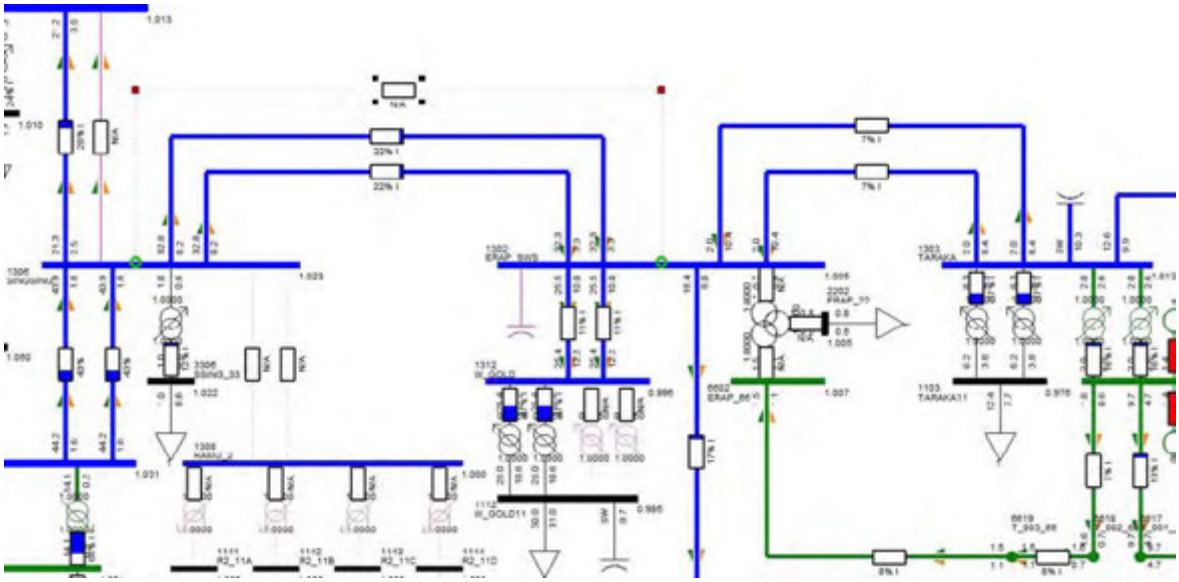
3) All main transformers except step-up transformers for generating units carry loads less

than their installed capacities.

4) To maintain the busbar voltage within appropriate levels, reactive power flow is controlled with tap-changers of transformers and compensation devices. The optimal tap positions of transformers and conditions of static capacitors and shunt reactors are indicated in Figure 4.4-1.

5) For reference, transmission system loss is about 3.5 % (5.1 MW) of its generating output of 164.8 MW under normal operating condition.

6) To confirm the reliability of new 132 kV transmission lines under the Project, the Survey Team carried out the power flow calculation with the single outage contingency (N-1) condition of Singsing–Erap line. Even during outage cases, overloading of other transmission lines above its thermal capacity and voltage deviations are not observed as shown in Figure 4.4-2. Therefore, it is confirmed that the 132 kV transmission line satisfies the N-1 criteria.



(Prepared by the Survey Team)

Figure 4.4-2 Power Flow under Single Contingency in 2015

7) In addition to the system developments during 2011-2015 mentioned in Clause 4.3 (2) 1), the following reactive power compensation devices are planned to maintain the busbar voltage within the appropriate level.

- 10 MVar on 11 kV bus of Wafi Gold SS

4.4.2 2020 Case

As for the power flow calculations in 2020, the Survey Team calculated two alternative cases: i) with Mongi HPS (2x30 MW) case; and, ii) without Mongi HPS case (development delayed).

Figures 4.4-3a and 4.4-3b (attached at the end of this chapter) show the results of power flow calculations for the 2020 system with and without Mongi HPS respectively. From the given figures, there is no serious problem in the load flow on the Ramu grid under normal operating condition for both cases.

The points to be noted are summarized below:

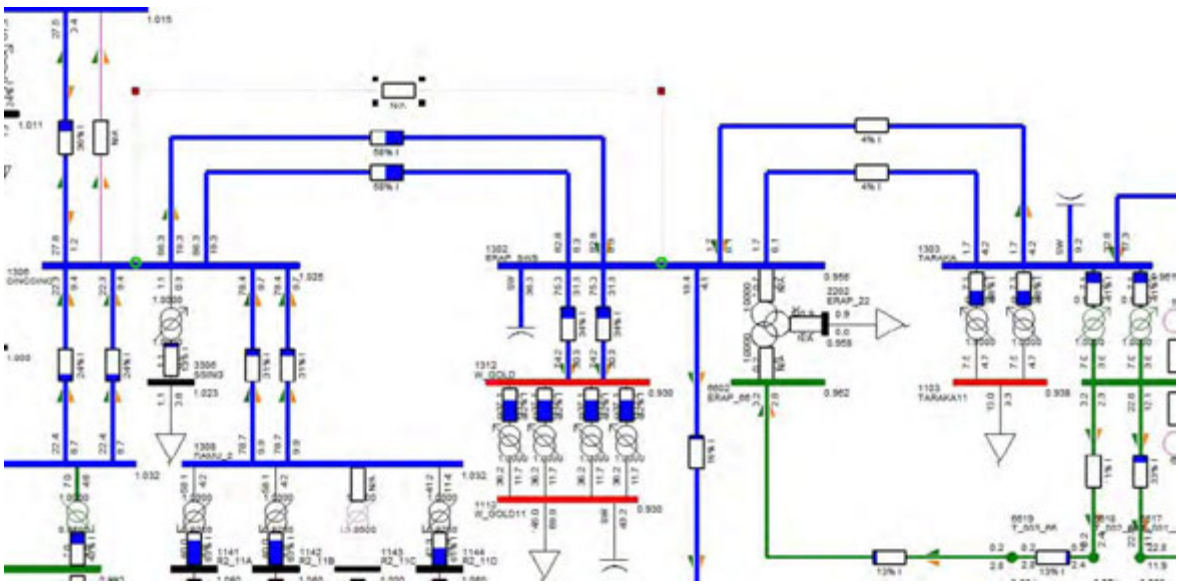
1) Voltage levels for all 132 kV, 66 kV and medium voltages busbars are maintained within ±5% of the rated voltage in both cases.

2) It is observed that all transmission lines operate with load flows less than 80% thermal rating under normal operating conditions in both cases.

3) All main transformers except step-up transformers for generating units carry loads less than their installed capacity in both cases.

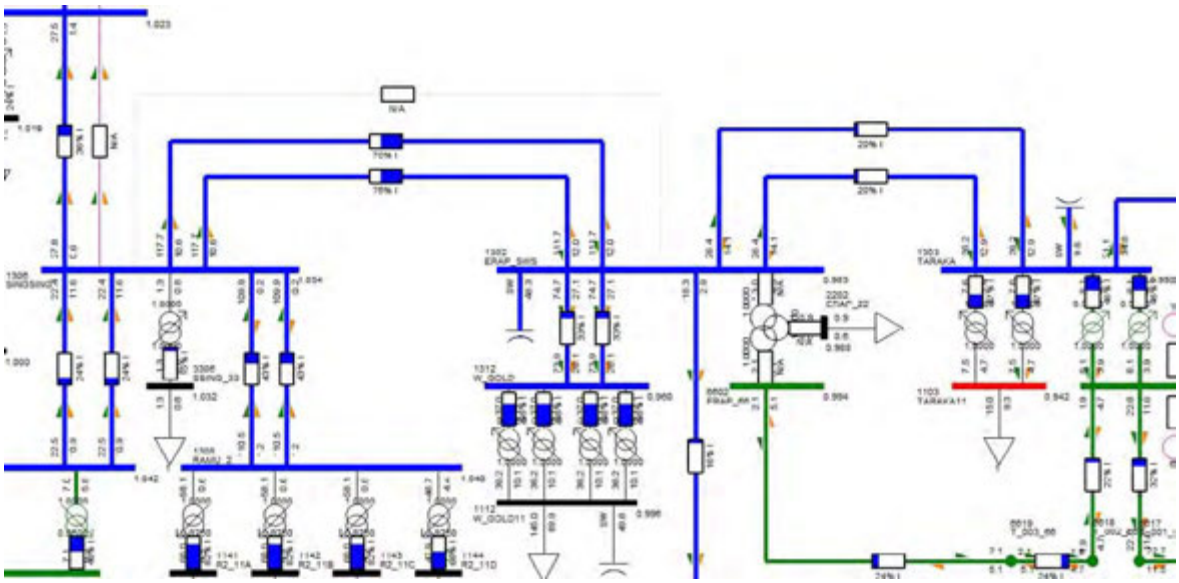
4) To maintain the busbar voltages within appropriate levels, reactive power flow is controlled with tap-changers of transformers and compensation devices. The optimal tap positions of transformers and conditions of static capacitors and shunt reactors are indicated in Figures 4.4-3a and 4.4-3b.

5) To confirm the reliability of new 132 kV transmission lines under the Project, the Survey Team carried out the calculations with the single outage contingency (N-1) condition of Singsing–Erap line in both cases. Even during outage, overloading of other transmission lines above its thermal capacity and voltage deviations are not observed in both cases as shown in Figures 4.4-4a and 4.4-4b. Therefore, it is confirmed that the candidate transmission line satisfies the N-1 criteria in both cases.



(Prepared by the Survey Team)

Figure 4.4-4a Power Flow under Single Contingency in 2020 with Mongi HPS



(Prepared by the Survey Team)

Figure 4.4-4b Power Flow under Single Contingency in 2020 without Mongi HPS

6) For reference, transmission system losses for both cases under the normal operation condition are calculated as follows:
   i) with Mongi HPS: about 6.7 % (19.1 MW) of its generating output of 284.7 MW
   ii) without Mongi HPS: about 8.1 % (23.3 MW) of its generating output of 289.1 MW

7) In addition to the system developments during 2016- 2020 mentioned in Clause 4.3 (2) 2), the following reactive power compensation devices are planned to maintain the busbar voltage within the appropriate level in both cases.
   - 5 MVar on 11 kV bus of Hidden Valley SS
   - 5 MVar on 22 kV bus of Kurumbukari Mine SS
   - 40 MVar on 132 kV bus of Erap SS
   - 40 MVar on 11 kV bus of Wafi Gold SS (50 MVar in total)

   In the case of without Mongi HPS, however, diesel generators temporarily installed in Singawa SS are used only to supply reactive power to maintain the system voltage.

4.4.3 2025 Case

Figure 4.4-5 (attached at the end of this chapter) shows the result of power flow calculations for the 2025 system. From the given figures, there is no serious problem in the load flow on the Ramu grid under normal operating condition.

The points to be noted are summarized below:

1) Voltage levels for all 132 kV, 66 kV and medium voltages busbars are maintained within ±5% of the rated voltage.

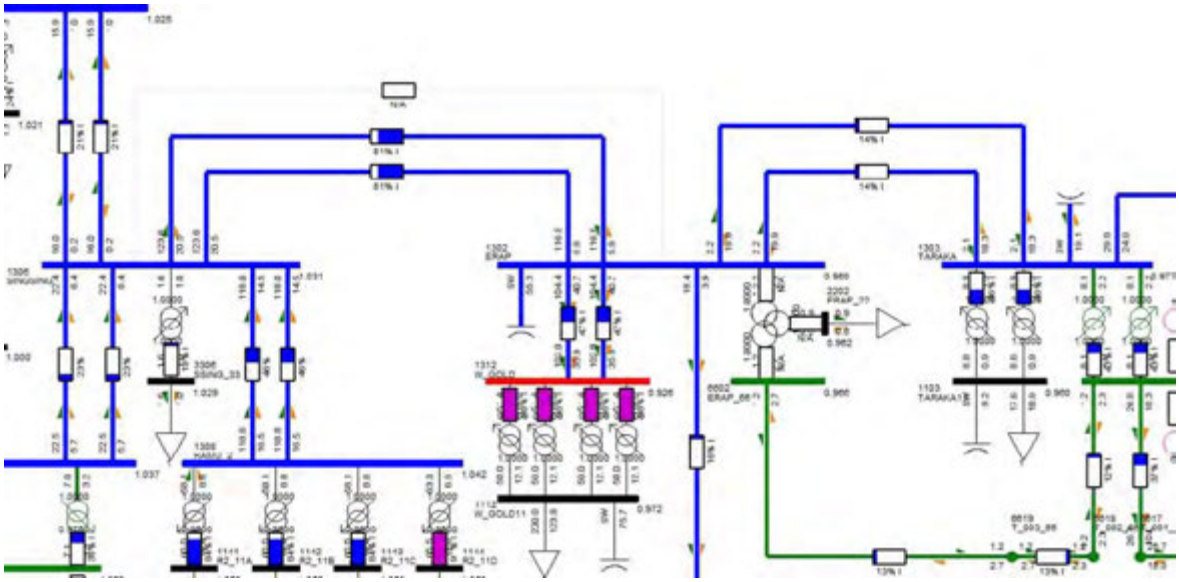
2) It is observed that all transmission lines operate with load flows less than 80% thermal

rating under normal operating conditions.

3) All main transformers except step-up transformers for generating units carry loads less than their installed capacity.

4) To maintain the busbar voltages within appropriate levels, reactive power flow is controlled with tap-changers of transformers and compensation devices. The optimal tap positions of transformers and conditions of static capacitors and shunt reactors are indicated in Figure 4.4-5.

5) To confirm the reliability of new 132 kV transmission lines under the Project, the Survey Team carried out the calculation with the single outage contingency (N-1) condition of Singsing–Erap line. Even during outage, overloading of the other transmission lines above its thermal capacity and voltage deviations are not observed as shown in Figure 4.4-6. Therefore, it is confirmed that the candidate transmission line satisfies the N-1 criteria.



(Prepared by the Survey Team)

Figure 4.4-6 Power Flow under Single Contingency in 2025

6) For reference, transmission system loss is about 8.2 % (29.6 MW) of its generating output of 361.4 MW under normal operating conditions.

7) In addition to the system developments during 2021- 2025 mentioned in Clause 4.3 (2) 3), the following reactive power compensation devices are planned to maintain the busbar voltage within the appropriate level in both cases.
   - 30 MVar on 11 kV bus of Wafi Gold SS (80 MVar in total)
   - 10 MVar on 132 kV bus of Erap SS (50 MVar in total)
   - 10 MVar on 132 kV bus (20 MVar in total) and 10 MVar static capacitors on 11 kV bus of Taraka SS

- 5 MVar on 11 kV bus of Milford SS (10 MVar in total)
- 20 MVar on 22 kV bus of Singawa SS (instead of diesel generators)

4.5 Considerations

(1) Reliability Criteria

Again, the objective of the power flow calculation is to validate whether 132 kV transmission lines from Ramu 1 HPS to Taraka SS through Singsing SS and Erap SS satisfies N-1 criteria for different demands and generating output cases in 2015, 2020 and 2025.

1) Ramu 1 HPS and Singsing SS section

This section satisfies the N-1 criteria because of the change to double-circuit line with the construction of Singsing SS. The loading on one of two lines is observed to be less than 50% for all cases.

2) Singsing SS and Erap SS section

As for the Singsing SS and Erap SS section, additional double-circuit transmission lines are mandatory to meet the N-1 criteria. Results of the calculation in 2020 and 2025 cases followed by the huge mining demand (as shown in Table 4.2-3) are to be considered also.

The necessity of installing a 3rd-circuit is a possibility and is greatly affected by the progress of Wafi gold mining development. To avoid unknown risks, as an alternative, the Singsing and Erap section is to be developed with double-circuit tower with single-circuit installation at the initial stage, and the 2nd-circuit is to be installed in accordance with the progress of the mining development.

In any case, the Survey Team will proceed with the basic design and cost estimate for the Singsing and Erap section as double-circuit transmission lines to the maximum extent possible.

3) Erap SS and Taraka SS section

As for the Erap SS and Taraka SS section, it is enough to add a single-circuit transmission line in order to satisfy the N-1 criteria because loading on one of two lines is observed to be less than 50% in all cases.

(2) Short-circuit Currents

For reference, Table 4.5-1 shows 3-phase short-circuit currents calculated at the 132 kV buses of the candidate substations:

Table 4.5-1 Result of Short-circuit Calculations

	2015		2020 with Mongi		2020 w/o Mongi		2025	
	PU	A	PU	A	PU	A	PU	A
Ramu 1 (#1301)	2.5006	3,281.28	4.0229	5,278.84	4.2990	5,641.14	4.6405	6,089.26
Erap (#1302)	2.4554	3,221.97	3.8876	5,101.30	3.9091	5,129.51	4.4020	5,776.30
Taraka (#1303)	2.3996	3,148.75	3.6556	4,796.87	3.6028	4,727.59	4.0364	5,296.56
Singsing (#1304)	2.5046	3,286.53	4.2501	5,576.97	4.4850	5,885.21	4.9619	6,511.00

(Prepared by the Survey Team)

Table 4.3-1 Node List

no.	code	name	Voltage	2015 Load		2015 Gen	2020 Load		2020 Gen	2025 Load		2025 Gen
			(kV)	P (MW)	(Mvar)	P (MW)	P (MW)	(Mvar)	P (MW)	P (MW)	(Mvar)	P (MW)
1103	Taraka11	Taraka SS	11	12.43	7.70		15.03	9.31		17.63	10.93	
1105	H_Vall11	Hidden Valley SS	11	18.00	11.16		18.00	11.16		18.00	11.16	
1107	Yonki11	Yobki HPS	11		0.00	18.00		0.00	18.00		0.00	18.00
1112	W_Gold11	Wafi Gold SS	11	50.00	30.99		145.00	89.86		200.00	123.95	
1114	Milfd_11	Milford SS	11	18.65	11.56	10.50	22.54	13.97	10.50	26.44	16.39	10.50
1126	Panand11	Paunda HPS	11		0.00	12.00		0.00	12.00		0.00	12.00
1131	R1_11a	Ramu 1 HPS	11		0.00	15.00		0.00	15.00		0.00	15.00
1132	R1_11b	Ramu 1 HPS	11		0.00	15.00		0.00	15.00		0.00	15.00
1133	R1_11c	Ramu 1 HPS	11		0.00	15.00		0.00	15.00		0.00	15.00
1134	R1_11d	Ramu 1 HPS	11		0.00	15.00		0.00	15.00		0.00	15.00
1135	R1_11e	Ramu 1 HPS	11		0.00	15.00		0.00	15.00		0.00	15.00
1141	R2_11a	Ramu 2 HPS	11		0.00			0.00	60.00		0.00	60.00
1142	R2_11b	Ramu 2 HPS	11		0.00			0.00	60.00		0.00	60.00
1143	R2_11c	Ramu 2 HPS	11		0.00			0.00	60.00		0.00	60.00
1144	R2_11d	Ramu 2 HPS	11		0.00			0.00	60.00		0.00	60.00
1146	Mongi11a	Mongi HPS	11		0.00			0.00	45.00		0.00	45.00
1147	Mongi11b	Mongi HPS	11		0.00			0.00	45.00		0.00	45.00
1301	Ramu_1	Ramu 1 HPS	132		0.00			0.00			0.00	
1302	Erap	Erap SS	132		0.00			0.00			0.00	
1303	Taraka	Taraka SS	132		0.00			0.00			0.00	
1304	Gusap	Gusap SS	132		0.00			0.00			0.00	
1305	H_Valley	Hidden Valley SS	132		0.00			0.00			0.00	
1306	Singsing	Singsing SS	132		0.00			0.00			0.00	
1307	Yonki	Yonki HPS	132		0.00			0.00			0.00	
1308	Ramu_2	Ramu s HPS	132		0.00			0.00			0.00	
1309	Singawa	Singawa SS	132		0.00			0.00			0.00	
1310	Meiro	Meiro SS	132		0.00			0.00			0.00	
1311	Ku_mine	Kurumbukari Mine SS	132		0.00			0.00			0.00	
1312	W_Gold	Wafi Gold SS	132		0.00			0.00			0.00	
1313	Mongi	Mongi HPS	132		0.00			0.00			0.00	
2201	Ramu1_22	Ramu 2 HPS	22	0.11	0.07		0.11	0.07		0.11	0.07	
2204	Gusap_22	Gusap SS	22	2.05	1.27		2.05	1.27		2.05	1.27	
2209	Singw_22	Singawa SS	22	13.32	8.25	30.00	16.10	9.98	30.00	18.89	11.71	30.00
2210	Meiro_22	Meiro SS	22	13.74	8.52	11.44	14.98	9.28	11.44	16.12	9.99	11.44
2211	K_mine22	Kurumbukari Mine SS	22	16.20	10.04		16.20	10.04		16.20	10.04	
2221	Kainan22	Kainanth SS	22	0.70	0.43		0.70	0.43		0.70	0.43	
2222	Himtov22	Himitovi SS	22	4.57	2.83		4.64	2.88		4.71	2.92	
2223	Kundi_22	Kundiawa SS	22	1.21	0.75	30.00	1.22	0.76		1.23	0.76	
2224	Kudjip22	Kudjip SS	22	2.68	1.66		2.76	1.71		2.83	1.75	
2225	Dobel22	Dobel SS	22	2.68	1.66		2.76	1.71		2.83	1.75	
2226	Panand22	Paunda HPS	22	1.54	0.95		1.55	0.96		1.55	0.96	
3302	Erap_33	Erap SS	33	0.81	0.50		0.88	0.55		0.95	0.59	
3306	SSing_33	Singsing SS	33	1.00	0.62		1.28	0.79		1.63	1.01	
6601	Ramu1_66	Ramu 1 HPS	66		0.00			0.00			0.00	
6602	Erap_66	Erap SS	66		0.00			0.00			0.00	
6603	Taraka66	Taraka SS	66		0.00	11.20		0.00	11.20		0.00	11.20
6609	Singw_66	Singawa SS	66		0.00			0.00			0.00	
6614	Milfd_66	Milford SS	66		0.00			0.00			0.00	
6617	T_001_66	between Milford-T1	66		0.00			0.00			0.00	
6618	T_002_66	between Milford-T2	66		0.00			0.00			0.00	
6619	T_003_66	between Erap-T3	66		0.00			0.00			0.00	
6621	Kainan66	Kainanth SS	66		0.00			0.00			0.00	
6622	Himtov66	Himitovi SS	66		0.00			0.00			0.00	
6623	Kundi_66	Kundiawa SS	66		0.00			0.00			0.00	
6624	Kudjip66	Kudjip SS	66		0.00			0.00			0.00	
6625	Dobel66	Dobel SS	66		0.00			0.00			0.00	
6626	Panand66	Paunda HPS	66		0.00			0.00			0.00	
6631	T_02_66	between Ramu1-Kainan	66		0.00			0.00			0.00	
6632	T_03_66	between Himitovi-Kudjip	66		0.00			0.00			0.00	
			Total	159.7	99.0	198.1	265.8	164.7	498.1	331.9	205.7	498.1

Table 4.3-2 Generating units

no.	code	name	type	id	Installed Capacity (MVA)	Output (MW)	note
1	1131	R1_11a	hydro	1	16.70	15.00	
2	1132	R1_11b	hydro	2	16.70	15.00	
3	1133	R1_11c	hydro	3	16.70	15.00	
4	1134	R1_11d	hydro	4	18.00	15.00	
5	1135	R1_11e	hydro	5	18.00	15.00	
6	1126	Panand11	hydro	1	7.50	6.00	
7	1126	Panand11	hydro	2	7.50	6.00	
8	1107	Yonki11	hydro	1	10.00	9.00	2012
9	1107	Yonki11	hydro	2	10.00	9.00	2012
10	1141	R2_11a	hydro	1	66.70	60.00	2018
11	1142	R2_11b	hydro	2	66.70	60.00	2018
12	1143	R2_11c	hydro	3	66.70	60.00	2018
13	1144	R2_11d	hydro	4	66.70	60.00	2018
14	1146	Mongi11a	hydro	1	33.30	30.00	2017
15	1147	Mongi11b	hydro	2	33.30	30.00	2017
16	6603	Taraka66	diesl	1	1.80	1.40	
17	6603	Taraka66	diesl	2	1.80	1.40	
18	6603	Taraka66	diesl	3	1.80	1.40	
19	6603	Taraka66	diesl	4	1.80	1.40	
20	6603	Taraka66	diesl	5	1.80	1.40	
21	6603	Taraka66	diesl	6	1.80	1.40	
22	6603	Taraka66	diesl	7	1.80	1.40	
23	6603	Taraka66	diesl	8	1.80	1.40	
24	1114	Milfd_11	diesl	1	3.50	3.00	
25	1114	Milfd_11	diesl	2	3.50	3.00	
26	1114	Milfd_11	diesl	3	3.50	3.00	
27	1114	Milfd_11	diesl	4	1.90	1.50	
28	2210	Meiro_22	diesl	1	0.60	0.50	
29	2210	Meiro_22	diesl	2	4.10	3.30	
30	2210	Meiro_22	diesl	3	4.10	3.30	
31	2210	Meiro_22	diesl	4	1.90	1.50	
32	2210	Meiro_22	diesl	5	1.90	1.50	
33	2210	Meiro_22	diesl	6	1.90	1.34	
34	2209	Singw_22	diesl	1	12.00	10.00	2015
35	2209	Singw_22	diesl	2	12.00	10.00	2015
36	2209	Singw_22	diesl	3	12.00	10.00	2015

Table 4.3-3 Transmission Lines Base 100 MVA

no.	code	name	code	name	Vol. kV	Len. km	Size mm2	cond	Type	id	R pu	X pu	B pu	ccc (MVA)
132 kV Line														
1	1301	Ramu_1	1306	Singsing	132	17.5	Panther	1	OH	1	0.01672	0.04049	0.00863	100
2	1301	Ramu_1	1306	Singsing	132	17.5	Panther	1	OH	2	0.01672	0.04049	0.00863	100
3	1306	Singsing	1302	Erap	132	96.9	Deer	1	OH	1	0.04570	0.21185	0.05069	150
4	1306	Singsing	1302	Erap	132	96.9	Deer	1	OH	2	0.04570	0.21185	0.05069	150
5	1306	Singsing	1302	Erap	132	96.9	Deer	1	OH	3	0.04570	0.21185	0.05069	150
6	1302	Erap	1303	Taraka	132	40.0	Deer	1	OH	1	0.01887	0.08745	0.02093	150
7	1302	Erap	1303	Taraka	132	40.0	Deer	1	OH	2	0.01887	0.08745	0.02093	150
8	1302	Erap	1305	H_Valley	132	110.0	AAAC	1	OH	1	0.06463	0.24602	0.05620	130
9	1306	Singsing	1304	Gusap	132	25.7	Tiger2	1	OH	1	0.03968	0.06168	0.01220	75
10	1304	Gusap	1310	Meiro	132	66.8	Tiger2	1	OH	1	0.10313	0.16033	0.03171	75
11	1310	Meiro	1311	Ku_mine	132	30.0	Tiger2	1	OH	1	0.04632	0.07200	0.01424	75
12	1307	Yonki	1301	Ramu_1	132	4.0	Tiger2	1	OH	1	0.00618	0.00960	0.00190	75
13	1303	Taraka	1309	Singawa	132	5.2	Deer	1	OH	1	0.00245	0.01137	0.00272	150
14	1308	Ramu_2	1306	Singsing	132	18.0	Goat	2	OH	1	0.03449	0.04189	0.00882	32
15	1308	Ramu_2	1306	Singsing	132	18.0	Goat	2	OH	2	0.03449	0.04189	0.00882	32
16	1302	Erap	1312	W_Gold	132	37.0	Goat	2	OH	1	0.07090	0.08611	0.01814	32
17	1302	Erap	1312	W_Gold	132	37.0	Goat	2	OH	2	0.07090	0.08611	0.01814	32
18	1313	Mongi	1309	Singawa	132	45.0	Panther	1	OH	1	0.04300	0.10411	0.02219	100
19	1313	Mongi	1309	Singawa	132	45.0	Panther	1	OH	2	0.04300	0.10411	0.02219	100
66 kV Line														
1	6603	Taraka66	6617	T_001_66	66	4.6	Camel	1	OH	1	0.00784	0.03780	0.00064	80
2	6617	T_001_66	6614	Milfd_66	66	2.6	Tiger1	1	OH	1	0.01606	0.02362	0.00033	36
3	6603	Taraka66	6618	T_002_66	66	4.6	Mink	1	OH	1	0.05865	0.04451	0.00054	23
4	6618	T_002_66	6619	T_003_66	66	36.0	Mink	1	OH	1	0.45898	0.34831	0.00424	23
5	6603	Taraka66	6609	Singw_66	66	5.5	Camel	1	OH	1	0.00937	0.04520	0.00077	80
6	6601	Ramu1_66	6631	T_02_66	66	15.2	Dog	1	OH	1	0.11650	0.14150	0.00186	32
7	6631	T_02_66	6621	Kainan66	66	4.0	Dog	1	OH	1	0.03066	0.03724	0.00049	32
8	6631	T_02_66	6622	Himtov66	66	63.9	Dog	1	OH	1	0.48978	0.59487	0.00783	32
9	6622	Himtov66	6632	T_03_66	66	60.2	Dog	1	OH	1	0.46142	0.56042	0.00738	32
10	6632	T_03_66	6623	Kundi_66	66	4.0	Dog	1	OH	1	0.03066	0.03724	0.00049	32
11	6632	T_03_66	6624	Kudjip66	66	48.3	Dog	1	OH	1	0.37021	0.44964	0.00592	32
12	6624	Kudjip66	6625	Dobel66	66	35.3	Dog	1	OH	1	0.27057	0.32862	0.00433	32
13	6625	Dobel66	6626	Panand66	66	37.7	Dog	1	OH	1	0.28896	0.35096	0.00462	32
14	6602	Erap_66	6619	T_003_66	66	5.0	Mink	1	OH	1	0.06375	0.04838	0.00059	23

Table 4.3-4 Transformers

no.	code	from	code	to	id	status	voltage (kV)			winding	tap		capacity (MVA)	R (pu)	X (pu)
1	1302	Erap	6602	Erap_66	1	1	132	66	33	YNyn0d11	F	17	10.00	0.0200	0.2420
2	1302	Erap	6602	Erap_66	2	1	132	66	33	YNyn0d11	F	17	10.00	0.0200	0.2420
3	1303	Taraka	1103	Taraka11	1	1	132	11		Dyn11	T	21	20.00	0.0810	0.7970
4	1303	Taraka	1103	Taraka11	2	1	132	11		Dyn11	T	21	20.00	0.0810	0.7970
5	1303	Taraka	6603	Taraka66	1	1	132	66		YNa0	F	3	20.00	0.0200	0.2420
6	1303	Taraka	6603	Taraka66	2	1	132	66		YNa0d11	F	5	20.00	0.0200	0.2420
7	1306	Singsing	3306	SSing_33	1	1	132	33		YNyn0d11	F	17	10.00	0.0200	0.2420
8	1309	Singawa	2209	Singw_22	1	0	132	11		Dyn11	T	17	20.00	0.0200	0.5250
9	1309	Singawa	2209	Singw_22	2	0	132	11		Dyn11	T	17	20.00	0.0200	0.5250
10	1309	Singawa	6609	Singw_66	1	0	132	66		YNa0d11	F	17	20.00	0.0200	0.2420
11	1309	Singawa	6609	Singw_66	2	0	132	66		YNa0d11	F	17	20.00	0.0200	0.2420
12	6609	Singw_66	2209	Singw_22	1	0	66	22	11	YNyn0d11	F	17	20.00	0.0488	0.3910
13	6609	Singw_66	2209	Singw_22	2	0	66	22	11	YNyn0d11	F	17	20.00	0.0488	0.3910
14	1305	H_Valley	1105	H_Vall11	1	1	132	11		Dyn11	T	17	25.00	0.0500	0.5250
15	1305	H_Valley	1105	H_Vall11	2	1	132	11		Dyn11	T	17	25.00	0.0500	0.5250
16	1312	W_Gold	1112	W_Gold11	1	0	132	11		Dyn11	T	17	50.00	0.0500	0.2100
17	1312	W_Gold	1112	W_Gold11	2	0	132	11		Dyn11	T	17	50.00	0.0500	0.2100
18	1312	W_Gold	1112	W_Gold11	3	0	132	11		Dyn11	T	17	50.00	0.0500	0.2100
19	1312	W_Gold	1112	W_Gold11	4	0	132	11		Dyn11	T	17	50.00	0.0500	0.2100
20	1304	Gusap	2204	Gusap_22	1	1	132	22		Dyn11	T	17	10.00	0.0200	0.2420
21	1310	Meiro	2210	Meiro_22	1	1	132	22		Dyn11	T	17	20.00	0.0500	0.5250
22	1310	Meiro	2210	Meiro_22	2	1	132	22		Dyn11	T	17	20.00	0.0500	0.5250
23	1311	Ku_mine	2211	K_mine22	1	1	132	22		Dyn11	T	17	20.00	0.0500	0.5250
24	1311	Ku_mine	2211	K_mine22	2	1	132	22		Dyn11	T	17	20.00	0.0500	0.5250
25	1131	R1_11a	6601	Ramu1_66	1	1	11	66		Dyn11	F	5	17.00	0.0434	0.4571
26	1132	R1_11b	6601	Ramu1_66	2	1	11	66		Dyn11	F	5	17.00	0.0434	0.4571
27	1133	R1_11c	6601	Ramu1_66	3	1	11	66		Dyn11	F	5	17.00	0.0434	0.4571
28	1134	R1_11d	1301	Ramu_1	1	1	11	132		Dyn11	F	5	18.00	0.0702	0.7020
29	1135	R1_11e	1301	Ramu_1	2	1	11	132		Dyn11	F	5	18.00	0.0702	0.7020
30	6601	Ramu1_66	2201	Ramu1_22	1	1	66	22		Dyn11	F	17	2.50	0.2430	2.4300
31	6601	Ramu1_66	2201	Ramu1_22	2	1	66	22		Dyn11	F	17	6.70	0.1124	1.1990
32	6601	Ramu1_66	1301	Ramu_1	1	1	66	132		Yyn0	F	5	20.00	0.0200	0.2410
33	6601	Ramu1_66	1301	Ramu_1	2	1	66	132		Yyn0	F	5	20.00	0.0200	0.2410
34	6601	Ramu1_66	1301	Ramu_1	3	1	66	132		Yyn0	F	5	20.00	0.0200	0.2410
35	6614	Milfd_66	1114	Milfd_11	1	1	66	11		Ynd11	F	17	20.00	0.0283	0.5966
36	6614	Milfd_66	1114	Milfd_11	2	1	66	11		Ynd11	F	17	20.00	0.0283	0.5966
37	6615	Milfd_66	1115	Milfd_11	1	1	66	22	11	Dyn11	F	5	1.00	0.4221	7.5800
38	6615	Milfd_66	1115	Milfd_11	2	1	66	22	11	Dyn11	F	5	1.00	0.4221	7.5800
39	6621	Kainan66	2221	Kainan22	1	3	66	22	11	YNyn0d11	F	17	6.25	0.1666	2.0000
40	6622	Himtov66	2222	Himtov22	1	3	66	22	11	YNyn0d11	F	21	10.00	0.0888	0.8800
41	6622	Himtov66	2222	Himtov22	2	3	66	22	11	YNyn0d11	F	21	10.00	0.0888	0.8800
42	6623	Kundi_66	2223	Kundi_22	1	3	66	22	11	YNyn0d11	F	17	6.25	0.1666	2.0000
43	6624	Kudjip66	2224	Kudjip22	1	3	66	22	11	YNyn0d11	F	21	10.00	0.0888	0.8800
44	6625	Dobel66	2225	Dobel22	1	3	66	22	11	YNyn0d11	F	21	23.00	0.0488	0.3910
45	1126	Panand11	6626	Panand66	1	1	6.6	66		Dyn11	F	5	15.00	0.0552	0.5807
46	6626	Panand66	2226	Panand22	2	3	66	22	11	YNyn0d11	F	17	6.70	0.1590	1.9160
47	1107	Yonki11	1307	Yonki	1	1	11	132		Dyn11	F	5	20.00	0.0200	0.5250
48	1141	R2_11a	1308	Ramu_2	1	0	11	132		Dyn11	F	5	60.00	0.0600	0.1750
49	1142	R2_11b	1308	Ramu_2	2	0	11	132		Dyn11	F	5	60.00	0.0600	0.1750
50	1143	R2_11c	1308	Ramu_2	3	0	11	132		Dyn11	F	5	60.00	0.0600	0.1750
51	1144	R2_11d	1308	Ramu_2	4	0	11	132		Dyn11	F	5	60.00	0.0600	0.1750
52	1146	Mongi11a	1313	Mongi	1	0	11	132		Dyn11	F	5	45.00	0.0450	0.2333
53	1147	Mongi11b	1313	Mongi	2	0	11	132		Dyn11	F	5	45.00	0.0450	0.2333

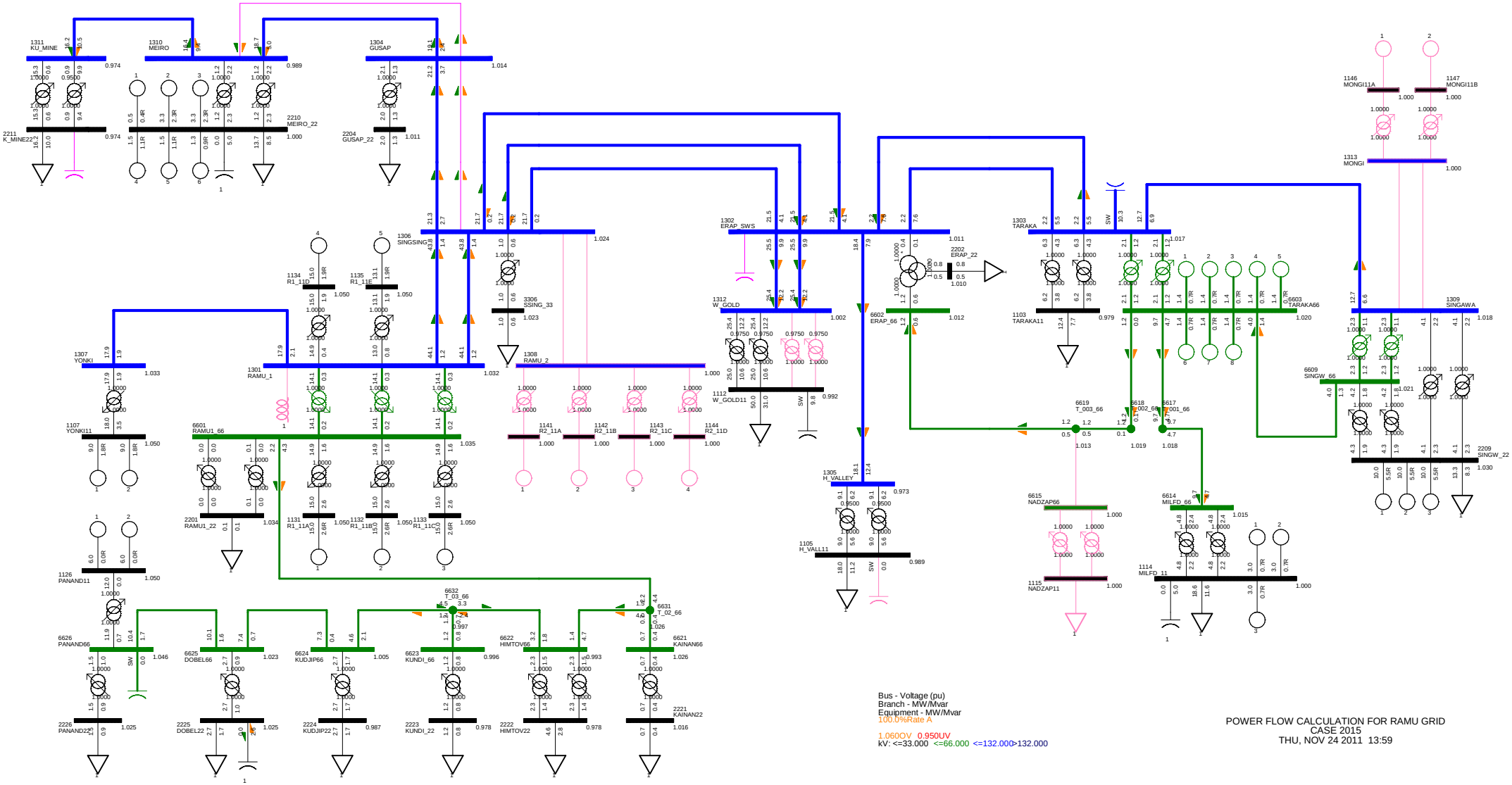


Figure 4.4-1 Result of Power Flow Calculations in 2015

(Prepared by the Survey Team)

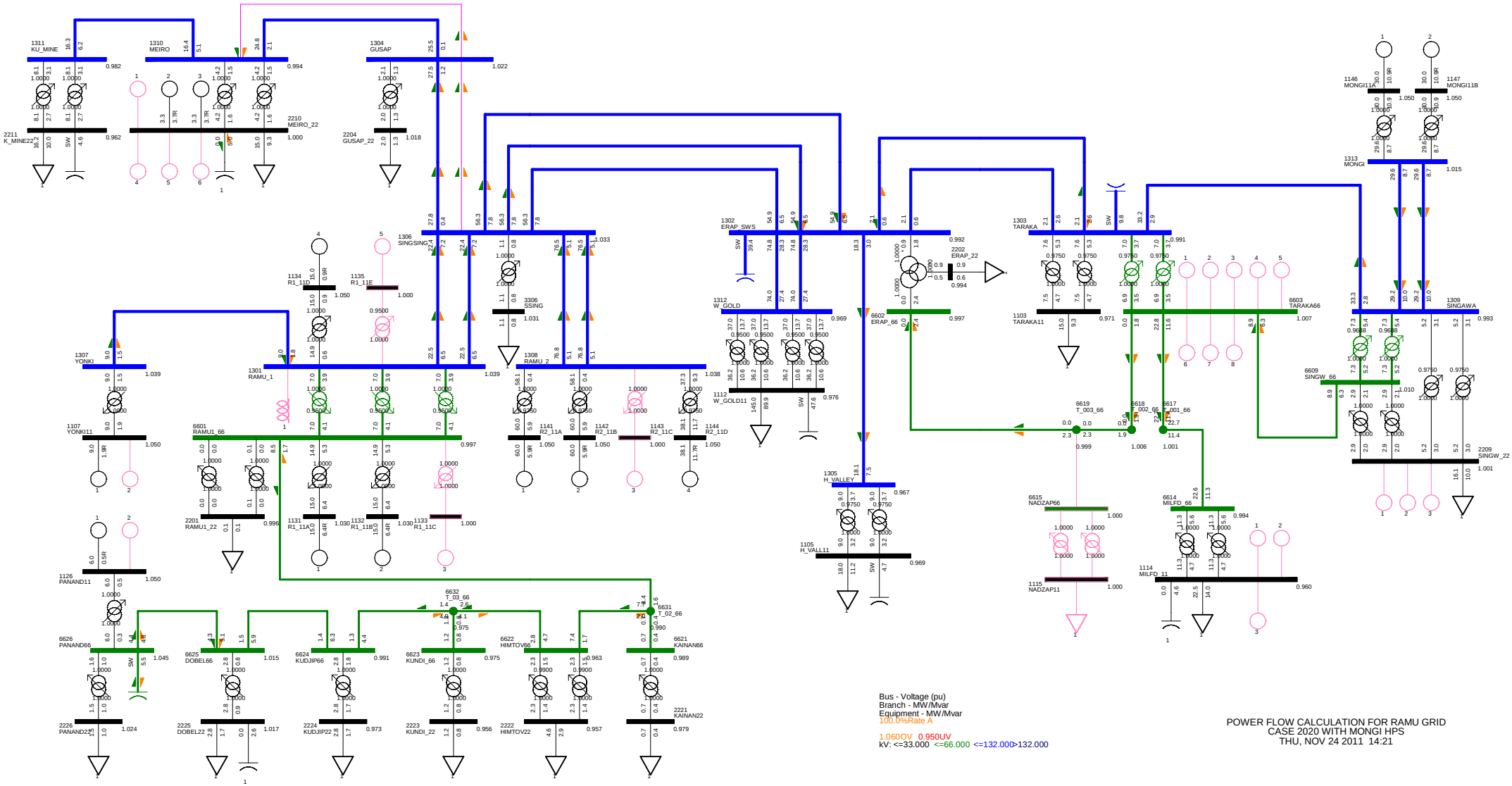


Figure 4.4-3a Result of Power Flow Calculations in 2020 with Mongi HPS

(Prepared by the Survey Team)

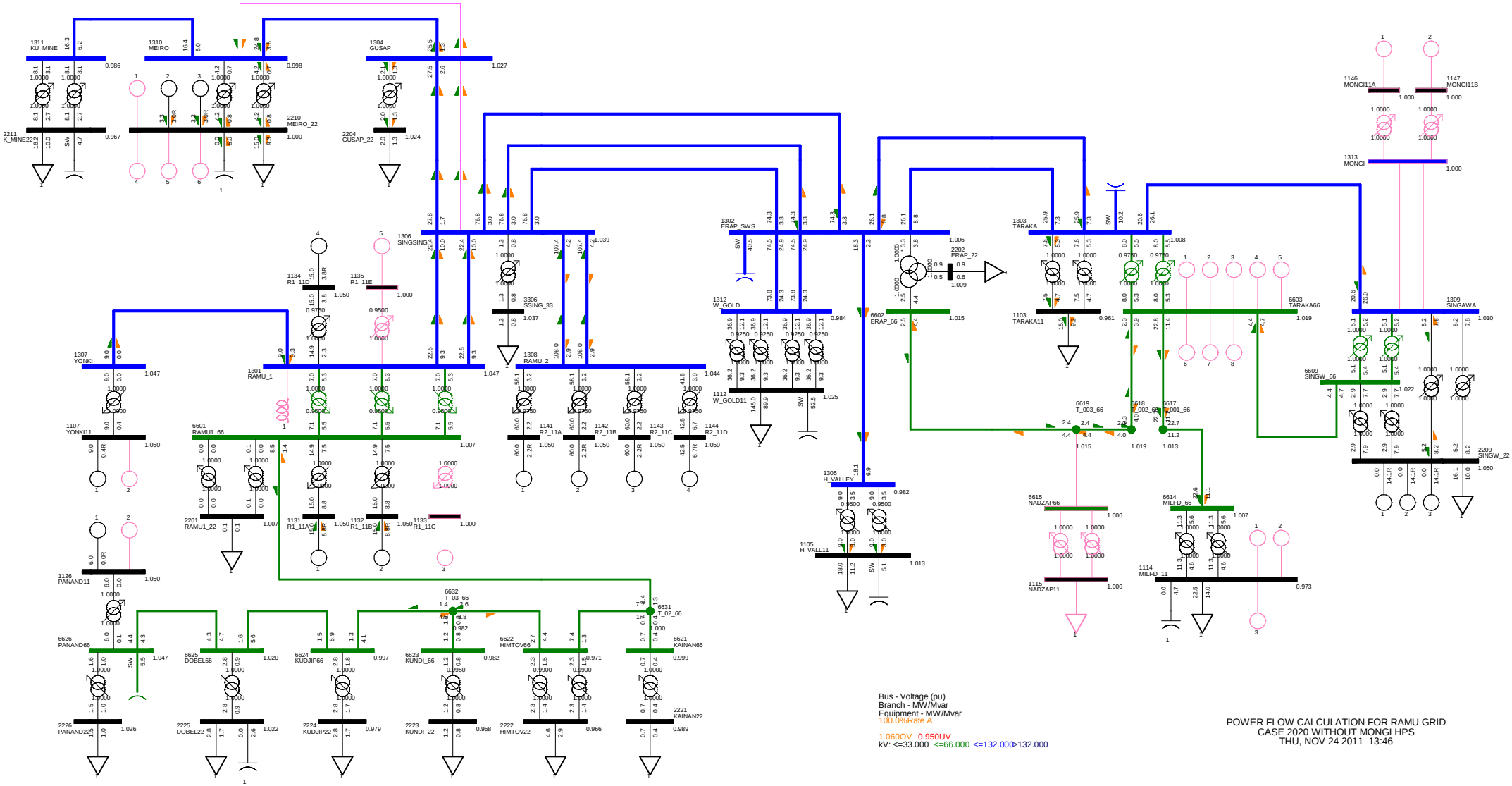


Figure 4.4-3b Result of Power Flow Calculations in 2020 without Mongi HPS

(Prepared by the Survey Team)

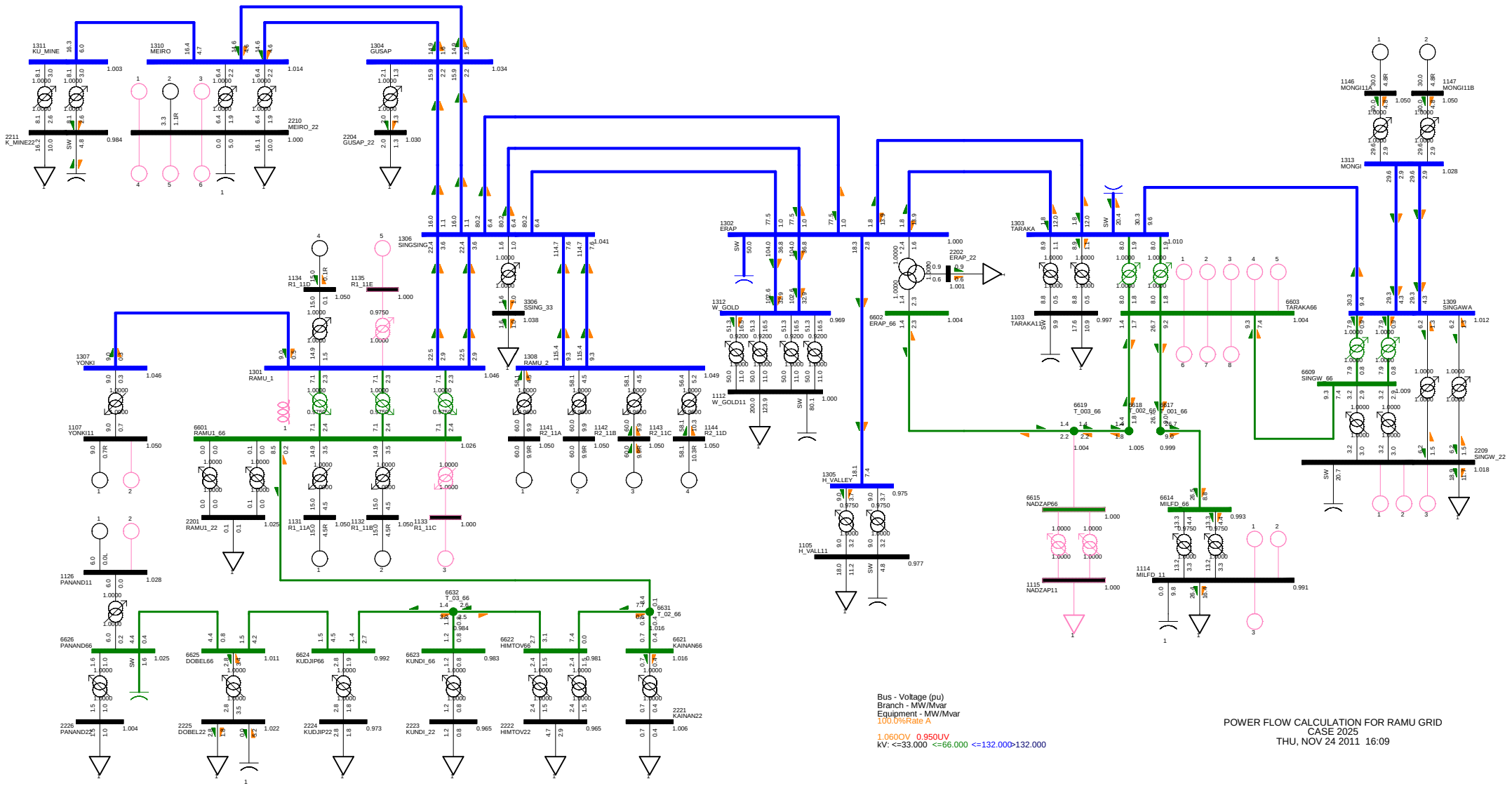


Figure 4.4-5 Result of Power Flow Calculations in 2025

(Prepared by the Survey Team)

CHAPTER 5

BASIC DESIGN OF TRANSMISSION LINES

CHAPTER 5 BASIC DESIGN OF TRANSMISSION LINES

5.1 General

In accordance with the following flow-chart, the basic design of transmission lines for the Project has been carried out:

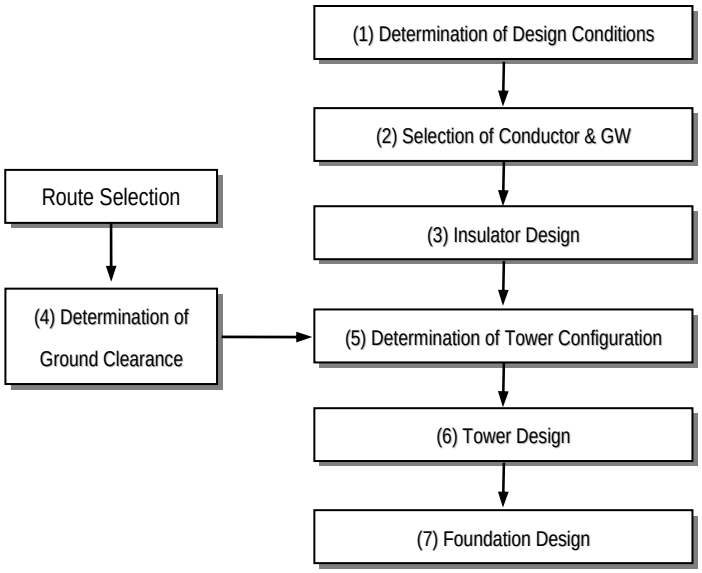


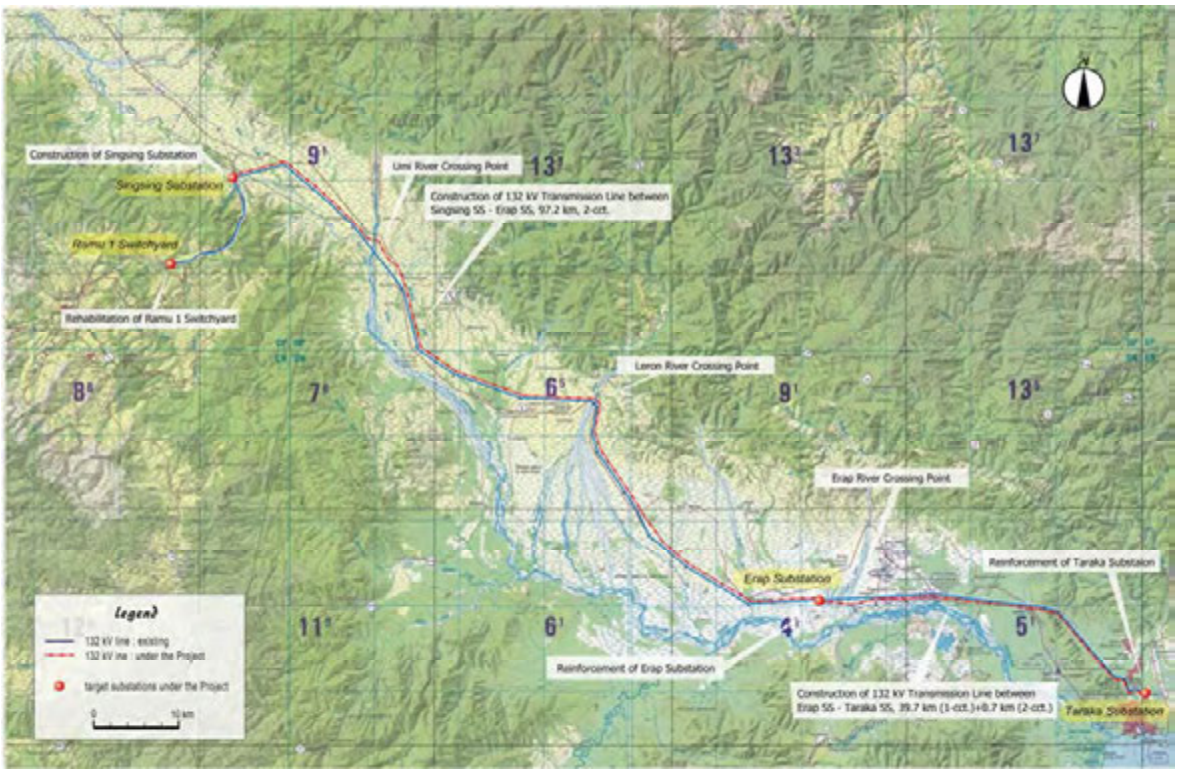
Figure 5.1-1 Transmission Line Design Flow

5.2 Transmission Line Route

(1) General

As described in Chapter 3, the existing transmission line mostly runs parallel with the Markham River because the rest of the area is composed of hilly mountain, especially between Taraka SS and Erap SS. The proposed route of the new 132 kV line will run along with the existing line considering easy maintenance together with the existing line, easy land acquisition, and less impact on the natural environment.

The new line will cross the tributary rivers by utilizing very long spans similar to the existing line. From Taraka SS towards the suburbs of Lae, where the new line crosses the congested areas, the route shall be selected to avoid resettlement as much as possible. In this area, double circuit towers will be erected to accommodate both the new line and the existing line at the same location of the existing 132 kV line. The route of the existing and proposed transmission lines are shown below and the details are shown in Attachment-3.



(Prepared by the Survey Team)

Figure 5.2-1 Existing and Planned Transmission Line Route

In the course of the site survey, it was found out that the new line route crosses three large rivers of Erap, Leron, and Umi. Among those locations, the estimated maximum span length range from 600 to 800 m to avoid erosion of the tower foundation.

As a result of discussions with the PPL, the new line between Taraka and Erap is planned to run along the southern side of the existing line. This is because there are enough spaces between the existing line and the Highlands Highway. On the other hand, a new line between Erap and Singsing is planned to run along the northern side of the existing line because of the advantages at the crossing points over the Leron and Umi Rivers.

(2) Distance of New line from Existing Line

The distance between the new 132 kV transmission line and the existing 132 kV transmission line (from New Singsing SS to Taraka SS section), is determined to be 50 m from centre to centre.

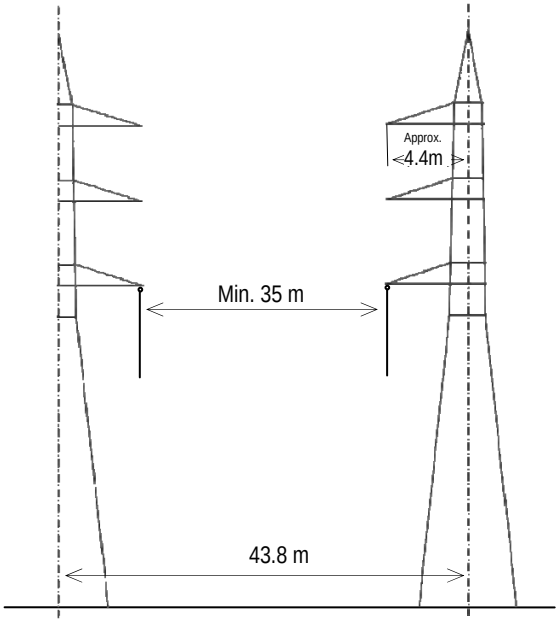
PPL's rule stipulates, "*Horizontal clearance of 132 kV outside conductors of power supply circuits irrespective of voltage shall be 35 m minimum.*[1]".

The minimum distance of the two lines shall be 35 m + approx. 4.4 m x 2 = 43.8 m (as shown in Figure 5.2-2). The width of each arm from the tower centre is assumed at 4.4 m.

[1] Sub-clause 8.2.6, Specification of 132 kV transmission line from Erap to Hidden Valley

Some errors generated from route survey mistakes were considered, and distance was fixed at 50 m.

However, the distance of the existing line from Ramu-1 to Erap (tower No.303 – No.304), and the existing line from Ramu-1 to Gusap were measured at only 20 m from centre to centre.



(Prepared by the Survey Team)

Figure 5.2-2 Distance between New and Existing Lines

(3) Outline of Line Route

Based on the result of power flow calculations described in Chapter 4, to transmit generated power from Ramu 1 HPS and other future plants, the following transmission lines shall be constructed as the first priority project.

1) 132 kV single-circuit overhead lines between Taraka SS and Erap SS

2) 132 kV double-circuit overhead lines between Erap SS and new Singsing SS

The power flow is to be directed from Ramu HPS to Taraka SS via Singsing SS. However, since the numbering of the existing 132 kV line towers from Taraka SS is made from Taraka (Lae) side, all the description of the line route will be made from Taraka SS side to Ramu HPS side in this report.

The line route shall be surveyed and selected, so that:

- Line length can be shortened as possible.
- Line access is easy for tower construction and future maintenance.
- Resettlement can be reduced and avoided.
- Clearing of obstacles does not damage any peripheral environment.

The proposed transmission line routes and its main features are described below.

1) 132 kV Taraka SS – Erap SS Line Route

The general features of the existing line route in terms of geographical point of view are described in Chapter 3. The geographical features for the new route are basically the same as the one for the existing line route since both lines run in parallel.

Starting from Taraka SS, the route runs within the congested area of Lae, where residents settled are considered as illegal settlers by the PPL. Due consideration for these settlers shall be made in accordance with various guidelines on informal settlers, such as JICA or World Bank. Due to the high density of population, obtaining

additional right-of-way (RoW) for the new line towers will be very difficult. Hence, in this area, the new line will be constructed on the existing RoW approximately 0.7 km. The towers of double circuits design, as shown in Dwg_PNG_TL_TWR_001 in Attachment-3, are to be constructed. These towers will carry both the existing and new lines. During construction of this section, to avoid a power outage of Lae, the PPL plans to construct new 66 kV transmission line between Erap and Taraka by their own fund.

After passing through these congested areas, the new line will run parallel with the existing line towards Erap SS by using the 132 kV single circuit towers as shown in Dwg_PNG_TL_TWR_002 in Attachment-3.

Before reaching Erap SS, the new line will cross over the Erap River. The river has wide riverbed without clear floodwalls. To avoid the tower foundations from washing away, special long span, pile-foundations and tower leg protection have to be considered in the design.

For incoming/outgoing of Erap SS, arrangement of the dead-end towers including erection of the new dead-end tower, demolition of the existing tower and shifting of the slack spans are required.

2) 132 kV Erap SS – Singsing SS Line Route

By using the new dead-end tower to be constructed in front of Erap SS, the new line will run parallel with the existing line. The double-circuit towers of vertical arrangement shown in Dwg_PNG_TL_TWR_001 are to be used for this section.

Since most of the areas are flat consisting of stock farms, the construction of the new line will be easy with the exception of river crossing sections. At this section, the new line route will cross over the Leron and Umi Rivers.

(4) Result of Soil Investigation

The Survey Team employed the local sub-consultant to carry out the soil investigation along the planned transmission line route. The soil investigation points selected 12 locations which include the river crossing, substation site, and the risky areas along the transmission line route.

Results of the investigation including Standard Penetration Test (SPT) to confirm the depth of supporting stratum with N-values greater than 30, bearing capacity, and the ground water table are summarizes in Table 5.2-1 and the details are shown in Table 5.2-2 attached at the end of this chapter.

Areas between Taraka SS to Tower No. 42 (about 20 km away from Taraka SS), and the

Leron River crossing area (about 80 km away from Taraka) consists of hilly terrain. The soil condition of the locality is steady and the ground water level is very low.

Areas between the Erap River crossing point (Tower No.85) and the areas about 70 km away from Taraka SS through Erap SS are almost alluvial fan and inundation areas. The areas are characterized by sandy soils with mixed cobble stones more than 200 mm in diameter until GL -3.0 m. The ground water tables are shallow at GL -1.0 m. However, the bearing capacities are estimated to exceed 10.0 tf/m^2, which is the stable stratum.

The design of the tower foundations shall consider the uplift force due to the high ground water in case pulling forces occur due to wind and tensile strength of tension towers. Furthermore, piling foundation work is considered difficult under such condition of the river bed with the cobble stones of more than 200 mm in diameter.

Table 5.2-1 Soil Investigation Summary

Survey Point		ext. TL towers	Ground water	Supporting stratum	Bearing capacity	Remarks
1	Erap River No.1	No. 83/84	-0.8 m	-3.6 m	11.4 tf/m^2	Inundation area
2	Erap River No.2	No. 85/86	-0.9 m	-3.4 m	11.6 tf/m^2	Inundation area
3	Rumu River	No. 112	-4.5 m	-1.9 m	11.6 tf/m^2	
4	Leron River	No. 181/182	-2.5 m	-0.8 m	44.4 tf/m^2	
5	Grambampam River	No. 260/261	-0.5 m	-2.6 m	19.4 tf/m^2	River channel area
6	Markham River	No. 284/285	-2.5 m	-0.5 m	44.7 tf/m^2	River channel area
7	Gusap River	No. 295/296	-2.5 m	-2.5 m	21.1 tf/m^2	
8	Taraka substation	No. 1	-3.0 m	-0.5 m	42.0 tf/m^2	
9	Erap substation	No. 91/92	-1.2 m	-2.9 m	15.8 tf/m^2	Inundation area
10	Singsing substation	No. 304	-2.5 m	-1.2 m	11.6 tf/m^2	
11	Numa City	No. 227	-2.3 m	-1.5 m	35.1 tf/m^2	
12	Zumin City	No. 249	-2.5 m	-1.5 m	11.4 tf/m^2	

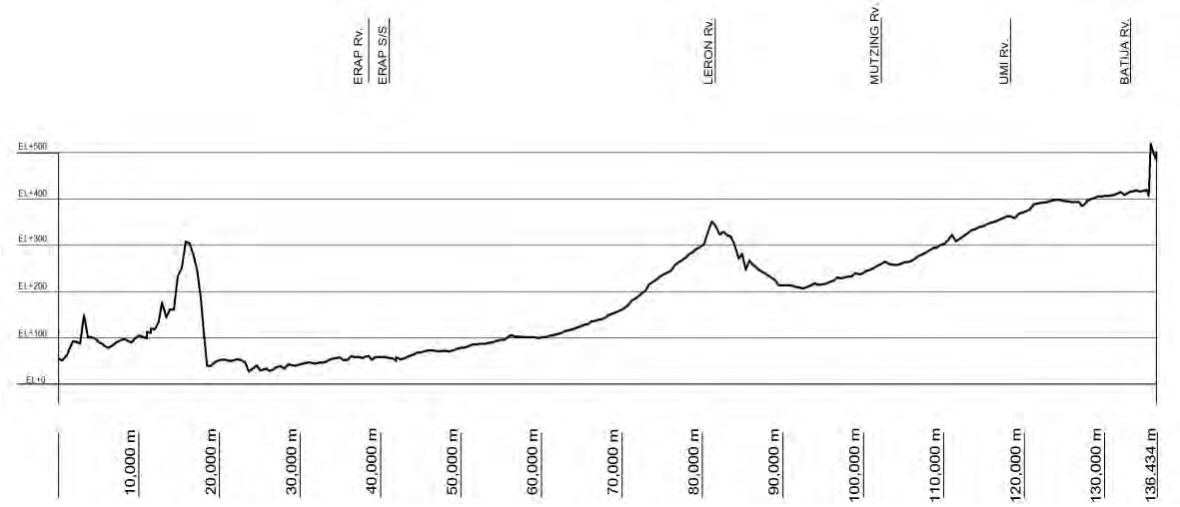
(Prepared by the Survey Team)

(5) Result of Topographic Survey

The Survey Team employed the local sub-consultant to carry out the topographic cross section survey with 1,000 m width at 50 m upstream and downstream of the tributary at the river crossing area of the planned transmission line.

As a result of the survey, it was determined that the profile of the transmission line, approximately 136 km long, is shown in Figure 5.2-3. The first 20 km of the line from Taraka SS passes the mountainous area with EL +300 m above sea level and goes down to the Markham River channel. The line meets the Erap River at about 35 km point from Taraka SS. After this point, the line crosses the Erap alluvial fan area and goes upstream along the Markham River. At around 70 km point from Takara SS, the line goes to the Leron River terrace area. The line goes back to the Markham River bed at about 100 km point. Finally, the line goes to Singsing SS with EL +501 m after passing the Umi River.

The planned transmission line will cross five rivers: Erap, Leron, Mutzing, Umi and Batija Rivers. Three of these five rivers are influenced by flood, these are: Erap, Leron and Umi Rivers.



(Prepared by the Survey Team)

Figure 5.2-3 Transmission Line Profile

5.3 Design Conditions

5.3.1 Applicable Standards

The PPL applied the standards shown in Table 5.3-1 in the design of electrical facilities such as transmission lines.

Table 5.3-1 Applicable Standards

no.	Equipment and Materials	Standards
1	Structural steel	AS 4100
2	Steel lattice structure	AS 3995
3	Commercial bolts	AS 1111
4	High strength steel bolts with associated nuts and washers for structural engineering	AS 1252
5	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles	AS/ANZ 4680:2006
6	Cement	AS 3972
7	Concrete works	AS 3600, AS 1379
8	The international system of units and its application (SI units)	PNGS 1000
9	General design requirements	PNGS 1001.1.
10	Dead and live loads	PNGS 1001.2,
11	Wind loads building	PNGS 1001.3,
12	Earthquake loading	PNGS 1001.4,
13	Insulator and Porcelain glass for overhead power lines – Performance, material, general requirements and dimensions	AS 2947.2-1989
14	Insulator and conductor fittings for overhead power lines – Performance, material, general requirements and dimensions	AS 4398.1-1996
15	Insulators – Ceramic or glass – Station post for indoor and outdoor use – Voltages greater than 1000 V a.c. – Characteristics.	AS 2947.2-1989
16	Insulator and conductor fittings for overhead power lines – Performance, material, general requirements and dimensions	AS 1154.1-2004
17	Insulator and conductor fittings for overhead power lines – Performance, material, general requirements and dimensions	AS 4398.1-1996

(Source: PPL's Specifications of 132 kV transmission line from Erap to Hidden Valley)

The Papua New Guinea Standard (PNGS) and Australian Standards (AS) were mainly used in the design of each electrical facility. In addition, other foreign standards and guidelines such as International Electrotechnical Commission (IEC) Standards, British Standards (BS), New Zealand Standards (NZS), Electricity Supply Association of Australia (ESAA), Limited's "Guidelines for design and maintenance of overhead distribution and transmission lines" were used to supplement their own standards. Considering the geographical conditions of PNG, employing standards of neighbouring countries such as Australia and New Zealand is reasonable and convenient. This is because there is higher possibility of purchasing equipment and materials from those industrialized countries than from other countries.

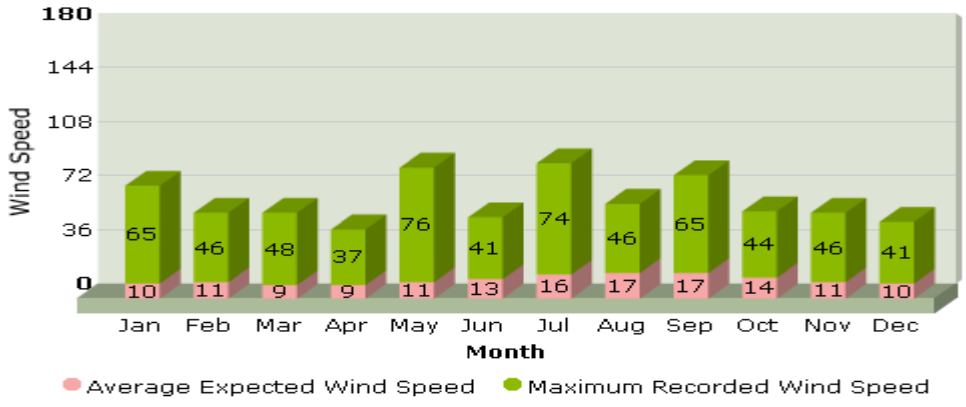
5.3.2 Climate and Natural Conditions

In designing transmission lines, the minimum and average temperatures are important in determining the sag of the conductor. Wind velocity or wind pressure is also important for sag and tower design.

The PPL's current standard does not mention such temperatures and wind velocities for design purpose. These values are specific to areas and the recommended values in AS cannot be directly used. According to the PPL, however, wind velocity of 37 m/s is used for design purpose.

(1) Wind Pressure

Figure 5.3-1 shows yearly trend of wind speed; the chart below plots the average daily wind speed of each month. It also shows the maximum recorded sustained wind speed for each month.



(Source: Weather2)

Figure 5.3-1 Monthly Wind Speed (km/hr)

Meanwhile, wind velocity of 37 m/s (133 km/h) is specified in PPL's Specifications for the 132 kV transmission line from Erap to Hidden Valley (hereinafter referred as "the PPL's Spec"). According to this requirement, wind pressure for conductor (cylindrical surfaces) is calculated

as:

Wind Pressure: P (N/m^2) = 0.625 x (37)^2 = 856 N/m^2 (87 kgf/m^2)

This value seems relatively large if PNG is not frequented by cyclones. For reference, power companies in Japan employ the design wind velocity of 40 m/s considering the frequent typhoon occurrence and this results to wind pressure of 980 N/m^2 on the conductor. However, the poor redundancy of the existing system might be the reason behind the introduction of such severe design conditions in PPL's past projects.

Wind pressure on the tower body is also calculated. The wind pressure on the tower varies subject to the standard employed. In this calculation, the formula of IEC 60826 is used.

Wind Pressure: A_t = 0.5 x 1.225 x (37/1.4)^2 x 2.2 x 2.1 = 1,976 N/m (200 kgf/m^2)

The above calculation was made assuming that the drag coefficient is 2.2, and the combined wind factor is 2.1, preliminarily.

(2) Temperature

The temperatures of Lae which are measured by weather stations of LAE A/F are presented in the web site[2]. The station is located at about 6.73° S 147.00° E with its height of about 8 m.

Table 5.3-2 shows the 24-hour average temperatures and average minimum temperatures.

Table 5.3-2 24-Hour Average Temperatures

(Unit: °C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
24h Average	27.4	27.5	27.3	26.8	26.2	25.5	24.9	25.0	25.5	26.1	26.8	27.1	26.3
Ave. Minimum	23.7	23.8	23.7	23.3	22.9	22.4	22.0	21.9	22.2	22.6	23.1	23.5	22.9

(Source: http://www.worldclimate.com; (LAE M.O. data))

Meanwhile, PPL's specifications on the contract for supply and delivery of outdoor electrical equipment for Ulagunan Power Station, 66/22 kV switchyard, to the port of Rabaul, specify the "minimum temperature in excess of 0 °C." In comparison with the above table for the average minimum temperature, the value of 0 °C is too strict and makes the conductor sag large. For the calculation of sag in this survey, the minimum temperature is applied as a result of the discussion with the PPL.

Average temperature for determining everyday stress (EDS) is set at 26 °C in this design based on the 24-hour average temperature from the table above.

[2] http://www.worldclimate.com.

(3) Rainfall

The monthly average rainfall from 2006 to 2010 measured in Aiyura station was 1,794 mm per year, and in Nadzab station was 1,763 mm per year as shown in Tables 5.3-3 and 5.3-4.

Table 5.3-3 Rainfall in Ajyura Station (Eastern Highland)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2006	133	263	181	0	0	88	82	78	28	97	178	273	1,403
2007	255	250	410	161	114	110	109	70	60	133	156	205	2,032
2008	213	251	292	215	149	0	98	103	88	159	213	178	1,959
2009	214	296	250	149	135	61	69	72	40	124	298	134	1,841
2010	174	240	243	76	118	32	104	200	35	127	209	196	1,736
Ave.	198	260	275	120	103	58	93	105	50	127	209	196	1,794

(Source: National Weather Services)

Table 5.3-4 Rainfall in Nadzab Station (Morobe)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2006	148	186	115	46	15	121	94	31	133	27	173	105	1,194
2007	120	243	163	74	126	65	214	215	179	119	86	264	1,868
2008	164	206	134	180	115	145	121	281	331	169	81	85	2,012
2009	182	318	187	109	128	0	355	46	52	106	117	153	1,753
2010	153	171	202	197	74	185	359	171	157	118	77	122	1,986
Ave.	154	225	160	121	91	103	229	149	170	108	107	146	1,763

(Source: National Weather Services)

According to the rainfall data of the National Weather Services, the intensity rainfall used in design is estimated, and in comparison with Logarithmic distribution, Takase and Gumbell methods as shown in Table 5.3-5. The calculation is shown in Table 5.3-6, attached at the end of this chapter.

Table 5.3-5 Intensity Rainfall for Flood Discharge

(unit: mm/day)

Return Period	1/200	1/100	1/50	1/10	Remarks
Aiyura Sta.	86.5	81.5	76.5	64.7	Upstream
Nadzab Sta.	134.4	124.0	114.3	91.2	Downstream

(Prepared by the Survey Team)

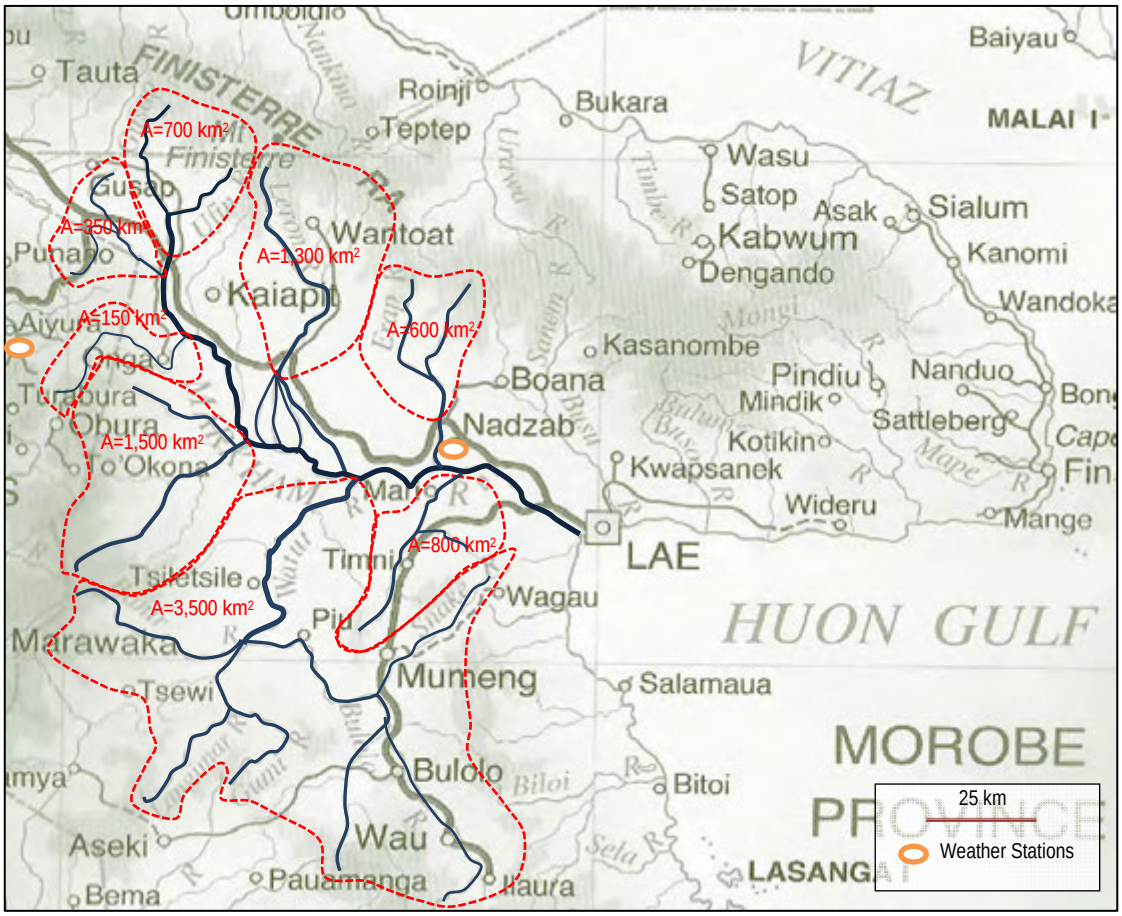
(4) River System

Figure 5.3-2 shows the catchment areas of the rivers around project sites.

The source of the Markham River is located at Mt. Finisterre (EL+3,088 m) in the Highland region of Madang province located at 200 km upstream of the estuary. The river flows down south after passing the Markham Highway, and flows down southeast, crossing the transmission line at Punano village.

The Markham River meets the Leron River, which flows down from the northern mountains at

point of 80 km from the estuary. After the confluence of the Leron River, the Markham River joints to the Erap River at Nadzab village located 40 km from the estuary, and discharges to the Solomon Sea, which then meanders; developing big sandbars downstream.



(Prepared by the Survey Team)

Figure 5.3-2 Rivers around Project Site

Table 5.3-7 and Figure 5.3-3 show the river system of the Markham River.

Table 5.3-7 River System of Markham River

Points	Basin	Catchment area	River slope	Ground elevation (left/right banks)	Flood discharge*1	Flood water level
A	Umi	700 km²	1/50	EL+353.96 / 353.15m	3,169 m³/s	EL+352.55 m
B	Leron	1,300 km²	1/70	EL+350.75/333.00 m	5,886 m³/s	EL+297.66 m
C	Erap	600 km²	1/45	EL+52.76/53.00 m	4,133 m³/s	EL+51.86 m
D	Punano	350 km²	1/30	EL+400 m	2,411 m³/s	R/Bank
E	Onga	150 km²	1/35	EL+370 m	1,033 m³/s	R/Bank
F	Obura	1,500 km²	1/90	EL+344 m	10,333 m³/s	R/Bank
G	Watut	3,500 km²	1/110	EL+158 m	24,111 m³/s	R/Bank
H	Mari	800 km²	1/120	EL+32 m	5,511 m³/s	R/Bank
	Total	8,900 km²			56,587 m³/s	

Notes: *1: estimated 100 years return period
(Prepared by the Survey Team)

(Prepared by the Survey Team)

Figure 5.3-3 River System of Markham River

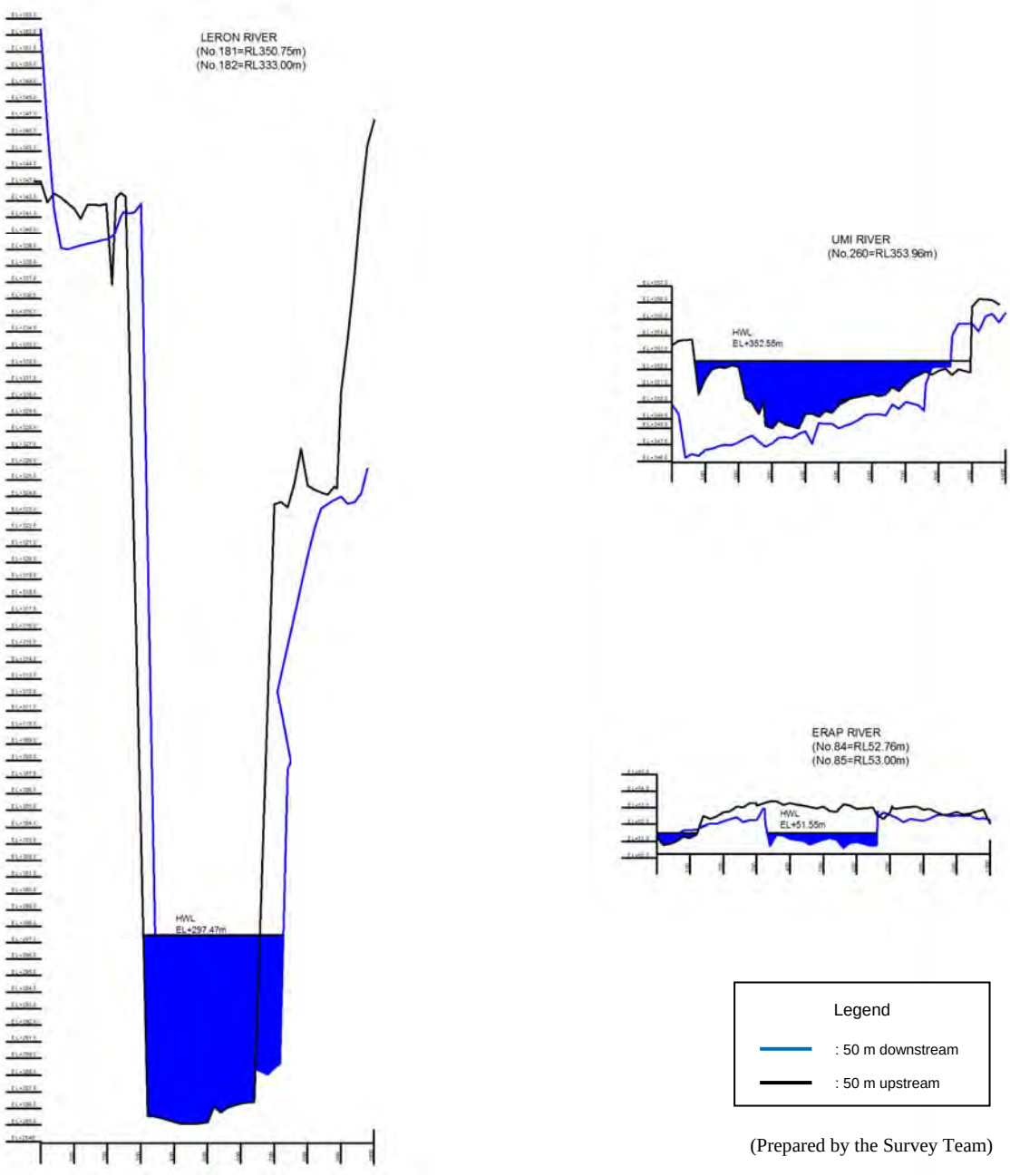
Points A, B and C in Table 5.3-7 are confluences from left bank after crossing the transmission line, and the flooding will be affected to the foundations. Consequently, the foundation design around the Umi and Erap Rivers must be considered the flooding affects.

Every tributary river forms an alluvial fan and develops river terraces at both sides of the river banks. Particularly, a point along the Leron River where the existing transmission line crosses Towers No. 181 and No. 182, forms the terrace which is more than 10 m high due to river erosion. Most of the new transmission line towers will be located on the dry riverbeds and sandbars, which are formed with a mixture of sand and cobble stones. The water table is relatively shallow due to the groundwater flow in the alluvial fans. Because of this, foundations for the new transmission line towers have to be designed so as to withstand large buoyancy.

(5) Inundation Water Level during Flooding

The planned transmission line will cross three large rivers such as the Umi River (Markham River, EL+359 m, top elevation of foundation), Leron River (EL+343 m) and Erap River (EL+53 m). The flood discharges from each sub-basin are estimated by the rational formula, while the flood water level is calculated by the non-uniformed flow method using HEC-RAS at the 50 m upstream and downstream, respectively of the tributary cross section as shown in Figure 5.3-4.

The foundation of Tower No.260 at the Umi River is constructed 6.0 m higher than the flood water level, while the foundation of Tower No.181 at the Leron River is constructed 45.0 m higher than the river bed. In addition, since the flood water level in the Erap fan area is estimated at EL+51.86 m, the existing foundations in the area have been elevated using steel frames for the top foundation to achieve EL+53 m. New foundations in such area should be approximately 2.0 m higher to avoid flooding and erosion.



(Prepared by the Survey Team)

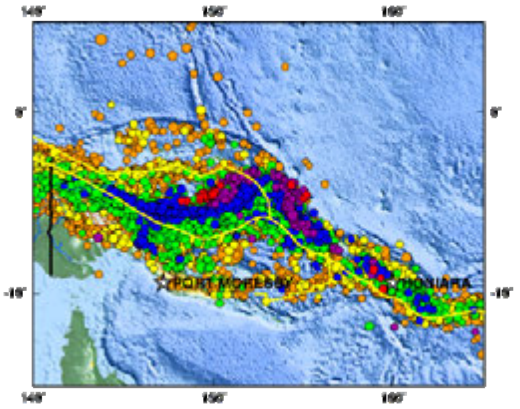
Figure 5.3-4 Flood Water Level Analysis

(6) Earthquake

The island as a whole has an area of 868,000 km^2, out of which the eastern part of 462,800 km^2 is the territory of PNG. Both geologically and topographically, the land is very new. It is situated in a zone where the earth's crust is very weak. Its boundary is in between two tectonic plates, those of the ancient continent of Australia and of the Pacific Ocean. It forms part of the so-called "Ring of Fire" around the edge of the Pacific, and most of the country has been formed comparatively by recent earth movements and volcanic activities.

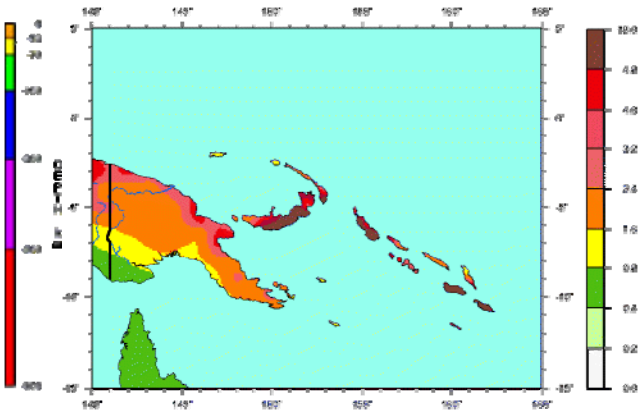
The volcanoes of New Britain are the result of subduction of the northward-migrating Solomon Sea Plate under the South Bismarck Plate. The volcanoes in the Solomon Islands

are associated with the Solomon Sea Plate as it is subducted beneath the Pacific Plate. Two short spreading centres, one at the southeast margin of the Solomon Sea Plate and the other at the north edge of the South Bismarck Plate, influence volcanism at Kavachi (Solomon Islands) and the Admiralty Islands, respectively. Figures 5.3-5 and 5.3-6 show the Seismicity Map and Seismic Hazard Map, respectively.



(Source: USGS)

Figure 5.3-5 Seismicity Map



(Source: USGS)

Figure 5.3-6 Seismic Hazard Map

5.3.3 Particular Conditions

The following conditions are applied to the transmission line design:

1) Stringent condition and EDS condition

Condition	Temperature	Wind
Stringent	0 deg C	37 m/s
EDS	26 deg C	Still air

2) Pollution level

Pollution is not considered as per the PPL's Spec.

3) Safety factors

Required minimum safety factors are determined in compliance with the PPL's Spec and international practices.

i) Conductor/ground-wire

- 2.5 to ultimate tensile strength (UTS) in maximum working condition
- 5.0 to UTS for EDS condition at supporting point (20 % to UTS)

ii) Insulator string

- 2.5 to rated ultimate strength (RUS) of the string in maximum working condition at supporting point.

iii) Tower

- Normal/Stringent condition: 1.5 to yield strength of materials
- Broken-wire condition (Normal condition + Breakage of one ground-wire or

one phase conductor): 1.0 to yield strength of materials

iv) Foundation

- Normal/Stringent condition: 2.5 to failing strength of foundations
- Broken-wire condition (Normal condition + Breakage of one ground-wire or one phase conductor): 1.5 to failing strength of foundations

5.4 Conductors and Ground-wires

The following design conditions for conductors and ground-wires are applied.

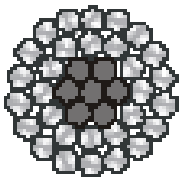
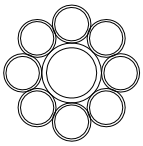
Table 5.4-1 Design Conditions of Conductors and Ground-wires

Loading condition	Wind velocity	Wind pressure	Conductor temp.	Safety factors
Stringent condition	37 m/sec	856 N/ m^2	0 C deg	2.5 (40%UTS)
EDS condition	0 m/sec	0 N/ m^2	26 C deg	5.0 (20%UTS)

(Prepared by the Survey Team)

(1) Conductors and ground-wires

Table 5.4-2 Conductors and Ground-wires

Type	Conductors	Ground-wires	
	ACSR 425 mm^2 (ASTM: Deer)	AC 70 mm^2 (ASTM: A220)	OPGW 70 mm^2 (ASTM: Type A)
Figure of section			
Component of stranded wires	Al: 30/4.27 mm St: 7/4.27 mm	AC: 7/3.5 mm	AC: 8/3.2 mm OP unit: 1/5.0
Total area of aluminium wires	429.6 mm^2	67.35 mm^2	77.89 mm^2
Overall diameter	29.89 mm	10.5 mm	11.4 mm
Weight	1,972.7 kg/km	426.5 kg/km	470.1 kg/km
Ultimate tensile strength	178.6 kN	77.3 kN	80.2 kN
Modulus of elasticity	80,000 N/mm^2	149,000 N/mm^2	142,000 N/mm^2
Coefficient of linear expansion	17.8 x 10^{-6}/℃	12.9*10^{-6}/℃	13.8x10^{-6}/℃
DC resistance at 20℃	0.06727 Ω/km	1.12 Ω/km	0.834 Ω/km
Allowable current	930 A	-	-

(Prepared by the Survey Team)

(2) Maximum Working Tension and EDS

The design span for wind pressure (wind span) for the proposed transmission line is assumed to be 400 m. However, the actual span will be around 700 m at maximum and the sag of the conductor needs to be minimized. The maximum working tensions and EDS conditions of both conductors and ground-wires are determined based on the safety factors as shown in Table 5.4-3.

Working tension of ground-wire is determined so that its sag is less than 80% of the conductor's sag under EDS conditions for a standard span length of 400 m.

Table 5.4-3 Maximum Working Tension and EDS (actual span = max. 700 m)

Type	UTS	Tension		Safety Factors
ACSR 425 mm^2	178.6 kN	Maximum Tension	50.9 kN	3.50 > 2.5
		EDS condition	30.8 kN	5.79 > 5.0
AC 70 mm^2	77.3 kN	Maximum Tension	16.8 kN	4.60 > 2.5
		EDS condition	8.6 kN	9.00 > 5.0
OPGW 70 mm^2	80.2 kN	Maximum Tension	18.4 kN	4.36 > 2.5
		EDS condition	9.6 kN	8.35 > 5.0

(Prepared by the Survey Team)

5.5 Insulator Sets

The design for the insulator stringing set was based on the design of the existing transmission line.

(1) Insulator type and size

The standard disc type porcelain insulator with ball and socket complying with AS 2947.2 is applied to the 132 kV transmission lines. This insulator basically complies with IEC.

Table 5.5-1 shows the selected insulator size and its strength.

Table 5.5-1 Insulator Size

Size	Height	Diameter	Electro-mechanical Failing Load
250 mm disc	146 mm	255 mm	160 kN for tension
250 mm disc	146 mm	255 mm	120 kN for suspension

(Prepared by the Survey Team)

(2) Number of insulator unit

1) Standard lightning impulse withstand voltage

Standard lighting impulse withstand voltage for 132 kV equipment is 650 kV and the minimum clearance at 650 kV is 1,300 mm as classified in IEC 60071-2.

2) Number of insulator units per string for 132 kV line

According to the PPL's Spec, the necessary creepage distance of insulators is 2,520 mm, therefore, the number of insulator unit per string of the standard string is nine units (2,520/320 = 8). From the standard lightning impulse withstand voltage; number of insulator unit per string of the standard set is determined at eight units. Number of insulator unit per string can be determined to be nine units by adding one unit for maintenance allowance. Required number of units in the PPL's Spec is justified.

(3) Insulator assembly

160 kN insulators shall be applied to tension insulator assembly under the Project to secure the safety factor of 2.5. For suspension insulators, 120 kN is strong enough and to be used. Insulator fittings also have to keep the same strength of insulators.

Table 5.5-2 Insulator Assemblies

Conductors	Maximum Tension (Span length: max. 700 m Weight span: 800 m)	Insulator assemblies	Safety factor
ACSR 425 mm^2	50.9 kN	160 kN for tension	3.14＞2.5
	15.5 kN	120 kN for suspension	7.76＞2.5

(Prepared by the Survey Team)

(4) Configuration of Insulator assembly

Table 5.5-3 shows designed dimension and configuration of insulator assemblies.

Table 5.5-3 Size of Insulator Assembly

Insulator Assemblies	Items	Values
Suspension Insulator Assembly	Number of 255 mm Insulator	9 units
	Length of 255 mm Insulator	1,314 mm
	Arcing Horn Gap	1,150 mm
	Insulator Assembly Length	1,900 mm
Tension Insulator Assembly	Number of 255 mm Insulator	9 units
	Length of 255 mm Insulator	1,314 mm
	Arcing Horn Gap	1,150 mm
	Insulator Assembly Length	2,000 mm

(Prepared by the Survey Team)

5.6 Ground Clearance

Severe condition of ground clearance will be observed when the conductor's temperature reaches 75°C, which is the maximum allowable operating temperature, under normal weather condition. The minimum height of conductor above ground is as given below according to PPL's regulation;

Table 5.6-1 Minimum Height of Conductor above Ground

No.	Applied areas	Height
(1)	Terrain accessible to pedestrians only	6.70 m
(2)	Roads and terrain accessible to vehicles	6.70 m
(3)	Power supply or communication circuits irrespective of voltage – lowest phase conductor of upper line to highest phase conductor or ground-wire of lower line	3.30 m
(4)	Power supply or communication circuits irrespective of voltage - lowest phase conductor of upper line to any point on a support of the lower line on which a person may stand	5.50 m
(5)	Any building or structure on which a person can stand or which he can lean a ladder against.	5.50 m

(Source: Table 8.1 of "Guidelines for design and maintenance of overhead distribution and transmission lines" of ESAA, and PPL's specifications)

When ACSR 425 mm^2 conductor is strung under 50.9 kN of working tension, conductor sags at 75°C of maximum allowable temperature for three typical span lengths are calculated as shown in Table 5.6-2.

Table 5.6-2 Conductor Sags

Span Length	400 m	500 m	700 m
Tension at 75°C	27.1 kN	28.2 kN	29.3 kN
Safety factors	6.57	6.33	6.10
Conductor sags	14.5 m	22.3 m	40.4 m

(Prepared by the Survey Team)

5.7 Tower Configurations

Design for the dimension of suspension and tension type towers for the Project are determined from examining the conductor clearance diagrams.

(1) Insulation Coordination

Insulation gaps for standard and abnormal states are worked out as below.

Gap lengths are used for clearance between conductor and tower member, between different phase conductors, and between conductor and ground wire.

Table 5.7-1 Insulation Gaps

Characteristic	Items	Values	Reasons
Voltage	Nominal voltage	132 kV	Complying with IEC60038
	Highest voltage	145 kV	Complying with IEC60038
Lightning Impulse	Length of 255 mm insulator	1,314 mm	146 mm x 9 units
	Arcing horn gap	1,150 mm	for impulse withstand voltage: 650 kV
	Standard insulation gap	1,282 mm	Arcing horn gap x 1.115 (111.5% of arcing horn gap)
Power frequency	Abnormal state insulation gap	200 mm	Complying with IEC60071-1, 60071-2
	Abnormal state phase gap	400 mm	Complying with IEC60071-1, 60071-2

(Prepared by the Survey Team)

(2) Clearance Design

1) Clearance between conductor and tower member

Lengths of cross-arms and vertical separation between cross-arms are determined from swinging angle of suspension insulator strings shown in Table 5.7-2 and conductor clearance diagrams applying values shown in Table 5.7-3.

Table 5.7-2 Swinging Angle of Conductor

Wind Velocity	10 m/sec	37 m/sec
Swinging angle of insulator strings	10 deg	60 deg
Applied clearance	Standard clearance	Abnormal clearance

(Prepared by the Survey Team)

Table 5.7-3 Values of Clearance Diagram

Tower type	Item	Formula and value
Suspension tower	Insulator assembly length	146 mm x 9 units + 500 mm (Fitting length) ≒ 1,900 mm
Tension tower	Jumper conductor depth	1,282 mm (standard insulation gap) x 1.2 + 100 mm (Margin for changing the shape of jumper conductor) ≒ 1,650 mm
Suspension and tension tower	Standard clearance (Swinging angle 10 deg)	1,282 mm (Standard insulation gap) + 150 mm (Step bolts length) = 1,450 mm
	Abnormal clearance (Swinging angle 60 deg)	200 mm (Abnormal state insulation gap) + 150 mm (Step bolts length) = 350 mm

(Prepared by the Survey Team)

2) Separation between conductors and between conductor and ground-wire

Minimum separation between two conductors and between conductor and ground-wire are determined to satisfy the following values when conductors will swing by wind blow.

- Between two conductors: 450 mm
  (Abnormal state phase gap; 400 mm + Conductor's diameter; around 50 mm)
- Between conductor and ground wire: 250 mm
  (Abnormal state insulation gap; 200 mm + Conductor's and ground wire's diameter; around 50 mm)

(3) Insulation design of ground-wires

Number and shielding angle to conductors of ground-wire are determined below. Following the existing double circuit towers in Port Moresby, the double circuit towers from Erap SS to Singsing SS will be equipped with two ground-wire arms.

i) 132 kV single circuit overhead line between the Taraka SS and Erap SS
Maximum shielding angle: 30 degrees

ii) 132 kV double circuit overhead line between the Erap SS and new Singsing SS
Maximum shielding angle: 5 degrees

(4) Tower configurations

Configurations for the following four standard types of towers are determined based on the above design conditions.

Table 5.7-4 Tower Configurations of 1-cct Towers

Towers	Suspension Tower	Tension Tower		
Line Horizontal Angle	0～3°	0～15°	0～30°	0～90° (Dead End)
Type	A	B	C	D
Height [m]	30.85	30.90	31.80	30.90
Arm Length [m]	7.6 (from Left to Right)	8.0	8.8	8.0
Base width of tower [m]	5.5	6.0	6.5	6.5
Body Extension [m]	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0
Conductor Height [m]	21	21	21	21

(Prepared by the Survey Team)

Table 5.7-5 Tower Configurations of 2-cct Towers

Towers	Suspension Tower	Tension Tower		
Line Horizontal Angle	0～3°	0～15°	0～30°	0～90° (Dead End)
Type	AA	BB	CC	DD
Height [m]	33.25	33.00	33.00	33.00
Arm Length [m]	8.0 (from Left to Right)	8.2	9.0	8.0
Base width of tower [m]	6.0	6.5	7.0	7.0
Body Extension [m]	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0	+3.0, +6.0, +9.0
Conductor Height [m]	21	21	21	21

(Prepared by the Survey Team)

Wider dimensions of tower leg at ground level produce lighter loads to the foundations, which allow economical design of the foundation. However, wider dimensions of tower legs will cause greater land acquisition.

5.8 Towers

Towers are provisionally designed in coordination with tower weights and foundation loads. Tower members shall be coated with a finishing of hot-dip galvanizing to ensure its durability. The following shows the basic condition for tower design:

(1) Tower design conditions

Tower design is carried out for the four standard towers classified in Tables 5.7-4 and 5.7-5, based on the following design conditions and span length.

1) Wind pressure

- Conductor 856 N/m^2
- Insulator strings 1,000 N/m^2
- Tower 1,976 N/m^2 (including pressure on its rear structures)

2) Standard span length and applied maximum span length

Table 5.8-1 Design Span Length

Towers	Type	Design Span Length (Wind Span)	Design Span Length (Weight Span)
Suspension	A & AA	400 m	800 m
Tension	B & BB	400 m	800 m
	C & CC	400 m	800 m
	D & DD	400 m	800 m

(Prepared by the Survey Team)

3) Loading conditions and safety factors

Table 5.8-2 Loading Conditions and Safety Factors for Tower Design

Loading conditions	Loads	Safety factor
Normal condition	Maximum load by wind (37 m/sec)	1.5 to yield strength of material
Abnormal condition (Broken wire condition)	Maximum load + one ground wire or one phase conductor breakage load for 1-cct towers and two phase conductors breakage load for 2-cct towers	1.0 to yield strength of material

(Prepared by the Survey Team)

(2) Results of tower design

Tables 5.8-3 and 5.8-4 summarize the results of tower design.

Table 5.8-3 Tower Weight and Foundation Load of 1-cct Towers

Tower	Suspension	Tension		
Line Horizontal Angle	0～3°	0～15°	0～30°	0～90° (Dead End)
Type	A	B	C	D
Weight [ton]	3.0	4.0	5.0	8.0
Foundation compression load [kN]: Normal load	120	160	200	300
Foundation uplift load [kN]: Normal load	60	80	130	180

(Prepared by the Survey Team)

Table 5.8-4 Tower Weight and Foundation Load of 2-cct Towers

Tower	Suspension	Tension		
Line Horizontal Angle	0～3°	0～15°	0～30°	0～90° (Dead End)
Type	AA	BB	CC	DD
Weight [ton]	5.0	7.0	10.0	14.0
Foundation compression load [kN]: Normal load	200	300	400	500
Foundation uplift load [kN]: Normal load	100	150	280	400

(Prepared by the Survey Team)

Typical tower drawings of 132 kV transmission line are shown in Dwg_PNG_TL_TWR_001 and Dwg_PNG_TL_TWR_002 in Attachment-3.

5.9 Foundations

(1) Standards

Industrial standards in PNG are developed by PNG Standard. However, for the foundation design including the load factors and design methods, Australia/New Zealand Standard (AS/NZS) was adopted.

AS 5,100 (Road/Bridge Design) contains;

Part 1: Scope and General Principles
Part 2: Design Load
Part 3: Foundation and Soil supporting structures
Part 4: Bearings and Deck Joints
Part 5: Concrete
Part 6: Steel and Composite Construction
Part 7: Rating of Existing Bridge

(2) Foundations of Transmission Line Tower

In the design of foundations for new transmission line towers, the angle of line, wind load, tower height and the span between towers, etc. shall be considered. These factors are to be incorporated into the stresses of tower legs (tension and compression), which will transfer to the foundation. Tables 5.9-1 and 5.9-2 show the design conditions.

Table 5.9-1 Foundation Stress of 1-cct Towers

Line Angle	Tension	Compression	Tower Type	
0 to 3 Degree	- 70 kN/m^2	+ 140 kN/m^2	A	Suspension
0 to 15 degree	- 105 kN/m^2	+ 210 kN/m^2	B	Light angle
0 to 30 degree	- 105 kN/m^2	+ 210 kN/m^2	C	Middle angle
0 to 90 degree	- 210 kN/m^2	+ 350 kN/m^2	D	Heavy angle

(Prepared by the Survey Team)

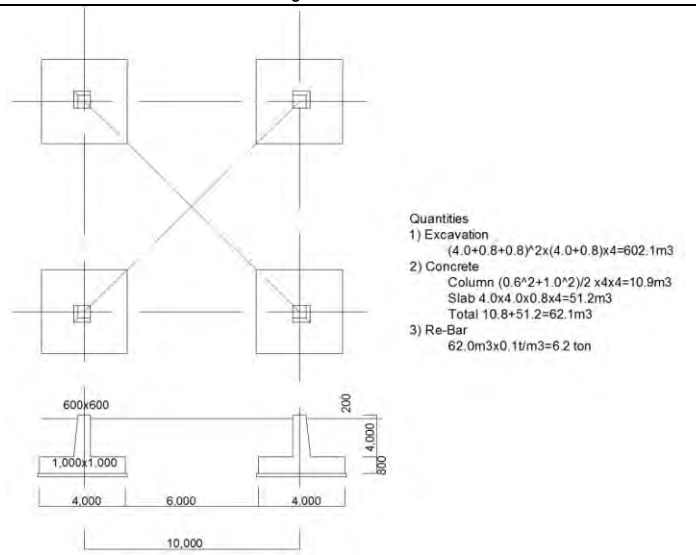
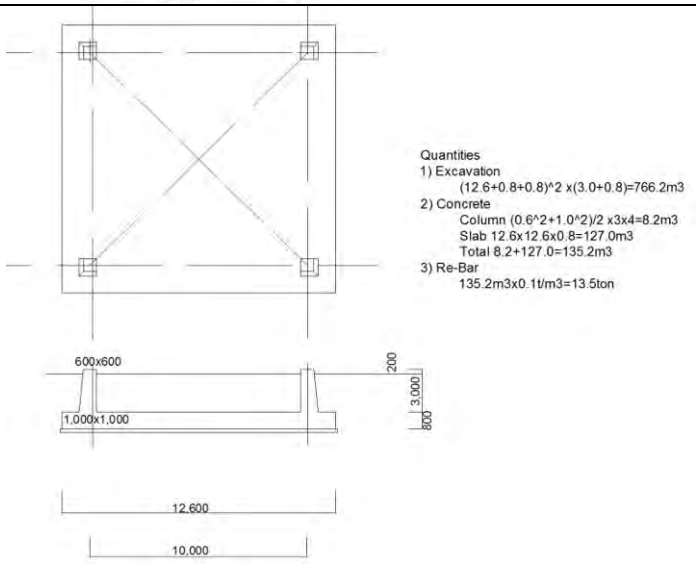
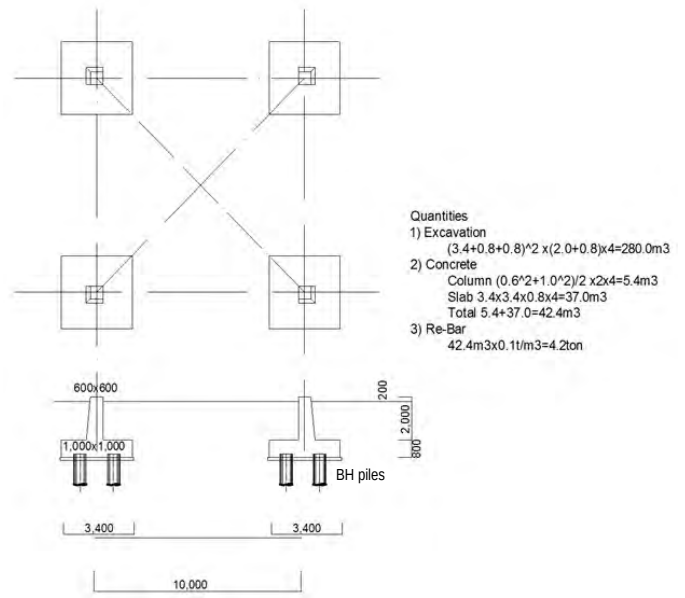
Table 5.9-2 Foundation Stress of 2-cct Towers

Line Angle	Tension	Compression	Tower Type	
0 to 3 Degree	- 100 kN/m^2	+ 200 kN/m^2	AA	Suspension
0 to 15 degree	- 150 kN/m^2	+ 300 kN/m^2	BB	Light angle
0 to 30 degree	- 150 kN/m^2	+ 300 kN/m^2	CC	Middle angle
0 to 90 degree	- 300 kN/m^2	+ 500 kN/m^2	DD	Heavy angle

(Prepared by the Survey Team)

The foundation shall be designed based on the ground water table and the soil condition. There will be three designs for the foundation as shown in Table 5.9-3.

Table 5.9-3 Foundation Types

Foundation Type		Foundation Size	Drawings for 2-cct Towers
Type 1	Spread	3.0m x 3.0m x 4 Nos. for 1-cct Towers 4.0 m x 4.0 m x 4 Nos. for 2-cct Towers	
Type 2	Mat	10.5m x 10.5m for 1-cct Towers 12.6 m x 12.6 m for 2-cct Towers	
Type 3	Pile	2.5m x 2.5m with Pile (D500 mm) for 1-cct Towers 3.4 m x 3.4 m with Pile (D600 mm) for 2-cct Towers	

(Prepared by the Survey Team)

5.10 Quantities of Line Materials

(1) Number of towers and total weights

Four types of towers used, (i.e., suspension type towers, tension type towers) are classified with deviated angle. Suspension type towers would be allocated in straight section and tension type towers would be allocated at every angle in deviating points of the line route pursuant to its angle. In addition, light angle towers would be allocated every 10 towers in straight section under the theory of failsafe.

Table 5.10-1 Numbers and Weights of 1-cct Towers

Type	Weight [ton]	Total Quantity	
		Towers [Units]	Total Weight [ton]
A	3.0	70	210.0
B	4.0	14	56.0
C	5.0	4	20.0
D	8.0	8	64.0
	Total	96	350.0

(Prepared by the Survey Team)

Table 5.10-2 Numbers and Weights of 2-cct Towers

Type	Weight [ton]	Total Quantity	
		Towers [Units]	Total Weight [ton]
AA	5.0	184	920.0
BB	7.0	10	70.0
CC	10.0	10	100.0
DD	14.0	13	182.0
Total		217	1,272.0

(Prepared by the Survey Team)

(2) Quantities of conductors and ground-wires

Quantity of conductors and ground-wires are calculated by route length [km] × 1.05 (allowance for sag and margin for stringing works).

Table 5.10-3 Conductor/Ground-wire for 1-cct Section

Type	Number [units]	Route Length [km]	Quantity [km]	Total Quantity [km]
ACSR 425 mm^2	3	39.7	41.7	125.1
OPGW 70 mm^2	1	39.7	41.7	41.7

(Prepared by the Survey Team)

Table 5.10-4 Conductor/Ground-wire for 2-cct Section

Type	Number [units]	Route Length [km]	Quantity [km]	Total Quantity [km]
ACSR 425 mm^2	6	97.2+0.7	102.8	616.8
OPGW 70 mm^2	1	97.2+0.7	102.8	102.8
AC 70 mm^2	1	97.2+0.7	102.8	102.8

(Prepared by the Survey Team)

(3) Quantities of insulators and insulator assemblies

Quantity of insulators and insulator assemblies are calculated based on the number of suspension and tension towers. In this report, double string assemblies are not considered.

Table 5.10-5 Insulators and Insulator Assemblies for 1-cct Section

Type	Items	Unit Q'ty [units]	Towers [units]	Total [units]
Suspension	Insulators	27	70	1,890
	Single Strings Assemblies	3		210
Tension	Insulators	54	20+6	1,404
	Single Strings Assemblies	6		156
	Insulators	54	4(+2*)	252
	Jumper Assemblies	3		14
Gantry	Insulators	27	2	54
	Single Strings Assemblies	3		6
	Insulators	54		108
	V-string Assemblies	3		6

Note*: single side only

(Prepared by the Survey Team)

Table 5.10-6 Insulators and Insulator Assemblies for 2-cct Section

Type	Items	Unit Q'ty [units]	Towers [units]	Total [units]
Suspension	Insulators	54	184	9,936
	Single Strings Assemblies	6		1,104
Tension	Insulators	108	33	3,564
	Single Strings Assemblies	12		396
	Insulators	54	34	1,836
	Jumper Assemblies	3		102
Gantry	Insulators	27	9	243
	Single Strings Assemblies	3		27
	Insulators	54		486
	V-string Assemblies	3		27

(Prepared by the Survey Team)

(4) Quantities of fittings

Fittings of conductor and ground-wire are designed as follows:

1) Vibration dampers of conductor and ground-wire

Dampers are installed in each conductor and in each ground-wire for all spans. The final quantity is as per the manufacturer's recommendation.

2) Compression sleeve of conductor and ground-wire

- Number of compression sleeve of conductor = Conductor length [km] ÷ 1.5 [km] (standard length of conductor per drum)
- Number of compression sleeve of ground-wire = ground-wire length [km] ÷ 3.5 [km] (standard length of ground-wire per drum)

3) Ground-wire stringing

Suspension ground-wire fitting is installed on suspension towers and tension ground-wire fittings for tension towers and substation gantries.

Table 5.10-7 shows the quantities of fittings.

Table 5.10-7 Quantities of Fittings

Fittings	units	1-cct Section.	2-cctSection
Conductor Dampers	sets	1,056*1	5,136*1
GW Dampers (AC, OPGW)	sets	352*1	1,712*1
Conductor Sleeves	pcs	84	395
GW Sleeves	pcs	0	40
Suspension GW Fittings (AC, OPGW)	sets	70	368
Tension GW Fittings (AC, OPGW)	sets	40	144

Note *1: 150 m-300 m span: 2 nos/phase, 300 m-550 m span: 4 nos/phase, and 550 m-700 m span: 6 nos/phase

(Prepared by the Survey Team)

(5) Quantities of tower foundations

Table 5.10-8 summarizes the quantities of tower foundations.

Table 5.10-8 Quantities of Tower Foundations

Type	for 1-cct towers		for 2-cct towers	
	Foundation Size	Q'ty	Foundation Size	Q'ty
Type 1	3.0 m x 3.0 m x 4 Nos.	75	4.0 m x 4.0 m x 4 Nos.	188
Type 2	10.5 m x 10.5 m	17	12.6 m x 12.6 m	28
Type 3	2.5 m x 2.5 m with Pile (D500 mm)	4	3.4 m x 3.4 m with Pile (D600 mm)	1

(Prepared by the Survey Team)

(6) Spare parts, tool and testing equipment

The following spare parts, tool and testing equipment are recommended to be provided for easy maintenance:

1) Line materials for maintenance

Complete set of standard towers, galvanized steel materials, bolts and nuts for replacement of damaged members, spare conductors or ground-wire with fittings, insulators with fittings, etc.

2) Tool and testing equipment

Insulator replacing devices, special tool for repairing work, portable earth-rod, insulation resistance measuring, electrician's hand tool, vehicle for inspection of facility, etc.

Estimate cost of spare parts, special tool and testing equipment is assumed to be around 3 % of the total cost of line materials.

Table 5.2-2 Result of Soil Investigation

No.	Investigation Point	T/L Tower	Location			Depth	Average	N	Ground	Bearing Capacity			CBR
			E	N	ALT	GL-m	Depth	more 30	Water	ABC kPa	Min kPa	tf/m2	(%)
1	Erap River (Tower 1)	No.83/No.84	55s466128E	9271190N	GL+60	-4.0	-3.6	32	-0.8	207	114	11.6	27
			55s466130E	9271181N		-3.0		36		114			8
			55s466123E	9271179N		-4.0		31		223			31
			55s466125E	9271188N		-3.3		32		172			18
			55s466124E	9271184N		-3.5		37		153			15
2	Erap River (Tower 2)	No.85/No.86	55s466405E	9271199N	GL+53	-2.6	-3.4	36	-0.9	114	114	11.6	8
			55s466403E	9271193N		-4.0		50		271			45
			55s466398E	9271200N		-3.6		30		207			27
			55s466398E	9271191N		-3.7		33		223			31
			55s466401E	9271195N		-3.1		31		190			22
3	Rumu River	No.112/No.113	55s454686E	9270572N	GL+83	-2.1	-1.9	32	-4.5	153	114	11.6	15
			55s454684E	9270577N		-2.0		30		114			8
			55s454697E	9270574N		-1.9		34		134			11
			55s454692E	9270579N		-1.7		30		134			11
			55s454690E	9270573N		-1.9		38		172			18
4	Leron River	No. 181/No.182	55s435796E	9294363N	GL+343	-1.0	-0.8	72	-2.5	501	435	44.37	150
			55s435786E	9294335N		-1.0		51		438			116
			55s435765E	9294347N		-1.0		40		438			116
			55s435781E	9294353N		-1.0		43		385			90
			55s435781E	9294353N		-0.5		46		476			136
			55s435781E	9294353N		-0.5		46		372			84
			55s435781E	9294353N		-0.5		46					
			55s435781E	9294353N		-0.5		46					
5	Markham (Umi) River	No.260/No.261	55s409745E	9312082N	GL+359	-0.5	-0.5	50	-2.5	464	438	44.7	129
			55s409738E	9312078N		-0.5		56		438			116
			55s409739E	9312088N		-0.5		71		488			143
			55s409731E	9312082N		-0.5		61		476			136
			55s409737E	9312082N		-0.5		69		513			158
6	Grambampam River	No.284/No.285	55s401821E	9319937N	GL+402	-2.6	-2.6	58	-0.5	223	190	19.4	31
			55s401825E	9319930N		-2.5		57		190			22
			55s401817E	9319933N		-2.6		57		223			31
			55s401819E	9319927N		-2.5		57		207			27
			55s401823E	9319932N		-2.6		60		255			40
7	Gusap River	No.295/No.296	55s382654E	9333380N	GL+417	-0.5	-2.5	40	-2.5	207	207	21.1	27
			55s382643E	9333380N		-0.5		48		344			72
			55s382652E	9333388N		-0.5		32		223			31
			55s382644E	9333386N		-0.5		37		286			50
			55s382647E	9333382N		-0.5		56		330			66
8	Taraka Substation	No.1	55s498590E	961541N	GL+55	-0.5	-0.5	79	-3	513	412	42.0	158
			55s498587E	961538N		-0.5		62		438			116
			55s498589E	961547N		-0.5		65		412			103
			55s498583E	961544N		-0.5		70		412			103
			55s498590E	961541N		-0.5		72		488			143
9	Erap Substation	No.91/No.92	55s462460E	9270856N	GL+58	-3.0	-2.9	46	-1.2	223	153	15.6	31
			55s462460E	9270881N		-3.0		46		223			31
			55s462441E	9270852N		-2.7		30		153			15
			55s462439E	9270873N		-3.0		39		172			18
			55s462453E	9270873N		-2.6		42		153			15
10	Sing Sing Substation	No.304	55s393721E	9329432N	GL+486	-1.0	-1.2	54	-2.5	271	114	11.6	45
			55s393713E	9320451N		-1.5		32		114			8
			55s393734E	9320446N		-1.0		73		358			78
			55s393741E	9320441N		-0.5		37		271			45
			55s393727E	9320447N		-2.0		57		190			22
11	Numa City	No.227	55s416631E	9299224N	GL+260	-1.5	-1.5	45	-2.3	438	344	35.1	116
			55s416634E	9299228N		-1.0		37		372			84
			55s416638E	9299219N		-1.5		36		344			72
			55s416637E	9299223N		-2.0		45		438			116
			55s416636E	9299222N		-1.5		43		344			72
12	Zumin City	No.249	55s412945E	9307996N	GL+333	-1.5	-1.5	38	-2.5	134	114	11.6	11
			55s412947E	9307998N		-1.5		33		114			8
			55s412945E	9307996N		-1.5		33		134			11
			55s412952E	9307991N		-1.5		46		438			116
			55s412947E	9307991N		-1.5		63		286			50

Table 5.3-6 Intensity Rainfall (1/2)

Aiyura : Eastern Highland Provincial (2006-2010)

No.	xi	2i-1/2N	log10xi	xi/xo	$\log_{10}xi-\log_{10}xo$	$(\log_{10}xi-\log_{10}xo)^{\wedge 2}$	xi-x	$(xi-x)^{\wedge 2}$
1	80.4	2.5	1.9053	1.544	0.1887	0.03562	27.6	762
2	66.4	7.5	1.8222	1.275	0.1057	0.01116	13.6	185
3	59.0	12.5	1.7709	1.133	0.0543	0.00295	6.2	38
4	58.4	17.5	1.7664	1.122	0.0499	0.00249	5.6	31
5	58.2	22.5	1.7649	1.118	0.0484	0.00234	5.4	29
6	56.4	27.5	1.7513	1.083	0.0348	0.00121	3.6	13
7	55.4	32.5	1.7435	1.064	0.0270	0.00073	2.6	7
8	55.2	37.5	1.7419	1.060	0.0254	0.00065	2.4	6
9	54.8	42.5	1.7388	1.053	0.0223	0.00050	2.0	4
10	54.0	47.5	1.7324	1.037	0.0159	0.00025	1.2	1
11	51.2	52.5	1.7093	0.983	-0.0072	0.00005	-1.6	3
12	50.6	57.5	1.7042	0.972	-0.0124	0.00015	-2.2	5
13	48.6	62.5	1.6866	0.934	-0.0299	0.00089	-4.2	18
14	47.6	67.5	1.6776	0.914	-0.0389	0.00151	-5.2	27
15	47.0	72.5	1.6721	0.903	-0.0444	0.00197	-5.8	
16	45.0	77.5	1.6532	0.864	-0.0633	0.00401	-7.8	61
17	44.4	82.5	1.6474	0.853	-0.0691	0.00478	-8.4	71
18	42.0	87.5	1.6232	0.807	-0.0933	0.00870	-10.8	117
19	41.2	92.5	1.6149	0.791	-0.1016	0.01033	-11.6	135
20	40.2	97.5	1.6042	0.772	-0.1123	0.01261	-12.6	159
Total	1056.0		34.3302			0.10291		1670
aveV	52.8	log10xo	1.7165			0.00515		84
		xo	52.0610		so	0.07173	s	9.138

INTENSITY RAINFALL (Aiyura)

1. Logarithmic distribution Method

(1) Condition

$$\log_{10} x_0 = 1.7165$$

$$\xi$$

$$\sigma_0^{\ 2} = \frac{\sum_{1}^{N}(\log_{10} xi - \log_{10} x_0)^2}{N} = \frac{0.1029}{20} = 0.0051$$

$$\sigma_0 = 0.072$$

$$\log_{10} x = \sigma_0 \xi + \log_{10} x_0$$

Return period		Intensity Rainfall
1/200	2.3263 × 0.0718 + 1.7165 = 1.902	(79.8 mm/d)
1/100	2.3263 × 0.0718 + 1.7165 = 1.884	(76.6 mm/d)
1/50	2.0537 × 0.0718 + 1.7165 = 1.864	(73.1 mm/d)
1/10	1.2815 × 0.0718 + 1.7165 = 1.809	(64.4 mm/d)

2. Takase Method

(1) Condition

$$\log_{10} x = \frac{\xi\sigma_0}{\sqrt{2}\sigma_\xi} + \log_{10} x_0 = \frac{\xi \times 0.07173}{\sqrt{2} \times 0.6851} = 0.074$$

$$\log_{10} x = \sigma_0 \xi + \log_{10} x_0$$

Return period		Intensity Rainfall
1/200	2.5758 × 0.074 + 1.7165 = 1.907	(80.7 mm/d)
1/100	2.3263 × 0.074 + 1.7165 = 1.889	(77.4 mm/d)
1/50	2.0537 × 0.074 + 1.7165 = 1.868	(73.8 mm/d)
1/10	1.2815 × 0.074 + 1.7165 = 1.812	(64.9 mm/d)

3. Gumbell Method

(1) Condition

$$\bar{x} = 52.8 mm/h$$

$$\sigma = \sqrt{\frac{\sum_{1}^{N}(xi - \bar{x})}{N}} = \sqrt{\frac{1670}{20}} = 9.138$$

Return period	K	Intensity Rainfall
1/200	3.683 × 9,138 + 52.8 = 86.5 mm/d	
1/100	3.137 × 9.138 + 52.8 = 81.5 mm/d	
1/50	2.529 × 9.138 + 52.8 = 76.5 mm/d	
1/10	1.304 × 9.138 + 52.8 = 64.7 mm/d	

4. Design Intensity Rainfall

R/Period	**1/200**	**1/100**	**1/50**	**1/10**	**Remark**
Intensity	**86.5 mm/d**	**81.5 mm/d**	**76.5 mm/d**	**64.7 mm/d**	

Table 5.3-6 Intensity Rainfall (2/2)

Nadzab : Morobe Provincial (2005-2010)

No.	xi	2i-1/2N	$\log_{10}$xi	xi/xo	$\log_{10}$xi-$\log_{10}$xo	$(\log_{10}xi-\log_{10}xo)^{\wedge 2}$	xi-x	$(xi-x)^{\wedge 2}$
1	107.4	2.5	2.0310	2.063	0.3145	0.09891	54.6	2981
2	90.2	7.5	1.9552	1.733	0.2387	0.05697	37.4	1399
3	90.0	12.5	1.9542	1.729	0.2377	0.05652	37.2	1384
4	76.2	17.5	1.8820	1.464	0.1654	0.02737	23.4	548
5	68.4	22.5	1.8351	1.314	0.1185	0.01405	15.6	243
6	65.8	27.5	1.8182	1.264	0.1017	0.01035	13.0	169
7	61.6	32.5	1.7896	1.183	0.0731	0.00534	8.8	77
8	64.8	37.5	1.8116	1.245	0.0951	0.00904	12.0	144
9	63.8	42.5	1.8048	1.225	0.0883	0.00780	11.0	121
10	60.6	47.5	1.7825	1.164	0.0660	0.00435	7.8	61
11	58.8	52.5	1.7694	1.129	0.0529	0.00279	6.0	36
12	58.6	57.5	1.7679	1.126	0.0514	0.00264	5.8	34
13	56.0	62.5	1.7482	1.076	0.0317	0.00100	3.2	10
14	55.4	67.5	1.7435	1.064	0.0270	0.00073	2.6	7
15	53.8	72.5	1.7308	1.033	0.0143	0.00020	1.0	
16	52.4	77.5	1.7193	1.007	0.0028	0.00001	-0.4	0
17	53.0	82.5	1.7243	1.018	0.0078	0.00006	0.2	0
18	50.8	87.5	1.7059	0.976	-0.0106	0.00011	-2.0	4
19	50.6	92.5	1.7042	0.972	-0.0124	0.00015	-2.2	5
20	50.2	97.5	1.7007	0.964	-0.0158	0.00025	-2.6	7
Total	1288.4		35.9782			0.29865		7229
aveV	64.4	log10xo	1.7989			0.01493		361
		xo	62.9377		so	0.12220	s	19.012

INTENSITY RAINFALL (Nadzab)

1. Logarithmic distribution Method

(1) Condition

$$\log_{10} x_0 = 1.7989$$

$$\xi$$

$$\sigma_0^{\ 2} = \frac{\sum_1^N (\log_{10} xi - \log_{10} x_0)^2}{N} = \frac{0.2987}{20} = 0.0149$$

$$\sigma_0 = 0.122$$

$$\log_{10} x = \sigma_0 \xi + \log_{10} x_0$$

Return period		Intensity Rainfall
1/200	2.3263 × 0.1221 + 1.7989 = 2.133	(129.7 mm/d)
1/100	2.3263 × 0.1221 + 1.7989 = 2.083	(121.1 mm/d)
1/50	2.0537 × 0.1221 + 1.7989 = 2.040	(109.6 mm/d)
1/10	1.2815 × 0.1221 + 1.7989 = 1.956	(90.4 mm/d)

2. Takase Method

(1) Condition

$$\log_{10} x = \frac{\xi \sigma_0}{\sqrt{2}\sigma_\xi} + \log_{10} x_0 = \frac{\xi \times 0.07173}{\sqrt{2} \times 0.6851} = 0.1261$$

$$\log_{10} x = \sigma_0 \xi + \log_{10} x_0$$

Return period		Intensity Rainfall
1/200	2.5758 × 0.1261 + 1.7989 = 2.166	(130.0 mm/d)
1/100	2.3263 × 0.1261 + 1.7989 = 2.092	(123.6 mm/d)
1/50	2.0537 × 0.1261 + 1.7989 = 2.056	(114.3 mm/d)
1/10	1.2815 × 0.1261 + 1.7989 = 1.960	(91.2 mm/d)

3. Gumbell Method

(1) Condition

$$\bar{x} = 64.4 mm/h$$

$$\sigma = \sqrt{\frac{\sum_1^N (xi - \bar{x})}{N}} = \sqrt{\frac{17229}{20}} = 19.013$$

Return period	K	Intensity Rainfall
1/200	3.683 × 19,013 + 64.4 = 134.4 mm/d	
1/100	3.137 × 19.013 + 64.4 = 124.0 mm/d	
1/50	2.529 × 19.013 + 64.4 = 113.7 mm/d	
1/10	1.304 × 19.013 + 64.4 = 99.2 mm/d	

4. Design Intensity Rainfall

R/Period	1/200	1/100	1/50	1/10	Remark
Intensity	134.4 mm/d	124.0 mm/d	114.3 mm/d	91.2 mm/d	

CHAPTER 6

BASIC DESIGN OF SUBSTATIONS

CHAPTER 6 BASIC DESIGN OF SUBSTATIONS

6.1 General

Based on the result of the power flow calculations, the selected scheme for the transmission of generated power from Ramu 1 HPS to Lae is to construct and extend the planned 132 kV substation in Singsing and the existing 132 kV substations in Erap and Taraka.

The Survey Team has visited the candidate substation sites and confirmed the availability and technical viability of new construction and extensions, and carried out the basic design for the substations as described in the succeeding sections.

6.2 Design Concepts

The following concepts shall be applied in the design of substations:

(1) General Concepts

Substation equipment is designed to maximize the functional role of substations in the overall power network, taking into account the following considerations:

a) Daily operation and maintenance (O&M) shall be performed safely and in accordance with approved procedures.
b) The connection shall be made as simple as possible without affecting the required performance from installed substation equipment.
c) In case a fault occurs in a substation, the extent of the fault's impact shall be kept to a minimum, and the necessary switching operations for shifting loads to other substations shall be performed immediately, without delay and trouble.
d) Design considerations must include facilitating future reinforcement and/or augmentation, when necessary.
e) Design must be technically and economically feasible.

(2) Type of Substations

The standard substation in PNG is, in principle, outdoor type with conventional equipment. An outdoor type substation is a substation with major facilities, such as main transformers, switchgear instruments, etc., installed in the open air.

On the other hand, another option for switchgear is the gas-insulated switchgear (GIS). A GIS system requires only 15% of the space necessary for an air-insulated switchgear (AIS) system. The costs for the GIS system and buildings, however, are several times higher than those of the AIS system. The GIS system is mostly suitable for areas with space

constraints such as city centres, industrial areas, etc. or areas with high air pollution levels.

For the basic design, the design considers AIS system for outdoor as well as GIS system depending on installation requirements and site condition.

(3) Busbar Arrangement

Currently, the existing 132 kV substations in the Ramu grid apply a variety of busbar systems, such as single busbar, main and transfer busbar, and one-and-a-half circuit breaker scheme. Therefore, the 132 kV busbar system shall be carefully decided for future standardization considering the following:

- supply reliability and security
- operational performance and flexibility
- capital costs
- maintenance and repair requirements
- space requirements
- outage rates of busbar scheme and failure rates for circuit breakers

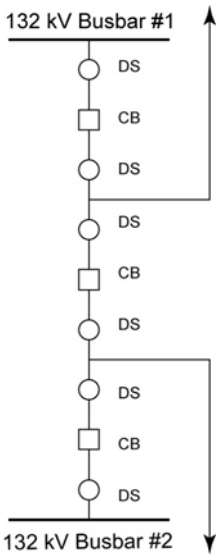


Figure 6.2-1
One-and-a-half CB Scheme
(Prepared by the Survey Team)

As a result of careful examination and discussions with PPL, the one-and-a-half circuit breaker scheme, as illustrated in Figure 6.2-1, is applied for the new 132 kV switchyard for the following reasons:

1) high reliability and flexibility for O&M
2) same as the design of Erap substation
3) common (worldwide) standard design for AIS
4) higher costs are offset by the above advantages

(4) Main Transformers

The 132 kV main transformers shall be oil-immersed type with on-load tap changer. Three-winding star-star-delta (Y-Y-Δ) connection is applied for the main transformers. Oil natural circulation air natural (ONAN) convection and/or oil natural circulation air forced (ONAF) cooling system is applied for the cooling system of the main transformer.

The unit capacity and number of units of main transformers in a substation are determined taking into comprehensive account the result of the demand forecast described in Chapter 4.

(5) Gas Insulated Switchgear (GIS)

The 132 kV GIS housing shall be filled with sulphur hexafluoride (SF6) gas, which is used as insulating and arc-quenching medium, with appropriate gas pressure. The components of

the GIS, such as surge arresters (SA), disconnectors (DS), gas insulated circuit breakers (GCB), current transformers (CT), capacitor type voltage transformers (CVT) and cable connection module respective functions, are housed either individually and/or shall be combined in compressed gas-tight enclosures. The GIS shall be for indoor use.

(6) Transmission Line Protections

Currently, distance relay is applied as main protection for the existing transmission lines between Ramu 1 and Taraka through Erap; however, there are no back-up protections. Directional over-current grounding protection relays are to be applied as back-up protection for the lines to reinforce the protection system.

(7) Communication System

Since the optical ground wire (OPGW), optical fibre distribution frame (ODF) and synchronous transport module - 1 (STM-1) with multiplexer have been installed on the existing 132 kV lines, replacement and modification design of telecommunication system including internal telephone system shall be considered.

(8) Other Concepts

1) Earthing transformers

In delta winding connection of the main transformer, where neutral earthing connection is not available, a neutral point shall be created using an earthing transformer. Earthing transformer having the zig-zag (interstar/ZNyn11) winding is used to achieve the required zero phase impedance stage which provides the possibility of neutral earthing condition. ONAN cooling system is applied to the earthing transformers.

2) Earthing system

In the switchyard of new substation, an underground earthing system should be properly laid in the form of a meshed grid. In case of extension of the existing substation, new earthing system should be connected to the existing system.

All equipment installed in a substation should be connected to an earthing system effectively. Resistance of the earthing system should be less than 0.2 ohm or designed based on IEEE80.

3) Countermeasures for disasters

i) Dust/salt pollution

For substations constructed in areas affected by dust contamination, appropriate countermeasures should be taken into account in the design based on the level of pollution. In PNG, salt pollution should be considered in the design.

ii) Lightning

For the protection of substation equipment from lightning, appropriate measures shall be taken in the design of the substation to achieve the required network reliability and site-specific conditions.

iii) Flood

For substations required in areas exposed to flooding, appropriate measures should be taken to minimize equipment trouble and to immediately restore the function of the station.

iv) Fire

Appropriate protection measures should be provided to operators and equipment from fire or explosion and, in the worst situations, to localize the fire within a limited area.

v) Earthquake

In the basic design of substations, influence of earthquake will be considered.

4) Consideration for environment

i) Noise

Include in the planning of a substation, that is to be newly constructed or expanded, necessary measures to limit noise within the reasonable levels.

ii) Vibration

Include in the planning of a substation to be constructed or expanded, necessary measures to limit the vibration levels in a substation within the country-recognized standard values.

iii) Harmony with environment

For a substation that is to be constructed or expanded, special attention should be given to the protection of the natural environment in the surrounding areas, and to the preservation of the living environment such as sunshine, scenery, radio interference, etc., as well as the harmony with the regional community.

6.3 Design Criteria

6.3.1 Applicable Standards

The design, materials, manufacture, testing, inspection and performance of all electrical and electromechanical equipment shall comply with the latest revision of the International Electrotechnical Commission Standard (IEC) as listed below:

IEC 60044-1	Instrument transformers - Part 1: Current transformers
IEC 60044-5	Instrument transformers - Part 5: Capacitor voltage transformers

IEC 60071	Insulation coordination
IEC 60076	Power transformers
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems
IEC 60265-2	High-voltage switches - Part 2: High-voltage switches for rated voltages of 52 kV and above
IEC 60694	Common specifications for high-voltage switchgear and controlgear standards
IEC 62271-100	High-voltage switchgear and controlgear - Part 100: High-voltage alternating-current circuit-breakers
IEC 62271-102	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switch

In cases where IEC standards are not applicable on the conditions, international standards such as ANSI, ASTM, BS, JIS, JEC, JEM, AS or DIN-VDE will be applied.

6.3.2 Insulation Co-ordination

Insulation co-ordination for the design of 132 kV, 66 kV and 33 kV equipment is as follows:

1)	Nominal system voltage	132 kV	66 kV	33 kV
2)	Rated voltage (r.m.s. value) (Highest voltage for equipment)	145 kV	72 kV	36 kV
3)	Rated frequency	50 Hz	50 Hz	50 Hz
4)	Insulation levels			
-	Rated short-duration power-frequency withstand voltage (r.m.s. value)	275 kV	140 kV	80 kV
-	Rated lightning impulse withstand voltage (peak value)	650 kV	325 kV	195 kV
-	Minimum clearance of phase-to-earth	1,300 mm	690 mm	350 mm
-	Standard clearance of phase-to-earth	1,500 mm	800 mm	400 mm
-	Minimum clearance of phase-to-phase	1,500 mm	800 mm	400 mm
-	Standard clearance of phase-to-phase	2,600 mm	1,500 mm	800 mm

6.4 Ramu 1 Switchyard

The following drawings in Attachment-3 show the basic design of Ramu 1 Switchyard:

Dwg_PNG_SS_RM1_001	Single Line Diagram: 132 kV Ramu 1 Switchyard
Dwg_PNG_SS_RM1_002	Layout Drawing: 132 kV Ramu 1 Switchyard
Dwg_PNG_SS_RM1_003	Section Drawing: 132 kV Ramu 1 Switchyard

From the issues identified in Sub-clause 3.3.1 (2) in Chapter 3, the following scope of works for Ramu 1 switchyard is to be executed under the Project:

1) Replacement of 132 kV outdoor switchgear

The following switchgear for 132 kV transmission line bays shall be replaced/installed:

i) 132 kV transmission line bay for Erap SS

- 145 kV GCB 1 set
- 145 kV CVT 3 pcs
- 120 kV SA 3 pcs

ii) 132 kV transmission line bay for Gusap SS

- 120 kV SA 3 pcs

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work for the above equipment shall be carried out and all necessary materials for the work such as power conductors, fittings, connectors, accessories, power and control cables, etc. shall be supplied and installed.

The above equipment shall be properly earthed with existing underground earthing mesh and all necessary materials such as earthing conductors shall be supplied.

2) Modification of protection panels

The following protection relays shall be supplied and modified:

- Distance protection relay (21B) for 132 kV Gusap line bay: 1 set
- Directional over-current/directional over-current grounding protection relay for 132 kV TL bays: 2 sets

The above protection system shall be integrated into the existing switchyard control system and transmission line protection in Ramu 1 switchyard.

Associated power and control cables with necessary accessories shall be supplied and modified.

3) Modification of communications equipment

The following optical-fibre telecommunications equipment shall be supplied and modified:

- Modification of synchronous transport existing multiplexer and STM-1 with multi-channels of not less than 2 Mbit/s interfaces
- Patch cables connecting existing multiplexer and STM-1 with the private automatic branch exchange (PABX).
- Access existing multiplexer and STM-1 with multi-channels (interfaces) each for 64 kbit/s to connect future SCADA equipment and telephone subscribers

- Installation of digital PABX equipment and telephone system

All cabling and wiring works with all necessary materials, such as power and control cables, optical fibre cables, etc., required for the above telecommunication equipment shall be supplied and modified.

4) Miscellaneous electrical equipment

The following miscellaneous electrical equipment shall be supplied and installed:

- 110 V DC system including one set of 110 V battery bank, two sets of chargers, one set of distribution board
- 48 V DC system including one set of 48 V battery bank, two sets of chargers, one set of distribution board
- 132 kV switchgear to be replaced under the Project shall be connected to the earthing wire with the existing substation of earthing system.

All necessary materials for the above works such as cables, connectors, accessories, etc. shall be supplied and installed.

5) Civil and building works

The associated civil works for the above works shall be executed as follows:

- Excavation and backfilling as required
- Construction of steel structures and equipment supports
- Construction of concrete foundation for all equipment
- Construction of cable pit
- Modification of control building to install new DC power supply systems

All necessary materials for the above works such as concrete, aggregate, reinforcement, accessories, etc. shall be supplied and constructed.

6) Other works

The following works for the above new equipment shall be carried out:

- Spare parts for at least 5 years of operation
- Tool and erection accessories as required
- Complete documentation for operation and maintenance
- Training for PPL staffs at manufacturer’s factory and at site

6.5 Singsing Substation

The following drawings in Attachment-3 show the basic design of Singsing substation:

Dwg_PNG_SS_SIS_001	Single Line Diagram: 132 kV System of Singsing Substation
Dwg_PNG_SS_SIS_002	Single Line Diagram: 33 kV System of Singsing Substation
Dwg_PNG_SS_SIS_003	Layout Drawing: Singsing Substation

Dwg_PNG_SS_SIS_004 Section Drawing: Singsing Substation

Singsing substation shall be newly constructed under the Project including one unit of 10 MVA 132/33 kV main transformer, six 132 kV transmission line bays, five 33 kV switchgear cubicles, control buildings, etc. The detailed scope of works for Singsing substation is as follows:

1) Construction of 132 kV outdoor switchyard

The following equipment shall be installed in the 132 kV switchyard:

i) One unit of 132/33 kV, 10 MVA, three-phase main transformer with on-load tap changer (OLTC).

ii) 132 kV one-and-a half circuit breaker scheme switchgear

The 132 kV one-and-a half circuit breaker scheme includes double tubular busbars, six transmission line bays and one transformer bay.

- 145 kV GCB	12 sets
- 145 kV disconnectors with earthing switch (DS/ES)	7 sets
- 145 kV DS	24sets
- 145 kV CT	36 pcs
- 145 kV CVT	24 pcs
- 120 kV SA	21 pcs
- 42 kV SA for main transformer secondary	3 pcs

The associated gantry structures for the above system shall be supplied and installed.

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work between the dead-end towers, associated gantry structures and the above equipment shall be carried out and all necessary materials for the work such as power conductors, tension insulator sets, fittings, post insulators, connectors, accessories, power and control cables, etc. shall be supplied and installed.

The above equipment shall be properly earthed with underground earthing mesh and all necessary materials such as earthing conductors shall be supplied.

2) Installation of protection and control panels

The following protection and control panels with remote operation supervisory device (Mini-SCADA) shall be supplied and installed:

<u>Protection panels</u>

- 132 kV TL bays protection	6 sets
- 132/33 kV main transformer protection	1 sets

- 132 kV busbar protection 1 set

Control panels

- 132 kV TL bay control/synchronize 6 sets
- 132/33 kV main transformer control 1 set
- 132/33 kV main transformer OLTC control 1 set
- 33 kV switchgear control 1 set (for 5 panels)

Mini-SCADA

- Remote operation monitoring device 1 lot

Associated power and control cables with necessary accessories shall be supplied and installed.

New protection scheme shall be coordinated with the existing protection scheme of Ramu 1 switchyard, Erap and Gusap substations.

All necessary meters including ammeters, voltmeters, watt-hour meters, etc. shall be supplied and installed.

The Mini-SCADA system shall be designed with control, monitoring and measuring of 132 kV switchyard, 132/33 kV main transformer, and 33 kV switchgear cubicles.

3) Installation of communications equipment

The following optical-fibre telecommunications equipment shall be supplied and installed:

- ODF for connection of at least five set racks / 24 core optical fibre cable
- Patch cables connecting ODF with STM-1 and multiplexer
- Supply STM-1 and multiplexer with multi channels of not less than 2 Mbit/s interfaces
- Access STM-1 and multiplexer with multi channels (interfaces) each for 64 kbit/s to connect future SCADA equipment and telephone subscribers
- Optical fibre splicing boxes (i.e., for termination of OPGW on the transmission line towers in the substation)
- Digital PABX equipment and telephone system

All cabling and wiring works with all necessary materials such as power and control cables, optical fibre cables, etc. required for the above telecommunication equipment shall be carried out.

4) Miscellaneous electrical equipment

The following miscellaneous electrical equipment shall be supplied and installed:

- 33/0.4 kV, 100 kVA outdoor type station service transformer with associated switchgear and power cables
- Outdoor type 75 kVA auto start module type diesel engine generator set with

associated switchgear, power cables and fuel tank

- Indoor type 36 kV metal enclosed switchgear and power cables connecting from the secondary side of 132/33 kV main transformer consisting of the following:
  i) 36 kV main transformer incoming feeder: 1 unit
  ii) 36 kV station service transformer feeder: 1 unit
  iii) 36 kV distribution line feeders: 3 units
- 400 V AC distribution switchboard including necessary cables and accessories
- 110 V DC system including two sets of 110 V battery banks, two sets of chargers, one set of distribution board
- 48 V DC system including two sets of 48 V battery banks, two sets of chargers, one set of distribution board
- Earthing system covering complete new substation area including earthing rods, conductors, etc.
- Overhead substation shield wire system including shield wires and supporting structures to protect against lightning
- Outdoor substation lighting system

All necessary materials for the above works such as cables, connectors, accessories, etc. shall be supplied and installed.

5) Civil and building works

The associated civil works for the above works shall be carried out as follows:

- Cleaning, cutting, filling, levelling and compacting of the new substation area
- Excavation and backfilling, as required
- Gravelling of the complete new substation area
- Construction of external security fences and gate
- Construction of station service road
- Construction of gantries for 132 kV switchyards
- Construction of steel structures and equipment supports
- Construction of concrete foundation for all equipment
- Construction of oil pit for main transformer
- Construction of drainage pit and conduit
- Construction of cable pit
- Construction of a complete substation control building with control room, 33 kV cubicle room, office, workshop, storage room, battery room, kitchen, toilet, etc.
- Construction of guard house beside the main gate
- Supply and installation of air conditioning and ventilation equipment for the substation building
- Supply and installation of lighting and power system for the substation control

building including distribution boards, socket outlet, etc.

- Supply and installation of water well and storage facility and wastewater and septic tank facility
- Supply and installation of firefighting equipment associated with air conditioning system for the control building

All necessary materials for the above works such as concrete, aggregate, reinforcement, accessories, etc. shall be supplied and constructed.

6) Other works

The following works for the above new equipment shall be carried out:

- Spare parts for at least 5 years of operation
- Tool and erection accessories as required
- Complete documentation for operation and maintenance
- Training for PPL staff at manufacturer's factory and at site

6.6 Erap Substation

The following drawings in Attachment-3 show the basic design of Erap substation:

Dwg_PNG_SS_ERP_001a	Single Line Diagram: 132 kV System of Erap Substation (Alt.-A)
Dwg_PNG_SS_ERP_001b	Single Line Diagram: 132 kV System of Erap Substation (Alt.-B)
Dwg_PNG_SS_ERP_002	Single Line Diagram: 66 kV and 33 kV Systems of Erap Substation
Dwg_PNG_SS_ERP_003a	Layout Drawing: Erap Substation (Alt.-A)
Dwg_PNG_SS_ERP_003b	Layout Drawing: Erap Substation (Alt.-B)
Dwg_PNG_SS_ERP_004	Section Drawing: Erap Substation

Two units of 10 MVA 132/66/33 kV main transformers with their bays, three 132 kV transmission line bays, six 33 kV switchgear cubicles, etc. are to be installed in Erap substation under the Project. The detailed scope of works for Erap substation is as follows:

1) Extension of 132 kV and 66 kV switchyards

The following equipment shall be supplied and installed:

i) Two units of 132/66/33 kV, 10 MVA, three-phase main transformers with OLTC

ii) 132 kV transmission line bays and main transformer bays

The 132 kV one-and-a half circuit breaker scheme includes double tubular busbars, three transmission line bays and one transformer bay.

- 145 kV GCB 8 sets

- 145 kV DS/ES 5 sets
- 145 kV DS 16 sets
- 145 kV CT 24 pcs
- 145 kV CVT 15 pcs
- 120 kV SA 15 pcs

iii) 66 kV main transformer bay

The 66 kV single busbar system includes single tubular busbar and two transformer bays.

- 72 kV GCB 3 set
- 72 kV DS/ES 2 set
- 72 kV DS 3 set
- 72 kV CT 6 pcs
- 72 kV CVT 12 pcs
- 69 kV SA 6 pcs

The associated gantry structures for the above system shall be supplied and installed.

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work between the dead-end towers, the associated gantry structures and the above equipment shall be carried out and all necessary materials for the work such as power conductors, insulator sets, fittings, post insulators, connectors, accessories, power and control cables, etc. shall be supplied and installed.

The above equipment shall be properly earthed with the existing earthing mesh and all necessary materials such as earthing conductors shall be supplied.

2) Extension and modification of protection and control panels

The following protection and control panels with Mini-SCADA system shall be supplied and installed:

i) 132 kV protection and control panels

<u>Protection panels</u>

- 132 kV TL bays protection 3 sets
- 132/66/33 kV main transformer protection 2 sets

<u>Control panels</u>

- 132 kV TL bay control/synchronize 3 sets
- Main transformer control for primary 2 sets
- Main transformer OLTC control 2 sets

ii) Modification of 132 kV protection panels

- Installation of directional over-current/directional over-current grounding relays for the existing 132 kV TL bays 2 sets
- Modification of 132 kV busbar protection 5 sets

iii) Installation of 66 kV protection and control panels

Protection panels

- Main transformer protection for secondary 2 sets
- Busbar protection 1 set

Control panels

- Main transformer control for secondary 2 sets
- Bus-tie control 1 set

iv) Installation of 33 kV control panels

- 33 kV switchgear control 1 set (for 11 panels)

v) Modification of Mini-SCADA

- Modification of Remote Transport Unit (RTU) 1 lot
- System upgrade for Mini-SCADA 1 lot

Associated control cables with necessary accessories shall be supplied and installed.

New protection scheme shall be coordinated with the existing protection scheme of Singsing, Taraka and Hidden Valley substations.

The existing busbar protection scheme shall be modified to be suitable for the new system configuration.

All necessary metering instruments including ammeters, voltmeters, watt-hour meters, etc. shall be supplied and installed.

The existing Mini-SCADA shall be modified to be designed with control, monitoring and measuring of 132 kV switchyard, 66 kV switchyard, 132/66/33 kV main transformers, 33 kV switchgear cubicles.

3) Modification of Communications Equipment

The following optical fibre communications equipment shall be supplied and modified:

- Modification of synchronous transport with the existing multiplexer and STM-1 with multi channels of not less than 2 Mbit/s interfaces
- Connecting patch cables with the existing multiplexer and STM-1 with PABX
- Accessing existing multiplexer and STM-1 with multi channels (interfaces) each for 64 kbit/s to connect future SCADA equipment and telephone subscribers
- Installation of digital PABX equipment and telephone system

All cabling and wiring works with all necessary materials such as power and control cables, optical fibre cables, etc. required for the above communication equipment shall be carried out.

4) Miscellaneous electrical equipment

The following miscellaneous electrical equipment shall be supplied and installed:

- Two units of 33/0.4 kV, 100 kVA outdoor type station service transformers with associated switchgear and power cables
- Two units of 33 kV outdoor type earthing transformers with associated switchgear and power cables
- Indoor type 36 kV metal enclosed switchgear and power cables connecting from the tertiary side of 132/66/33 kV main transformers consisting of the following:
  - i) 36 kV main transformer incoming feeders: 2 units
  - ii) 36 kV station service transformer feeders: 2 units
  - iii) 36 kV earthing transformer feeders: 2 units
  - iv) 36 kV bus section cubicle: 1 unit
  - v) 36 kV distribution line feeders: 4 units
- Addition of 400 V AC distribution switchboard including necessary cables and accessories
- Installation of 48 V DC system including two sets of 48 V battery banks, two sets of chargers, one set of distribution board
- Extension of earthing system covering the complete new substation area including earthing rods, conductors, etc. These extended earthing systems shall be connected to the earthing wire with the existing earthing system.
- Overhead substation shield wire system including shield wires and supporting structures for protection against lightning
- Outdoor substation lighting system

All necessary materials for the above works such as cables, connectors, accessories, etc. shall be supplied and installed.

5) Civil and building works

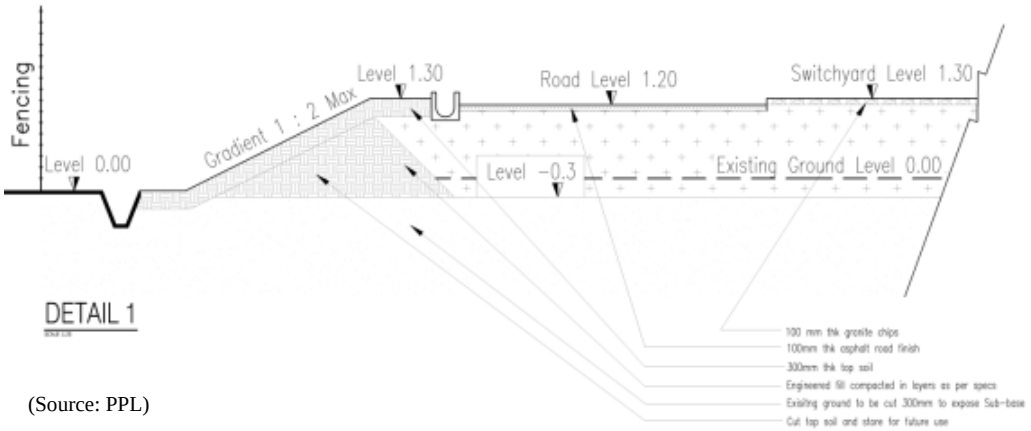
The associated civil and building works for the above works shall be carried out as follows:

- Cleaning, cutting, filling, levelling and compacting of the new substation area
- Excavation and backfilling as required
- Gravelling of the complete new substation area
- Construction of external security fences and gate
- Construction of station service road

- Construction of gantries for 132 kV and 66 kV switchyards
- Construction of steel structures and equipment supports
- Construction of concrete foundation for all equipment
- Construction of oil pit for main transformer
- Construction of drainage pit and conduit
- Construction of cable pit
- Extension of control building with 33 kV switchgear cubicle room, storage room, etc. with air conditioning and ventilation equipment, lighting and power system, and firefighting equipment

All necessary materials for the above works such as concrete, aggregate, reinforcement, accessories, etc. shall be supplied and constructed.

Especially, Erap substation has embankment with a height of 1.3 m from the natural ground level to avoid erosion from flood as shown in Figure 6.6-1. As for the extension area for the Project, embankment up to the same level is needed.



(Source: PPL)

Figure 6.6-1 Embankment for Erap Substation

6) Other Works

The following works for the above new equipment shall be carried out:

- Spare parts for at least 5 years of operation
- Tools and erection accessories as required
- Complete documentation for operation and maintenance
- Training for PPL staff at manufacturer's factory and at site

6.7 Taraka Substation

The Survey Team visited Taraka substation in November 2011 and found the issues as described in Sub-clause 3.3.4 in Chapter 3. To sum up the situation in a few words, conditions of power equipment are not very good. This causes the unstable power supply situation in Lae.

As for the extension and rehabilitation of 132 kV switchyard in Taraka substation, installation of one 132 kV transmission lines bay for Erap, installation of surge arresters and replacement of circuit breakers for the existing transmission line bay for Erap, modification of four main transformer bays with new circuit breakers and current transformers, and replacement of capacitor voltage transformers on 132 kV busbar shall be executed under the Project. For these extension and rehabilitation, the Survey Team has studied the following three alternative plans considering supply reliability, limitation of land space, construction workability, easiness of operation and maintenance (O&M), and costs:

Plan A: Rehabilitation of 132 kV switchgear with full AIS

Plan B: Only 132 kV transmission line feeders shall be GIS and the other parts such as 132 kV busbar and main transformer bays shall be AIS

Plan C: Rehabilitation of 132 kV switchgear with full GIS

Table 6.7-1 shows the comparison of alternative plans.

Table 6.7-1 Comparison of Alternative Plans

Description		PLAN - A		PLAN - B		PLAN - C	
1.	Reliability and Stability						
1-1.	System Reliability	- Accident by dispersal object	ave. shutdown 42.0 h/year	- No accident of GIS by dispersal object	ave. shutdown 32.0 h/year	- No accident by dispersal object	ave. shutdown 7.0 h/year
1-2.	System Lifetime	- Maintenance cycle: AIS (frequent) - Lifetime: AIS (about 20 years)	lifetime 20 years	- Maintenance cycle: GIS (less), AIS (frequent) - Lifetime: GIS (about 25 years), AIS (about 20	lifetime 20 years	- Maintenance cycle: GIS (less) - Lifetime: GIS (about 25 years) - Less parts number because of unit type	lifetime 25 years
1-3.	Probability of Accident	- Accident by dispersal object - Accidents caused by creatures	accident prob. 5.75 % /y	- Cable accidents of GIS caused by rat's bite - AIS: same as Plan - A	accident prob. 4.38 % /y	- Cable accidents caused by rat's bite	accident prob. 0.96 % /y
2.	Operation & Maintenance (O&M)						
2-1.	Local Operability	- Possibility of fatal accident with energized parts - Elec. shock by misconception errors of sense	manual operation time 2.3 h (7 feeders)	- No possibility of fatal accident for GIS - Necessity of initial operation training for GIS - AIS: same as Plan - A	manual operation time 1.9 h (7 feeders)	- No possibility of fatal accident - Necessity of initial operation training	manual operation time 0.6 h (7 feeders)
2-2.	Remote Operability	- Necessity of initial O&M training after of C&P panels - Necessity of operation and earthing check	remote operation time 1.2 h (7 feeders)	- Better operability new C&P panels for GIS - Necessity of initial operation training for GIS - AIS: same as Plan - A	remote operation time 0.9 h (7 feeders)	- Better operability new C&P panels - Necessity of initial operation training	remote operation time 0.3 h (7 feeders)
2-3.	Maintenance Easiness &	- Many maintenance items - Easy replacement of exposure parts - Necessity of high-place works - Replacement work affected by weather - Necessity of dust proof room for CB	detailed mente. (30 years) 30 times	- Only visual and gas pressure check for GIS - Easy replacement of GIS unit type parts - GIS replacement work not affected by weather - AIS: same as Plan - A	detailed mente. (30 years) 30 times	- Only visual and gas pressure check - Easy replacement of unit type parts - Replacement work not affected by weather	detailed mente. (30 years) 3 times
2-4.	Maintenance Risk	- Exposure of energized parts - Elec. shock by misconception errors of sense	dangerousness High	- No exposure of GIS's energized parts - AIS: same as Plan - A	dangerousness Middle	- No exposure of energized parts	dangerousness Low
2-5.	Shutdown & Accident Response	- Necessity of operation and earthing check - Elec. shock by misconception errors of sense	Ave. remote op. time 10.0 min/cct	- Quick response of GIS shutdown and earthing - AIS: same as Plan - A	Ave. remote op. time 7.9 min/cct	- Quick response of shutdown and earthing	Ave. remote op. time 2.5 min/cct
3.	Workability & Working Efficiency						
3-1.	Construction Easiness	- No special installation technique - Reuse of existing C&P panels - Necessity of detail survey for existing ccts. - Many preparation works for shutdown - Complicated switching procedure - Possible of fatal accident with energized parts - Necessity of preparation work for high-place	construction period 18 months	- Less preparation works for shutdown of GIS - Easy switching procedure of GIS - No necessity of GIS's high-place works - Necessity of supervisor for GIS installation - AIS: same as Plan - A	construction period 15 months	- Replacement full newly C&P panels - Necessity of detail survey for only TR protection circuits - Less preparation works for shutdown - Easy switching procedure of GIS - No necessity of high-place works - Necessity of supervisor for GIS installation	construction period 13 months
3-2.	Number of Shutdown Work	- About 4 to 5 months shutdown period	shutdown time 8.0 h/ 18 times (144.0 h)	- About 3.5 months shutdown period - Less shutdown period than Plan-A	shutdown time 8.0 h/ 14 times (112.0 h)	- About 1 month shutdown period - Many less shutdown period than Plan-A	shutdown time 8.0 h/ 4 times (32.0 h)
3-3.	Construction Risk	- Possible of fatal accident with energized parts - Necessity of high-place works - Miss-trip when modification of C&P panels - Elec.l shock by misconception errors of sense	Dangerous High	- Falling accident of heavy equipment for GIS (at about max 3.0 t) - AIS: same as Plan - A	Dangerous Middle	- Falling accident of heavy equipment (at about max 3.0 t)	Dangerous Low
4.	Costs (refer to Table 7.2-2)	100%		217%		343%	

(Prepared by the Survey Team)

The following drawings in Attachment-3 show the basic design of Taraka substation with three alternative plans:

Dwg_PNG_SS_TRK_001a	Single Line Diagram: Taraka Substation (Plan A)
Dwg_PNG_SS_TRK_002a	Layout Drawing: Taraka Substation (Plan A)
Dwg_PNG_SS_TRK_003a	Section Drawing: Taraka Substation (Plan A)
Dwg_PNG_SS_TRK_001b	Single Line Diagram: Taraka Substation (Plan B)
Dwg_PNG_SS_TRK_002b	Layout Drawing: Taraka Substation (Plan B)
Dwg_PNG_SS_TRK_003b	Section Drawing: Taraka Substation (Plan B)
Dwg_PNG_SS_TRK_001c	Single Line Diagram: Taraka Substation (Plan C)
Dwg_PNG_SS_TRK_002c	Layout Drawing: Taraka Substation (Plan C)
Dwg_PNG_SS_TRK_003c	Section Drawing: Taraka Substation (Plan C)

In addition to the above 132 kV extension and rehabilitation plans, 66 kV switchyard in Taraka substation needs to be rehabilitated to ensure reliable and stable power supply to Lae.

The detailed scope of works for Taraka substation is as follows:

1a) Extension and rehabilitation of 132 kV switchyard (Plan-A)

Extension of one transmission line bay and rehabilitation of existing busbar and four transformer bays.

- 145 kV GCB 6 sets
- 145 kV DS/ES 1 set
- 145 kV DS 1 set
- 145 kV CT 15 pcs
- 145 kV CVT 9 pcs
- 120 kV SA 3 pcs
- 120 kV SA for suspension type 3 pcs

1b) Extension and rehabilitation of 132 kV switchyard (Plan-B)

Installation of two 132 kV GIS for TL bay and 132 kV AIS for busbar and four main transformer bays:

i) Installation of 132 kV GIS TL bays

- 145 kV incoming unit 2 units
- 145 kV feeder unit 1 unit
- 145 kV busbar CVT unit 1 unit
- Outdoor use cable head 3 sets

ii) Modification of 132 kV busbar and transformer bays with AIS

- 145 kV GCB 4 sets
- 145 kV CT 12 pcs

- 145 kV CVT 6 pcs

1c) Extension and rehabilitation of 132 kV switchyard (Plan–C)

Installation of full GIS for two 132 kV TL bays, busbar and four main transformer bays:

- 145 kV incoming unit 2 units
- 145 kV feeder unit 5 units
- 145 kV busbar CVT unit 1 unit
- Outdoor use cable head 7 sets

The associated gantry structures for the above system shall be supplied and installed.

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work between the dead-end towers, the associated gantry structures and the above equipment shall be carried out and all necessary materials for the work, such as power conductors, insulator sets, fittings, post insulators, connectors, accessories, power and control cables, etc. shall be supplied and installed.

The above equipment shall be properly earthed with existing underground earthing mesh and all necessary materials, such as earthing conductors, shall be supplied.

2) Replacement of 66 kV transmission line bay and transformer bays

66 kV single busbar system includes two transmission line bays, two transformer bays and bus-tie GCB.

- 72 kV GCB 5 sets
- 72 kV CT 12 pcs
- 72 kV VT 3 pcs
- 69 kV SA 6 pcs

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work between the dead-end towers, the associated gantry structures and the above equipment shall be carried out and all necessary materials for the work such as power conductors, insulator sets, fittings, post insulators, connectors, accessories, etc. shall be supplied and installed.

The above equipment shall be properly earthed with existing underground earthing mesh and all necessary materials such as earthing conductors shall be supplied.

3) Protection and control panels

a) Installation and modification of protection and control panels for Plan-A

<u>Protection panels</u>

- 132 kV TL line bays protection 1 set

Control panels

- 132 kV TL bay control/synchronize 1 set

Modification of protection panels

- Main transformer control for primary 4 sets
- Main transformer protection 4 sets
- 132 kV TL bays directional over-current/ directional over-current grounding relays for the existing TL bays 1 set
- 132 kV existing busbar protection 5 sets

b) Installation and modification of protection and control panels for Plan-B

Protection panels

- 132 kV GIS incoming protection 2 sets
- 132 kV GIS feeder protection 1 set
- 132 kV GIS busbar protection 1 set

Control panels

- 132 kV GIS incoming control/synchronize 2 sets
- 132 kV GIS feeder control/synchronize 1 set

Modification of protection panels

- Main transformer control for primary 4 sets
- Main transformer protection 4 sets
- 132 kV existing busbar protection 7 sets

c) Installation and modification of protection and control panels for Plan-C

Protection panels

- 132 kV GIS incoming protection 2 sets
- 132 kV GIS feeder protection 5 sets
- 132 kV GIS busbar protection 1 set

Control panels

- 132 kV GIS incoming control/synchronize 2 sets
- 132 kV GIS feeder control/synchronize 5 sets

Modification of protection panels

- Main transformer control for primary 4 sets
- Main transformer protection 4 sets
- 132 kV existing busbar protection 7 sets

Associated power and control cables with necessary accessories shall be supplied and installed.

The protection scheme shall be coordinated with the existing protection scheme.

The existing busbar protection scheme shall be modified to be suitable for the new system configuration.

All necessary meters including ammeters, voltmeters, watt-hour meters, etc. shall be supplied and installed.

4) Modification of communications equipment

The following optical-fibre communications equipment shall be supplied and modified:

- Modification of synchronous transport existing multiplexer and STM-1 with multi-channels of not less than 2 Mbit/s interfaces
- Connecting patch cables with existing multiplexer and STM-1 with PABX
- Accessing existing multiplexer and STM-1 with multi-channels (interfaces) each for 64 kbit/s to connect future SCADA equipment and telephone subscribers
- Installation of digital PABX equipment and telephone system

All cabling and wiring works with all necessary materials such as power and control cables, optical fibre cables, etc. required for the above communication equipment shall be carried out.

5) Miscellaneous electrical equipment

The following miscellaneous electrical equipment shall be supplied and installed:

- 110 V DC system including one set of 110 V battery bank, two sets of chargers, one set of distribution board
- Overhead substation shield wire system including shield wires and supporting structures to protect against lightning

All necessary materials for the above works such as cables, connectors, accessories, etc. shall be supplied and installed.

6) Civil and building works

The associated civil and building works for the above works shall be carried out as follows:

- Excavation and backfilling as required
- Gravelling of the complete extension area
- Construction of gantries for 132 kV switchyard
- Construction of steel structures and equipment supports
- Construction of concrete foundation for all equipment
- Construction of cable pit
- Construction of GIS building with 132 kV GIS room and storage room with air conditioning and ventilation equipment, lighting and power system, and firefighting

equipment (only for Plan-B and Plan-C)

All necessary materials for the above works such as concrete, aggregate, reinforcement, accessories, etc. shall be supplied and constructed.

7) Other works

The following works for the above new equipment shall be carried out:

- Spare parts for at least 5 years of operation
- Tool and erection accessories as required
- Complete documentation for operation and maintenance
- Training for PPL staffs at manufacturer's factory and at site

6.8 Specifications of Major Equipment

6.8.1 Main Power Transformers

(1) 132/33 kV Main Transformers

1) Type

Three-phase, oil-immersed type, ONAN/ONAF cooling type with on-load tap changing device

2) Ratings

i)	Rated power	10/12 MVA (ONAN/ONAF)
ii)	Rated frequency	50 Hz
iii)	Rated voltage ratio	132/33/11 kV
v)	Vector group notation	Yyn0d11 or Yyn0d1
vi)	Short-circuit impedance	8.5 % (10 MVA base, rated tap)

3) Insulation levels

The main transformers shall withstand the following voltages:

i)	HV line terminal and neutral	LI / AC	650 / 275 kV
ii)	LV line terminal and neutral	LI / AC	195 / 80 kV

* LI: Lightning impulse withstand voltage
AC: Short duration AC withstand voltage

4) On-load tap changing equipment

i)	Step	± 8 x 1.25 %
ii)	Number of tap steps	17 taps

(2) 132/66/33 kV Main Transformer

1) Type

Three-phase, oil-immersed type, ONAN/ONAF cooling type with on-load tap changing device

2) Ratings

i)	Rated power	10/12 MVA (ONAN/ONAF)
ii)	Number of phase	3 phase
iii)	Rated frequency	50 Hz
iv)	Rated voltage ratio	132/66/33 kV
v)	Vector group notation	Yyn0d11 or Yyn0d1
vi)	Short-circuit impedance	8.5 % (10 MVA base at 75°C, rated tap)

3) Insulation levels

The main transformers shall withstand the following voltages:

i)	HV line terminal	LI / AC	650 / 275 kV
ii)	MV line terminal	LI / AC	325 / 140 kV
iv)	LV line terminal	LI / AC	195 / 80 kV

* LI: Lightning impulse withstand voltage
AC: Short duration AC withstand voltage

4) On-load Tap Changing Equipment

i)	Step	± 8 x 1.25 %
ii)	Number of tap steps	17 taps

6.8.2 145 kV Gas Insulated Switchgear

1) Type

The GIS shall be metal-enclosed, three-phase busbar and switchgear type, for indoor use, and filled with SF6 insulation gas.

2) Circuit breakers

i)	Rated voltage	145 kV
ii)	Rated main busbar normal current	not less than 1,250 A
iii)	Rated feeder busbar normal current	1,250 A
iv)	Rated frequency	50 Hz
v)	Rated short-circuit breaking current	25, 40 kA, 1 sec.
vi)	Rated interrupting time	less than or equal to 3 cycle
vii)	Rated operating sequence	O - 0.3 sec. - CO - 3 min. - CO
viii)	Rated closing operation voltage	110 V DC
ix)	Rated control voltage	110 V DC
x)	Rated insulation level	
	a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	275 kV
	b) Rated lightning impulse withstand voltage (peak value)	650 kV

The circuit breakers shall be suitable for three-phase collective tripping and rapid auto-reclosing provided with a motor-operated spring mechanism and shall comply with the related IEC standards/recommendations.

The circuit breakers shall be equipped with motor-charged spring operated mechanism for 110 V DC and the mechanism shall ensure uniform and positive closing and opening.

3) Disconnectors and earthing switches

i)	Rated voltage	145 kV
ii)	Rated normal current	1,250 A
iii)	Rated frequency	50 Hz
iv)	Rated short-circuit withstand current	25, 40 kA, 1 sec.
v)	Rated control voltage	110 V DC
vi)	Rated insulation level	
	a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	275 kV
	b) Rated lightning impulse withstand voltage (peak value)	650 kV

The disconnectors and earthing switch shall both be motor-operated and provided with a manual operating mechanism with a hand crank.

Motor-operated disconnectors and earthing switch shall be designed with three-pole operation and the motor shall be operated on 110 V DC.

Where specified, the disconnectors shall be fitted with approved three-phase line earthing devices, mechanically coupled or interlocked with main disconnector so that the earthing device and main disconnector cannot be closed at the same time.

4) Current transformers

i)	Highest system voltage	145 kV
ii)	Rated frequency	50 Hz
iii)	Rated insulation level	
	a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	275 kV
	b) Rated lightning impulse withstand voltage (peak value)	650 kV
iv)	Rated current ratio	as specified in single line diagram of Taraka substation
v)	Accuracy classes	5P20 for protection, Class 0.5 for metering

5) Voltage transformers (inductive type)

i)	Highest system voltage	145 kV

ii) Rated frequency 50 Hz

iii) Voltage ratio $\frac{132\,\text{kV}}{\sqrt{3}} : \frac{110\,\text{V}}{\sqrt{3}} : \frac{110\,\text{V}}{\sqrt{3}}$

iv) Accuracy classes 0.5

v) Rated insulation level

a) Rated short-duration power-frequency withstand voltage (r.m.s. value) 275 kV

b) Rated lightning impulse withstand voltage (peak value) 650 kV

6) Surge arresters

i) Rated voltage (r.m.s. value) 120 kV

ii) Rated frequency 50 Hz

iii) Nominal discharge current 10 kA

iv) Long-duration discharge class Class 3 (Table-5, IEC 60099-4)

v) Pressure-relief current 40 kA

vi) Rated insulation level for insulators

a) Rated short-duration power-frequency withstand voltage (r.m.s. value) 275 kV

b) Rated lightning impulse withstand voltage (peak value) 650 kV

6.8.3 Outdoor Switchgear

(1) Circuit Breakers

1) Type

The 145 kV and 72 kV circuit breakers shall be SF6 gas type, with three-pole collective arrangement and for outdoor use. The circuit breakers shall be suitable for three-phase collective tripping and rapid auto-reclosing provided with a motor-operated spring mechanism and shall comply with the related IEC standards/recommendations.

2) Ratings

i)	Rated voltage	72 kV	145 kV
ii)	Rated normal current	1,250 A	1,250 A
iii)	Rated frequency	50 Hz	
iv)	Rated short-circuit breaking current	25, 40 kA, 1 sec.	
v)	Rated interrupting time	less than or equal to 3 cycles	
vi)	Rated operating sequence	O - 0.3 sec. - CO - 3 min. - CO	
vii)	Rated closing operation voltage	110 V DC	
viii)	Rated control voltage	110 V DC	

ix) Rated insulation level

a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	140 kV	275 kV
b)	Rated lightning impulse withstand voltage (peak value)	325 kV	650 kV

3) Operating Mechanism

The circuit breakers shall be equipped with motor-charged spring operated mechanism for 110 V DC and the mechanism shall ensure uniform and positive closing and opening. Pneumatic systems operating with compressed air are not recommended.

(2) Disconnectors and Earthing Switches

1) Type

The 145 kV and 72 kV disconnectors shall be three-phase, two-column rotary and centre air break type with horizontal operation. Earthing switch shall be triple-pole, single-throw, vertical single break and manual three-phase group operation type.

The disconnectors and earthing switches shall be suitable for outdoor use. The earthing switches shall be mounted on the disconnectors whenever necessary where specified.

2) Ratings

i)	Rated voltage	72 kV	145 kV
ii)	Rated normal current	1,250 A	1,250 A
iii)	Rated frequency	50 Hz	
iv)	Rated short-circuit withstand current	25 kA, 1 sec.	
v)	Rated control voltage	110 V DC	
vi)	Rated insulation level		
a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	140 kV	275 kV
b)	Rated lightning impulse withstand voltage (peak value)	325 kV	650 kV

3) Operating mechanism

The disconnectors shall be motor-operated and provided with a manual operating mechanism with a hand crank. The earthing switch shall be provided with a manual operating mechanism.

Motor-operated disconnectors shall be designed with three-pole operation and the motor shall be operated on 110 V DC.

4) Earthing switches

Where specified, the disconnectors shall be fitted with approved three-phase line earthing devices, mechanically coupled or interlocked with main disconnector so that the earthing device and main disconnector cannot be closed at the same time.

(3) Current Transformers

1) Type

The 145 kV and 72 kV current transformers shall be single-phase, porcelain-insulated, oil-immersed and air-tight sealed post insulator type, for outdoor use and shall be designed in accordance with IEC 60044-1.

2) Ratings

i)	Highest system voltage	72 kV	145 kV
ii)	Rated frequency	50 Hz	
iii)	Rated insulation level		
a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	140 kV	275 kV
b)	Rated lightning impulse withstand voltage (peak value)	325 kV	650 kV
iv)	Rated current ratio	as specified in single line diagram of each substation	
v)	Accuracy classes	5P20 for protection, Class 0.5 for metering	

(4) Capacitor Voltage Transformers

1) Type

The 145 kV and 72 kV voltage transformers shall be single-phase, capacitor type and shall be designed in accordance with IEC 60044-5.

2) Ratings

i)	Highest system voltage	72 kV	145 kV
ii)	Rated frequency	50 Hz	
iii)	Voltage ratio	$\frac{66\,\text{kV}}{\sqrt{3}} : \frac{110\,\text{V}}{\sqrt{3}} : \frac{110\,\text{V}}{3}$	$\frac{132\,\text{kV}}{\sqrt{3}} : \frac{110\,\text{V}}{\sqrt{3}} : \frac{110\,\text{V}}{\sqrt{3}}$
iv)	Accuracy classes	0.5 and 1.0	
v)	Rated insulation level		
a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	140 kV	275 kV
b)	Rated lightning impulse withstand voltage (peak value)	325 kV	650 kV

(5) Surge Arresters

1) Type

The 120 kV and 96 kV surge arresters shall be gapless, metal-oxide, outdoor and heavy duty type. The arresters shall be designed in accordance with IEC 60099-4.

2) Ratings

i)	Rated voltage (r.m.s. value)	96 kV	120 kV
ii)	Rated frequency	50 Hz	
iii)	Nominal discharge current	10 kA	
iv)	Long-duration discharge class	Class 3 (Table-5, IEC 60099-4)	
v)	Pressure-relief current	40 kA	
vi)	Rated insulation levels for insulators		
a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	140 kV	275 kV
b)	Rated lightning impulse withstand voltage (peak value)	325 kV	650 kV

6.8.4 Indoor Switchgear Cubicles

1) Type

The 36 kV switchgear cubicles shall be indoor, three-phase, metal-enclosed type. Circuit breakers for 36 kV cubicles shall be vacuum or gas insulated type, suitable for rapid auto-reclosing provided with a motor-operated spring mechanism and shall comply with the related IEC 60694 standards/recommendations.

2) Ratings

i)	Rated voltage	36 kV
ii)	Rated normal current	1,250 A
iii)	Rated frequency	50 Hz
iv)	Rated short-circuit withstand current	25 kA, 1 sec.
v)	Rated control voltage	110 V DC
vi)	Rated insulation level	
a)	Rated short-duration power-frequency withstand voltage (r.m.s. value)	80 kV
b)	Rated lightning impulse withstand voltage (peak value)	195 kV

3) Necessary equipment and operating mechanism

The following equipment and operating mechanism shall be used:

i) CB, CT, VT, DS, ES and SA

ii) Remote control module with Mini-SCADA

iii) Protection relays such as over-current, over-current grounding, under-voltage, over-voltage, auto-reclosing, etc. shall be equipped and mounted with front side.

iv) All necessary metering instruments including ammeters, voltmeters, watt-hour meters, etc. shall be mounted with front side.

v) ES shall be equipped with CB and DS with interlock mechanism

6.8.5 Protection and Control Equipment

Protection and control equipment for 132 kV and 66 kV systems shall be mounted in the cubicles and installed in totally air conditioned substation control rooms. Control panels shall incorporate all necessary control and indication devices for the operation of equipment at the associated substation.

New equipment shall be operated independently of each other, applying decentralized modules for alarm (monitoring) and tripping functions.

Remote operation supervisory devices (Mini-SCADA) shall incorporate all necessary control and indication devices for the operation of equipment at Singsing substation. The Mini-SCADA system shall be equipped and composed with desktop PC and shall be installed in totally air conditioned substation control rooms.

(1) Protection Relays

The following protection relays shall be supplied:

1) 132 kV and 66 kV transmission line protection
   - Distance relay phase and earth (main protection)
   - Directional over-current and directional over-current grounding fault relay (back up protection)
   - Auto-reclosing relay
   - Breaker failure relay
   - Synchro check relay

2) 132 kV and 66 kV busbar protection
   - Ratio differential relay

3) Power transformer protection
   - Restricted earth fault relay
   - Ratio differential current relay
   - Over-current relay
   - Over-current ground relay (51N)
   - Directional earth fault relay

- Breaker failure relay
- Synchro check relay
- Automatic voltage regulation relay
- Buchholz relay (2 steps)
- Pressure relief device for main tank
- Temperature detectors for winding (2 steps, cooler control contacts)
- Temperature detectors for oil (2 steps)
- Dial type thermometers for indicating top oil and winding temperatures
- Dial type oil level indicator for conservator
- Low oil level for transformer
- Tap changer failure protection
- Oil pressure relay for OLTC
- Pressure relief device for OTLC
- Low oil level for OTLC
- Cooling fan failure protection
- Circulation pump failure protection
- Circulation oil flow failure protection

4) 33 kV distribution line protection

- Over-current relay
- Over-current ground relay
- Negative phase relay
- Under-voltage relay
- Over-voltage relay
- Auto-reclosing relay
- Over-current relay for feeder
- Over-current ground relay for feeder
- Negative phase relay for feeder
- Auto-reclosing relay for feeder

(2) Control Equipment

Control panels to be supplied shall include all devices necessary for the safe and effective control of the equipment being supplied.

Control panels shall include control and indication of all 132 kV and 66 kV circuit breakers and disconnectors. The control switches for the circuit breakers and disconnectors shall be flash mounted on the front of the control panels.

The front panel shall include a mimic diagram reflecting the actual layout of the 132 kV and 66 kV switchgear. The mimic diagram shall have different colours for different voltages.

All control and indicator circuit shall be designed for 110 V DC. Fuses for various DC circuits for control, protection relay, indication, etc. shall be mounted in separate board. Each circuit shall be supervised by voltage relays giving alarm in case of voltage failure or fuse trip.

Position indication signals of switches and breakers for transmission by the supervisory control scheme shall be derived from separate, normally open and closed auxiliary contacts, provided and connected up to terminal blocks in the associated control panels.

(3) Mini-SCADA

The Mini - SCADA for 132 kV and 33 kV systems including control and indication of all 132 kV and 33 kV circuit breakers and disconnectors and metering of several elements shall also be supplied and installed.

Mini - SCADA shall be composed of the substation control software and remote terminal unit (RTU), and shall carry out the equipment operation, equipment indication, fault indication and the instrumentation from the desktop PC.

6.8.6 Optical Fibre Communication Equipment

Optical fibre telecommunication system between substations shall be supplied and installed to transmit the following signals:

i) Tele-protection signal for protection relay
ii) Telephone signal (PABX)
iii) SCADA (as future module)

The optical fibre system consists of the OPGW, STM-1 (156 Mbps) which includes multiplexer function.

The STM-1 equipment together with the necessary interfaces for the connection with all other parts of the telecommunication network is necessary.

The overall equipment provides the necessary voice frequency and digital signal multiplexing, de-multiplexing, encoding, decoding and all associated supervisory functions.

A failure of one element of the system must not affect the availability and performance of the overall system.

All OPGW sections and all STM-1 must have the capacity to transmit the complete volume of telecommunication channels. The STM-1 must have the functionality for add-and-drop. The reliability will be higher than the link and in the loop configuration, and dependent on the

number of meshes.

1) Synchronous Transport Module-1 (156 Mbps)

The STM-1 equipment performs electrical to optical conversions and vice versa and consists of optical transmitting and receiving parts. This equipment also has the multiplexer functions. The STM-1 shall meet the latest recommendations of the International Telecommunication Union Telecommunication Standardization Sector (ITU-T). It shall be operated at a minimum of 8 Mbps.

Transmission capacities shall always be a multiple of PCM, at least 30 channels (primary and second order multiplexers).

All digital multiplexers shall be equipped with internal clock and interfaces for external clock synchronization based on the relevant ITU-T recommendation. Preferably, station GPS receivers shall be used to synchronize all multiplexers in the network.

All multiplexers shall have interfaces for connection of the control, monitoring, protection signalling and utility communication equipment. For transmission of protection signals, the multiplexers shall be equipped with special interfaces ensuring electromagnetic compatibility according to IEC 60255-5 (2000-12).

The minimum capacity of the fibre links multiplexer is 2.04 Mbps (30 x 64 kbps).

The protection signals shall be transferred using dedicated fibres or priority channels or by bypassing the multiplexing stage.

2) Optical approach cables

Optical fibre cable shall have necessary mechanical and thermal characteristics. Optical fibre unit shall meet the ITU Recommendations G-652 and G-655, and its material shall meet the requirements of IEC 60793-1 and -2.

3) Outdoor splicing boxes

The outdoor splicing boxes (SB) shall be mounted on the gantry steel structures and shall accommodate pass-through splicing and fibre termination.

4) Indoor SB/Optical Distribution Frame (ODF)

The indoor SB/ODF shall be wall-mounted type or rack-mount type and shall accommodate pass-through splicing and interconnection for the equipment.

CHAPTER 7

PROJECT COST ESTIMATION

CHAPTER 7 PROJECT COST ESTIMATION

7.1 Construction Cost of Transmission Lines

The construction cost of transmission lines for the Project is estimated under the following assumptions:

1) The construction cost of transmission lines for the Project is to be estimated by multiplying the standard unit prices of equipment and civil and erection works with the quantities calculated in Chapter 5. The standard unit prices have been prepared referring to recent contract prices of international competitive bidding (ICB) projects such as the 132 kV transmission line from Erap to Hidden Valley. Various ICB price data prepared by the Survey Team have also been referred to.

2) The costs are estimated either as part of foreign currency (FC) portion (in US$) or local currency (LC) portion (US$ conversion)[1].

Table 7.1-1 summarizes the construction costs of transmission lines for the Project. Table 7.1-2, attached at the end of this chapter, shows the details of the estimate.

Table 7.1-1 Construction Cost of Transmission Lines

		Double Circuit Section 132 kV Singsing – Erap and Incoming to Taraka		Single Circuit Section 132 kV Erap - Taraka	
	Items	FC (US$)	LC (US$)	FC (US$)	LC (US$)
1	General	3,517,000.00	0.00	0.00	0.00
2	Plant and Equipment	10,587,800.00	8,287,400.00	2,535,100.00	3,219,200.00
3	Civil Works and Erection	0.00	4,652,900.00	0.00	1,451,900.00
4	Spare Material	316,700.00	0.00	76,100.00	0.00
	Subtotal	14,422,400.00	12,940,300.00	2,611,200.00	4,671,100.00
	Total FC & LC	FC 27,362,700.00		LC 7,282,300.00	
	Grand Total	34,645,000.00			

(Prepared by the Survey Team)

[1] "FC" in this report means expenditures spent abroad for procurement, ocean freight and insurance of the imported equipment and materials of the facilities and other general works for the local installation of the facilities. "LC" means all expenditures spent in PNG including costs for expatriate persons, procurement of local products, labours, inland transportation, insurance, hiring of heavy equipment, installation of facilities and a part of survey, compensation of lands, houses and vegetation and others. "LC" does not always mean the amount contributed by the Government of PNG.

7.2 Construction Cost of Substations

Construction cost of substation facilities for the Project are estimated based on the design of substations described in Chapter 6.

1) Standard unit prices

The standard unit prices have been determined based on the recent contract prices of ICB projects implemented in PNG. Various ICB price data in other countries prepared by the Survey Team have also been referred to.

2) Estimate conditions

Estimate conditions for the substation equipment are as follows;

a) All substation equipment will be procured from abroad because there is no manufacture of electrical equipment in PNG, and the cargo, insurance and freight (CIF) prices are estimated under FC portion (in US$). Cost of installation work of the equipment is estimated under LC portion (in US$).

b) Costs for procurement of spare parts, tools and training are estimated at 5 % of the total equipment cost for each substation.

c) The cost of civil and erection works would be estimated under LC portion (in US$).

d) For Taraka substation, as described in Clause 6.6 in Chapter 6, the costs of three alternative plans are estimated.

Table 7.2-1 summarizes the construction costs of substation facilities for the Project. Table 7.2-2, attached at the end of this chapter, shows the details.

Table 7.2-1 Construction Cost of Substations

	Ramu 1 Switchyard		Singsing SS		Erap SS	
Items	FC (US$)	LC (US$)	FC (US$)	LC (US$)	FC (US$)	LC (US$)
Plant & Equipment	306,500.00	106,600.00	7,492,400.00	1,278,500.00	7,543,400.00	1,363,900.00
Civil Works	0.00	48,700.00	0.00	3,165,600.00	0.00	2,092,600.00
Subtotal	*306,500.00*	*155,300.00*	*7,492,400.00*	*4,444,100.00*	*7,543,400.00*	*3,456,500.00*
	Taraka SS (Plan-A)		Taraka SS (Plan-B)		Taraka SS (Plan-C)	
Items	FC	LC	FC	LC	FC	LC
Plant & Equipment	1,358,300.00	423,300.00	3,341,600.00	584,200.00	5,667,900.00	687,400.00
Civil Works	0.00	199,100.00	0.00	380,100.00	0.00	442,400.00
Subtotal	*1,358,300.00*	*622,400.00*	*3,341,600.00*	*964,300.00*	*5,667,900.00*	*1,129,800.00*
	Plan-A Cost		Plan-B Cost		Plan-C Cost	
	FC	LC	FC	LC	FC	LC
Total FC & LC	16,700,600.00	8,678,300.00	18,683,900.00	9,020,200.00	21,010,200.00	9,185,700.00

(Prepared by the Survey Team)

7.3 Total Project Costs

The assumptions in the estimate of the total project costs are as follows:

1) Assumed costs for land acquisitions, land use for tower bases and compensation for crop damage are included under LC portion.

2) Consulting service fee including remunerations and direct costs are estimated under both FC and LC portions.

3) Contingencies for both FC and LC portions are estimated at 8 % of each portion of the total construction costs.

Table 7.3-1 shows the total costs for the Project.

Table 7.3-1 Total Project Costs

Items	FC (US$)	LC (US$)	Total (US$)
1. Transmission Line Component			
1.1 132 kV Singsing - Erap 2-cct line	14,422,400.00	12,940,300.00	27,362,700.00
1.2 132 kV Erap - Taraka 1-cct line	2,611,200.00	4,671,100.00	7,282,300.00
2. Substation Component			
2.1 Ramu 1 switchyard	306,500.00	155,300.00	461,800.00
2.2 Singsing substation	7,492,400.00	4,444,100.00	11,936,500.00
2.3 Erap substation	7,543,400.00	3,456,500.00	10,999,900.00
2.4a Taraka substation (Plan-A)	1,358,300.00	622,400.00	1,980,700.00
2.4b Taraka substation (Plan-B)	3,341,600.00	964,300.00	4,305,900.00
2.4c Taraka substation (Plan-C)	5,667,900.00	1,129,800.00	6,797,700.00
3. Land & ROW Compensation			
3.1 Erap substation (0.46 ha)	-	8,720.00	8,720.00
3.2 Land use for tower bases (308 towers)	-	268,600.00	268,600.00
3.3 Compensation for crop damage	-	654,000.00	654,000.00
4. Consulting Fee			
4.1 Remuneration	2,878,100.00	319,100.00	3,197,200.00
4.2 Direct Costs	355,300.00	1,469,300.00	1,824,600.00
5. Contingency (8% of 1+2)			
5.1 Contingency Plan-A	2,698,700.00	2,103,200.00	4,801,900.00
5.2 Contingency Plan-B	2,857,400.00	2,130,500.00	4,987,900.00
5.3 Contingency Plan-C	3,043,500.00	2,143,800.00	5,187,300.00
Grand Total (Plan-A)	39,666,300.00	31,112,620.00	70,778,920.00
Grand Total (Plan-B)	41,808,300.00	31,481,820.00	73,290,120.00
Grand Total (Plan-C)	44,320,700.00	31,660,620.00	75,981,320.00

(Prepared by the Survey Team)

7.4 Cost Reduction Measures

Although the Survey Team economically designed transmission lines and substations, this clause describes some project cost reduction measures as for reference.

(1) Reduction of Initial Costs

1) Transmission line between Singsing SS and Erap SS section

As mentioned in Clause 4.5, additional double-circuit transmission lines are mandatory to meet the N-1 criteria for the Singsing SS and Erap SS section considering the forecast of huge mining demand. However, the necessity of installing a 3rd-circuit is greatly affected by the progress of Wafi gold mining development. To avoid unknown risks and to save initial costs, as an alternative, the section is to be developed with double-circuit towers with single-circuit installation at the initial stage, and the 2nd-circuit is to be installed in accordance with the progress of the mining development.

2) Application of composite insulators

In case composite insulators are to be applied for the transmission lines under the Project instead of porcelain insulators, approximately 15 - 20 % of insulator costs can be reduced.

Composite insulators have advantages of anti-pollution performance in high polluted area and light weight for easy and economical transportation and installation. However, composite insulators have less lifetime comparing with porcelain insulators, which have more than 30 years lifetime.

(2) Reduction of O&M Costs

1) Introduction of GIS system to Taraka SS

Although initial cost of GIS system is higher than that of AIS system as mentioned in Clause 6.7, GIS system has advantages of higher reliability and easy O&M and can contribute to reduction of O&M cost. The details are described in Clause 10.2.

2) Introduction of low-loss type conductors

Low-loss type conductors such as LL-ACSR/AS can contribute to transmission loss reduction especially on heavily loaded transmission lines, and contribute to saving of generating costs. Although the initial cost of adopting low-loss conductor is about two times that of conventional ACSR, the initial investments can be recouped by saving of generating costs. The details are described in Clause 11.2.

Table 7.1-2 Breakdown of Cost Estimation for Transmission Lines

No.	Description	Unit	Q'ty	Unit Price (USD)		Amount (USD)		Erection (USD)	Total (USD)	Total (PGK eq.)
				CIF	Local	Foreign	Local			
1. General										
1	Project Management by Contractor	lot	1	3,300,000.0		3,300,000.0			3,300,000.0	7,568,800.0
2	Tower Tests (A, AA, B, DD)									
	Type A, AA	type	2	40,500.0		81,000.0			81,000.0	185,800.0
	Type B, DD	type	2	68,000.0		136,000.0			136,000.0	311,900.0
				Subtotal for General		*3,517,000.0*	*0.0*	*0.0*	*3,517,000.0*	*8,066,500.0*
2. 132 kV 2-cct Line between Singsing-Erap (97.2 km) and Incoming line to Taraka (0.7 km)										
1	Mobilization, camp, clearing, and survey	lot	1					743,000.0	743,000.0	1,704,100.0
2	Foundations									
	Type 1 for 2-cct towers	set	188		31,000.0		5,828,000.0		5,828,000.0	13,367,000.0
	Type 2 for 2-cct towers	set	28		68,000.0		1,904,000.0		1,904,000.0	4,367,000.0
	Type 3 for 2-cct towers	set	1		83,930.0		83,900.0		83,900.0	192,400.0
	Type 2 for 1-cct towers	set	5		61,200.0		306,000.0		306,000.0	701,800.0
	Type 3 for 1-cct towers	set	1		75,540.0		75,500.0		75,500.0	173,200.0
3	Materials procurement									
1)	Towers									
	Type AA	set	184	14,080.0		2,590,700.0		545,200.0	3,135,900.0	7,192,400.0
	Type BB	set	10	19,710.0		197,100.0		41,500.0	238,600.0	547,200.0
	Type CC	set	10	28,150.0		281,500.0		59,300.0	340,800.0	781,700.0
	Type DD	set	13	39,410.0		512,300.0		107,800.0	620,100.0	1,422,200.0
	Type B	set	3	11,260.0		33,800.0		8,500.0	42,300.0	97,000.0
	Type D	set	3	22,520.0		67,600.0		17,000.0	84,600.0	194,000.0
2)	Conductor and ground-wire									
	ACSR Deer	km	616.8	5,930.0		3,657,400.0		2,237,000.0	5,894,400.0	13,519,300.0
	AS 70 mm2	km	102.8	2,970.0		305,300.0		54,600.0	359,900.0	825,500.0
	OPGW 70 mm2	km	102.8	4,450.0		457,400.0		209,700.0	667,100.0	1,530,000.0
3)	Insulators									
	Suspention single string assemblies (12t)	set	1,104	1,050.0		1,159,200.0		163,400.0	1,322,600.0	3,033,500.0
	Tension single string assemblies (16t)	set	432	1,600.0		691,200.0		93,300.0	784,500.0	1,799,300.0
	Tension jumper assemblies (12t)	set	102	650.0		66,300.0		11,800.0	78,100.0	179,100.0
	Gantry single string assemblies	set	27	810.0		21,900.0		4,200.0	26,100.0	59,900.0
	Gantry V-string assemblies	set	27	1,210.0		32,700.0		6,300.0	39,000.0	89,400.0
4)	Fittings									
	Conductor dampers	sets	5,136	50.0		256,800.0		43,100.0	299,900.0	687,800.0
	GW dumpers (AC,OPGW)	sets	1,712	40.0		68,500.0		12,300.0	80,800.0	185,300.0
	Conductor sleeves	pcs	395	150.0		59,300.0		27,700.0	87,000.0	199,500.0
	GW sleeves (AC)	pcs	40	60.0		2,400.0		1,600.0	4,000.0	9,200.0
	Suspension GW fittings (AC,OPGW)	sets	368	120.0		44,200.0		88,300.0	132,500.0	303,900.0
	Tension GW fittings (AC,OPGW)	sets	144	300.0		43,200.0		89,300.0	132,500.0	303,900.0
4	Temporary 132 kV line									
1)	Temporary 132 kV line for Singsing (3 km)	lot	1	39,000.0	90,000.0	39,000.0	90,000.0	66,000.0	195,000.0	447,200.0
2)	Dismantle of existing line Traka incoming (0.7 km)	lot	1					22,000.0	22,000.0	50,500.0
5	Spare and tools (3% of equipment cost)	lot	1	317,600.0		317,600.0			317,600.0	728,400.0
				Subtotal for 132 kV 2-cct line		*10,905,400.0*	*8,287,400.0*	*4,652,900.0*	*23,845,700.0*	*54,691,700.0*
3. 132 kV Erap - Taraka, 1-cct Line (39.7 km)										
1	Mobilization, camp, clearing, and survey	lot	1.0					311,000.0	311,000.0	713,300.0
2	Foundations									
	Type 1 for 1-cct towers	set	75		29,140.0		2,185,500.0		2,185,500.0	5,012,600.0
	Type 2 for 1-cct towers	set	12		63,920.0		767,000.0		767,000.0	1,759,200.0
	Type 3 for 1-cct towers	set	3		78,900.0		236,700.0		236,700.0	542,900.0
3	Materials procurement									
1)	Towers									
	Type A	set	70	10,140.0		709,800.0		149,300.0	859,100.0	1,970,400.0
	Type B	set	11	13,520.0		148,700.0		31,300.0	180,000.0	412,800.0
	Type C	set	4	16,890.0		67,600.0		14,200.0	81,800.0	187,600.0
	Type D	set	5	27,030.0		135,200.0		28,400.0	163,600.0	375,200.0
2)	Conductor and ground-wire									
	ACSR Deer	km	125.1	5,930.0		741,600.0		692,800.0	1,434,400.0	3,289,900.0
	AC 70 mm2	km	-							
	OPGW 70 mm2	km	41.7	4,450.0		185,500.0		85,000.0	270,500.0	620,400.0
3)	Insulators									
	Suspention single string assemblies (12t)	set	210	1,050.0		220,500.0		31,100.0	251,600.0	577,100.0
	Tension single string assemblies (16t)	set	120	1,600.0		192,000.0		25,900.0	217,900.0	499,800.0
	Tension Jumper assemblies (12t)	set	14	650.0		9,100.0		1,600.0	10,700.0	24,500.0
	Gantry single string assemblies	set	6	810.0		4,900.0		900.0	5,800.0	13,300.0

Table 7.1-2 Breakdown of Cost Estimation for Transmission Lines

No.	Description	Unit	Q'ty	Unit Price (USD)		Amount (USD)		Erection (USD)	Total (USD)	Total (PGK eq.)
				CIF	Local	Foreign	Local			
	Gantry V-string assemblies	set	6	1,210.0		7,300.0		1,400.0	8,700.0	20,000.0
4)	Fittings									
	Conductor dampers	sets	1,056	50.0		52,800.0		7,400.0	60,200.0	138,100.0
	GW dumpers(OPGW)	sets	352	40.0		14,100.0		2,100.0	16,200.0	37,200.0
	Conductor sleeves	pcs	84	150.0		12,600.0		5,900.0	18,500.0	42,400.0
	GW sleeves	pcs	0	60.0		0.0		0.0	0.0	0.0
	Suspension GW fittings (OPGW)	sets	70	120.0		8,400.0		16,800.0	25,200.0	57,800.0
	Tension GW fittings (OPGW)	sets	40	300.0		12,000.0		24,800.0	36,800.0	84,400.0
4	Temporary 132 kV line									
1)	Temporary 132 kV line for Erap (1 km)	lot	1	13,000.0	30,000.0	13,000.0	30,000.0	22,000.0	65,000.0	149,100.0
5	Spare and tools (3% of equipment cost)	lot	1	76,100.0		76,100.0			76,100.0	174,500.0
	Subtotal for 132 kV 1-cct line					*2,611,200.0*	*3,219,200.0*	*1,451,900.0*	*7,282,300.0*	*16,702,500.0*
	Grand Total					17,033,600.0	11,506,600.0	6,104,800.0	34,645,000.0	79,460,700.0

Note:

1) Exchange Rate:

1 PNG Kina = 35.324 Japanese Yen

1 US dollar = 80.99 Japanese Yen

1 Euro = 116.55 Japanese Yen

Table 7.2-2 Breakdown of Cost Estimation for Substations

No.	Description	Unit	Q'ty	Unit Price (USD)		Amount (USD)		Erection (USD)	Total (USD)	Total (PGK eq.)
				CIF	Local	Foreign	Local			
1. Ramu 1 Switchyard										
1.	*Outdoor Switchgears*									
1)	132 kV Taraka bay	lot	1.0	50,000.0	0.0	50,000.0	0.0	15,000.0	65,000.0	149,100.0
2)	132 kV Gusap bay	lot	1.0	17,700.0	0.0	17,700.0	0.0	5,400.0	23,100.0	53,000.0
3)	Above item accessories, earthing, etc.	lot	1.0	4,800.0	0.0	4,800.0	0.0	1,500.0	6,300.0	14,400.0
2.	*Control and Protection Device*									
1)	Modification of TL protections	lot	1.0	78,100.0	0.0	78,100.0	0.0	23,500.0	101,600.0	233,000.0
3.	*Telecommunication System*									
1)	Modification of STM-1, PABX, etc.	lot	1.0	39,500.0	0.0	39,500.0	0.0	11,900.0	51,400.0	117,900.0
4.	*Common items*									
1)	110 V & 48 V DC power supply system	lot	1.0	53,000.0	0.0	53,000.0	0.0	21,200.0	74,200.0	170,200.0
2)	Accessories for conduit, cable, lag, etc.	lot	1.0	24,300.0	0.0	24,300.0	0.0	7,300.0	31,600.0	72,500.0
5.	*Civil Works*									
1)	Foundation Works	lot	1.0	0.0	19,500.0	0.0	19,500.0	0.0	19,500.0	44,700.0
2)	Extension of DC Battery Room	lot	1.0	0.0	29,200.0	0.0	29,200.0	0.0	29,200.0	67,000.0
6.	*Others*									
1)	Design for electrical & civil works	lot	1.0	17,700.0	6,400.0	17,700.0	6,400.0	0.0	24,100.0	55,300.0
2)	Commissioning	lot	1.0	0.0	14,400.0	0.0	14,400.0	0.0	14,400.0	33,000.0
3)	Other Services (spare parts, training and etc.)	lot	1.0	21,400.0	0.0	21,400.0	0.0	0.0	21,400.0	49,100.0
				Subtotal for Ramu 1 Switchyard		*306,500.0*	*69,500.0*	*85,800.0*	*461,800.0*	*1,059,200.0*
2. Singsing Substation										
1.	*Outdoor Switchgear*									
1)	132 kV transmission line bay	bays	6.0	100,100.0	0.0	600,600.0	0.0	180,200.0	780,800.0	1,790,800.0
2)	132 kV bus section	bays	5.0	77,800.0	0.0	389,000.0	0.0	116,700.0	505,700.0	1,159,900.0
3)	132 kV transformer bay	bay	1.0	50,000.0	0.0	50,000.0	0.0	15,000.0	65,000.0	149,100.0
4)	132 kV one-and-half CB scheme busbars	lot	1.0	103,400.0	0.0	103,400.0	0.0	41,400.0	144,800.0	332,100.0
2.	*Transformers*									
1)	132/33 kV 10/12MVA OLTC transformer	unit	1.0	844,300.0	0.0	844,300.0	0.0	101,400.0	945,700.0	2,169,000.0
2)	33/0.415-0.24 kV 100kVA transformer	unit	1.0	13,000.0	0.0	13,000.0	0.0	3,900.0	16,900.0	38,800.0
3.	*33 kV Switchgear*									
1)	33 kV metal-enclosed switchgear	lot	1.0	557,200.0	0.0	557,200.0	0.0	83,600.0	640,800.0	1,469,700.0
4.	*Control and Protection Panel*									
1)	132 kV control & protection panel	lot	1.0	816,400.0	0.0	816,400.0	0.0	81,700.0	898,100.0	2,059,900.0
2)	Mini-SCADA	lot	1.0	812,200.0	0.0	812,200.0	0.0	40,700.0	852,900.0	1,956,200.0
5.	*Telecommunication System*									
1)	Construction of STM-1, MUX, PABX, etc	lot	1.0	560,900.0	0.0	560,900.0	0.0	56,100.0	617,000.0	1,415,100.0
6.	*Miscellaneous Electrical Equipment*									
1)	75 kVA 0.415-240 kV DEG set with fuel tank	lot	1.0	33,800.0	0.0	33,800.0	0.0	6,800.0	40,600.0	93,100.0
2)	110 V & 48 V DC power supply system	lot	1.0	53,000.0	0.0	53,000.0	0.0	21,200.0	74,200.0	170,200.0
3)	LVAC distribution system	lot	1.0	50,500.0	0.0	50,500.0	0.0	3,600.0	54,100.0	124,100.0
4)	Gantries & support structures	lot	1.0	311,500.0	22,000.0	311,500.0	22,000.0	23,400.0	356,900.0	818,600.0
5)	Earthing, lightning, outdoor lighting system, etc.	lot	1.0	610,900.0	90,000.0	610,900.0	90,000.0	35,100.0	736,000.0	1,688,100.0
6)	Accessories for conduit power/control cables, lag, etc.	lot	1.0	1,248,600.0	0.0	1,248,600.0	0.0	149,900.0	1,398,500.0	3,207,600.0
7.	*Civil Works*									
1)	All civil works including foundation, etc.	lot	1.0	0.0	2,261,100.0	0.0	2,261,100.0	904,500.0	3,165,600.0	7,260,600.0
8.	*Others*									
1)	Design for electrical & civil works	lot	1.0	124,900.0	63,100.0	124,900.0	63,100.0	0.0	188,000.0	431,200.0
2)	Commissioning, factory test, etc.	lot	1.0	0.0	142,700.0	0.0	142,700.0	0.0	142,700.0	327,300.0
3)	Other Services (spare parts, training and etc.)	lot	1.0	312,200.0	0.0	312,200.0	0.0	0.0	312,200.0	716,100.0
				Subtotal for Singsing Substation		*7,492,400.0*	*2,578,900.0*	*1,865,200.0*	*11,936,500.0*	*27,377,500.0*
3. Erap Substation										
1.	*Outdoor Switchgear*									
1)	132 kV transmission line bay	bays	3.0	100,100.0	0.0	300,300.0	0.0	90,100.0	390,400.0	895,400.0
2)	132 kV bus section	bays	4.0	79,300.0	0.0	317,200.0	0.0	95,200.0	412,400.0	945,900.0
3)	132 kV transformer bay	bays	2.0	50,000.0	0.0	100,000.0	0.0	30,000.0	130,000.0	298,200.0
4)	132 kV one-and-half CB scheme busbars	lot	1.0	104,000.0	0.0	104,000.0	0.0	41,600.0	145,600.0	333,900.0
5)	66 kV transformer bay	bays	2.0	87,900.0	0.0	175,800.0	0.0	52,800.0	228,600.0	524,300.0
6)	66 kV bus section	bay	1.0	80,000.0	0.0	80,000.0	0.0	24,000.0	104,000.0	238,500.0
7)	66 kV single tubular busbars	lot	1.0	62,700.0	0.0	62,700.0	0.0	25,100.0	87,800.0	201,400.0
2.	*Transformers*									
1)	132/66/33 kV 10/12 MVA OLTC transformer	units	2.0	844,300.0	0.0	1,688,600.0	0.0	202,700.0	1,891,300.0	4,337,800.0

Table 7.2-2 Breakdown of Cost Estimation for Substations

No.	Description	Unit	Q'ty	Unit Price (USD)		Amount (USD)		Erection (USD)	Total (USD)	Total (PGK eq.)
				CIF	Local	Foreign	Local			
2)	33 kV earthing transformer	units	2.0	170,400.0	0.0	340,800.0	0.0	40,900.0	381,700.0	875,500.0
3)	33/0.415-0.24 kV 100 kVA transformer	units	2.0	13,000.0	0.0	26,000.0	0.0	7,800.0	33,800.0	77,500.0
3.	*33 kV Switchgear*									
1)	33 kV metal-enclosed switchgear	lot	1.0	1,077,900.0	0.0	1,077,900.0	0.0	161,700.0	1,239,600.0	2,843,100.0
4.	*Control and Protection Panel*									
1)	132 kV/ 66 kV control & protection panel	lot	1.0	823,000.0	0.0	823,000.0	0.0	82,300.0	905,300.0	2,076,400.0
2)	Modification of TL & busbar protection	lot	1.0	92,300.0	0.0	92,300.0	0.0	27,700.0	120,000.0	275,200.0
3)	Modification of Mini-SCADA	lot	1.0	81,300.0	0.0	81,300.0	0.0	4,100.0	85,400.0	195,900.0
5.	*Telecommunication System*									
1)	Modification of STM-1, PABX, etc.	lot	1.0	118,400.0	0.0	118,400.0	0.0	35,600.0	154,000.0	353,200.0
6.	*Miscellaneous Electrical Equipment*									
1)	48 V DC power supply system	lot	1.0	21,300.0	0.0	21,300.0	0.0	8,600.0	29,900.0	68,600.0
2)	LVAC distribution system for SWG room	lot	1.0	50,500.0	0.0	50,500.0	0.0	3,600.0	54,100.0	124,100.0
3)	Gantries & support structures	lot	1.0	222,500.0	22,000.0	222,500.0	22,000.0	17,200.0	261,700.0	600,200.0
4)	Earthing, lightning, lighting system, etc.	lot	1.0	407,900.0	60,700.0	407,900.0	60,700.0	23,500.0	492,100.0	1,128,700.0
5)	Accessories for conduit power/control cables, lag, etc.	lot	1.0	1,064,200.0	0.0	1,064,200.0	0.0	127,800.0	1,192,000.0	2,733,900.0
7.	*Civil Works*									
1)	All civil works including foundation, etc.	lot	1.0	0.0	1,494,700.0	0.0	1,494,700.0	597,900.0	2,092,600.0	4,799,500.0
8.	*Others*									
1)	Design for electrical & civil works	lot	1.0	111,100.0	48,900.0	111,100.0	48,900.0	0.0	160,000.0	367,000.0
2)	Commissioning, factory test, etc.	lot	1.0	0.0	130,000.0	0.0	130,000.0	0.0	130,000.0	298,200.0
3)	Other Services (Spare parts, training and etc.)	lot	1.0	277,600.0	0.0	277,600.0	0.0	0.0	277,600.0	636,700.0
				Subtotal for Erap Substation		*7,543,400.0*	*1,756,300.0*	*1,700,200.0*	*10,999,900.0*	*25,229,100.0*
4a. Taraka Substation (Plan-A)										
1.	*Outdoor Switchgear*									
1)	132 kV transmission line bay	bay	1.0	91,100.0	0.0	91,100.0	0.0	27,400.0	118,500.0	271,800.0
2)	Modification of 132 kV transmission line bay	bay	1.0	35,100.0	0.0	35,100.0	0.0	10,600.0	45,700.0	104,800.0
3)	132 kV bus section	bays	2.0	14,900.0	0.0	29,800.0	0.0	9,000.0	38,800.0	89,000.0
4)	132 kV transformer bay	bay	4.0	54,000.0	0.0	216,000.0	0.0	64,800.0	280,800.0	644,000.0
5)	Modification of 132 kV single busbar	lot	1.0	51,300.0	0.0	51,300.0	0.0	20,600.0	71,900.0	164,900.0
6)	66kV transmission line bay	bays	2.0	68,500.0	0.0	137,000.0	0.0	41,100.0	178,100.0	408,500.0
7)	66 kV transformer bay	bays	2.0	53,600.0	0.0	107,200.0	0.0	32,200.0	139,400.0	319,700.0
8)	66 kV bus section	bay	1.0	87,100.0	0.0	87,100.0	0.0	26,200.0	113,300.0	259,900.0
9)	Modification of 66 kV single busbar accessories	lot	1.0	16,500.0	0.0	16,500.0	0.0	6,600.0	23,100.0	53,000.0
2.	*Control and Protection Panel*									
1)	132 kV control & protection panel	lot	1.0	77,100.0	0.0	77,100.0	0.0	7,800.0	84,900.0	194,700.0
2)	Modification of TL & busbar protection	lot	1.0	63,900.0	0.0	63,900.0	0.0	19,200.0	83,100.0	190,600.0
3.	*Telecommunication System*									
1)	Modification of STM-1, PABX, etc.	lot	1.0	39,500.0	0.0	39,500.0	0.0	11,900.0	51,400.0	117,900.0
4.	*Miscellaneous Electrical Equipment*									
1)	110 V & 48 V DC power supply system	lot	1.0	53,000.0	0.0	53,000.0	0.0	21,200.0	74,200.0	170,200.0
2)	Gantries & support structures	lot	1.0	44,500.0	22,000.0	44,500.0	22,000.0	4,700.0	71,200.0	163,300.0
3)	Earthing, lightning, lighting system, etc.	lot	1.0	75,000.0	32,800.0	75,000.0	32,800.0	5,400.0	113,200.0	259,600.0
4)	Accessories for conduit power/control cables, lag, etc.	lot	1.0	164,900.0	0.0	164,900.0	0.0	19,800.0	184,700.0	423,600.0
5.	*Civil Works*									
1)	All civil works including foundation, etc.	lot	1.0	0.0	142,200.0	0.0	142,200.0	56,900.0	199,100.0	456,700.0
6.	*Others*									
1)	Design for electrical & civil works	lot	1.0	19,800.0	11,500.0	19,800.0	11,500.0	0.0	31,300.0	71,800.0
2)	Commissioning, factory test, etc.	lot	1.0	0.0	28,500.0	0.0	28,500.0	0.0	28,500.0	65,400.0
3)	Other Services (Spare parts, training and etc.)	lot	1.0	49,500.0	0.0	49,500.0	0.0	0.0	49,500.0	113,500.0
				Subtotal for Taraka Substation (Plan-A)		*1,358,300.0*	*237,000.0*	*385,400.0*	*1,980,700.0*	*4,542,900.0*
4b. Taraka Substation (Plan-B)										
1.	*Gas Insulated Switchgear*									
1)	132 kV incoming unit	units	2.0	493,800.0	0.0	987,600.0	0.0	69,200.0	1,056,800.0	2,423,900.0
2)	132 kV feeder unit	unit	1.0	493,800.0	0.0	493,800.0	0.0	34,600.0	528,400.0	1,211,900.0
3)	132 kV busbar CVT unit	unit	1.0	222,200.0	0.0	222,200.0	0.0	15,600.0	237,800.0	545,400.0
2.	*Outdoor Switchgear*									
1)	132 kV bus section	bays	2.0	14,900.0	0.0	29,800.0	0.0	9,000.0	38,800.0	89,000.0
2)	132 kV transformer bay	bay	4.0	54,000.0	0.0	216,000.0	0.0	64,800.0	280,800.0	644,000.0
3)	Cable head for 132 kV power cable	sets	3.0	6,500.0	0.0	19,500.0	0.0	5,900.0	25,400.0	58,300.0
4)	Modification of 132 kV single busbar	lot	1.0	13,800.0	0.0	13,800.0	0.0	5,600.0	19,400.0	44,500.0

Table 7.2-2 Breakdown of Cost Estimation for Substations

No.	Description	Unit	Q'ty	Unit Price (USD)		Amount (USD)		Erection (USD)	Total (USD)	Total (PGK eq.)
				CIF	Local	Foreign	Local			
5)	66 kV transmission line bay	bays	2.0	68,500.0	0.0	137,000.0	0.0	41,100.0	178,100.0	408,500.0
6)	66 kV transformer bay	bays	2.0	53,600.0	0.0	107,200.0	0.0	32,200.0	139,400.0	319,700.0
7)	66 kV bus section	bay	1.0	87,100.0	0.0	87,100.0	0.0	26,200.0	113,300.0	259,900.0
8)	Modification of 66 kV single busbar accessories	lot	1.0	16,500.0	0.0	16,500.0	0.0	6,600.0	23,100.0	53,000.0
3.	*Control and Protection Panel*									
1)	132 kV control & protection panel	lot	1.0	231,300.0	0.0	231,300.0	0.0	23,200.0	254,500.0	583,700.0
2)	Modification of TL & busbar protection	lot	1.0	56,800.0	0.0	56,800.0	0.0	17,100.0	73,900.0	169,500.0
4.	*Telecommunication System*									
1)	Modification of STM-1, PABX, etc.	lot	1.0	39,500.0	0.0	39,500.0	0.0	11,900.0	51,400.0	117,900.0
5.	*Miscellaneous Electrical Equipment*									
1)	110 V & 48 V DC power supply system	lot	1.0	53,000.0	0.0	53,000.0	0.0	21,200.0	74,200.0	170,200.0
2)	Gantries & support structures	lot	1.0	111,300.0	55,000.0	111,300.0	55,000.0	11,700.0	178,000.0	408,300.0
3)	Earthing, lightning, lighting system, etc.	lot	1.0	80,700.0	28,300.0	80,700.0	28,300.0	5,500.0	114,500.0	262,600.0
4)	Accessories for conduit power/control cables, lag, etc.	lot	1.0	272,600.0	0.0	272,600.0	0.0	32,800.0	305,400.0	700,500.0
6.	*Civil Works*									
1)	All civil works including foundation, etc.	lot	1.0	0.0	271,500.0	0.0	271,500.0	108,600.0	380,100.0	871,800.0
7.	*Others*									
1)	Design for electrical & civil works	lot	1.0	47,400.0	12,400.0	47,400.0	12,400.0	0.0	59,800.0	137,200.0
2)	Commissioning, factory test, etc.	lot	1.0	0.0	54,300.0	0.0	54,300.0	0.0	54,300.0	124,500.0
3)	Other Services (Spare parts, training and etc.)	lot	1.0	118,500.0	0.0	118,500.0	0.0	0.0	118,500.0	271,800.0
	Subtotal for Taraka Substation (Plan-B)					*3,341,600.0*	*421,500.0*	*542,800.0*	*4,305,900.0*	*9,876,100.0*
4c. Taraka Substation (Plan-C)										
1.	*Gas Insulated Switchgear*									
1)	132 kV incoming unit	units	2.0	493,800.0	0.0	987,600.0	0.0	69,200.0	1,056,800.0	2,423,900.0
2)	132 kV feeder unit	unit	5.0	493,800.0	0.0	2,469,000.0	0.0	172,900.0	2,641,900.0	6,059,400.0
3)	132 kV busbar CVT unit	unit	1.0	222,200.0	0.0	222,200.0	0.0	15,600.0	237,800.0	545,400.0
2.	*Outdoor Switchgear*									
1)	Cable head for 132 kV power cable	sets	7.0	6,500.0	0.0	45,500.0	0.0	13,700.0	59,200.0	135,800.0
2)	66 kV transmission line bay	bays	2.0	68,500.0	0.0	137,000.0	0.0	41,100.0	178,100.0	408,500.0
3)	66 kV transformer bay	bays	2.0	53,600.0	0.0	107,200.0	0.0	32,200.0	139,400.0	319,700.0
4)	66 kV bus section	bay	1.0	87,100.0	0.0	87,100.0	0.0	26,200.0	113,300.0	259,900.0
5)	Modification of 66 kV single busbar accessories	lot	1.0	16,500.0	0.0	16,500.0	0.0	6,600.0	23,100.0	53,000.0
3.	*Control and Protection Panel*									
1)	132 kV control & protection panel	lot	1.0	616,700.0	0.0	616,700.0	0.0	61,700.0	678,400.0	1,556,000.0
2)	Modification of TL & busbar protection	lot	1.0	56,800.0	0.0	56,800.0	0.0	17,100.0	73,900.0	169,500.0
4.	*Telecommunication System*									
1)	Modification of STM-1, PABX, etc.	lot	1.0	39,500.0	0.0	39,500.0	0.0	11,900.0	51,400.0	117,900.0
5.	*Miscellaneous Electrical Equipment*									
1)	110 V & 48 V DC power supply system	lot	1.0	53,000.0	0.0	53,000.0	0.0	21,200.0	74,200.0	170,200.0
2)	Gantries & support structures	lot	1.0	89,000.0	44,000.0	89,000.0	44,000.0	9,400.0	142,400.0	326,600.0
3)	Earthing, lightning, lighting system, etc.	lot	1.0	68,900.0	7,900.0	68,900.0	7,900.0	3,900.0	80,700.0	185,100.0
4)	Accessories for conduit power/control cables, lag, etc.	lot	1.0	473,100.0	0.0	473,100.0	0.0	56,800.0	529,900.0	1,215,400.0
6.	*Civil Works*									
1)	All civil works including foundation, etc.	lot	1.0	0.0	316,000.0	0.0	316,000.0	126,400.0	442,400.0	1,014,700.0
7.	*Others*									
1)	Design for electrical & civil works	lot	1.0	56,800.0	12,800.0	56,800.0	12,800.0	0.0	69,600.0	159,600.0
2)	Commissioning, factory test, etc.	lot	1.0	0.0	63,200.0	0.0	63,200.0	0.0	63,200.0	145,000.0
3)	Other Services (Spare parts, training and etc.)	lot	1.0	142,000.0	0.0	142,000.0	0.0	0.0	142,000.0	325,700.0
	Subtotal for Taraka Substation (Plan-C)					*5,667,900.0*	*443,900.0*	*685,900.0*	*6,797,700.0*	*15,591,300.0*
	Grand Total (Plan-A)					16,700,600.0	4,641,700.0	4,036,600.0	25,378,900.0	58,208,700.0
	Grand Total (Plan-B)					18,683,900.0	4,826,200.0	4,194,000.0	27,704,100.0	63,541,900.0
	Grand Total (Plan-C)					21,010,200.0	4,848,600.0	4,337,100.0	30,195,900.0	69,257,100.0

Note:

1) Exchange Rate:
1 PNG Kina = 35.324 Japanese Yen
1 US dollar = 80.99 Japanese Yen
1 Euro = 116.55 Japanese Yen

2) Cost Comparison of GIS
Plan-A: USD 1,980,700.00 (100 %)
Plan-B: USD 4,305,900.00 (217 %)
Plan-C: USD 6,797,700.00 (343 %)

CHAPTER 8

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

CHAPTER 8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 Environmental and Social Considerations

8.1.1 Project Components

The Project consists of two major components. The first component involves installation of a new 132 kV transmission line between Singsing and Taraka through Erap, which will be in parallel with the existing transmission line. The existing transmission line stretches from Ramu 1 to Taraka through Erap; however, the new transmission line is to be constructed only from Singsing to Taraka through Erap. The second component aims to reinforce/ rehabilitate existing substations located at three different locations namely, Ramu 1 switchyard, Erap and Taraka substations as well as to newly construct Singsing substation.

For both components, investigation of the project's environmental and social concerns is required. In this stage, no resettlement is expected but negotiation for the acquisition of lands and easements are anticipated as preparatory works for the new transmission lines and the extension of existing switching stations.

8.1.2 Environmental and Social Background of the Project Site

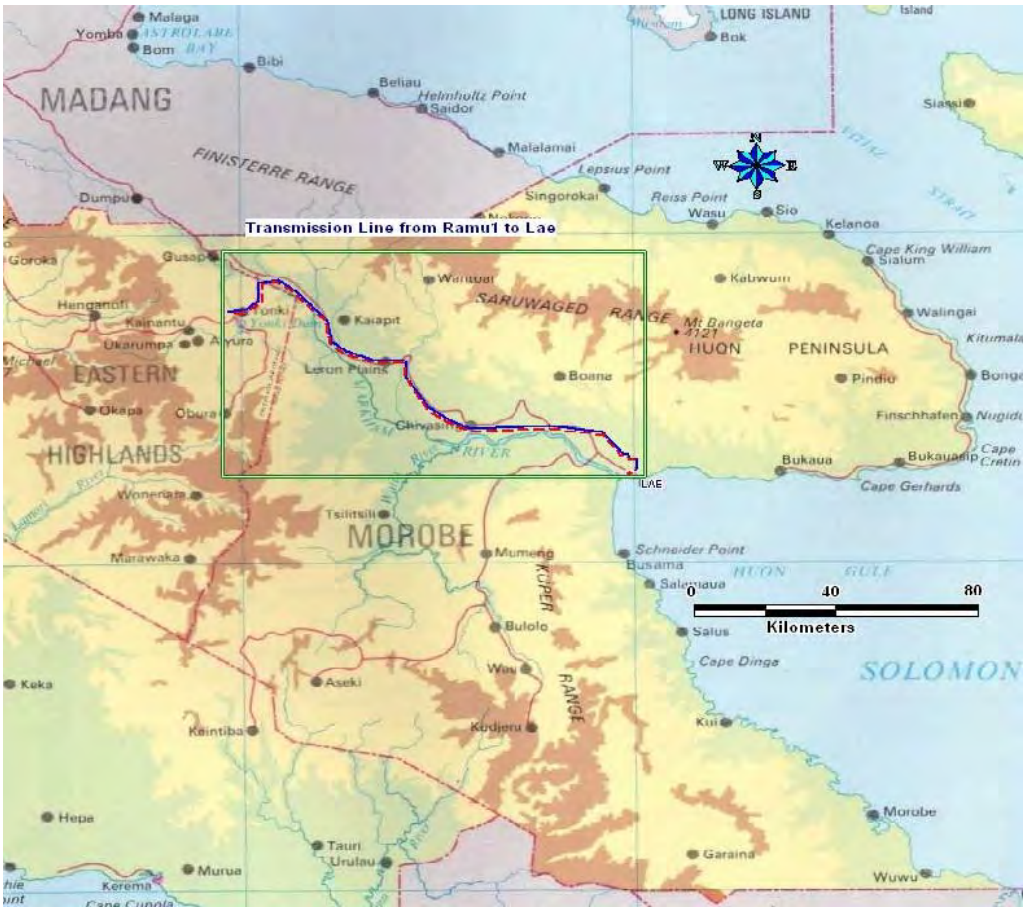
(1) General

The transmission line will traverse Morobe Province. The province, located at the central part of PNG, has a population of 539,404 (source: National Census 2000). Two of the nine districts within the province, the districts of Huon Gulf and Markham, are main project sites. The capital of Morobe Province, Lae, is the second largest city in PNG and it is growing as the centre of business and industry of the province. Morobe Province has rich natural resources and diverse flora and fauna, and most people rely, as source of livelihood, on farming or subsistence agriculture or cash crops in the vast rural area.

Land tenure system in PNG is managed by customary ownership. The majority of land in PNG is customary land while alienated land managed by the government is only a few percent in the urban regions. The Government of PNG (GoPNG) aims to amend legislation and policies to enable use of customary land to promote effective national development.

The highlands highway connects Lae and highland area and also links Madang Province in the southwest. As a consequence, many migrants from Highlands Region or Mandan Province reach Morobe province through the road. In fact, gold mining development in

Morobe Province provides employment opportunities not only to local communities but also to migrants from outside the province. Rapid industrial development brings benefit to the province, and at the same time, economic disparity leads social unrest in urban areas. There are no protected places supported by existing conservation initiatives by the GoPNG in the project site. No sacred and historical sites are recognized in the project area; however, a few burial sites are located within the vicinity of 1 km from the existing transmission line and those sites are also holy places for the communities.



(Prepared by the Survey Team)

Figure 8.1-1 Map of Morobe Province

(2) Climate

There are two typical climate types namely, rainy and dry seasons at the project site. Due to recent global climate change, the area often experiences extreme weather conditions, such as flooding and landslides, which are related to El Nino effect. It has been recognized that the rainy season is from May to August, while dry season is from January to April. Rich water resources in the region depend on abundant annual rainfall, which is between 2,500 mm and 3,000 mm. Average temperature is around 20 – 26 degrees Celsius and most of the project site are locate inland area where it is generally cooler than the costrel area.

(3) Vegetation and Land Use

Majority of vegetation in the project site consists of grass land, and main land for cattle field activities. Communities select different types of agricultural products for cash crop or subsistence foods creating a highly varied village vegetation. Coconut, banana, mango cassava and taro are common around the communities. Such products are suitable to the local environment especially with the main soil type. Also, cocoa and copra plantations are developed by private companies as one of the typical cash crops, which also includes palm oil. The forest is also an important resource for the local community, particularly for materials to build houses.

8.1.3 Frameworks of Environmental and Social Considerations in PNG

(1) Environmental Policies of PNG

Conservation of the environment is highly supported by the Constitution of PNG. Sustainable development is one of the crucial issues for a country, such as PNG, that is rich in natural resources and biological diversity. In Preamble 4 of the Constitution, which is the principle on environmental management and conservation, states that "*We declare our fourth goal to be for PNG'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".* Based on this understanding of the Constitution, the GoPNG has initiated the preparation of strategic documents that promote the implementation of a National Biodiversity Strategy and Action Plan (NBSAP), which promotes effective planning, implementation and decision-making for sustainable biodiversity conservation. In addition, the Medium Term Development Plan (MTDP) is developed to specify indicators, deliverables and cost for sustainable environment.

(2) Related Laws and Regulations of PNG

The Environmental Act 2000 came into force in 2004 by integrating three different legislations: the Environmental Planning Act, the Environmental Contaminant Act and the Water Resources Management Act.

The Environmental Act 2000 is a main legal instrument that regulates environmental impact assessment and management in PNG. Its administration and regulation are conducted by the Department of Environment and Conservation (DEC), which is the government agency designated to manage natural resources and sustain environmental quality.

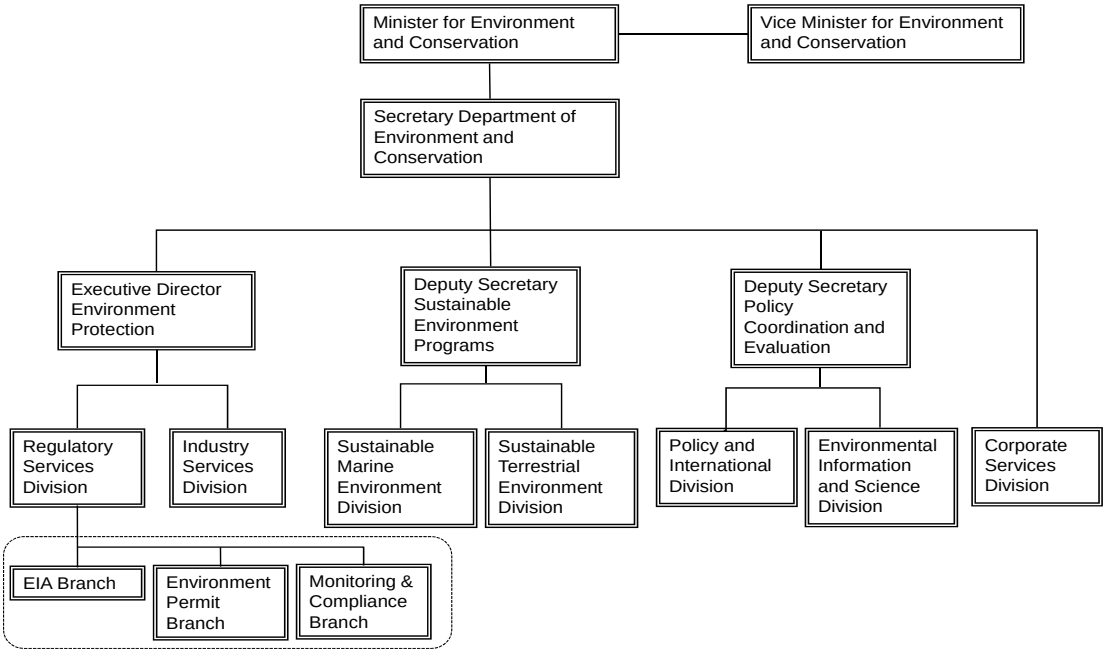
Under the Environmental Act 2000, five pieces of regulation as listed below were enacted in 2002. Each regulation deals with EIA and licensing procedures as a comprehensive part of the Environmental Act 2000.

1) Environment (Permits and Transitional) Regulation 2002
2) Environment (Prescribed Activities) Regulation 2002
3) Environment (Fee and Charge) Regulation 2002
4) Environmental (Water and Quality Criteria) Regulation 2002
5) Environmental (Procedures) Regulation 2002

The legal framework has to identify the environmental quality requirements for local communities and provide the appropriate level of environmental protection through the regulatory process by issuing the necessary environmental permits.

(3) EIA Implementing Agency

DEC is the executive government agency designated to enforce the Environmental Act 2000 and its regulations. It is composed of three divisions, namely, Policy Coordination and Evaluation, Sustainable Environment Management, and Environment Protection. The Division of Environment Protection has three separate branches: EIA Branch, Environmental Permit Branch, and Monitoring & Compliance Branches. The three branches are responsible for environmental assessment and issuance of permits. As per Section 16 of the Environmental Act 2000, the Director of Environment has the authority to administer the Act, and issue permits in accordance with the Act. An environment council is established for the purpose of reviewing the Director's decision and also for providing advice to the Minister (the Act, Section 19). Nevertheless, this procedure is mainly required for Level 3 activities. In order to deliver effective environmental assessment, DEC organizes consistent system for screening and decision-making processes.



(Source: DEC and PNG Power)

Figure 8.1-2 Organization Chart of DEC

(4) EIA Procedure

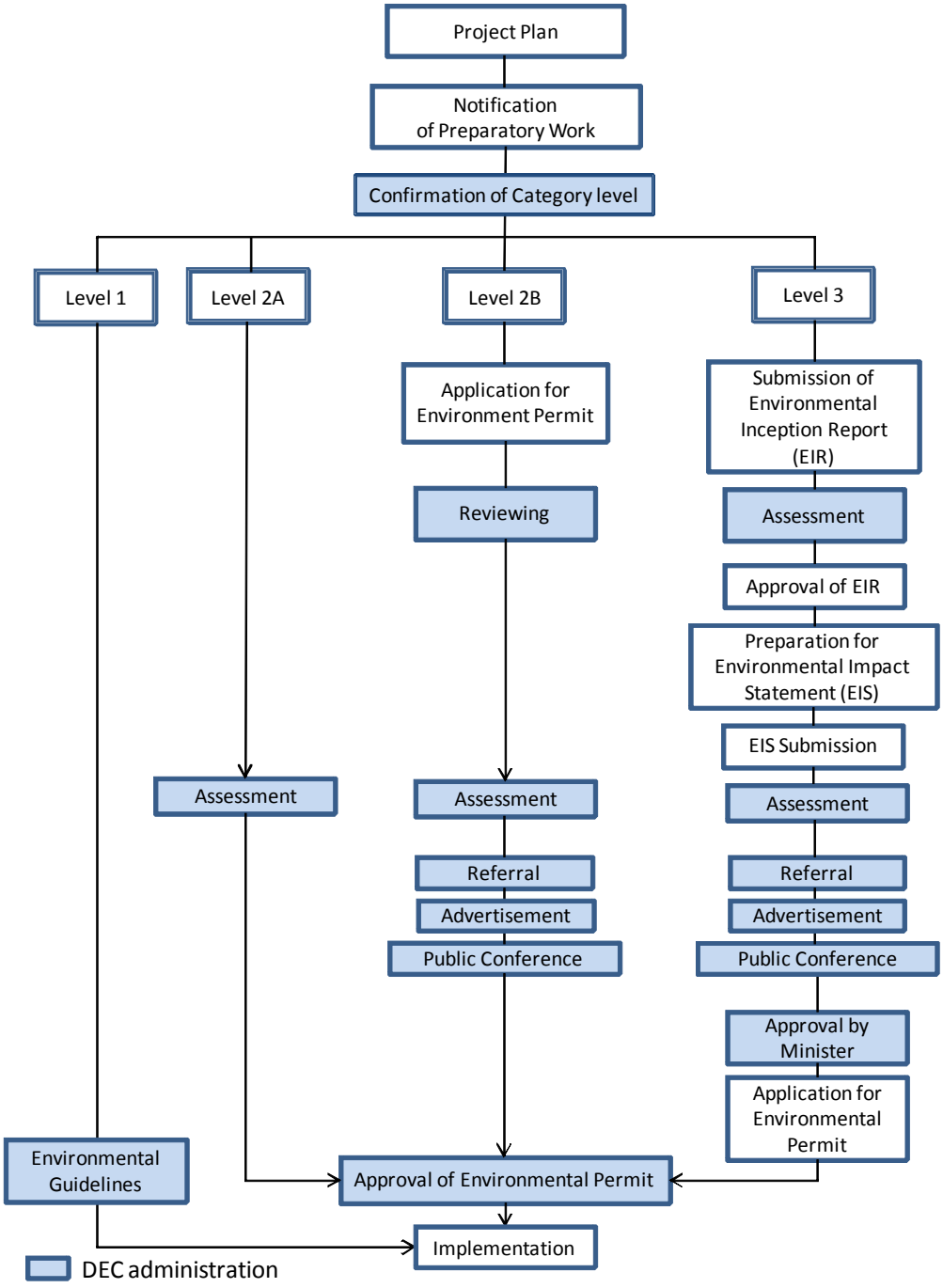
The Environment Act 2000 requires licensing procedures according to level of activities with potential environmental harm. Activities are categorized into three levels by Environment (Prescribed Activities) Regulation 2002. Moreover, sub-category is prescribed in each level based on the project size or environmental risk level.

Level 3 activities are those that have the potential to cause serious environmental harm, including high risk of serious environmental harm due to the type of industrial activities, such as manufacturing, large-scale mining and industrial waste disposal. These activities are subject to follow the entire process of environmental assessment including preparation of the Environmental Impact Statement (EIS).

Level 2 activities are those that have the potential to cause environmental harm. Such activities are divided into two categories, namely, Level 2A and Level 2B. Level 2A involves petroleum or mineral exploration and minor forest activities, while, Level 2B involves manufacturing, chemical processes and mid-sized mining and infrastructure projects. Level 2B activities are required permit approval process together with preparatory feasibility studies, referral, advertisement and public conference. Because it is noted that Level 2B activities are expected to have higher risk as compared to Level 2A. Although it is not necessary to prepare a full Environmental Impact Statement for Level 2B category; project background, major environmental impacts are clarified under “Notification of Preparatory Work” and upon application for an environment permit. Assessment for Level 2A category by DEC is processed within 30 days, while for Level 2B category, 90 days is required for the approval process after the submission of application.

Level 1 activities are assumed to have very low risk of causing environmental harm. However, such activities are supposed to comply with the Act and its regulations. Nevertheless, application for an environmental permit is not required.

Figure 8.1-3 shows the environmental regulatory process.



(Source: Hearing from DEC and PNG Power)

Figure 8.1-3 Environmental Regulatory Process

(5) EIA Procedure concerning the Project

1) Identifying project category

The level of the project has officially categorized as Level 2B by DEC. The project include the construction of new transmission lines and extension of existing substation facilities. Also the project is not part of any conservation reserve or national/social heritage areas. Furthermore, logging operations is not expected during construction and operation. Additionally, the possibility of damming and river diversion, both during

construction and operation, is very low.

According to these conditions of the project the relevant sub-category on Environment (Prescribed Activities) Regulation 2002 that justified the level of the project is as follows:

Level 2B Sub-Category

Sub-Category 12: Infrastructure

12.6 Operation of electricity transmission lines or pipelines greater than 10 km in length.

2) EIA Procedure for the Project

The Project Proponent, PPL is undertaking preparatory works towards environment permit application. The notification of the application was submitted to DEC by PPL on January 5, 2012 prior to the permit application. Following this, DEC confirmed the project category as level 2B in February 2012 according to contents of the notification. PPL is now preparing the environment permit application and reports according to level 2B procedures. PPL plans to submit the application by March 2012 so that the permit should be approved by DEC in June 2012 which will be 90 days after the submission. Early submission of the application is required in order not to delay starting project implementation.

8.1.4 Examination of Alternative Plans

The Survey Team examined the following possible alternative plans to minimize environmental impacts of the project

Alternative 0: No project implementation

Alternative 1: New route discussed by PPL and the Survey Team after the survey (Described at Chapter 5)

Alternative 2: Initial route proposed by PPL (Install new transmission lines at south side of the existing transmission lines)

Due to rapid increase in industrial development demand for power supply in the area, electrification is one of the prioritized issues in Morobe Province. The benefits from the power supply, which include quality life improvement to local communities, have been noticed. Likewise, absence of power supply will possibly promote use of diesel generators that could cause environmental harm. Thus, Alternative 0 implies termination of continuous development of the area, which is unlikely to be selected.

In comparison to Alternative 2, Alternative 1 (refer to Figure 5.2-1) has less influence on the widening of Leron and Umi River channel. During rainy season, landslides and erosion

may occur at weak slopes particularly in low lands and river banks. In order to avoid exposure of tower poles to extensive erosion and depositional activities near the river side, Alternative 1 is geologically favourable for the development of the project. In addition, under Alternative1, a relatively large space is available for the construction of tower poles, so the construction of the tower poles can be managed easily.

With respect to cost and technology, there is no difference between Alternatives 1 and 2. Also, the social impacts identified in both plans are of the same level since Alternative 1 and 2 have same stakeholders related to land acquisitions. Therefore, it has been concluded that Alternative 1 is the most feasible at this stage.

8.1.5 Environmental Scoping

Environmental scoping below is presented by the Survey Team based on the baseline survey. The method of the survey includes field survey, village interview and literature review. The scoping is applicable to Alternative 1, which is identified as the most feasible option at this stage.

Table 8.1-1 Environmental Scoping

Environmental Item	Provisional Scoping		Scoping after the survey		Description
	During Construction	After Construction (Operation)	During Construction	After Construction (Operation)	
1. Pollution control					
Air Quality	B-	D	B-	D	Construction vehicles and equipment could increase gas and dust emissions during construction.
Water Quality	C-	D	C-	D	Construction work along the riverbanks and the building of the tower poles could cause temporary water deterioration.
Industrial Wastes	B-	D	C-	D	Construction sites for transmission lines and switching stations are scattered. The amount of waste will be in small portions at each site. Appropriate waste management is required.
Soil Contamination	D	D	D	D	No impact on soil contamination is expected.
Noise and Vibration	B-	D	C-	D	Construction work could produce noise and vibration. However, bored piles will be used, instead of pile driving during construction to minimize noise and vibration expected from large- scale use of pile drivers.
Ground Subsidence	B-	D	D	D	Cobbled stones are commonly recognized in the project site thus, ground subsidence is less likely occurred in the area of this soil type.
Odour	D	D	D	D	No odour may be produced during construction.
Bottom Sediment	D	D	D	D	There is no possibility of pollution from sediments.
2. Natural Environment					
Protected Areas	D	D	D	D	No protected area is recognized within the project site.
Ecosystem	D	D	D	D	No significant impact on local ecosystem is expected. No particular impacts on Fauna and Flora in the project site.
Hydrology	C-	D	B-	C-	River system and groundwater drainage system are influenced by climate change in the project site. The construction works at Main Markham River and wide

Environmental Item	Provisional Scoping		Scoping after the survey		Description
	During Construction	After Construction (Operation)	During Construction	After Construction (Operation)	
					extended flood plain areas should be a concern for possibility of extensive erosion.
Topography and Geology	B-	D	B-	C-	Natural bank erosion may occur during rainy season that may lead to flooding especially along Umi, Leron, and Erap rivers. Avoid these unstable riverbank areas for the installation of transmission lines and switching stations. Continuous monitoring is required.
3. Social Environment					
Resettlement	B-	D	C-	D	No resettlement is identified at this stage. Only land or easement acquisition is required for new transmission lines, extending to Singsing and Erap substations and tower poles. However, most of the land areas are customary lands which should be handled carefully.
Living and Livelihood	B+/C-	B+/C-	B+/C-	B+/C-	Opportunities for employment could increase during construction. Also increase of power supply could improve livelihood in the area. However, inequality of employment and power supply may cause conflict among local communities or ethnic groups.
Heritage	D	D	D	D	No national/social heritage is recognized in the area.
Landscape	D	D	D	D	No significant change in landscape is expected.
Ethnic Minorities and Indigenous People	D	D	D	D	Particular minority groups are not recognized.
Land Use and Natural Resource	B-	C-	B-	D	There are some farms to be reduced for tower pole construction.
Water Use	D	D	D	D	No significant impact is expected on water use.
Existing Social Infrastructure and institution	D	D	D	D	There is low possibility of impact on social infrastructure and institutions.
Misdistribution of Benefit and Damage	B-	C-	B-	C-	Appropriate attention to equal employment of local work force could avoid misdistribution of benefits and damage.
Gender/Children's right	D	D	D	D	No significant impact on gender or children's right is expected.
HIV/AIDS and dieses	C-	D	C-	D	HIV/AIDS or other infectious diseases could be spread by workers during construction. Awareness of the emergent needs should be considered.
Working Condition	C-	N/A	B-	N/A	Injuries due to accidents or incidence of diseases could increase during construction. Access to the construction site should be controlled particularly in surrounding pasture areas where livestock exist.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

D+/-: No impact is expected.

(Prepared by the Survey Team)

8.1.6 Result of Survey on Environmental and Social Considerations

The survey identified several components which may affect environmental and social conditions of the project site.

(1) Summary

The transmission lines run through Morobe Province, which is a culturally diverse area with

over 170 different languages. On the other hand, formation of diversity leads to inequality on opportunities. While most people in rural Morobe highly depend on rich natural resources, the level of development has not been equally distributed throughout the area. The new transmission lines are expected to improve livelihood. At the same time, there is a possibility that unequal distribution of benefits from the project will cause conflicts between the communities if, for example, no consideration is given to local employment and power supply.

During the survey, it was observed that the physical natural environment exists in the 2 km corridor of the existing transmission line (1 km extension of corridor at both sides of the existing transmission line) that covers approximately 27,000 ha in total. About 70% of the survey area is a natural vegetation region where Kunai grass (Imperata Cyindrica), the main food for cattle, is dominant due to the favourable climatic conditions. Actually, many cattle herds are observed at specific project sites and thus, strict access restriction to such sites and provision of fences during construction are necessary to prevent accidental contact with cattle and communities around the project site.

Since agriculture is the major income source, varieties of crops are selected by villages in the project site. Acquisition of land or easements of some agricultural farms and gardens for self-consumptions, commercial farms are anticipated. Thus, demand for compensation for losses in agricultural production will be raised by land owners during/after the construction.

Some swamps and flood plains exist near riversides or creeks. Hence, it is suggested that positioning of tower poles should be considered carefully in order to avoid potential landslides and soil erosion. Besides, effective technology against landslides and erosion will also be required to prevent the project facilities from collapse due to natural hazards.

Potential pollution caused by construction even after such stage should be regularly managed and monitored by PPL and the contractor. Construction site management plan should be required from the selected contractor in order to organize a safe and hygienic working environment.

(2) Project category based on JICA guidelines

According to JICA Guidelines for Environmental and Social Considerations (Published in April 2010), the project, power transmission and distribution lines, is not with a wide range of impacts or irreversible impacts. Also the impacts by the project will not affect the area broader than the site as well as not includes project in sensitive sectors that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas. Therefore it is fair to judge that candidate project should be

categorized as Category B. The rationale behind the decision is that the level of environmental and social impacts of the project are relatively low, and the spread of impacts will be controlled and mitigated as long as adequate monitoring and mitigation measures are implemented. However, unexpected potential impacts caused by natural hazards or socioeconomic situation need to be monitored carefully.

(3) Conclusion

There are no irreversible environmental and social impacts identified during the survey; however, it is essential to implement environmental monitoring including measurement of the effectiveness of mitigation measures, as well as the socioeconomic situation at the project site. At this stage of the survey, it has been concluded that the impacts arising during construction and operation will be minimized and mitigated to insignificant levels.

8.1.7 Environmental and Social Impact Assessment

Although it is realized that the project will not have significant environmental and social impacts at this stage, certain potential impacts are identified through the survey. Appropriate mitigation plan and monitoring system should be managed by the PPL, contractors and concerned organizations such as DEC. Based on the environmental scoping environmental and social impact is assessed as below.

1) Air quality

No significant air quality impacts have been identified so far. However, some extent of air pollution is expected due to use of diesel equipment and fugitive dust during construction phase. Heavy traffic around the project site is also expected to increase gas emissions, which will affect local communities and livestock.

2) Water quality

The project will not have significant negative impacts on water quality. Turbid water is expected to temporarily affect water quality during construction.

3) Industrial waste

During construction, industrial waste is expected to be generated. Suitable waste management plan and monitoring system are required to minimize its environmental impact.

4) Noise and Vibration

Drilling and excavating works will potentially produce noise and vibration during construction. However, the project plans recommend application of the method of drilling boreholes that will produce less noise and vibration compared to other large equipment for drilling.

5) Ground Subsidence

There is less potential risk of ground subsidence. Many cobbled stones were identified along the transmission line route, as observed during the survey. The nature of the stone prevents potential ground subsidence of the area.

6) Hydrology

The project area can be divided in to three areas, namely, the upper slope (close to highland area including Singsing), the mid-slope (between the Leron plains down to the Erap plains), and the lowlands (from Erap down to the Markham downstream). The mid-slope features narrow and sudden widening of river channels which transform to various sizes and lengths. This geographical terrain leads to erosion and depositional activities. Umi, Leron, and Erap rivers and other tributaries and streams are either connected to the main Markham River or otherwise flow to swampy areas or seep into the ground surface. The transmission lines in the area are potentially exposed to risk of erosion and depositional activities, although the level of this risk is not high at the moment.

7) Topography and geology

The soil types at the mid-slope and the lowland areas have similar compositions, which retain much moisture and can be typically influenced by climate change. The project area is anticipated to be exposed to seasonal heavy rainfall and flooding. Under these circumstances, the building, extension of tower poles and switching stations are potentially threatened by river course or landslide. The areas near Leron and Erap rivers, as well as the surroundings of Erap switching station, are subject to such risks.

8) Resettlement

During the survey, no resettlement at this stage is required along the route of the new transmission lines. In case of new resettlements identified, PPL confirmed to provide compensation accordingly.

9) Living and livelihood / Misdistribution of benefit and damage

The construction will contribute to the increase in local employment. In the same way, new transmission lines and the future electrification of Morobe Province will possibly produce positive impacts. Yet, inequitable employment opportunities among specific communities or ethnic groups may create conflict in the area.

10) Land use

Easement acquisition along the new transmission line route includes farm lands cultivating cash crops or subsistence foods. Thus, the necessary compensation should be provided.

11) HIV/AIDS and dieses

The risk of HIV/AIDS and other infectious diseases on workers is anticipated during

construction. Awareness programs should be given to workers as well as local communities during such phase.

12) Working conditions

Working conditions may result to accidents during the construction and livestock intrusion into the project site, especially in pasture areas. This can be mitigated by requiring the use of fences during the construction.

8.1.8 Mitigation Measures

This section reviews the potential impacts caused by project implementation. To mitigate and minimize those impacts, necessary measures are identified at this stage. Throughout the project design, significant impacts are not predicted; however, due to seasonal climate change or natural hazards such as heavy rainfall and flooding, river system and vegetation in lowland could be affected. Also, natural resource is a vital part of local communities in the area. Hence, appropriate mitigation measures and environmental management processes are required to preserve the existing environment of the project site.

Table 8.1-2 Mitigation Measure

No.	Impact	Proposed Mitigation Measures	Implementing Organization	Responsible Organization	Cost (PGK) Lump sum
Pre-Construction stage					
1	Resettlement	-Design to reconstruct double circuits towers 2-3km up Northwest from Taraka SS area to avoid resettlement.	PPL	PPL	To be compensated according to local lows and JICA guidelines if any
Construction stage					
1	Soil erosion	-Avoid the unstable landform implementing transmission lines. -Provide technology for building tower poles to prevent soil erosion.	PPL	PPL	N/A
2	Noise/Vibration	-Avoid operation during night time. -Applied borehole technique to reduce noise and vibration	Contractor	PPL	N/A
3	Air pollution	Provide masks for workers. Also provide fences and protection in the area not to affect air pollution surrounding community.	Contractor	PPL	5,000
4	Land use	Compensation of the loss of agriculture products	PPL	PPL	To be estimated upon construction
5	Public health and safety	Provide public awareness program of health and safety for workers	PPL and Contractor	PPL and Contractor	5,000
6	Traffic control	Provide fences and notices around construction sites	PPL and Contractor	PPL and Contractor	5,000
Operation stage					
1	Land use	Compensate if any damage caused by the operation	PPL	PPL	To be monitored damages during operation and compensated according to land acquisition and compensation policies.

(Prepared by the Survey Team)

As far as resettlement is concerned, there are no residential areas directly affected by the

project at this stage. At the initial project design stage, it is considered as part of the mitigation measures for resettlement to reconstruct double circuit towers instead of single circuit towers to reduce land occupancies. In fact, the area is located at 2-3 km up to northwest from Taraka substation and covered by villages and commercial facilities and thus, it is more advantageous to avoid such route.

8.1.9 Monitoring Plan

In accordance with the project implementation, necessary monitoring should be undertaken with defined frequency and timing during construction and operation stages. Project monitoring activities that focus on significant environmental and social concerns are summarized in Table 8.1-3.

Table 8.1-3 Environmental and Social Monitoring Plan

Item	Parameters/ Indicator	Measurement Point	Monitoring Frequency	Responsibility for monitoring
Construction Stage				
Air pollution	SO_2,	Construction site and the surrounding area	Quarterly	Contractor
	NO_2,			Contractor
	CO_2			Contractor
Noise/Vibration	Level of noise and vibration	Construction site and the surrounding area	Quarterly	Contractor
Soil erosion	Level of erosion	River side and slope area near tower poles	Quarterly	PPL and Contractor
Water use	-Level of discharge water -Quality of groundwater	Construction site and the surrounding area	Quarterly	PPL and Contractor
Industrial waste	Amount of the waste	Construction site	Quarterly	Contractor
Traffic control	-Vehicle speed -Level traffic control	Construction site	Quarterly	Contractor
Public health and safety	-Level of awareness on health and sanitation -Type of safety gears -Access control	Construction site	Quarterly	PPL and Contractor
HIV and illness of workers	Number of illness workers	Construction site	Quarterly	PPL and Contractor
Storage and handling of construction materials	Status of the materials in the storage	Construction site	Quarterly	Contractor
Operation Stage				
Air pollution	SO_2,	Project site and the surrounding	Quarterly for 6 month after construction (Once a year after 1 year of the operation then once every 5 years after 10 years of operation)	PPL
	NO_2,			PPL
	CO_2			PPL

Item	Parameters/ Indicator	Measurement Point	Monitoring Frequency	Responsibility for monitoring
Noise/Vibration	Level of noise and vibration	Project site and the surrounding area	Same as above	PPL
Soil erosion	Level of soil erosion	River side and slope area near tower poles	Same as above	PPL
Water quality	Quality of water	Project site and the surrounding area	Same as above	PPL

(Prepared by the Survey Team)

During the construction the contractor will make regular monitoring reports to PPL based on the criteria of DEC. PPL who is a proponent of the project will verify the reports from the contractor prior to a submission to DEC. During the operation, PPL will be responsible for the monitoring and reporting to DEC. The monitoring form is in Attachment 4-1.

Furthermore, management of the periodic monitoring program during operation is recommended. After ten years of operation, it is preferable to implement environmental monitoring once in every five years to assess the impacts of the project in long term.

8.1.10 Environmental Checklist

Environmental Checklist (Power Transmission and Distribution Lines) is attached in Attachment 4-2.

8.2 Land Acquisition and Resettlement

8.2.1 Project Component Relating to Land Acquisition and Resettlement

The Project aims to enhance the power supply reliability and stability of the Ramu Transmission System. The project components, which will create land and easement issues include: (i) rehabilitation of Erap substation, and (ii) construction of 132 kV transmission line between Singsing and Taraka through Erap.

For the extension of Erap substation, acquisition of state-owned land will be required. Land for tower sites will be cleared through Access Agreements with landowners, which was developed and utilized during the past transmission line project of PPL. Entry and access to easement for transmission line will also be permitted by landowners through the Access Agreements.

The project has been designed in order to avoid and minimize involuntary resettlement, land acquisition and loss of livelihood. Singsing substation will be constructed within the PPL's land property in order to avoid additional land acquisition. The route of the project transmission line will fundamentally run in parallel with the existing line, which will go around settlements to avoid any involuntary resettlement. Furthermore, in the area, which is

approximately 1 km from Taraka substation, the new line will be installed right on the existing Right-of-Way (RoW) and the towers for the double circuits, which will carry both the existing and new lines will be constructed. This ensures avoidance of involuntary resettlement in residential areas.

8.2.2 Land Acquisition and Compensation Policy for the Project

(1) Legal Framework of PNG

Majority of lands in PNG are customary lands, which are defined as land that is owned or possessed by an automatic citizen or community of automatic citizens by virtue of rights of a proprietary or possessory kind that belongs to that citizen or community, and arise from and are regulated by custom.

Land other than customary land is the property of the State, which occupies approximately 3 % of all the land in PNG. State-owned land can be alienated to public and private entities in the form of leasehold and freehold.

The principal PNG laws include: (i) Constitution of the Independent State of Papua New Guinea 1975; (ii) Land Act 1996; and, (iii) Land Disputes Settlement Act 2000. The GoPNG does not have any laws or policies for involuntary resettlement.

Land Act 1996 stipulates that land is acquired by agreement or by compulsory process. Although there are no official guidelines to provide the steps for land acquisition by agreement, basic steps for enabling the use of customary land for development purposes is summarized below.

1. Identify parcel of land of interest
2. Check for tenure status with the Department of Lands & Physical Planning or Provincial or Administration Office (if it is not held under a 99-year State Lease, it is held under customary tenure)
3. If customary land, identify landowning clans
4. Verify landowner's claims by cross-checking any documentation they may have with the Department of Lands & Physical Planning
5. When landowning groups are identified, initiate the process of conversion of tenure from customary land to leasehold (Note: the landowners may have begun the process of converting to Leasehold through formation of Incorporated Landowning Group (ILG), if so check for evidence of incorporation into the Investment Promotion Authority)
6. When the appropriate ILGs are formed, proceed with the application to register for conversion through the Department of Lands & Physical Planning
7. If the application is successful, the Lands Department will recognize the ILG(s) as the legitimate owners of the parcel of land of interest and duly accord proper documentation (certificates, etc) for the appropriate lease
8. After this procedure the ILGs are free to engage in service contracts (such as those issued by PNG

Power for use of land for pylons and land clearing near tower-bases) with the state or other development partners for the use of the parcel of land

(Prepared by the Survey Team)

(2) JICA Policies on Involuntary Resettlement

JICA Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred to as JICA Guidelines) require appropriate and suitable considerations for environmental and social impacts, which refer not only to the natural environment, but also to social issues such as involuntary resettlement and respect for human rights of indigenous peoples. The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan includes elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no

recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period (between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

(Source: JICA 2010 and World Bank OP 4.12)

(3) Comparison of JICA's Policy and PNG Legal Framework

The GoPNG does not have any laws or policies on involuntary resettlement. Therefore, some of the key principles of JICA Policy do not correspond with the provisions of PNG laws. A detailed policy comparison of JICA's policy and PNG legal framework is given in the following table.

Table 8.2-1 Comparison of JICA's Policy and PNG Legal Framework

No	JICA Guidelines	Laws of PNG	Policy on The Project
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	No provisions in legal documents	Priority is to be given to avoidance of involuntary resettlement, land acquisition and loss of means of livelihood.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	No provisions in legal documents	When involuntary resettlement, land acquisition and loss of livelihood are unavoidable, effective measures to minimize impact and to compensate for losses will be taken.
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	No provisions on legal documents	Where displacement of households and land acquisition are unavoidable, all PAPs will be fully compensated and assisted so that they can improve or at least restore their previous economic status.
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	In the determination of the amount of compensation payable in respect of land acquired by compulsory process, regard shall be had to the value of the land at the date of acquisition. (Section 23 of Land Act 1996) -> No gap with JICA GL	The land will be acquired by agreement, not by compulsory process. The amount of compensation will be decided by negotiation with landowners based on the full replacement cost as much as possible.
5	Compensation and other kinds of assistance must	No provisions in legal	Payment for land acquisition will be

No	JICA Guidelines	Laws of PNG	Policy on The Project
	be provided prior to displacement. (JICA GL)	documents	made prior to construction work. The amount of compensation associated with Access Agreement will be fixed during the clearance, therefore compensation will be provided after the clearance.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	No provisions in legal documents	(The Project is not expected to require large-scale involuntary resettlement.)
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	No provisions in legal documents	In preparing a resettlement action plan, consultations must be held with the affected people and their communities.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	No provisions in legal documents	Consultations are held in Pidgin (Papua New Guinea's national language) and are facilitated by district officers, in order to be given in proper form and manner.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	No provisions in legal documents	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of a compensation plan.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Land Disputes Settlement Act provides a just, efficient and effective machinery for the settlement of disputes in relation to interests in customary land (Land Disputes Settlement Act 2000) -> No gap with JICA GL	In conformity to Land Disputes Settlement Act 2000, existing land mediation mechanism will be applied for the Project.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	No provisions in legal documents	Socioeconomic survey will be conducted during the feasibility study.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	No provisions in legal documents	Not only landowners but also settlers will be provided compensation for crop damage and relocation.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	No provisions in legal documents	Landowners will be given the choice between replacement land or cash payment at the negotiation.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB	No provisions in legal documents	When landowners request replacement land, support for the

No	JICA Guidelines	Laws of PNG	Policy on The Project
	OP4.12 Para.6)		transition period will be provided.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	No provisions in legal documents	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	No provisions in legal documents	Since the project entaisl small land acquisition, abbreviated resettlement plan is to be prepared.

(Prepared by the Survey Team)

(4) Land Acquisition Policy for the Project

PPL prepared the land acquisition and compensation policy for the project in order to fill in the gaps between PNG's Land Act 1996 and JICA policies on involuntary resettlement.

Land Acquisition and Compensation Policy for the Project

I. The GoPNG will use the Project Land Acquisition Policy (the Project Policy) for the project for the Reinforcement of Ramu Transmission System in the Independent State of PNG specifically because existing national laws and regulations have not been designed to address involuntary resettlement according to international practice, including JICA's policy. The project policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to rehabilitate themselves to at least their pre-project conditions. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between the Papua New Guinea legal framework for resettlement and JICA's Policy on Involuntary Resettlement, practicable mutually agreeable approaches will be designed consistent with Government practices and JICA's Policy.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.

III. Where displacement of households is unavoidable, all PAPs (including communities) who will lose assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore their former economic and social conditions.

IV. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which, on account of project implementation, would have his, her or their:
- Standard of living adversely affected;
- Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently; or
- Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently.

V. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing, and any such factors that may discriminate against achievement of the objectives outlined above. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to

such compensation and rehabilitation measures or resettlement objectives. Not only landowners but also settlers residing, working, doing business and/or cultivating land within the project impacted areas, are entitled to compensation for their lost assets (land and/or non-land assets), at a replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living.

VII. People temporarily affected are to be considered as PAPs, and resettlement plans shall be prepared to address the issue of temporary acquisition.

VIII. The resettlement plans will be designed in accordance with JICA's Policy on Involuntary Resettlement, PNG's Land Act 1996 and past practices of PPL.

IX. Payment for land and/or non-land assets will be based on the principle of replacement cost.

X. PAPs will be given the choice between provision of replacement land and cash compensation at the beginning of negotiation with PAPs who are dependent on agricultural activities. When cash compensation is chosen, or appropriate replacement land in a same customary land is not available for the project, cash compensation will be provided.

XI. Replacement lands, if the preferred option of PAPs, should be within the immediate customary land of the affected lands wherever possible, and should be of comparable in terms of productive capacity and potential. As a second option, cash compensation should be provided.

XII. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs.

XIII. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.

XIV. PAPs will be involved in the process of developing and implementing resettlement plans.

XV. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible, be involved in the decisions that are made concerning their resettlement.

XVI. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation) within the agreed implementation period. The funds for all resettlement activities will come from the GoPNG.

XVII. Land acquisition and payment of release of tower sites will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. The amount of compensation for damaged crops and relocation cost (if any) will be determined during the clearance, and payment will be made after the clearance.

XVIII. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process. This will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and compensation.

XIX. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the land acquisition management system.

(Prepared by the Survey Team)

8.2.3 Scope of Impact

Table 8.2-2 provides the 2000 Census Results for Huon District and Markham District.

Table 8.2-2 2000 Census Results for the Project-Affected Districts

District	Local Level Government (LLG)	No. of wards	Population		
			Male	Female	Total
Huon District	Morobe Rural LLG	21	5,753	5,417	11,170
	Salamaua Rural LLG	17	5,449	4,951	10,400
	Wampar Rural LLG	27	20,393	17,560	37,953
	Sub-total	65	31,595	27,928	59,523
Markham District	Onga/Waffa Rural LLG	13	4,355	3,977	8,332
	Umi/Atzera Rural LLG	30	14,149	13,489	27,638
	Wantoat/Leron Rural LLG	20	6,826	6,573	13,399
	Sub-total	63	25,330	24,039	49,369
Total		128	56,925	51,967	108,892

(Source: 2000 Census)

There are no occupants identified on the project site. The number of landowning clans/ extended families affected by the project is estimated as 80 clans. Socio-economic conditions of the affected clans/ extended families are summarized in Table 8.2-3.

Table 8.2-3 Overview of Project-Affected Clans/Extended Families

Major Items	Total Average
Average Number of Family Members	3.7 Persons / Household
Church Membership	Seven-Day Advanced Church (36%), Lutheran (32%), Assembly of God (11%), Four Square (7%), Roman Catholic (7%), Church of Christ (4%), Apostolic Brotherhood Church (3%)
Education Level of Household Heads	Not Completed Primary School (21%), Completed Primary School (67%), Higher Education (12%)
School Enrolment Ratio of School Age Children in Project-Affected Areas	39%
Source of Lighting or Energy	Solar Panel (5%), Generator (5%), Main Electricity (5%), Hurrican Lamp (62%), Coleman Lamp (7%), Car Battery (9%), Others (7%)
Source of Drinking Water	River (50%), Ground Water from Wells (32%), Rain Water from Drums (14%), Water from Tanks (4%)
Household Assets	Mobile Phone (75%), DVD/VCD (14%), Radio/Cassette Player (43%), Fan (7%), Lights (14%), Computer (7%), TV (11%), Chain Saw (4%), Refrigerator (7%), Sawing Machine (21%)
Current Employment Status	Mechanical Tradesman (3%), PR Officer (3%), Highway Driver (4%), Subsistence Gardener (86%), Security (4%)
Average Annual Household Income	Vegetables (K133), Betelnut (K98), Copra (K11), Cocoa (K11), Meat (K96), Fish (K10), Handicraft (K54), Trade Store (K21), Others (K32),
Average Annual Household Spending	Clothes (K201.07), Education (K51.07), Household Items(K200), Electricity (K178.61), Health (K228.21), Transport (K271.79), Savings(K0)

(Prepared by the Survey Team)

8.2.4 Compensation Details

(1) Estimated Scope of Land Acquisition and Compensation Details

Expected impacts are: (i) land acquisition for the extension of Erap substation, (ii) land use for tower bases and easement for transmission lines, and (iii) loss of crops and trees.

Relocation of structures is not expected at the feasibility study stage; however, this will be confirmed by the route survey of transmission line during the pre-construction stage. PPL has agreed to fully compensate the groups affected by the relocation of structures and resettlement, in case it is required.

Table 8.2-4 provides the expected land-related impacts of the Project.

Table 8.2-4 Expected Land-related Impacts

Project Components	Type of Impact	Quantity
Extension of Erap substation	Land Acquisition	0.46 ha
	Loss of Cash Crops and Trees	0
	Relocation of Structures	0
Construction of 132 kV Transmission Line	Land to be released	3.0 ha
	Easement	Length: 138.5 km Width: 40 m
	Loss of Cash Crops and Trees	401,150
	Relocation of Strictures	0

(Prepared by the Survey Team)

The following are the details of the impacts and compensation.

1) Extension of Erap substation

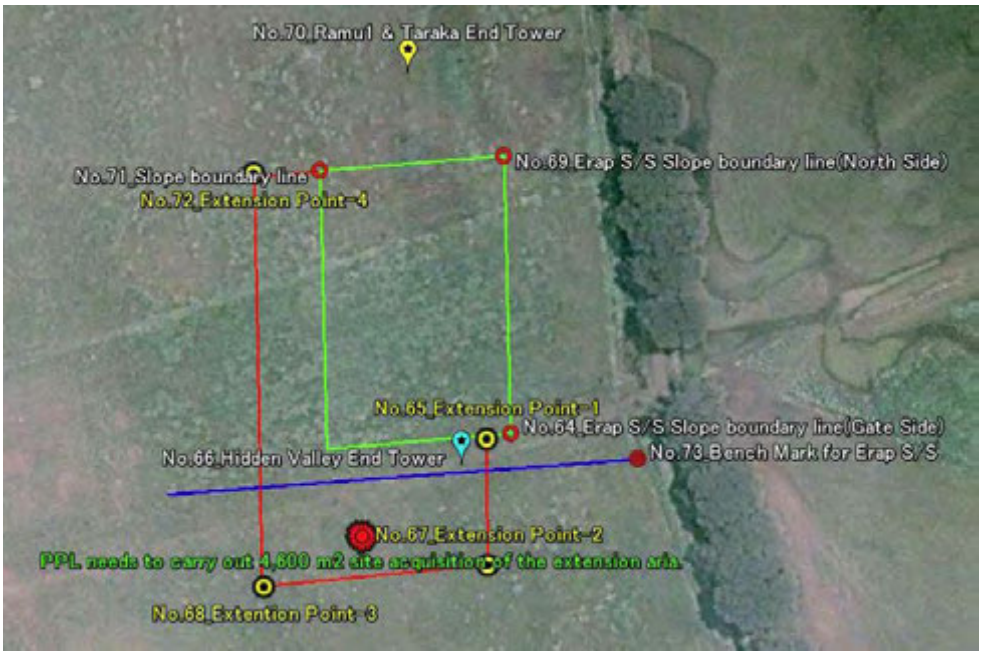
For the extension of Erap substation, approximately 0.46 ha of land will be acquired. Details of the land to be acquired are summarized in Table 8.2-5 and Figure 8.2-1.

Table 8.2-5 Land Acquisition for Erap Substation

Project Components	Estimated Land Loss (ha)	Current Land Use	Type of Land	Landowner
Extension of Erap substation	0.46	Grass land	State-owned land	HORNIBROOK

(Prepared by the Survey Team)

The land to be acquired for Erap substation is state-owned land and the price will be determined through negotiation with the current landowner. Since this area is grassland and currently unutilized, no loss of cash crops and trees or relocation of structures is foreseen. The current landowner of the land is HORNIBROOK NGI. HORNIBROOK is an industrial and resource development company in PNG and its head office is located in Lae. They operate broad range of businesses such as steel fabrication, motor transport, building, bridging, onsite works, labour hire, equipment hire and estate business.



(Prepared by the Survey Team based on Google earth)

Figure 8.2-1 Extension of Erap Substation

2) Construction of Transmission Lines

For the construction of 132 kV transmission lines, land areas for tower bases and easement for transmission lines are required. Land for tower base will be released by landowning clans/extended families by deeds instead of being purchased. Authorization for entry and access to easement will also be secured from landowning clans/extended families through agreements. This mechanism was developed and applied for the project for the construction of Hidden Valley transmission line. In this mechanism, ownership of the land will still belong to the current landowner who will facilitate the negotiation

Landowners will be provided compensation for released land for the tower base and all related damages and detriments, in particular, any damage to crops and trees. The damage to crops and trees on the lands for tower bases is not significant because the land used for each tower base is a small fraction and the residual is economically viable. Therefore the project does not cause significant loss of livelihood.

Table 8.2-6 provides the details of the land and easement.

Table 8.2-6 Land and Easement for the Transmission Line

Land Release for Tower Bases			
Required land area per tower (m^2)	Estimated Number of Towers Requiring Land Release	Estimated Land Release (ha)	Number of Affected Clans
100	308	3.0	80
Easement for Transmission Line			
Estimated Length (km)	Width (m)	Area (ha)	
138.50	40	554.0	

(Prepared by the Survey Team)

The estimated amount of damage to crops and trees is summarized in Table 8.2-7.

Table 8.2-7 Estimated Damage to Crops and Trees

Type of Crops and Trees	No. of Crops and Trees
Mango	9,000
Banana	12,000
Cocoa	800
Oil palm	9,000
Vanilla	1,000
Rubber	200
Coffee	300
Betel Nut	10,000
Breadfruit tree	4,000
Sago	600
Bamboo	1,000
Sugarcane	6,000
Pawpaw	5,000
Laulau	1,000
Cassava	2,000
Taro	30,000
Aibika	80,000
Yam	25,000
Tomato	150,000
Pumpkin	30,000
Watermelon	9,000
Ceremonial Grounds	20
Sacred Sites	10
Grave Sites	20
Hardwood	500
Semi-Hardwood	1,000
Lesser Known useful species	3,000
Pine trees	500
Canoe Tree	200
All other Tress	10,000
Total	401,150

(Source: PPL)

The price of land to be released will be finalized by the Valuer General's Office and agreed with landowners through stakeholder meetings. PPL has sent a letter to the Valuer General's Office requesting for price increase from the project for the construction of the Hidden Valley and Erap substation.

For the compensation on damaged crops and trees, the Compensation Schedule for Trees and Plants, All Regions, published by the Valuer General's Office, Department of Lands, will be applied to the Project. The latest version was published in January 2008 and is reviewed regularly by a designated committee. The committee composed of representatives from relevant government departments, statutory authorities and government corporations including PPL. CPI and other economic indicators are used as a reference for review.

(2) Entitlement Matrix

Table 8.2-8 provides the eligibility and entitlement.

Table 8.2-8 Entitlement Matrix

No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)
1	Permanent Acquisition of Land	Legal owner,	Landowners will be provided replacement land or cash compensation. The price will be set through the negotiation.
		Informal settlers with no legalizable rights	Informal settlers will be provided compensation only for their damaged crops, trees, and structures on acquired land.
2	Temporary Use of Land	Legal owners of land, including customary land owning clans/ extended families	Landowners will be provided payment as negotiated under the agreement.
3	Loss of crops and trees	All affected persons irrespective of legal status	Agreement will be signed before the clearance. The amount of loss will be determined at the clearance. Affected persons are encouraged to be physically present during the clearance so they could observe and record all the damages done to their crops and trees. Compensation will be made according to the Compensation Schedule for Trees and Plants, All Regions, published by the Valuer General's Office.
4	Loss of livelihood	Vulnerable households identified through the implementation	Vulnerable affected people will receive priority employment for project construction and maintenance work.
5	Unforeseen impact	Concerned affected persons	Determined as per the Land Acquisition and Compensation Policy on the Project.

(Prepared by the Survey Team)

8.2.5 Grievance Mechanism

The appropriate and accessible grievance mechanisms must be established for the project, and the PPL, in collaboration with District Land Officers, will be in charge of handling complaints from affected people and their communities.

In PNG, the Land Disputes Settlement Act 2000 establishes procedures for resolution of landownership disputes on customary land. It has a mediation process whereby a designated mediator meets with the disputing parties to resolve grievances. The existing mediation-based dispute settlement mechanisms will be applied to the project. Disputes other than land disputes are expected to be resolved at the PMU level.

8.2.6 Implementation Framework

1) PPL

PPL will be the Implementing Agency for the project and is responsible for planning, implementation and monitoring of activities related to land acquisition and compensation for losses related to the project.

2) Provincial Administrations

Provincial Administrations, including Provincial Land Officers and District Land Officers, will assist the PPL in terms of planning, implementation and monitoring of activities

related to land acquisition and compensation.

8.2.7 Implementation Schedule

Table 8.2-9 provides the implementation schedule for land acquisition and Access Agreements.

Table 8.2-9 Implementation Schedule

No.	Activities	Schedule
A. Land Acquisition		
1	Confirm land requirements	February, 2012
2	Negotiate with Landowner (HORNIBROOK)	February, 2012
3	Finalize the price	February, 2012
4	Report the result of negotiation to JICA	April, 2012
5	Get authorization from Department of Land for land survey	May, 2012
6	Boundary Survey	May, 2012
7	Prepare "Survey Plan"	June, 2012
8	Submit SP to Survey General Office	July, 2012
9	DLPP approval of "Survey Plan"	August, 2012
10	Report the progress of DLPP approval to JICA	September, 2012
11	Make a payment to landowners	September, 2012
12	Prepare Land Acquisition Completion Report and submit it to JICA	October, 2012
13	Clearance of acquired land and start of civil work	November, 2012
B. Access Agreement		
1	Confirmation of the size and location of land required for tower bases	October, 2012
2	Follow-up meeting with affected people	October, 2012
3	Negotiation with each land owning group leader	October, 2012
4	Signing of "Access Agreement"	March, 2013
5	Report the result of negotiation to JICA	September, 2013
6	Cleaning of land for tower base and easement	March, 2014
7	Counting the number of damaged crops and relocated houses	March, 2014
8	Payment for the land for tower base	September, 2014
9	Payment for damaged crops and house relocation	March, 2014
10	Prepare Completion Report for Land Issues and submit it to JICA	November, 2015

(Prepared by the Survey Team)

8.2.8 Budget and Financing Plan

(1) Land Acquisition and Compensation Costs

The estimated costs for the compensation for land and assets are shown in Table 8.2-10.

Table 8.2-10 Land Acquisition and Compensation Costs

No.	Items	Cost (Kina)
A. Land Acquisition		
1	Land Acquisition (0.46 ha of grass land)	20,000
B. Access Agreement		
2	Release of Tower Bases	616,000
3	Compensation for Damaged Crops	1,500,000
Total		2,136,000

(Prepared by the Survey Team)

(2) Source of Funding

All costs related to land acquisition, land use, easement and compensation, including operation and monitoring costs, will be financed by PNG government funds through PPL.

8.2.9 Monitoring Plan

PPL, in collaboration with provincial administrators, shall monitor all activities related to land acquisition and Access Agreements, such as negotiations and payments.

The monitoring form is attached in Attachment 4-1.

8.3 Stakeholders Meetings

(1) Consultation with District Administration

PPL has consulted the Huon Gulf District Administration on 11 November 2011. The meeting was held in the Huon Gulf District Office. Four officers, including the District Administrator, attended the meeting. The District Administrator recognized that social issues were complex, and recommended that the Survey Team allows the district administration officers and PPL officers to facilitate meetings in *"Tok Pisin"* during stakeholder meetings with landowners and clan leaders.

Acting Markham District Administrator was consulted on 12 November 2011. The meeting was held in the Markham District Office in Mutzing. The Acting District Administrator commented that the proposed transmission lines running parallel to the existing ones would inevitably have an impact, which could be mitigated to ensure minimal effects.

(2) Consultation with Landowners and Clan Leaders

PPL has consulted landowners and clan leaders who will be affected by the project. Table 8.3-1 summarizes concerns raised during stakeholder meetings.

The minutes of stakeholder meetings are attached in Attachment-4-3.

Table 8.3-1 Summary of Stakeholder Meetings

Date	Location	No. of Participants	Major Concerns
12 Nov 2011	Zifasing, Wampar local level government, Huon Gulf District	13	The project description was explained to participants. Major concerns were: 1) Increased prices of land areas for the tower base and land clearing contracts, and 2) Provision of the minimum supply kit (MSK), which is under the Rural Electrification Project.
12 Nov 2011	Mutzing local level government	9	The project description was explained to participants. Major concerns raised were: 1) Improved contracts or compensation methods, and 2) Proposal to construct a substation in Mutzing.
14 Jan 2012	Zifasing, Wampar local level government, Huon Gulf District	13	Responses to comments at the previous meeting, and the compensation plan was provided 1) Land clearing contract rates will be increased, 2) Affected people will be informed of the rate for the release of land for the tower base, as set by the Valuer General's Office, and 3) All landowners can get a copy of the Compensation Schedule for Trees and Plants through the district and ward officers.
14 Jan 2012	Zifasing, Wampar local level government, Huon Gulf District	16	This meeting was held for a certain single extended family in Zifasing. The project description was explained. The major concern was that no payment has been made for the existing transmission line.
15 Jan 2012	Mutzing local level government	76	Responses to comments raised during the previous meeting and the compensation plan were provided as follows: 1) Land clearing contract rates will be increased, 2) Compensation for distribution lines, schools and clinics, and considerations for radiation were requested, and 3) Affected people will be informed on the rate for the release of land for the tower base when set by the Valuer General's Office

(Prepared by the Survey Team)

CHAPTER 9

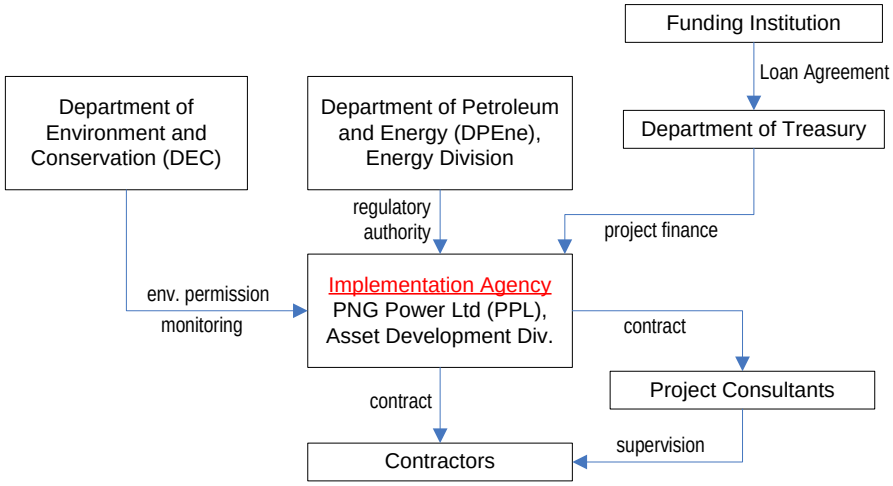
PROJECT IMPLEMENTATION PLAN

CHAPTER 9 PROJECT IMPLEMENTATION PLAN

9.1 Implementation Policy

9.1.1 Implementation Organization

A draft organization for implementation of the Project is as below:



(Prepared by the Survey Team)

Figure 9.1-1 Organization for the Project Implementation

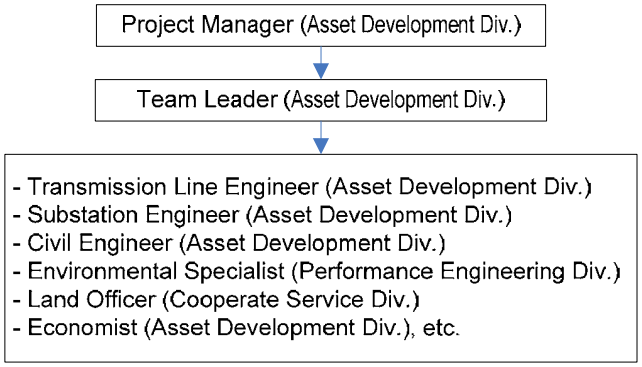
Following are the envisioned undertakings allotted to the implementation agency (PPL), consultants and contractors for the Project.

(1) Implementation Agency

The implementation agency for the Project will be the PPL under the supervision of the Energy Division of the DPEne, because the PPL is sole power utility in PNG and has sound financial status as described in Sub-clause 2.3.3. The PPL also has enough technical capabilities to implement the Project though abundant experience as implementation agency for several similar transmission line and substation projects. In particular, the project office organized under the Corporate Project Team of the Asset Development Division of the PPL will be responsible for the Project implementation.

The PPL will be responsible for the following in the implementation of the Project:

1) Organization of a Project Management Unit (PMU) for the Project will be as shown in Figure 9.1-2. The PMU mainly consists of staff of the Asset Development Division, the other specialists such as environmental specialists, land officer, etc. are to be assigned from the other divisions when needed.



(Prepared by the Survey Team)

Figure 9.1-2 Project Management Unit

2) Coordination among the related departments and provincial authorities for smooth implementation of the Project
3) Acquisition of right to enter into the Project areas and acquisition of land/compensation of houses in the right-of-way of the transmission line
4) Prior securing of the environmental certificate for the Project from the DEC
5) Employment of the project consultants, and cooperation with and assistance to them
6) Close communication with institution(s) of the project fund on tendering, contracts, procurement, project progress and the other information
7) Tender announcement, tender closing, evaluation and contract
8) Assistance to the contractor for custom clearance of import/re-export equipment and materials, special tools, etc. for the Project
9) Issuance of payment certificates
10) Assignment of operators and maintenance staffs for new facilities
11) Commissioning of facilities, operation and maintenance

The PPL has to secure budget and staffs to execute the above duties.

(2) Project Consultants

The consultants will be responsible for the following:

1) Detailed design for the Project, including field survey for transmission line route
2) Preparation of detailed design report for PPL approval
3) Preparation of tender documents for PPL approval
4) Clarification and evaluation of tenders
5) Assistance to the PPL in the contract negotiation with the prospective tenderers and in conclusion of the contracts
6) Checking and approval of shop drawings to be submitted by the contractors
7) Witnessing of factory tests
8) Project management and supervision
9) Preparation of project completion report

10) Issuance of taking over certificate, defect rectification certificate and final completion certificate
11) Transferring of technical knowledge to the PPL engineers

(3) Contractors

The contract is to be made on a turnkey basis. The contractors shall therefore be responsible for the following:

1) Engineering and procurement of the transmission line and substation equipment and materials including route survey, soil investigation, and design of towers, foundations and stringing
2) Shop test, packing, shipping, customs clearance and delivery to sites
3) Preparation of several calculation reports such as CT VT analysis, relay setting, etc.
4) Civil and building works, and installation, erection, assembling and stringing works
5) Pre-commissioning and commissioning tests, and energizing of transmission lines and substations
6) Training for the PPL engineers at the manufacturer's factory
7) On-the-job training for the PPL engineers at the project sites during construction
8) Maintenance of facilities during defect liability period

9.1.2 Procurement of Goods and Services

(1) Mode of Procurement

The Project shall be divided into two components, (i.e., Lot-A for transmission lines and Lot-B for substations) under an International Competitive Bidding (ICB) mode according to the estimated cost and specialty required in the Project. Tender documents shall be released to tenderers that will pass the pre-qualification criteria.

(2) Origin for Procurement

Origin of the equipment and materials for the Project will not be specified due to the principle of the ICB; however, the successful tenderer shall have experience in similar projects, be financially stable, employ capable engineers to manage the Project, and the tender shall propose first class equipment and materials. Tender documents shall therefore clearly mention the tenderer's qualification and experience, equipment quality, function and technical guarantees, etc., and their evaluation criteria to prevent lowering the quality of the Project.

So far, there is no local manufacturer available that produces the required electrical equipment and materials for the Project. Thus, all electrical equipment shall be imported. PNG enterprises may only participate in the Project as sub-contractors by supplying laborers

and civil/building works.

(3) Guarantee Period

It will be specified in the contract documents that the plant shall be guaranteed for a certain period after take over. It is proposed that a 24-month guarantee period be specified in the tender documents. If equipment has defects, poor quality, improperly installed, etc., an accident may arise in a few months after energizing. The 24-month guarantee required for the plant is preferable on the project cost and relative risk.

Besides, it is preferably mentioned in the tender documents that the contractor has the duty to train PPL's operators and maintenance staff during construction and defects liability period.

9.2 Work Allocation

The Project is to be executed on turnkey basis; however, some works shall be carried out with the PPL's assistance or by the PPL.

Work allocation between the contractors and the PPL is as follows:

(1) Procurement of Equipment and Materials

1) Contractors
- Electrical engineering
- Shop tests and test reports
- Packing, shipping, customs clearance, transportation of equipment and materials
- Storage of equipment and materials at the sites
- Invoicing of progress payments

2) PPL
- Review and approval of shop drawings with assistance of the consultant
- Witnessing of shop tests and notice to shipping release
- Import license, customs duty
- Allocation of land for storage
- Issuance of payment certificates

(2) Construction and Installation

1) Contractors
- Profile survey, soil investigation and civil engineering
- Tower foundation, erection and stringing works
- Substation works
- Commissioning tests

- Invoicing of progress and final payments

2) PPL
   - Land acquisition
   - Compensation for land and crop
   - Arrangement during power outages
   - Witness commissioning tests, and permission to energize
   - Issuance of progress and final payment certificates

9.3 Supervision Plan

The Project after the tender would be supervised by PPL staffs and the consultant. Each assignment and task is mentioned below:

(1) PPL Staffs

1) Project Manager
   To be assigned throughout the whole project period, attend monthly progress meeting, communicate with funding authorities, issue statement of performance, etc.

2) Electrical Engineer
   To work as consultant's counterpart and manage line inspectors, one for substation and one for transmission line.

3) Environmental Specialist
   To monitor the environmental and social conditions, and discuss countermeasures with the related province and/or district office, if necessary.

4) Inspectors
   To check quality of works done by the contractor, certify bill of quantities; at least two civil inspectors and two electrical inspectors for transmission line works, and two civil inspectors and two electrical inspectors for substation works are needed.

5) Accountant/Administrator
   To check payment balance, arrange VISA for foreign supervisors, customs duty, commercial matter, etc.

(2) Consultant

A project consultant is to be assigned as an engineer or advisor depending on the PPL's policy. Major task of the consultant would be as follows:

1) Detailed design and preparation of tender documents
   The consultant will carry out detailed design, cost estimation and detailed implementation plan for the Project through discussions with PPL and in accordance

with the results of the field survey and investigation. The design report will include design calculation, criteria and cost. Upon the approval of the report by PPL and the funding institutions, the consultant will prepare the tender documents for the Project.

2) Public tender and contract

The consultant will assist PPL in the public announcement of the tender, tender opening, tender evaluation, contract negotiation and preparation of the contract documents.

3) Review of the contractor's documents

The consultant will review all documents submitted by the contractor, (i.e., shop drawings, programs, design calculations, test procedures, O&M manuals, relay settings, etc).

4) Supervision of contractors' site works and coordination

Throughout the whole period of the contractor's site works, the consultant will supervise all site works, maintain quality of the project, and coordinate the progress and engineering of the contractor's scope of work.

5) Commissioning tests

Upon the request of the contractor, the consultant will carry out the final check of the plant with PPL engineers. They will jointly confirm that all pre-commissioning test certificates are presented, O&M manuals are presented, trainings for PPL operators are finished, and then energizing of the plant will be arranged.

Taking over certificate will be issued upon successful energizing of the plant.

(3) Others

1) Safety of Construction Works

Substation works under the Project include extension of the existing substations. Since some works will be carried out under live condition or tentatively de-energized condition of the existing switchgear, the contractor shall carefully execute the work avoiding workers' accidents and damages to the running equipment.

Transmission line work includes crossing over the national highway and the existing distribution line. These works shall be carefully carried out with special stringing tools to prevent traffic problems or fatal accidents by wire slipping, etc.

2) Transportation of Heavy Equipment

Most heavy equipment to be procured under the Project is 132 kV three-phase main power transformer to be transported via Lae Port to the sites. Transportation weight of the transformer is assumed at approximately 30 tons. According to the PPL, exact weight limits of the bridges on the way to the sites are unknown, but this is not a

problem because experience in past projects showed that heavy equipment of more than 30 tons have been transported along this route.

3) Prevention of Disturbance to Environment during Construction

Most of the selected transmission line routes will pass through meadowland. The transport of materials and workers during the construction period through these meadowlands may subject these areas to trampling disturbance. The contractors shall prepare a construction plan, so that the works could be carried out to avoid trampling as much as possible.

9.4 Quality Control Plan

(1) Quality Control of Equipment and Materials to be supplied

The consultant will check quality control manuals to be submitted by the contractor, if manufacturing is judged not follow those procedures; he will instruct or reject to take over the materials.

The consultant and the PPL engineers will witness shop tests for major equipment to be procured under the Project.

(2) Quality Control during Construction

1) Contractor's documents

The contractor shall submit the construction schedule, shop drawings, design calculations, test procedures, test reports, O&M manuals, quality control plans and safety plans for approval of the PPL and/or consultant.

2) Sample tests of materials

The contractor shall present sample of concrete and re-bars to be used for foundations and buildings and carry out compression tests on concrete samples from mixing batches at authorized laboratories.

3) Control of site works

During the construction period of transmission line works (foundations, tower erection and stringing operation) and substation works (land expansion, foundations, expansion works of substation building and installation of equipment), the consultant and PPL inspectors will check damages on equipment and materials, and order the repair or replacement of the damaged equipment and materials. Prior to the issuance of payment certificates to the contractors, the consultant and/or PPL inspectors will inspect not only the progress but also the quality of all facilities claimed by the contractors in their application for payment.

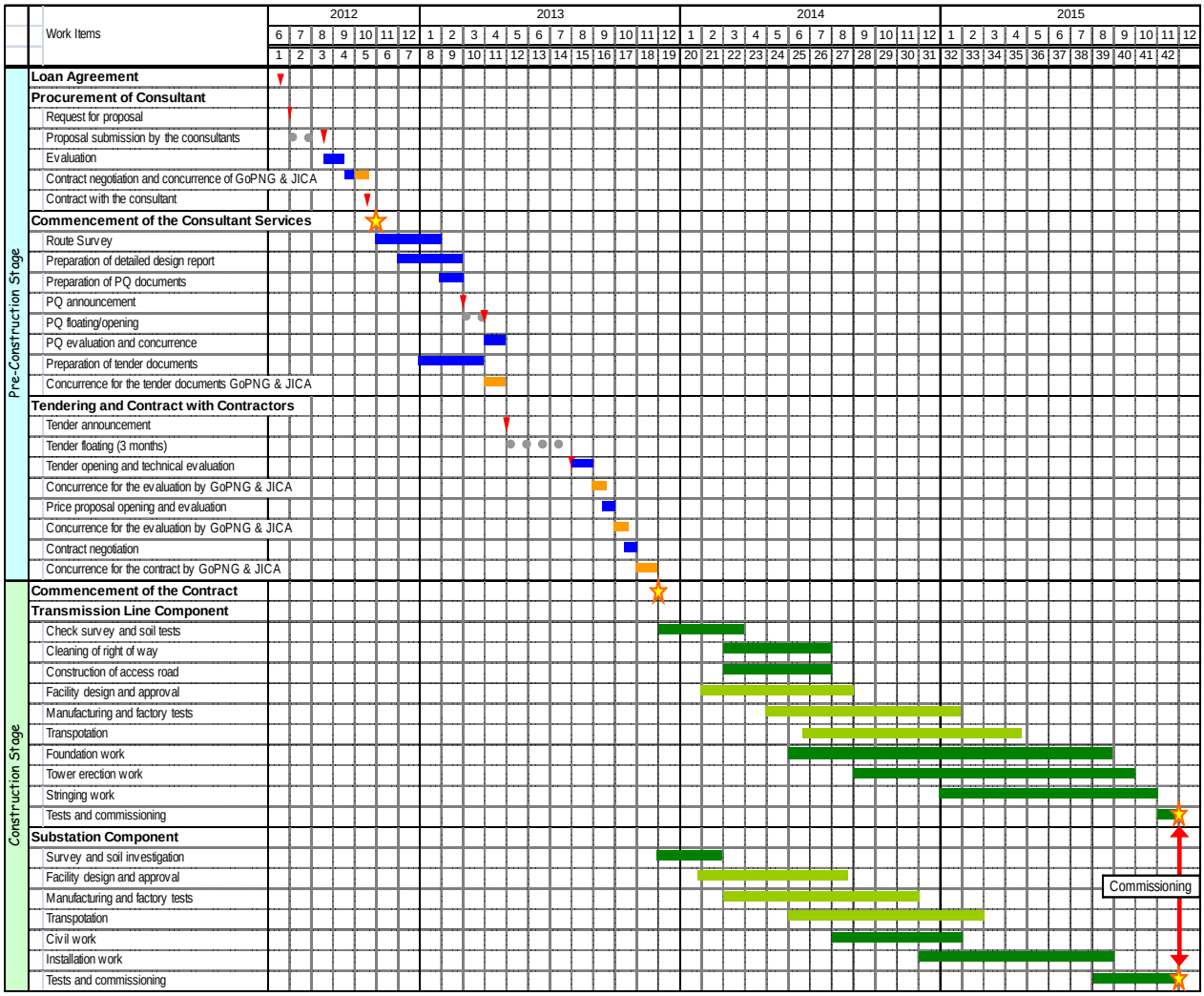
4) Commissioning tests

The consultant and PPL representative will check the test report, and function and performance of substation equipment before the energizing.

9.5 Implementation Schedule

Figure 9.5-1 shows the overall implementation schedule of the Project.

The preconstruction stage including route survey, preparation of design report, pre-qualification (PQ) and tender documents, tender calling, tender evaluation, contract negotiation and award of contract for both contract components, (i.e., Lot-A for transmission lines and Lot-B for substations), is assumed to be 18 months starting from the conclusion of loan agreement. The construction period of the project is assumed to be 24 months.



(Prepared by the Survey Team)

Figure 9.5-1 Implementation Schedule

Lot-A contractor shall first carry out profile survey to finalize the tower type, following the tower and foundation design. The construction of tower foundation shall be started in six

months, at a rate of 20 towers per month. The contractor shall organize at least three gangs to keep the implementation schedule.

Lot-B contractor shall execute construction works in parallel with four substations. Especially, Singsing and Erap substations need land filling and formation. These works should be carried out quickly and left for a period so that soil compaction and stability could be maintained. Pre-commissioning tests, including individual equipment test, function test, secondary and primary injection, and stability check, need about four months; therefore, installation of major equipment shall be completed in 21 months from the award of contract.

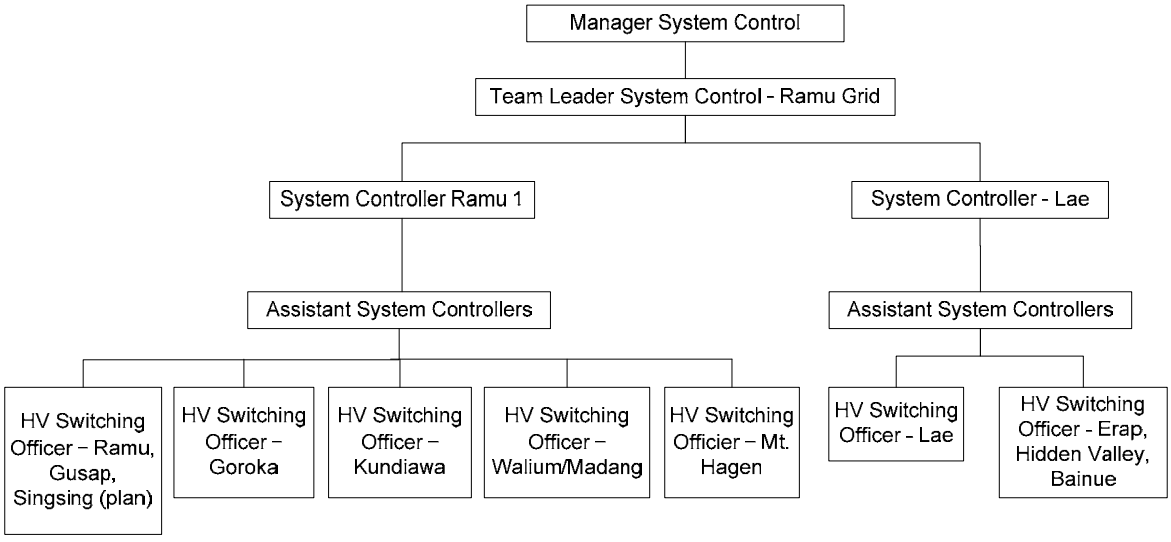
The consultant shall preferably monitor both contracts so that construction of transmission lines and substations could be completed on time, and energizing the substation can be done smoothly without idling. After energizing the transmission lines and substations, stability of protection relay and phase rotation shall be confirmed. Station service system, fed from temporary power supply, shall be changed to permanent power from auxiliary transformer.

Taking over certificate will be issued to the contractor upon confirming the transformer's stability after 24 hours of energizing.

Final certificate will be issued after defects liability period of 24 months, inspection and final test by the consultant. The Project will be terminated upon issuance of the final certificate.

9.6 Operation and Maintenance Plan

Figure 9.6-1 shows the current/future system operation organization of the Ramu grid.

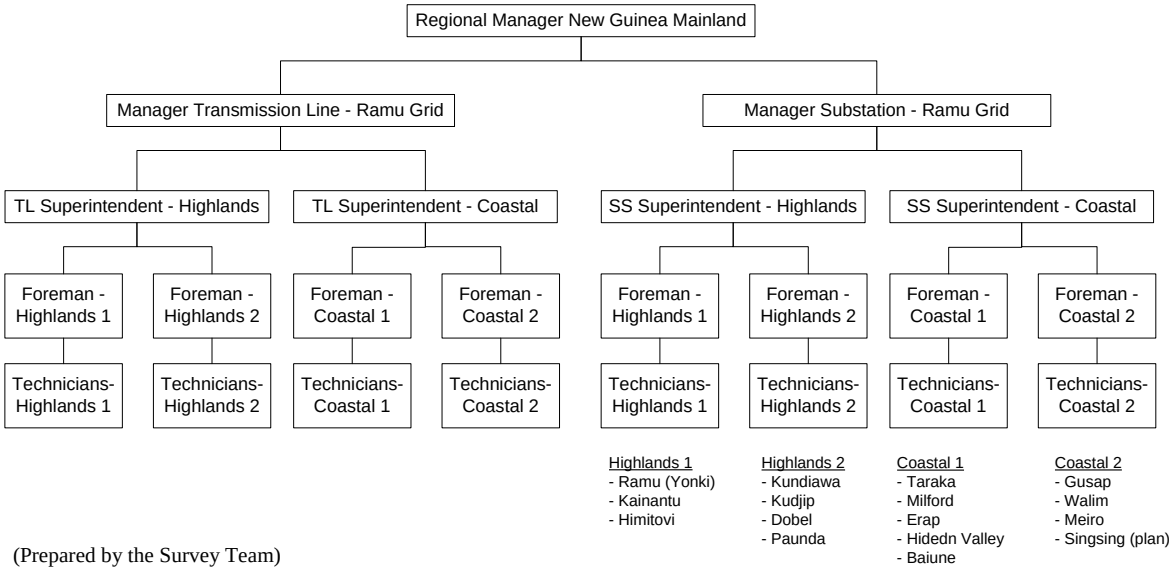


(Prepared by the Survey Team)

Figure 9.6-1 System Operation Organization

As shown in the figure, the System Controller – Ramu 1 is responsible for Ramu 1 operation, and the System Controller – Lae is responsible for Taraka and Erap operation. As for the operation of new Singsing substation, the System Controller – Ramu 1 is to be responsible.

Figure 9.6-2 shows the system maintenance organization relating to the Ramu grid.



(Prepared by the Survey Team)

Figure 9.6-2 System Maintenance Organization

The Transmission Line Superintendent – Coastal is to be responsible for maintenance of new transmission line between Taraka and Singsing, same as the existing line.

As for the substation maintenance, the Substation Superintendent – Highland is responsible for maintenance of Ramu 1, and the Substation Superintendent – Coastal is responsible for maintenance of Taraka and Erap. As for the maintenance of new Singsing substation, the Substation Superintendent – Coastal is to be responsible.

There is no major issue found on the current PPL's O&M system for transmission lines and substations. O&M for new 132 kV lines and substations to be constructed under the Project would follow the existing PPL's procedures.

The following are recommendations to attain a stable and sustainable O&M:

1) Training for PPL's staff

Since the 132 kV GIS will be firstly introduced to the PPL under the Project, advanced technology shall be given to the nominated O&M staff through offshore and onshore training even if GIS requires very little maintenance.

In addition, PPL staff including the trained engineers will participate in the construction works of transmission lines and substations. Through the on-the-job-training (OJT), they will further understand functions, characteristics, and components of various

equipment, inspection/test methods and others. The contract for the Project should include the contractor's duty of executing OJT for PPL's operators during equipment installation, tests of various facilities and initial operation of the substation under the supervision of the contractor.

Having these PPL employees, who are anticipated to become operators and maintenance crew after commissioning of the Project, participate in project construction is an effective training program. Another effective program for training in substation O&M is to have supplier's experts jointly operate and maintain the substation for a certain period during the initial stages of operation.

2) O&M of Transmission Lines

The existing transmission lines are maintained through patrol, inspection and repair by the PPL's maintenance staff. The maintenance program of transmission lines is planned so that the same section and facility would be inspected at a minimum rate of twice a year. In thick tree and grass areas, inspections are particularly carried out before and after the rainy season to prevent ground faults of the lines caused by the trees or grasses in contact with the energized parts of the lines.

3) O&M of Substations

Generally, O&M manuals for a completed substation are for preparation and submittal by the related contractors to PPL, with the consultant's approval before the commissioning of the substation. Manuals submitted by the contractor should cover in detail, technical specifications, characteristics, composition of components, dismantling and inspection procedures, frequencies of parts replacement, etc. of all equipment installed in the substation.

The most important factor in ensuring correctness of O&M is to strictly adhere to all articles stipulated in the manuals. This depends on the awareness of the employees in charge, as well as on the daily employee education conducted by responsible PPL staff. From this perspective, PPL's management and related consultants should pay special attention on the ways to raise employee morale by giving emphasis on the importance of O&M works. Furthermore, management efforts should be concentrated on developing employee habits of making quick and accurate reports.

4) Procurement of test equipment, special tool and spare parts

Test equipment and special tools for O&M use are classified as common equipment, even if from different manufacturers. These should be procured for groups in substations for their common use. However, for spare parts of substation equipment, if manufacturers are different, different parts have to be procured.

CHAPTER 10

PROJECT EVALUATION

CHAPTER 10 PROJECT EVALUATION

10.1 Methodology of Economic Evaluation

(1) General

In general, a project will be evaluated not only with engineering aspect, but also with economic and financial aspects taken into consideration. The engineering aspects are based on the technical feasibility of the project from the viewpoints of construction, and operation and maintenance (O&M). On the other hand, economic analysis focuses on the economic costs and benefits under study, in terms of the national economy. In other words, economic analysis includes evaluation of the degree of economic impacts of the project under study on the national economy.

In case of the project under study, project inputs such as construction costs and O&M costs of new transmission lines are evaluated in terms of the national economy. These project inputs are called “economic costs”.

Decreased long-term investment costs due to reinforcement of transmission lines such as reduced capacity of thermal power or energy costs are also evaluated in terms of its effect on the national economy. This reduction in investment costs are classified as “economic benefits”. In this case, the benefits should be at least as great as those obtainable from other marginal investment opportunities.

Economic costs and benefits are estimated throughout the project life. The first year of the project life is the time when the first construction disbursement is made, while the last year is when the facilities constructed under the project are to be scrapped.

For the economic evaluation of this study, the following steps will be taken:

1) Measurement of economic costs and benefits, and comparison between candidate projects.
2) Sensitivity tests for concluding the base case of such comparison.

Economic costs and benefits throughout the project life are compared in terms of present values. If the total present value of economic costs, C, equals that of economic benefits, B, (B/C = 1), the discount rate used to calculate the present value is called the economic internal rate of return (EIRR).

(2) Identification of Economic Benefits

The economic benefit of a countermeasure under the study can be estimated as the gap between the energy cost under the "with the project" scenario and the "without the project" scenario. In this case, the energy cost evaluated as energy value is as mentioned below. The energy cost counted as economic benefit should be considered as the total of these values.

(3) Selection of Project Combinations

For the estimation of optimal project cost and benefits, the best selection should be made considering the existing situation of the transmission systems in PNG.

The following alternatives were studied in Chapter 6:

Plan-A Rehabilitation of 132 kV switchgear with full air insulated switchgear (AIS)
Plan-B Only 132 kV transmission line feeders are to be GIS while other parts such as 132 kV busbar and main transformer bays are to be AIS
Plan-C Rehabilitation of 132 kV switchgear with full GIS

These costs and benefits were estimated in terms of the long-run marginal cost (LRMC) as the countermeasure.

(4) Evaluation of Economic Benefits

In order to evaluate the benefits, an energy value described as "MWh-value" was calculated. The MWh-value represents fuel and variable O&M costs of the power plant, and is called "energy benefit".

Fuel and variable O&M costs depend on the condition of the thermal power plant's facilities. Without this reinforcement project, future power demand forecast considering mines and other industrial demands will be supplied by thermal power generators, which are comparatively insufficient than hydro power. In the case of the project, a unit value of cost per MWh is estimated based on standard fuel cost per MWh generated by thermal power, which is used for switching load as marginal demand. The benefit is calculated using this unit value multiplied, by the designed with- and without- energy cost.

(5) Identification of Economic Cost

Economic cost was identified as the opportunity cost of the project.

(6) Evaluation of Economic Cost

1) Foreign currency (FC) portion

The FC portion of the construction costs was estimated as either cost, insurance, and

freight (CIF) or free on board (FOB) basis. These international prices are assumed to reflect the economic cost directly.

2) Local currency (LC) portion

Since it was presumed that local markets in developing countries are distorted by price and border controls and other regulations, prices in the domestic markets do not reflect economic scarcity of products and services. This means that the prices can not be used to evaluate economic costs of local procurement and have to be adjusted into economic prices.

In this case, standard conversion factors (SCF) are used to convert the costs in domestic markets, to economic costs. Also, a SCF is estimated by using export and import statistics. However, SCF is applied only to tradable goods. The economic costs of non-tradable goods and services have to be separately calculated.

(7) Evaluation Criteria for EIRR

EIRR is calculated and used as an index of economical feasibility. It is defined by the following formula:

$$\sum_{t=1}^{t=T} \frac{C_{ep}}{(1+R)^t} = \sum_{t=1}^{t=T} \frac{B_{cc}}{(1+R)^t}$$

where:

T = last year of the project life

C_{ep} = annual economic cost flow of the project under study in year t

B_{cc} = annual benefit flow derived from an alternative candidate in year t

R = EIRR

10.2 Result of Economic Evaluation

10.2.1 Economic Cost

The net construction cost of each candidate project was estimated based on the costs mentioned in previous chapters. Using these net construction costs, economic costs of the candidate projects were estimated. In this case, costs include the following four items: (1) material cost, (2) labour cost, (3) land compensation, and (4) consulting fee, which is 7% of (1) and (2). For estimating the economic cost of the plans, the following conditions were considered based on discussion with PPL:

1) Labour costs are allocated in the LC portion.
2) Personal income tax with a rate of 25% is applied to labour costs.
3) Import levies by the custom with a rate of 2% are applied to the material costs in the FC

portion.

For estimation of the actual necessary construction cost, price escalation rates of 3.0% for the FC portion and 7.0% for the LC portion were applied. Meanwhile, a physical contingency with a rate of 8% was applied.

The results of estimation of economic costs are shown in Table 10.2-1, which are presented in detail in Attachment 5-1. In this case, price escalation should be excluded in the economic analysis.

Table 10.2-1 Estimation of Economic Cost (US$)

Alternatives	FC portion	LC portion	Total
Plan-A	39,666,336.00	25,732,324.71	65,398,660.71
Plan-B	41,808,300.00	26,535,577.79	68,343,877.79
Plan-C	44,320,704.00	26,528,019.55	70,848,723.55

(Prepared by the Survey Team)

10.2.2 Economic Benefits

In the case of "without the project", PPL should supply electricity using thermal generators to cover additional demands of new operated mines and industries around Lae so that customers may be served without any trouble. If the projects are executed, these additional thermal costs will be saved because of enough supply capacities from hydropower plants around Ramu. These saved costs are the economic benefits in case of similar projects with reinforcement of transmission line.

To be exact, costs of thermal and hydro generation are calculated based on exact historical record of PPL. However, the Survey Team could not find these data, and thus, unit marginal energy cost is set to international standard rate of generation estimated by Energy Information Administration, Annual Energy Outlook 2011. The unit marginal energy cost was estimated at US$ 121.0/MWh (Thermal) and US$ 84.5/MWh (Hydro) based on discussions with the Strategy Planning & Marketing Division of PPL.

Moreover, actual situation of air pollution around Lae is serious because of the rapid progress in the area. Reducing the operation of thermal generators can lead to the reduction of CO_2, SO_x and NO_x emission. This means that the project can lead to savings on external costs, which the residents around Lae bear. Consequently the project will produce economic as well as environmental and social benefits. The unit marginal discharge cost of gas was estimated at US$ 8.93 /MWh (CO_2), US$ 6.86 /MWh (SO_x) and US$ 1.34 /MWh (NO_x) based on the Primary CDM Market of 2009 moving average.

In general, these types of projects are designed to serve for at least 30 years from

completion of the works. The effects increase with demand growth corresponding to at least ten years, as the transmission volume is also expected to increase during such ten years after the projects have started. After reaching the maximum transmission capacity, it is assumed that the same amount of transmission volume is sustained up to the end of the project life, which ends 30 years after the completion of each project.

Annual O&M cost of transmission line is estimated as 0.5% of economic cost. In the case of substation operations, GIS has less O&M cost than AIS. Advantages of GIS from economic aspect are listed below.

1) Less man-power for daily inspection (AIS: daily / GIS: weekly)
2) Less frequency for part replacement (AIS: annual / GIS: every 15 years)

O&M cost of substations is estimated as the preconditions above in Attachment 5-2.

10.2.3 Economic Evaluation

The economic evaluation of each plan was made by using cash flows of said economic costs and benefits. The results are summarized in Table 10.2-2 and detailed in Attachment 5-3. In this case, the B/C ratio is the comparison between the net present values of benefit and cost, and B-C is the net cash balance between benefit and cost also in their net present values. For calculation of net present value, a discount rate of 8% was equally applied to similar projects.

Table 10.2-2 Result of Economic Evaluation

Alternatives	EIRR (%)	B/C ratio	B-C (US$)
Plan-A	26.74%	3.32	163,058,787
Plan-B	27.03%	3.33	163,184,652
Plan-C	27.23%	3.36	163,790,138

(Prepared by the Survey Team)

10.3 Methodology of Financial Evaluation

(1) General

Financial analysis appraises the degree of financial return of a project under study that is expected to earn, and is carried out in terms of project owner's profitability. Project inputs and outputs are evaluated in terms of market prices. The inputs evaluated are called "financial costs" and "financial benefits".

Financial costs and benefits throughout the project life are compared in terms of present values. If the total present value of financial costs equals that of financial benefit (B/C = 1),

the discount rate used to calculate the present value is called the financial internal rate of return (FIRR)".

(2) Identification of Financial Costs and Benefits

Financial costs include direct construction cost, taxes, compensation, physical contingency, consulting fee, and engineering expenses. However, price escalation is excluded from the costs. Financial benefit is gained from the increased sales revenue of electricity.

(3) Evaluation Criteria for FIRR

FIRR is calculated and used as an index of financial feasibility of the project. It is defined by the following formula:

$$\sum_{i=1}^{1=T} \frac{C_{ft}}{(1+Rf)^t} = \sum_{i=1}^{i=T} \frac{B_{ft}}{(1+Rf^t}$$

where:

T = last year of the project life

C_{ft} = annual financial cost flow of the project under study in year t

B_{ft} = annual benefit flow derived from an alternative plan in year t

Rf = FIRR

10.4 Result of Financial Evaluation

10.4.1 Financial Cost

In the estimation of financial cost, similar conditions in the case of economic evaluation are followed. However, financial cost includes additional factors listed below:

1) Personal income tax for labour
2) Import levies for materials

The results of estimation of financial costs are shown in Table 10.4-1. In this case, price escalation should be excluded in the financial analysis.

Table 10.4-1 Estimation of Financial Cost (US$)

Alternatives	FC portion	LC portion	Total
Plan-A	39,666,336.00	32,005,263.52	71,671,599.52
Plan-B	41,808,300.00	32,445,737.89	74,254,037.89
Plan-C	44,320,704.00	32,684,550.88	77,005,254.88

(Prepared by the Survey Team)

10.4.2 Financial Benefit

Whether the cost for the project of transmission line reinforcement is exceeded or not, the development of the mine will be done from the aspect of profitability of mine operators. These institutional customers will have self-generation facilities if electricity tariff of PPL is more expensive than self-generation cost by mine operators or IPPs. Therefore, PPL has to consider a tariff that is more reasonable than the unit cost of self-generation. Accordingly, a margin of generation cost between self-generated power and hydro power, which is called provisional revenue, is a financial benefit for financial evaluation similar to that for economic evaluation.

Moreover, the power outage around Lae will decrease if the project cost is exceeded and the line satisfies the N-1 criteria. It means the PPL can recover the imputed sales opportunities by power outage and the projects will produce financial benefits. The PPL recorded power outage around Lae sorted by technical reasons, so that the benefit from transmission reinforcement can be divided from other reasons like distribution troubles. Record of power outage is shown in Table 10.4-2.

Table 10.4-2 Record of Power Outage in Taraka and Milford

Monthly Average	Outage time (hour)	Lost sales energy (MWh)
1. Present: Actual situation (2011)	83.53	149.27
2. Target: Estimation after construction (2015)	45.61	89.07

(Source: PPL)

10.4.3 Financial Evaluation

The financial evaluation of the project was made by using cash flows of the said financial costs and the provisional revenue to be given as a financial benefit using the same method for the economic evaluation. Corresponding results are shown in Table 10.4-3 below and detailed in Attachment 5-4. In this case, the B/C ratio is the comparison between the net present values of benefit and cost, and B-C is the net cash balance between benefit and cost, also in their net present values. For calculation of net present value, a discount rate of 10% was equally applied to similar projects.

Table 10.4-3 Result of Financial Evaluation

Alternatives	FIRR (%)	B/C ratio	B-C (US$)
Plan-A	19.58	2.18	86,921,303
Plan-B	19.54	2.16	86,282,707
Plan-C	19.61	2.17	87,305,305

(Prepared by the Survey Team)

10.5 Sensitivity Analysis

There are constant fluctuations in the prices of construction materials used for these kinds of projects as a reflection of the condition of the economy. Considering this situation, a sensitivity analysis was carried out under a pessimistic case with condition of plus 30% cost. Table 10.5-1 shows the results of sensitivity analysis for EIRR and FIRR.

Table 10.5-1 Sensitivity Analysis

Alternatives	EIRR (%) base case	EIRR (%) +30% cost	FIRR (%) base case	FIRR (%) +30% cost
Plan-A	26.74	22.15	19.58	15.95
Plan-B	27.03	22.32	19.54	15.87
Plan-C	27.23	22.45	19.61	15.92

(Prepared by the Survey Team)

As shown in the table, the resulting EIRR values for the base case range from 26.74% to 27.23% as already studied, which is reasonably high compared with similar projects. Under the most pessimistic case with condition of 30% cost increase, the EIRR values are still high enough as it range from 22.15% to 22.45%. This means that these projects under study are economically sound.

Meanwhile, the FIRR under both the benefit and cost in the base case resulted from 19.54% to 19.61% as already studied, which is also reasonably high compared with similar projects. Under the most pessimistic case with condition of 30% cost increase, the FIRR values are still high enough as it range from 15.87% to 15.95%. This means that these projects under study are financially sound.

10.6 Operation and Effect Indicators

Envisaged quantitative and qualitative effects of the Project are as follows:

1) Quantitative effects
   - Reduction of forced power outage time in Lae (Taraka and Milford substations) caused by transmission line accidents
   - Reduction of lost sales energy caused by the outage in Lae
   - Transformer capacity of the candidate substations
   - Capacity utilization ration of the candidate substations (Peak loads / TR capacity)

2) Qualitative effects
   - Economic development such as promotion of investments by realization of stable electric power supply in Lae and neighboring areas
   - By installing new main transformers in Singsing and Erap substations, putting into

place to expand the distribution network around the area, and secondarily, improvement of electrification ratio and living standards of the area

Table 10.6-1 shows operation and effect indicators to measure the quantitative effects of the Project including present values in 2011 and target values in 2018, three years after completion of the Project.

Table 10.6-1 Operation and Effect Indicators

	Indicators	Present (2011)	Target (2018)
-	Forced outage time in Lae	83.5 hrs	46.0 hrs
-	Lost sales energy in Lae	149.3 MWh	90.0 MWh
-	Tr. capacity of candidate substations	149.2 MVA	179.2 MVA
-	Capacity utilization ratio of candidate substations	51.1%	48.0%

(Prepared by the Survey Team)

CHAPTER 11

CONCLUSION AND RECOMMENDATION

CHAPTER 11 CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

(1) Objectives and Necessity of the Project

The main objectives of the Project are:

1) to reinforce the efficiency of Ramu grid, which is considered to directly stabilize electric power supply and economic development of Lae; and,
2) to increase the opportunities of neighboring communities of the project sites in terms of benefiting from reliable and stable electricity supply.

The above objectives confirm the power sector development policy of GoPNG as discussed in Chapter 2.

In addition, implementation of the Project is urgently needed not only for reinforcement of the Ramu grid, but also for securing the power supply reliability to Lae, where remarkable economic development is taking place, and ensuring the power supply capability for rapidly increasing mining demand.

(2) Scope of the Project

1) Transmission line components
   i) 132 kV double-circuit overhead transmission line from Taraka substation to Taraka Junction, 0.7 km, and 132 kV single-circuit overhead transmission line from Taraka Junction to Erap substation, 39.7 km
   ii) 132 kV double-circuit overhead transmission line between Erap substation and new Singsing substation, 97.2 km
2) Substation components
   i) Rehabilitation of Ramu 1 switchyard
   ii) Construction of Singsing substation including one unit of 132/33 kV 10 MVA main power transformer and six 132 kV transmission line bays
   iii) Augmentation of Erap substation including additional two units of 132/66/33 kV 10 MVA main power transformers and three transmission line bays
   iv) Rehabilitation of Taraka substation with the following three alternative plans including additional one 132 kV transmission line bay

   Plan A: Rehabilitation of 132 kV switchgear with full AIS

   Plan B: Only 132 kV transmission line feeders are to be GIS, and the other

parts such as 132 kV busbar and main transformer bays are to be AIS

Plan C: Rehabilitation of 132 kV switchgear with full GIS

Although implementation of all the above mentioned scope is needed to achieve the objective of the Project, as a result of discussion with the PPL, if it dares to give a priority to the scope, it becomes as follows:

1) Transmission line Singsing – Erap section with associated substation facilities
2) Transmission line Erap – Taraka section with associated substation facilities
3) Additional transformers to Erap substation

(3) Project Costs

Table 11.1-1 summarizes the total costs for the Project.

Table 11.1-1 Total Project Costs

Items	FC (US$)	LC (US$)	Total (US$)	Total (PGK eq.)	Total (JPY eq)
1. Transmission Line Component	17,033,600.00	17,611,400.00	34,645,000.00	79,433,300.00	2,805,898,000
2. Substation Component					
2.1 Plan-A	16,700,600.00	8,678,300.00	25,378,900.00	58,188,500.00	2,055,437,000
2.2 Plan-B	18,683,900.00	9,020,200.00	27,704,100.00	63,519,600.00	2,243,755,000
2.3 Plan-C	21,010,200.00	9,185,700.00	30,195,900.00	69,232,700.00	2,445,566,000
3. Land & ROW Compensation	-	931,320.00	931,320.00	2,135,400.00	75,427,000
4. Consulting Fee	3,233,400.00	1,788,400.00	5,021,800.00	11,513,900.00	406,715,000
5. Contingency (8% of 1+2)					
5.1 Contingency Plan-A	2,698,700.00	2,103,200.00	4,801,900.00	11,009,700.00	388,906,000
5.2 Contingency Plan-B	2,857,400.00	2,130,500.00	4,987,900.00	11,436,200.00	403,970,000
5.3 Contingency Plan-C	3,043,500.00	2,143,800.00	5,187,300.00	11,893,400.00	420,119,000
Grand Total (Plan-A)	39,666,300.00	31,112,620.00	70,778,920.00	162,280,800.00	5,732,383,000
Grand Total (Plan-B)	41,808,300.00	31,481,820.00	73,290,120.00	168,038,400.00	5,935,765,000
Grand Total (Plan-C)	44,320,700.00	31,660,620.00	75,981,320.00	174,208,700.00	6,153,725,000

(Prepared by the Survey Team)

To evaluate the project benefits, construction costs shown in the above table are converted to economic and financial costs as shown in Table 11.1-2.

Table 11.1-2 Conversion of Project Costs

	Economic Cost (US$)			Financial Cost (US$)		
	FC	LC	Total	FC	LC	Total
Plan-A	39,666,336.00	25,732,324.71	65,398,660.71	39,666,336.00	32,005,263.52	71,671,599.52
Plan-B	41,808,300.00	26,535,577.79	68,343,877.79	41,808,300.00	32,445,737.89	74,254,037.89
Plan-C	44,320,704.00	26,528,019.55	70,848,723.55	44,320,704.00	32,684,550.88	77,005,254.88

(Prepared by the Survey Team)

(4) Project Effect and Evaluation

If the project is executed, sales revenue will increase while power outage will decrease, corresponding to the reinforcement of transmission line. In this case, unit marginal sales revenue is the same as the self-generation cost for mine operators because they can select reasonable alternatives of power generation. Consequently, PPL will have to offer the most reasonable price to these groups. Therefore, the margin between the cost of thermal and hydro generation, known as a probable revenue source, will be the economic benefit and financial benefit of the project.

Moreover, displacing thermal into hydro for provisional demand will decrease emission gases, which is considered as an external economic cost. Furthermore, decreasing power outage will increase sales revenue as financial benefit, which is realized as imputed sales opportunities. The estimated results are shown in Attachment 5.

The result of EIRR and FIRR calculation, and sensitivity analysis, considering the case of +30% cost, are as follows:

Table 11.1-3 Sensitivity Analysis

Alternatives	EIRR (%) base case	EIRR (%) +30% cost	FIRR (%) base case	FIRR (%) +30% cost
Plan-A	26.74	22.15	19.58	15.95
Plan-B	27.03	22.32	19.54	15.87
Plan-C	27.23	22.45	19.61	15.92

(Prepared by the Survey Team)

From the result, enough economic and financial benefits are expected from each plan based on the state of the national economy and the type of managerial finance of PPL, even if construction costs are increased by 30%.

(5) Environmental and Social Considerations

1) Environmental Assessment

The project category has been officially confirmed as Level 2B by the DEC. Therefore, PPL is now preparing for the permit application according to the procedure for Level 2B project and targeting to submit the application by March 2012. The local communities in the project area depend their livelihood on the rich natural resources of the area, as well as seasonal climate change which may cause the impacts to the project facilities. Hence, it is important to consider minimizing such impacts by adopting adequate mitigation measures and conducting regular monitoring process.

2) Land Issues

The design of the Project took consideration of avoidance and minimization of involuntary resettlement, land acquisition and loss of livelihood. Therefore, involuntary

resettlement and relocation of structures are not expected. It has been noted that the Project requires (i) acquiring approximately 0.46 ha of land for the extension of Erap substation, (ii) obtaining agreements for land release for tower bases and transmission line easement, and (iii) compensation for damaged crops and trees.

Table 11.1-4 provides the summary of expected land-related impacts caused by the Project.

Table 11.1-4 Expected Impacts

Project Components	Type of Impact	Amount
Extension of Erap Substation	Land Acquisition	0.46 ha
	Loss of Cash Crops and Trees	0
	Relocation of Structures	0
Construction of 132 kV Transmission Line	Land Release	3.0 ha
	Easement	Length: 138.5 km Width: 40 m
	Loss of Cash Crops and Trees	401,150
	Relocation of Structures	0

(Prepared by the Survey Team)

The land areas around existing Erap substation is state-owned and will be acquired through negotiation with its current landowner. For the land for tower bases and transmission line easement, landowners will be provided compensation for the release of such land and all damages and detriments that may be caused, in particular, damages to economic crops and trees.

11.2 Recommendations

(1) Project Scope

The Survey Team has studied three alternative rehabilitation plans for Taraka substation. As a result of economic and financial evaluation, Plan C shows highest EIRR/FIRR values among the plans as shown in Table 11.1-2. In addition, Plan C also has advantages from viewpoints of reliable power supply and ease of O&M.

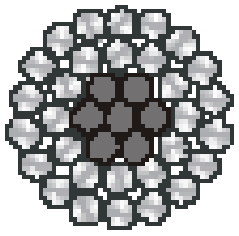
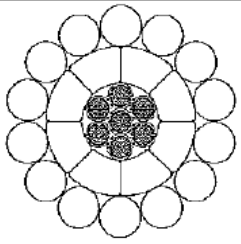
Therefore, it is strongly recommended that the Project is to be implemented with Plan C, considering the importance and actual situation of Taraka substation.

Arrangement of project finance is also an urgent matter. The PPL shall request the project fund from an international supporting organization. The estimated project cost with Plan C is approximately US$ 75.9 million on the basis of ICB. All information required for the preparation of the request for application, are available in this report.

(2) Applicability of Japanese Technology

Japanese-made low-loss type conductors such as LL-ACSR/AS can be applied to both new construction and reconstruction of important transmission lines. Low-loss type conductors have the same outer shape as normal ACSR conductors; however, their aluminum cross-section area is larger by 20–30% as shown in Table 11.2-1, if reducing electrical resistance is intended. These conductors contribute to transmission loss reduction especially on heavily loaded transmission lines.

Table 11.2-1 Specification of Conductors

items	units	ACSR 425 mm^2 (ASTM: Deer)	LL-ACSR/14AC 510 mm^2
Type	-	conventional ACSR	low loss type
Component of stranded wires	nos/mm	30/4.27-AL 7/4.27-St	14/5.30-HAL 8/TW-HAL 7/33-14AC/1770
Nominal diameter	mm	29.9	29.9
Cross sectional area	mm^2	Al: 429.6 St: 100.2 Total: 529.8	Al: 509.4 AC: 59.87 Total: 569.3
Nominal weight	kg/km	1,973	1,834
DC resistance at 20℃	Ω/km	0.06727	0.05509
Minimum breaking load	KN	178.6	168.8
Modulus of elasticity	GPa	89.1	73.2
Coefficient of linear expansion	/deg.C	17.8 x 10^{-6}	20.3 x 10^{-6}
Current carrying capacity (AC resistance)	A (Ω/km)	730 (0.0825) at 75 deg.C 943 (0.0865) at 90 deg.C	804 (0.0679) at 75 deg.C 1,039 (0.0712) at 90 deg.C
Sag (50.9 kN max. tension) at 75℃ (span 400/500 m) at 90℃ (span 400/500 m)	m	 14.49 /22.32 (730 A) 15.00 /22.86 (943 A)	 14.22 /21.90 (804 A) 14.80 /22.51 (1,039 A)
Safety factors Maximum tension (50.9 kN) EDS condition (30.8 kN)	-	 3.50 > 2.5 5.79 >5.0	 3.32 > 2.5 5.48 > 5.0
Cross section	-		

(Prepared by the Survey Team)

As a case study, the Survey Team studied the case where 132 kV Singsing – Erap 2-cct 97.2 km transmission line applies LL-ACSR conductors instead of ACSR Deer, with the following assumptions:

1) Peak loads on the line in 2015, 2020 and 2025 are taken from the results of power flow calculations as shown in Figures 4.4-1, 4.4-3a and 4.4-5, respectively. Loads of the other years are proportionately calculated from the obtained results.

2) Power factor: 0.85

3) Load factor: 0.55

4) Conductor resistances

- ACSR Deer: 0.0800 Ω/km (at 66 ^{o}C)
- LL-ACSR/14 AC 510 mm^2: 0.0655 Ω/km (at 64 ^{o}C)

5) Annual loss calculating formula

Annual loss = Nos. of conductors/cct. X line length (km) X Nos. of cct. X conductor resistance (Ω/km) X (load current (A))^2 X (0.3 X load factor + 0.7 X (load factor)^2) X 24 hrs. X 356 days

6) Average generation cost applied for the study: US$ 0.0981/kWh (weighted average cost of thermal (US$ 0.1210/kWh) and hydro (US$ 0.0845/kWh) generations applied for economic evaluations in 2015 (thermal : hydro=37.5 : 62.5))

7) Prices of Conductors (2-cct, 97.2 km)

- ACSR Deer: JPY 281,685,600 (JPY 460,000/km x 97.2 km x 6 nos (2-cct) x 1.05)
- LL-ACSR/14AC 510 mm^2: JPY 562,494,800 (JPY 930,000/km x 97.2 km x 6 nos x 1.05)
- Difference: JPY 287,809,200 (eq. PGK 8,147,695-)

Table 11.2-2 shows the result of the case study.

Table 11.2-2 Result of Case Study

Items	unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Peak loads per cct	MW	21.7	28.62	35.54	42.46	49.38	56.3	61.08	65.86	70.64	75.42	80.2	80.2	80.2	80.2
Eq. current per cct	A	112.0	147.0	183.0	218.0	254.0	290.0	314.0	339.0	364.0	388.0	413.0	413.0	413.0	413.0
Annual Losses on Deer (2 cct)	MWh	1,930.7	3,326.7	5,155.1	7,316.8	9,934.0	12,950.5	15,181.5	17,696.4	20,402.6	23,181.5	26,264.0	26,264.0	26,264.0	26,264.0
Annual Losses on LL-ACSR (2 cct)	MWh	1,580.9	2,722.8	4,221.1	5,990.1	8,132.0	10,604.0	12,429.0	14,488.4	16,703.0	18,980.2	21,505.0	21,505.0	21,505.0	21,505.0
Difference of annual losses	MWh	349.8	604.0	934.0	1,326.7	1,802.0	2,346.5	2,752.5	3,207.9	3,699.7	4,201.3	4,759.1	4,759.1	4,759.1	4,759.1
Annual cost savings	kUSD	34.3	59.3	91.7	130.3	176.9	230.4	270.3	315.0	363.3	412.5	467.3	467.3	467.3	467.3
	eq.kJPY	2,782.0	4,802.8	7,427.3	10,550.5	14,329.7	18,660.1	21,888.2	25,510.0	29,420.5	33,409.8	37,845.1	37,845.1	37,845.1	37,845.1
Recoup the initial invesomet	kJPY	285,027.2	280,224.4	272,797.1	262,246.7	247,916.9	229,256.8	207,368.6	181,858.5	152,438.0	119,028.2	81,183.1	43,337.9	5,492.8	-32,352.4

(Prepared by the Survey Team)

Although the initial cost of adopting LL-ACSR conductor is about two times that of ACSR Deer, the initial investments can be recouped within 14 years as shown in the above table.

Therefore, it is recommended to introduce such low-loss conductors not only under the Project but for planned transmission lines such as Ramu 2 – Singsing and Erap – Wafi Gold lines, on which heavy loads are forecasted.

(3) Maximization of the Project Effect

To maximize the effect of the Project, the PPL is requested to implement the following developments on 66 kV transmission and distribution lines:

1) 66 kV transmission lines between Erap SS and Nadzab T-branch point to connect to Taraka SS.
   - 66 kV transmission line 1-cct, 5.0 km (PGK 7,500,000.0)
   - 66 kV transmission line bay at Erap SS (PGK 262,000.0)

2) 33 kV distribution lines from Erap SS
   - 3 feeders 30 km each (PGK 9,000,000.0-)

3) 33 kV distribution lines from Singsing SS
   - 3 feeders 50 km each (PGK 10,800,000.0-)

The cost for the above developments is estimated to be about PGK 27,562,000.0- in total.

(4) Environmental and Social Considerations

1) Environmental assessment

In order to minimize impacts, preparation of adequate environmental management and monitoring plans should be included as one of the conditions for selecting contractors who intend to bid. Also, it is suggested to organize necessary stakeholder's meetings to share on-going project details before actual construction commences, in order to avoid irreversible impacts.

In addition, while development of power sector in PNG has increased, awareness raising program on the issue of environmental and social impacts within the PPL should be effective to promote common perceptions for sustainable environmental protection in PNG. Since the environmental office in PPL has only one staff at the moment, limited activities for environmental and social considerations are being managed at present.

2) Land issues

Access agreements will be applied on the Project for land release for tower bases and easement. There is a concern that the completion of signing of agreements with all landowners will require long periods and may delay the Project. However, the negotiation cannot start before the location of towers are finalized through the route survey. Therefore, It is recommended to hold follow-up stakeholder meetings effectively and timely in order to raise awareness of landowners before the negotiation starts.

In addition, the PPL should negotiate with the Valuer General's Office for higher rate for a tower base than the project involving construction of Hidden Valley and Erap substation, as the land for the tower base is larger.

(5) Construction of Load Dispatching Centre (LDC) for Ramu Grid

Currently, there is no LDC for the Ramu grid, which totally operates the network elements

such as generating units, circuit breakers, etc. Since the current Ramu grid is a very simple system with only one major hydropower station, Ramu 1 HPS, and radial transmission network, no difficulty is expected in the operation of the network without the LDC. However, planned future system will be more complicated with large power stations and demand centers. Such power network can no longer be controlled without a computerized control system. Construction of LDC for the future Ramu grid is therefore recommended.

ATTACHMENTS

Contacted Personnel: Papua New Guinea Side

Name	Position
Mr. Tony Koiri	Chief Exective Officer PNG Power Ltd.
Mr. Lawrence Solomon	Director of Strategy and Marketing PNG Power Ltd.
Mr. John L. Yanis	General Manager of Asset Development PNG Power Ltd.
Mr. Alex Oa	General Manager of Performance Engineering PNG Power Ltd.
Mr. Brendan Raftery	Chief Financial Officer PNG Power Ltd.
Mr. Francis Uratun	Acting Manager of Strategic Infrastructure Planning PNG Power Ltd.
Mr. Francis Mamia	Manager of Corporate Projects PNG Power Ltd.
Mr. Wabing Stahl Mileng	Manager of System Control and System Operations PNG Power Ltd.
Mr. Nelson K. Philip	Manager of Organization Development PNG Power Ltd.
Mr. Mairawesi Pulayasi	Engineer of Distribution Planning PNG Power Ltd.
Mr. Kero Tom	Financial Planner Strategy Planning & Marketing PNG Power Ltd.
Mr. Kalip Salo	Manager of Lands & Community Support PNG Power Ltd.
Mr. Steven CT Kerowa	Team Leader of Lands & Community Relations PNG Power Ltd.
Mr. Titus Tsigese	Environmental Officer PNG Power Ltd.
Mr. Jones Pokarop	Maintenance Bureau PNG Power Ltd.
Mr. Chris Bais	Exective Advisor PNG Power Ltd.
Mr. Morgan Legra	Acting Electrical Manager of Workshop in Lae PNG Power Ltd.
Mr. Reichert Thanda	Acting First Assistant Secretary Department of National Planning and Monitoring
Mr. Joseph Turia	Former First Assistant Secretary Department of National Planning and Monitoring
Ms. Elizabeth Kup	Senior Aid Coordinator Department of National Planning and Monitoring
Ms. Jenny Tumun	Acting Assitant Secretary Department of National Planning and Monitoring
Ms. Barbara Tiki	Aid Coordinator Department of National Planning and Monitoring
Mr. Vore Veve	Director, Energy Division Department of Petroleum and Energy
Mr. Alu Alu	Research Officer, Energy Division Department of Petroleum and Energy
Mr. Buri Gari	Assistant Director, Economic Corporation Department of Foreign Affairs and Trade
Ms. Evangeline Taunao	Financial Analyst Independent Public Business Corporation

Name	Position
Dr. Angelica Braun	Director Prime Minister's Office & National Exective Council
Mr. George Nodalo	Information and Communication Technology Advisor Depertment of Finance
Mr. Stanley Wokia	Senior Policy Officer Depertment of State Enterprise
Mr. Kingley Lore	First Assistant Secretary, Policy Depertment of State Enterprise
Ms. Caroline Korea	Policy Officer Depertment of State Enterprise

Concerned Personnel: Japan Side and Others

Name	Position
Mr. Yoshiki Takahama	First Secretary Embassy of Japan
Mr. Kou Shishido	Second Secretary Embassy of Japan
Mr. Takashi Tsuji	Resident Representative JICA Papua New Guinea Office
Ms. Hikari Miyahara	Project Formulation Advisor JICA Papua New Guinea Office
Mr. Noriyuki Ito	Assistant Resident Representative JICA Papua New Guinea Office
Mr. John Kol	Development Officer JICA Papua New Guinea Office
Mr. Kazuyoshi Ogawa	Development Advisor Department of National Planning and Monitoring

Transmission Line

Tower Foundation at the Middle Bank of the Erap River

Transmission Line Crossing over the Leron River (1/2)

Transmission Line Crossing over the Leron River (2/2)

Transmission Line Crossing over the Markham River

Tower Foundation in Markham River

Bent Pile Foundation

Singsing Substation and Transmission Line

Transmission lines for Gusap (#602) and Erap (#601)

Planned Singsing Substation Site (1/2)

Planned Singsing Substation Site (2/2)

Rock Yard near Planned Singsing Substation Site

Transmission Line Crossing over the Erap River

Tower Foundation at the East Bank of the Erap River

Ramu 1 Switchyard

Ramu 1 Switchyard Overview

Erap Line Bay

Loop of OPGW for Future Use

132/22 kV Distribution Transformer

132 kV Circuit Breaker

Line Trap and Potential Device

Erap Substation

Erap SS overview (1/2)

Erap SS overview (2/2)

Extension Area

Transmission Line to Hidden Valley SS

Double Circuit Tower

Storage Batteries

Taraka Substation

Taraka SS Overview

132 kV Tower for Erap

8 x 1.8 MW Diesel Engine Generators

Static Var Compensator

66 kV Switchgear

No.1 Main Transformer 132/66 kV, 15/20 MVA

Environmental and Social Considerations

Stakeholder Meeting in Huon District (1/2)

Stakeholder Meeting in Huon District (2/2)

Stakeholder Meeting in Markham District (1/2)

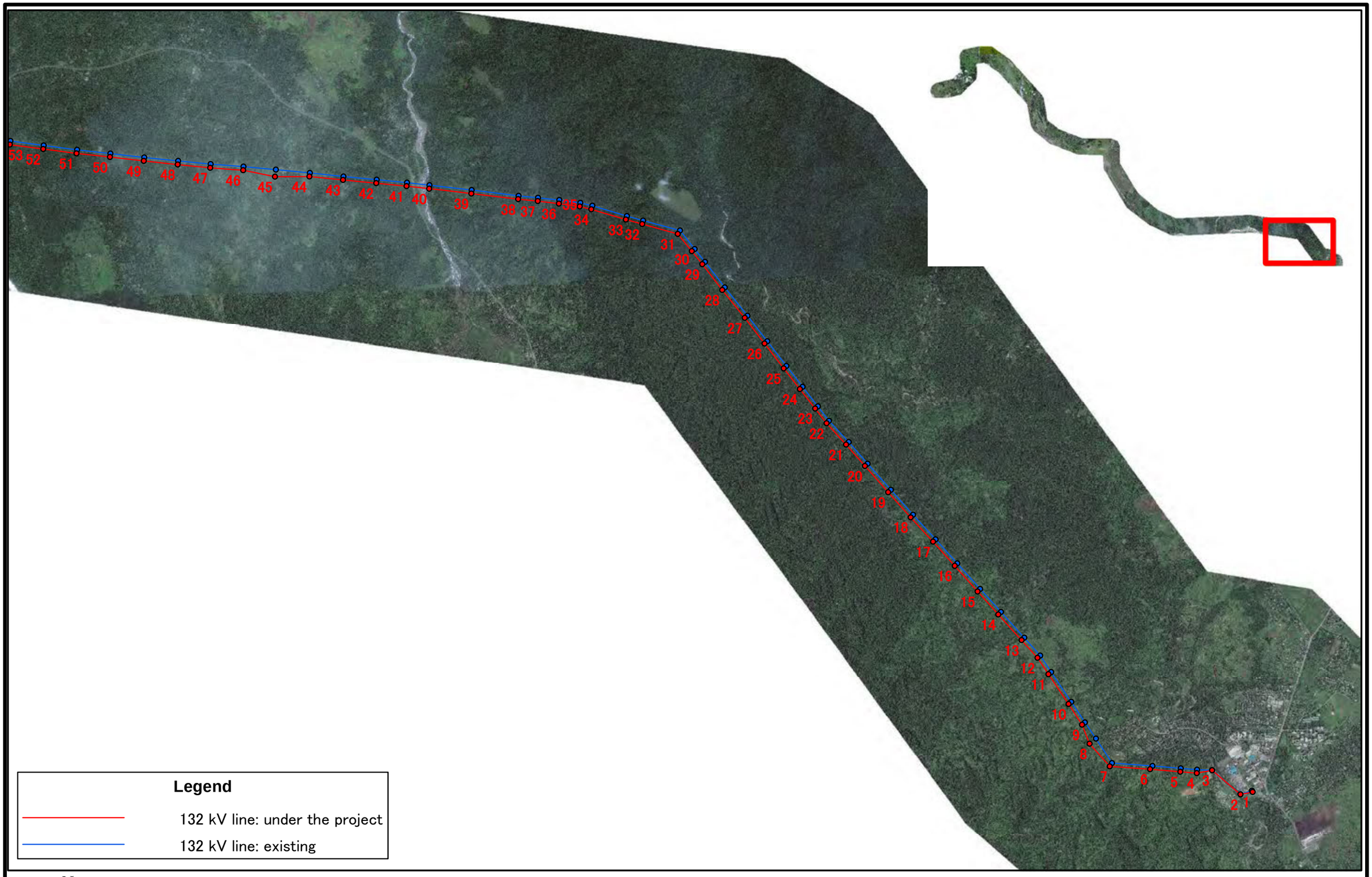
Stakeholder Meeting in Markham District (2/2)

Local Market in Markham District

Firewood as Cooking Fuel

ATTACHMENT-3 DRAWINGS

1.	PNG_TL_RUT_001-006	Existing and Proposed Transmission Line Route
2.	PNG_TL_TWR_001	132 kV Tower Type (Double Circuit)
3.	PNG_TL_TWR_002	132 kV Tower Type (Single Circuit)
4.	PNG_SS_RM1_001	Single Line Diagram: 132 kV Ramu 1 Switchyard
5.	PNG_SS_RM1_002	Layout Drawing: 132 kV Ramu 1 Switchyard
6.	PNG_SS_RM1_003	Section Drawing: 132 kV Ramu 1 Switchyard
7.	PNG_SS_SIS_001	Single Line Diagram: 132 kV System of Singsing Substation
8.	PNG_SS_SIS_002	Single Line Diagram: 33 kV System of Singsing Substation
9.	PNG_SS_SIS_003	Layout Drawing: Singsing Substation
10.	PNG_SS_SIS_004	Section Drawing: Singsing Substation
11.	PNG_SS_ERP_001	Single Line Diagram: 132 kV System of Erap Substation
12.	PNG_SS_ERP_002	Single Line Diagram: 66 kV and 33 kV Systems of Erap Substation
13.	PNG_SS_ERP_003	Layout Drawing: Erap Substation
14.	PNG_SS_ERP_004	Section Drawing: Erap Substation
15.	PNG_SS_TRK_001a	Single Line Diagram: Taraka Substation (Plan A)
16.	PNG_SS_TRK_002a	Layout Drawing: Taraka Substation (Plan A)
17.	PNG_SS_TRK_003a	Section Drawing: Taraka Substation (Plan A)
18.	PNG_SS_TRK_001b	Single Line Diagram: Taraka Substation (Plan B)
19.	PNG_SS_TRK_002b	Layout Drawing: Taraka Substation (Plan B)
20.	PNG_SS_TRK_003b	Section Drawing: Taraka Substation (Plan B)
21.	PNG_SS_TRK_001c	Single Line Diagram: Taraka Substation (Plan C)
22.	PNG_SS_TRK_002c	Layout Drawing: Taraka Substation (Plan C)
23.	PNG_SS_TRK_003c	Section Drawing: Taraka Substation (Plan C)
24.	PNG_SS_COM_001	Telecommunication System



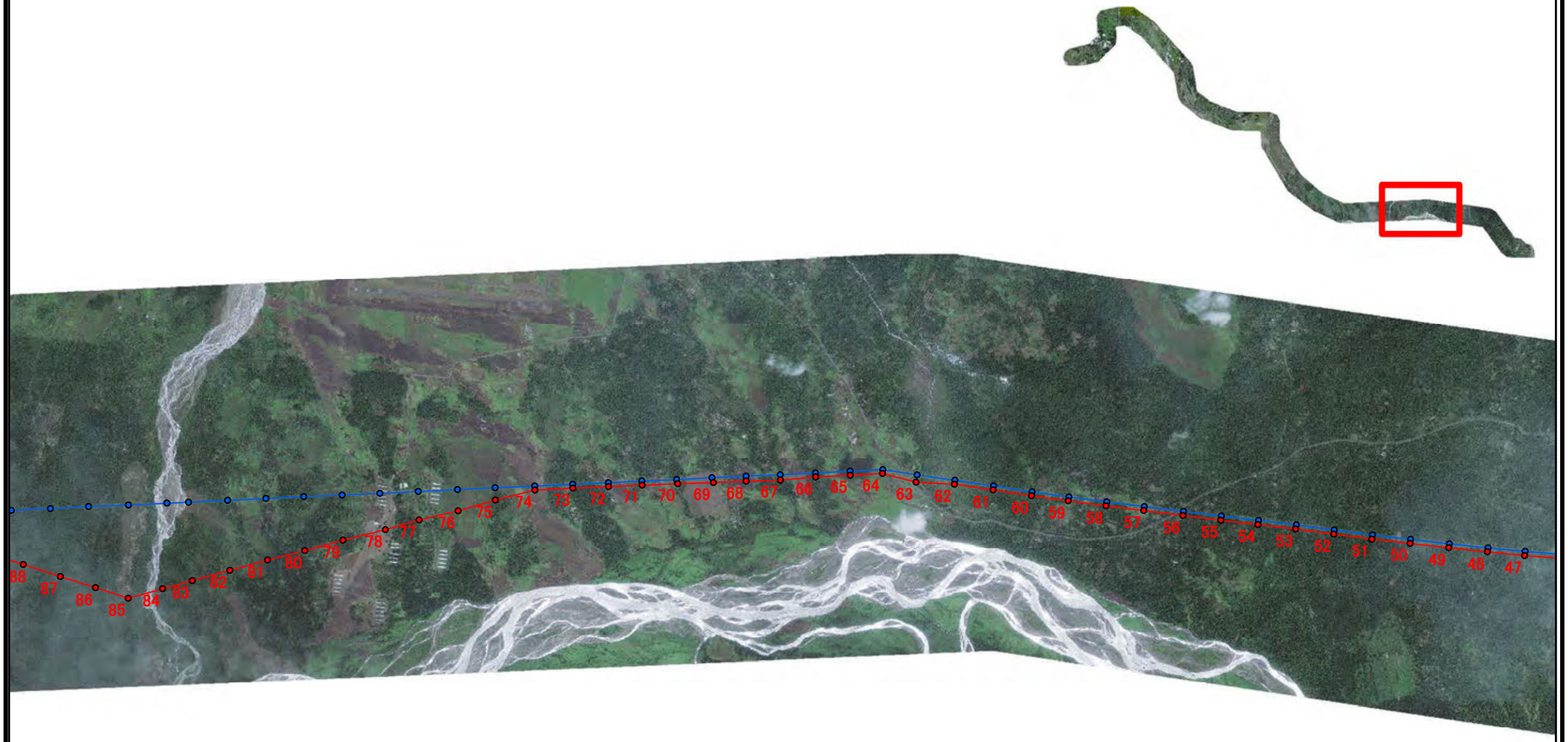
Legend

- 132 kV line: under the project
- 132 kV line: existing

N
W E
S

DWG NO.PNG_TL_RUT_001
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE(1/8)

0 0.5 1 2 3 4 km



Legend

132 kV line: under the project

132 kV line: existing

N

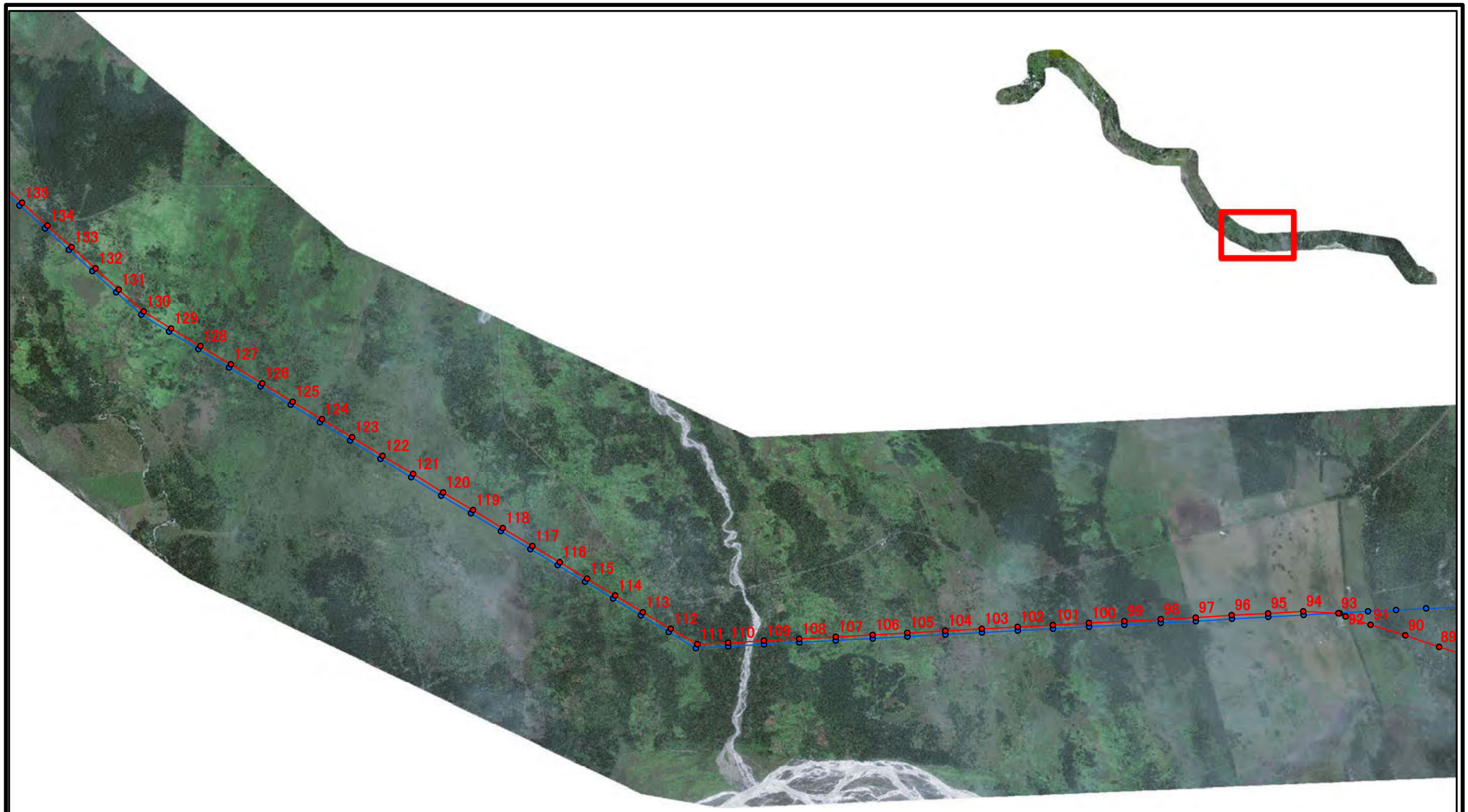
W E

S

DWG NO. PNG_TL_RUT_002

EXISTING AND PROPOSED TRANSMISSION LINE ROUTE (2/8)

0 0.5 1 2 3 4 km



Legend

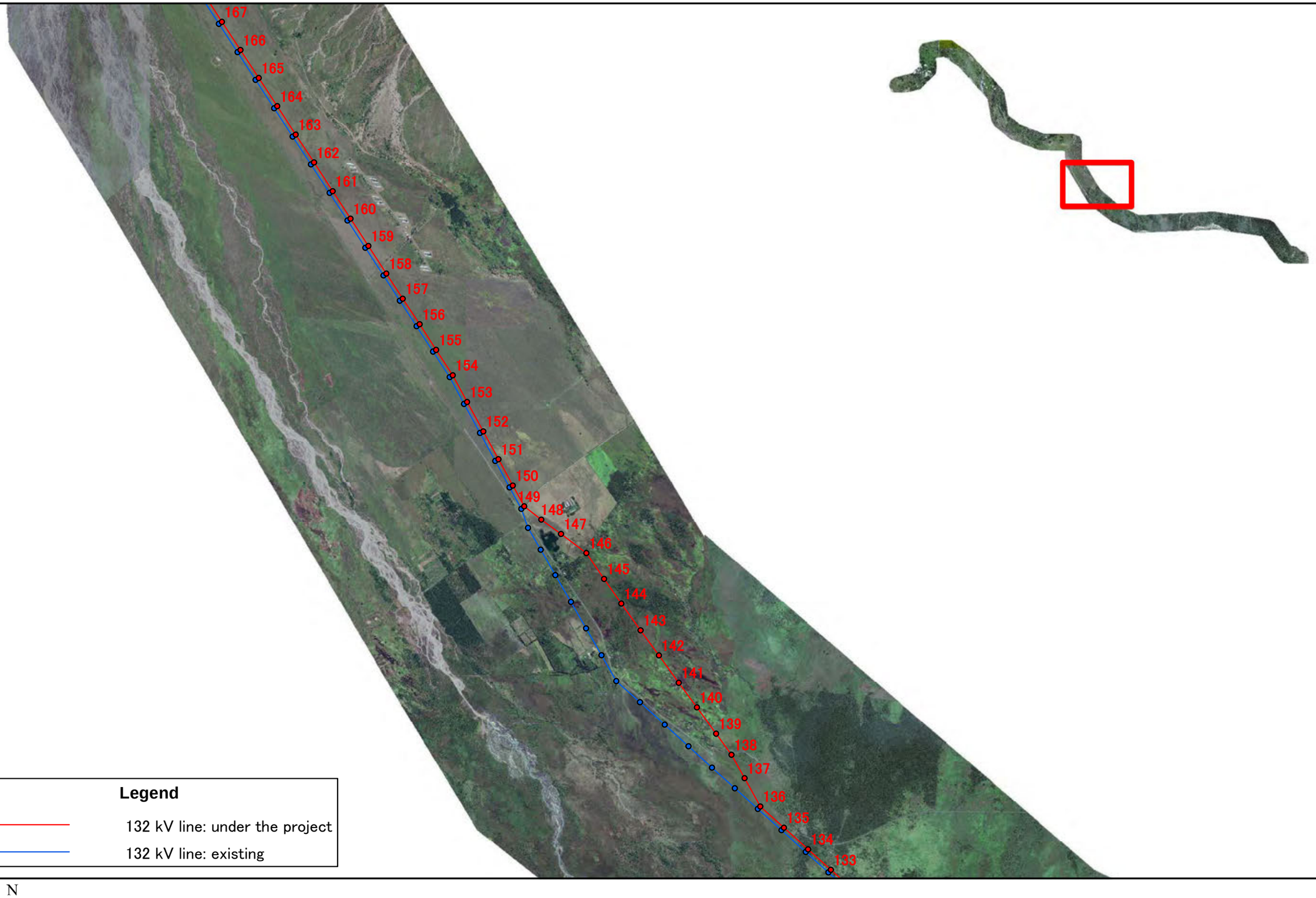
132 kV line: under the project

132 kV line: existing

N
W E
S

DWG NO. PNG_TL_RUT_003
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE (3/8)

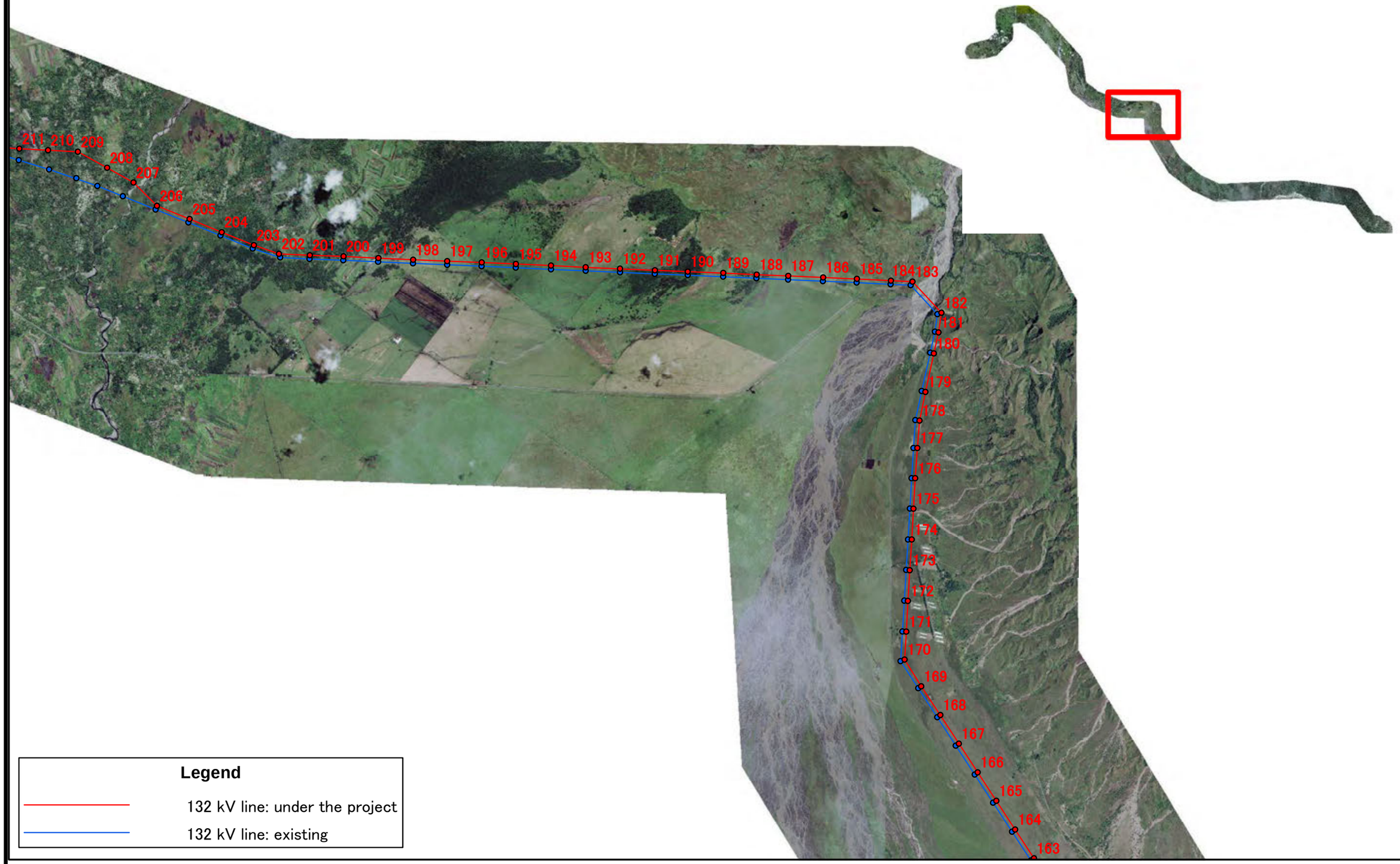
0 0.5 1 2 3 4 km



N
W E
S

DWG NO. PNG_TL_RUT_004
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE (4/8)

0 0.5 1 2 3 4
km



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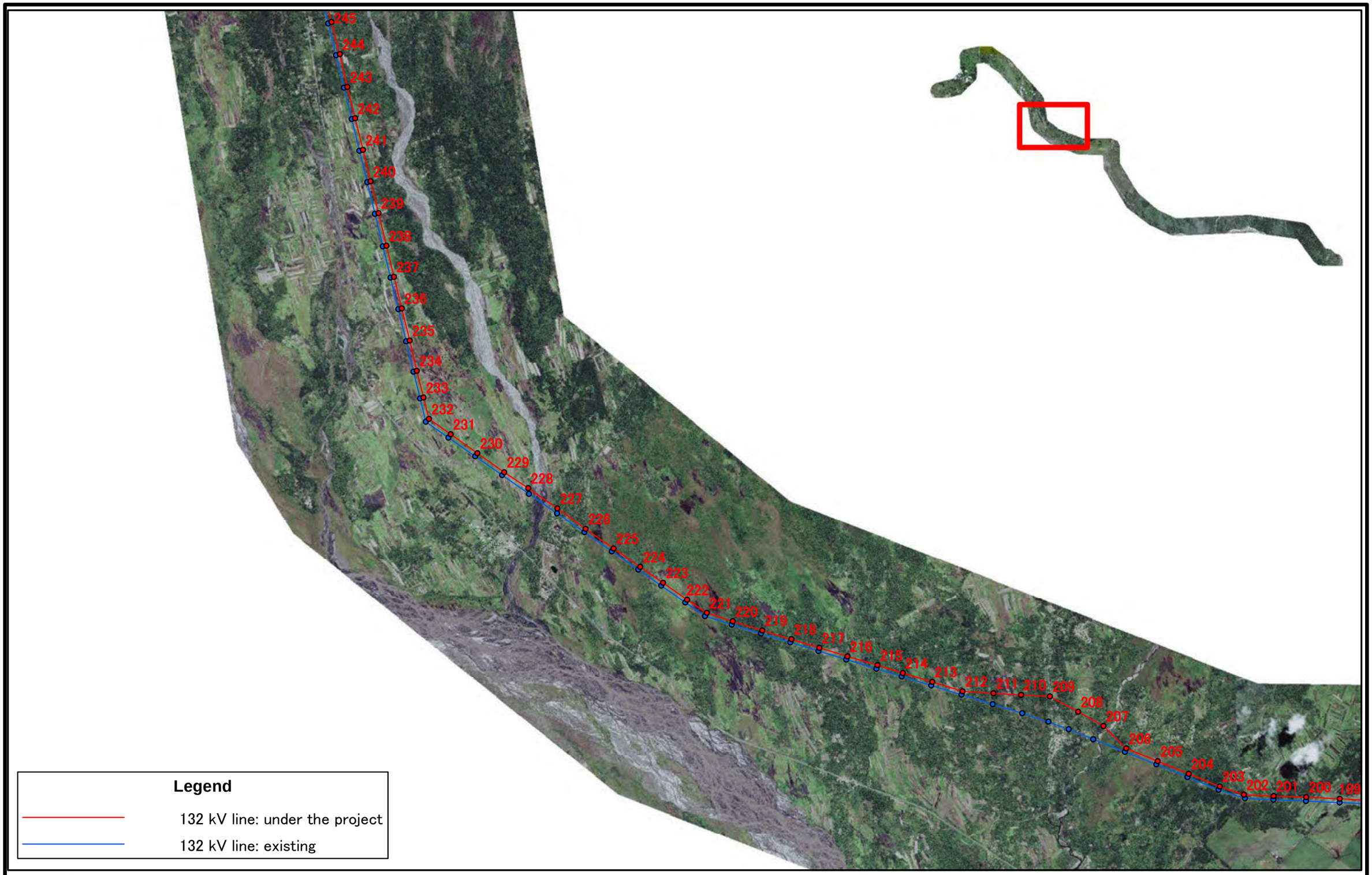
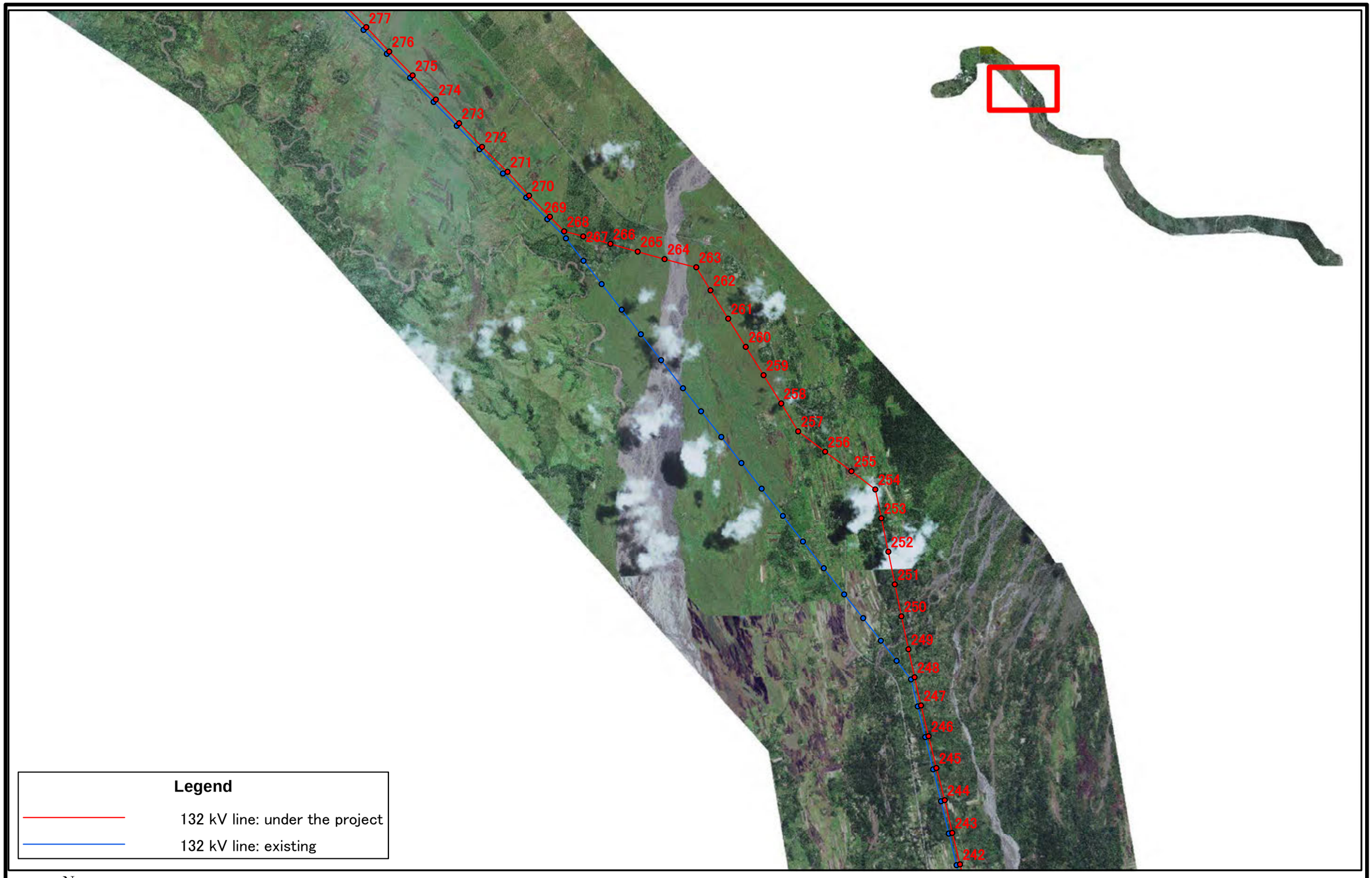
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE(5/8)



DWG NO.PNG_TL_RUT_006
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE(6/8)



Legend

132 kV line: under the project

132 kV line: existing

N

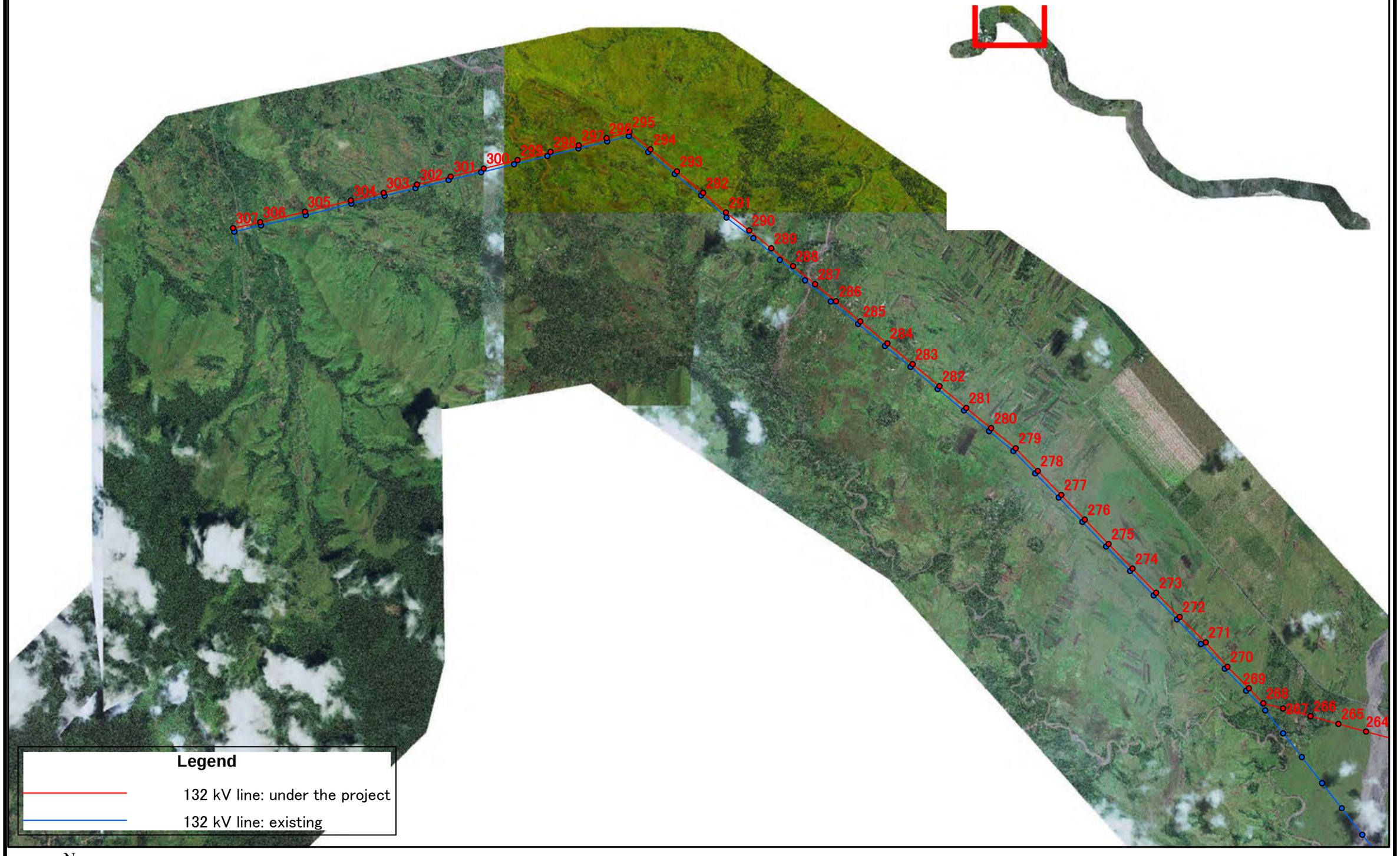
W E

S

DWG NO.PNG_TL_RUT_007

EXISTING AND PROPOSED TRANSMISSION LINE ROUTE(7/8)

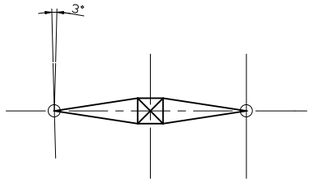
0 0.5 1 2 3 4 km



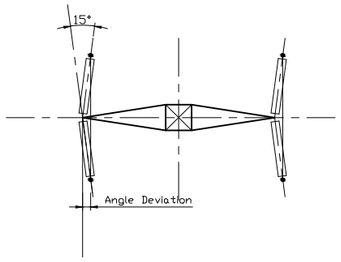
N
W E
S

DWG NO. PNG_TL_RUT_008
EXISTING AND PROPOSED TRANSMISSION LINE ROUTE (8/8)

0 0.5 1 2 3 4
km



Shield Angle less than 15 °



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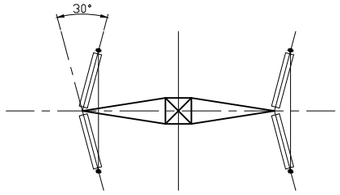
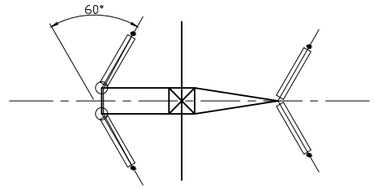
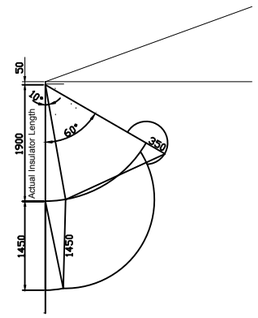


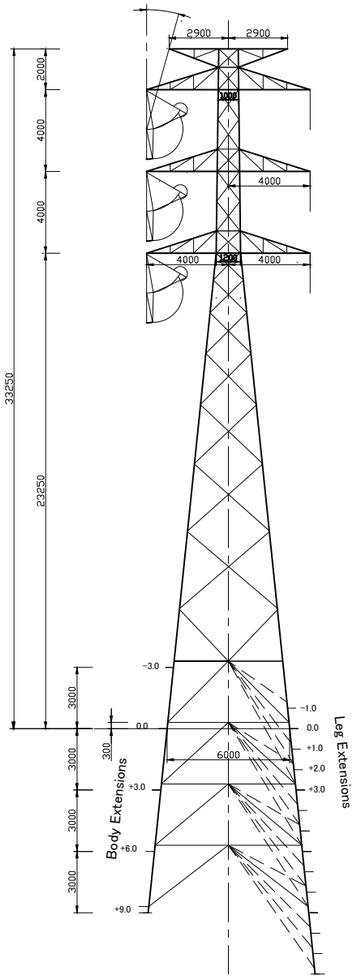
Shield Angle less than 15 °



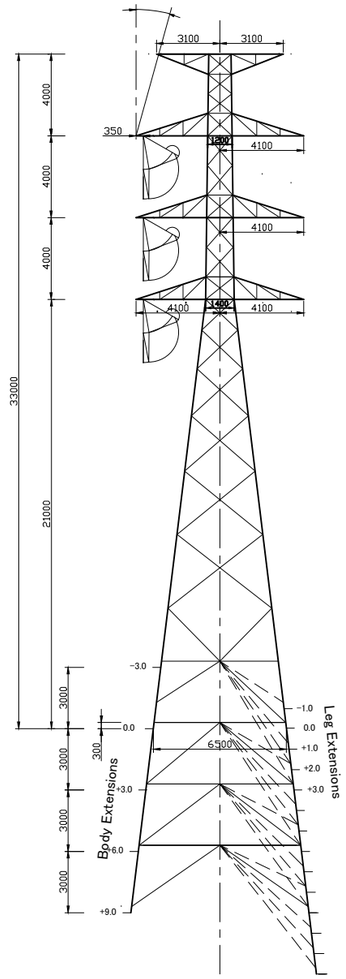
Shield Angle less than 15 °



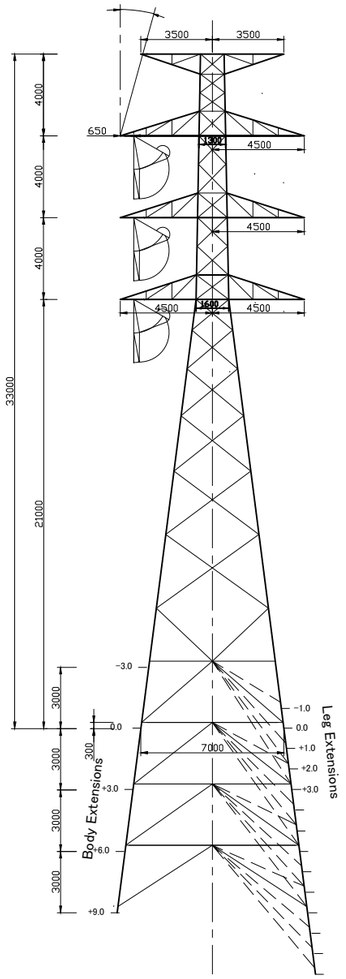
for Suspension Tower



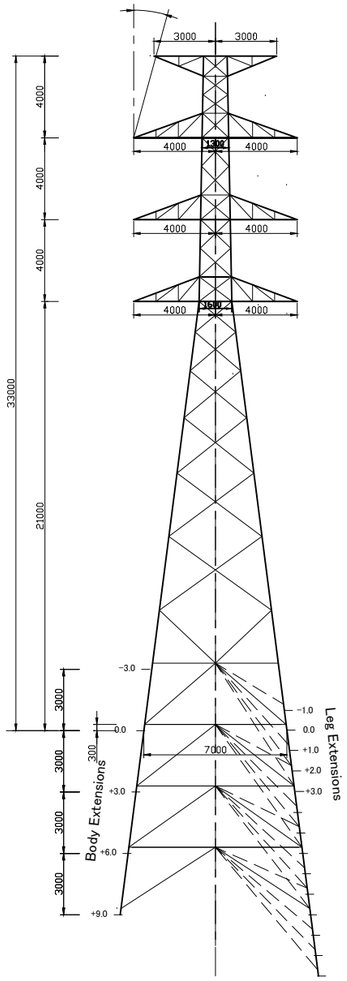
TYPE-A TOWER
(0 to 3 degree)



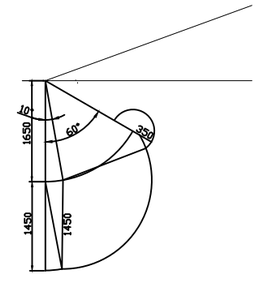
TYPE-B TOWER
(0 to 15 degree, & section)



TYPE-C TOWER
(0 to 30 degree)

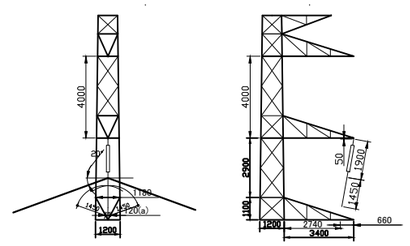


TYPE-D TOWER
(0 to 60 degree)



for Jumper Loop

CLEARANCE DIAGRAM



CATENARY ANGLE

Note

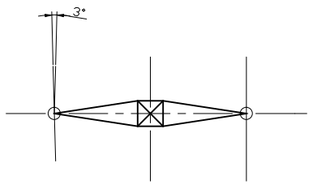
Max. catenary angle is 20° assuming 400 m span length and 90 m level difference.

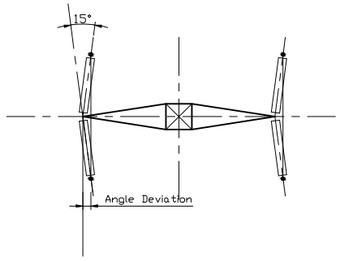
tanθ＝WS/2T+h/S＝1.973*400/2*2,763+90/400＝0.368　θ＝20°

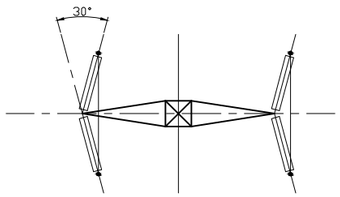
W = Unit weight of conductor
(1.973 kg/m)
S = Span length (400 m)
T = Conductor tension at max.
temperture of 75°C(2,763 kgf)
h = Level difference (90 m)

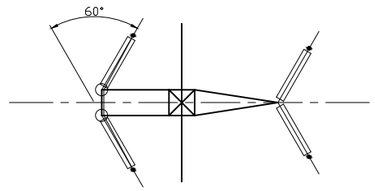
REFERENCE ONLY

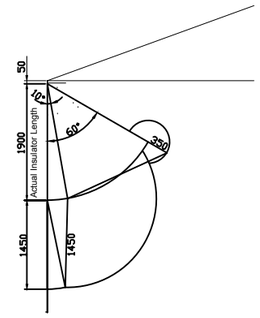
DRAWING NUMBER: DWG NO. PNG_TL_TWR_001			
DRAWING TITLE: 132KV TOWER TYPE (DOUBLE CIRCUIT)			
PREPARED BY: MR. MORI	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY 2012



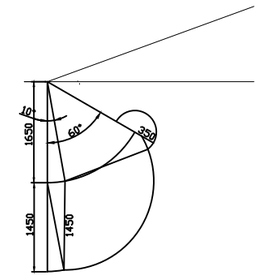








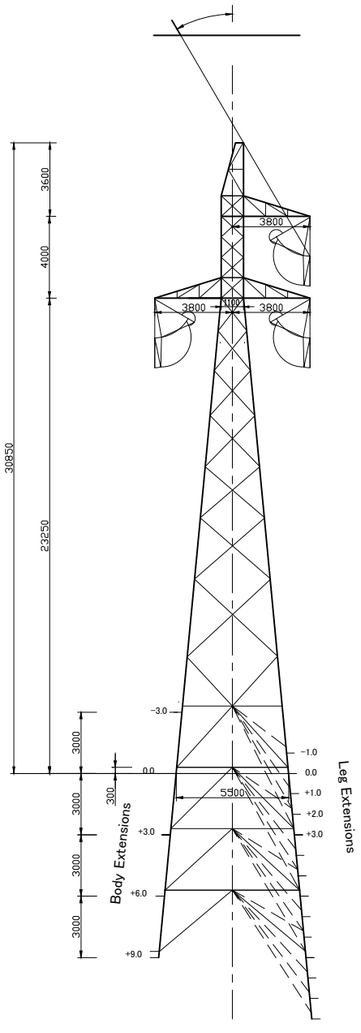
for Suspension Tower



for Jumper Loop

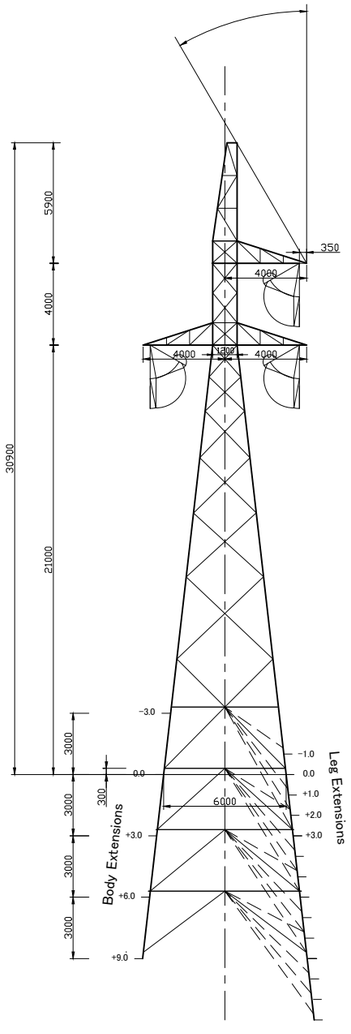
CLEARANCE DIAGRAM

Shield Angle less than 30 °



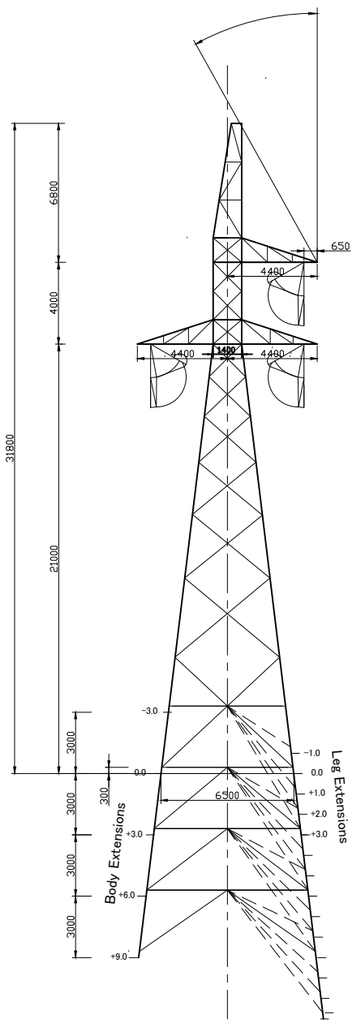
TYPE-A TOWER
(0 to 3 degree)

Shield Angle less than 30 °



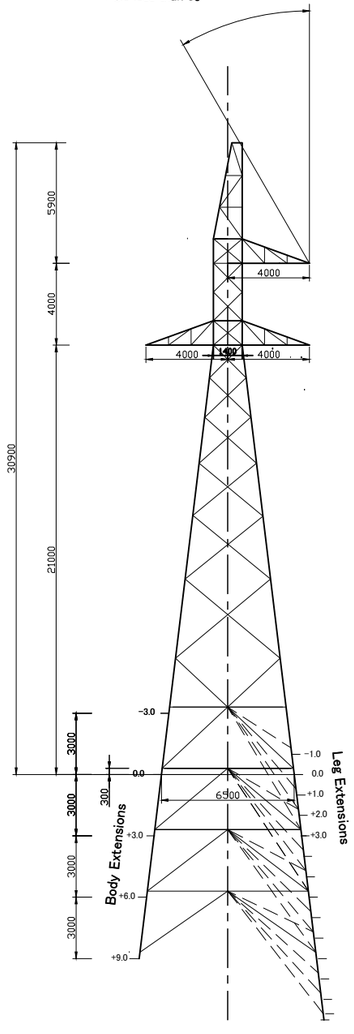
TYPE-B TOWER
(0 to 15 degree, & section)

Shield Angle less than 30 °

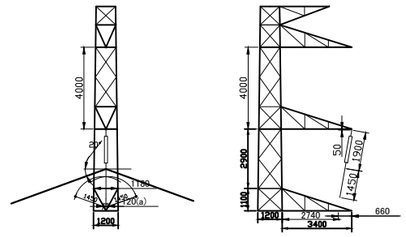


TYPE-C TOWER
(0 to 30 degree)

Shield Angle less than 30 °



TYPE-D TOWER
(0 to 60 degree)



CATENARY ANGLE

Note

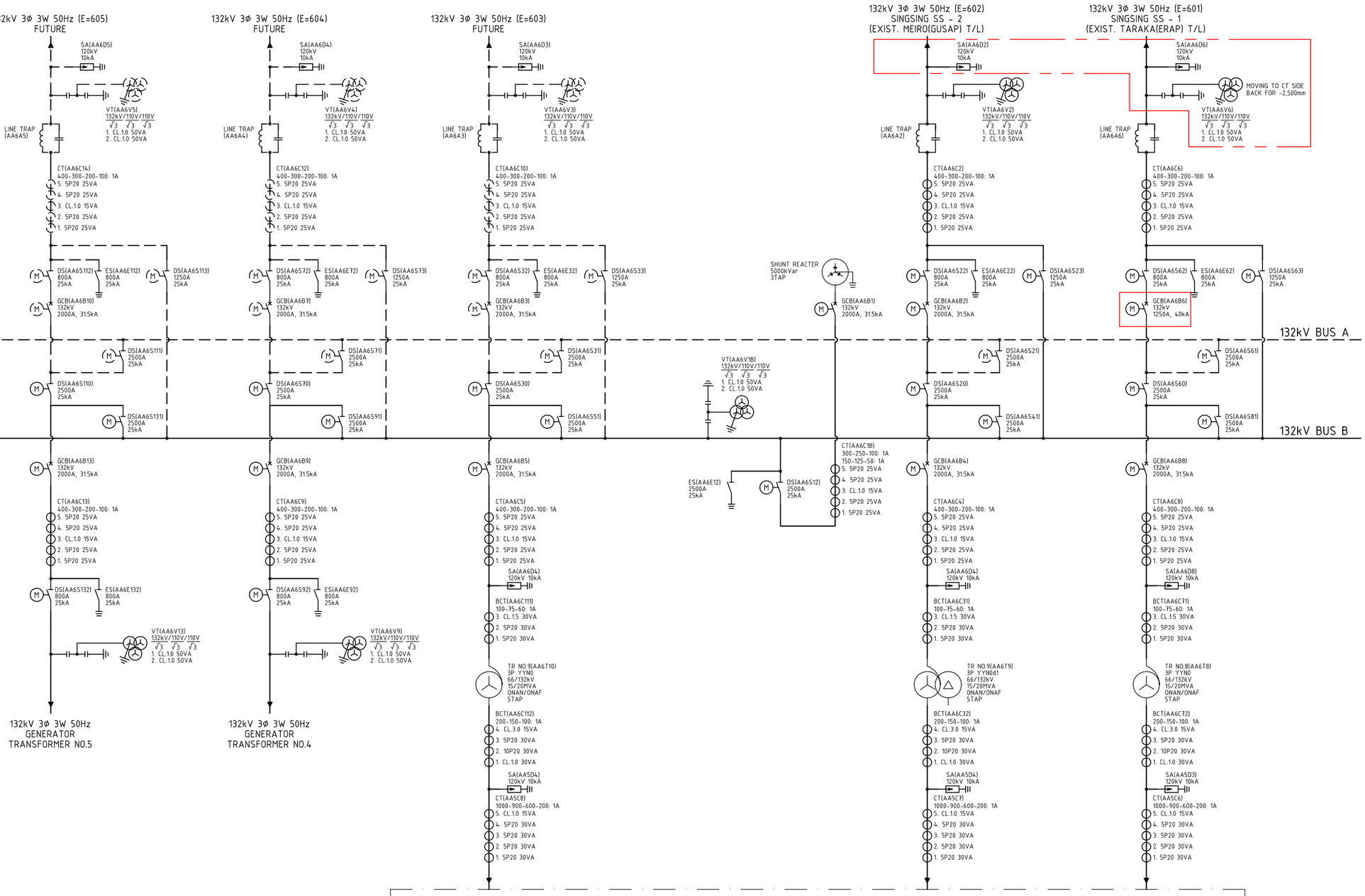
Max. catenary angle is 20° assuming 400 m span length and 90 m level difference.

tanθ＝WS/2T+h/S＝1.973*400/2*2,763+90/400＝0.368　θ＝20°

W = Unit weight of conductor
(1.973 kg/m)
S = Span length (400 m)
T = Conductor tension at max.
temperture of 75°C(2,763 kgf)
h = Level difference (90 m)

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_TL_TWR_002			
DRAWING TITLE: 132KV TOWER TYPE (SINGLE CIRCUIT)			
PREPARED BY: MR. MORI	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY 2012



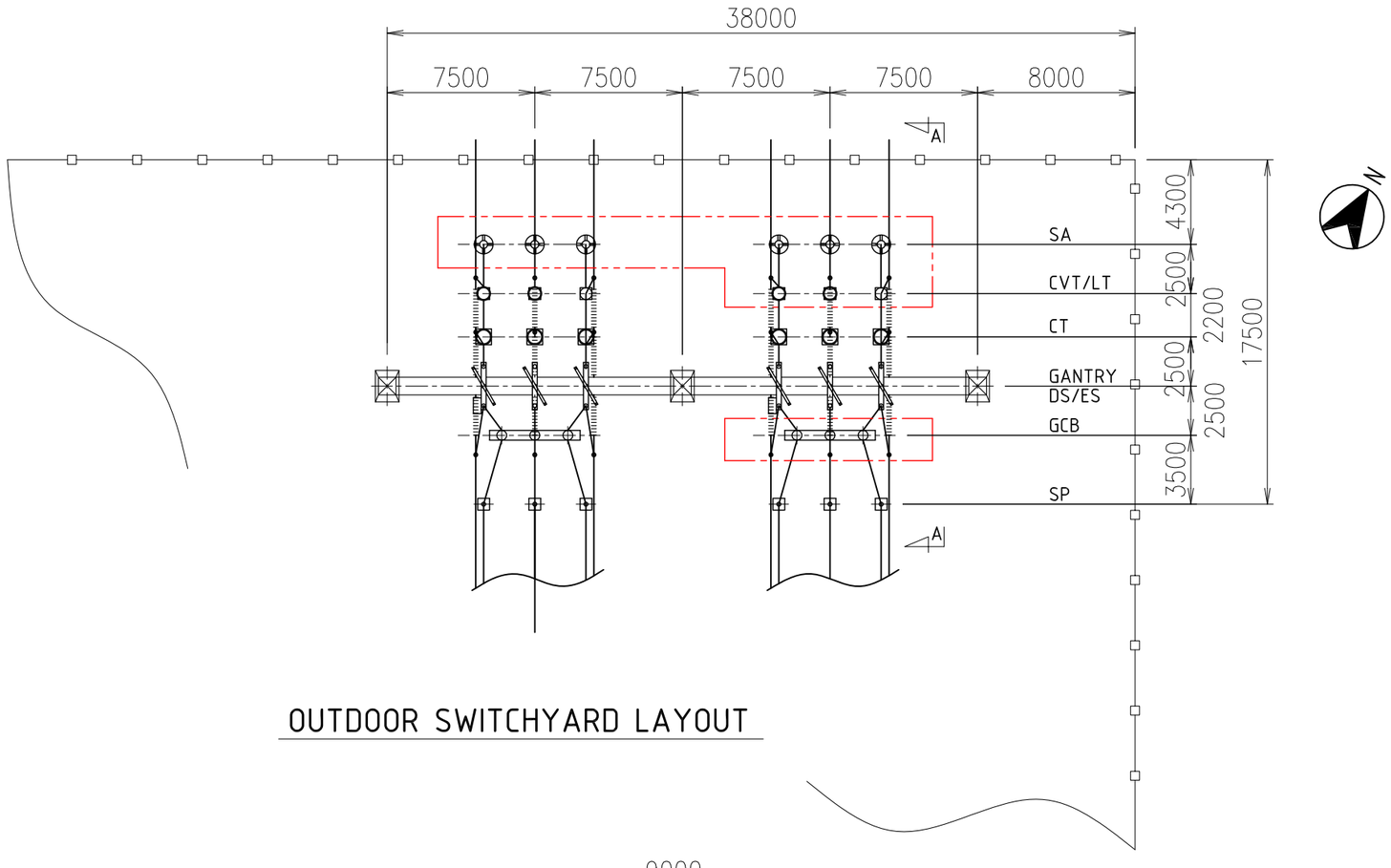
NOTE:

: UNDER THE PROJECT SCOPE

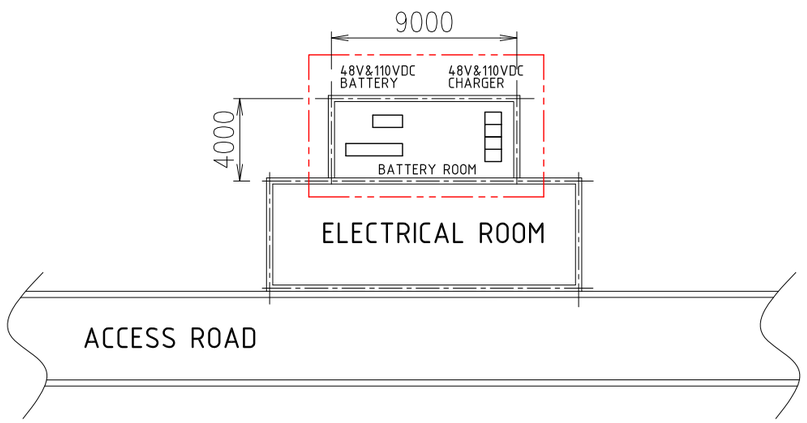
: PLANNED

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_RM1_001			
DRAWING TITLE: SINGLE LINE DIAGRAM: 132 kV RAMU 1 SWITCHYARD			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



OUTDOOR SWITCHYARD LAYOUT



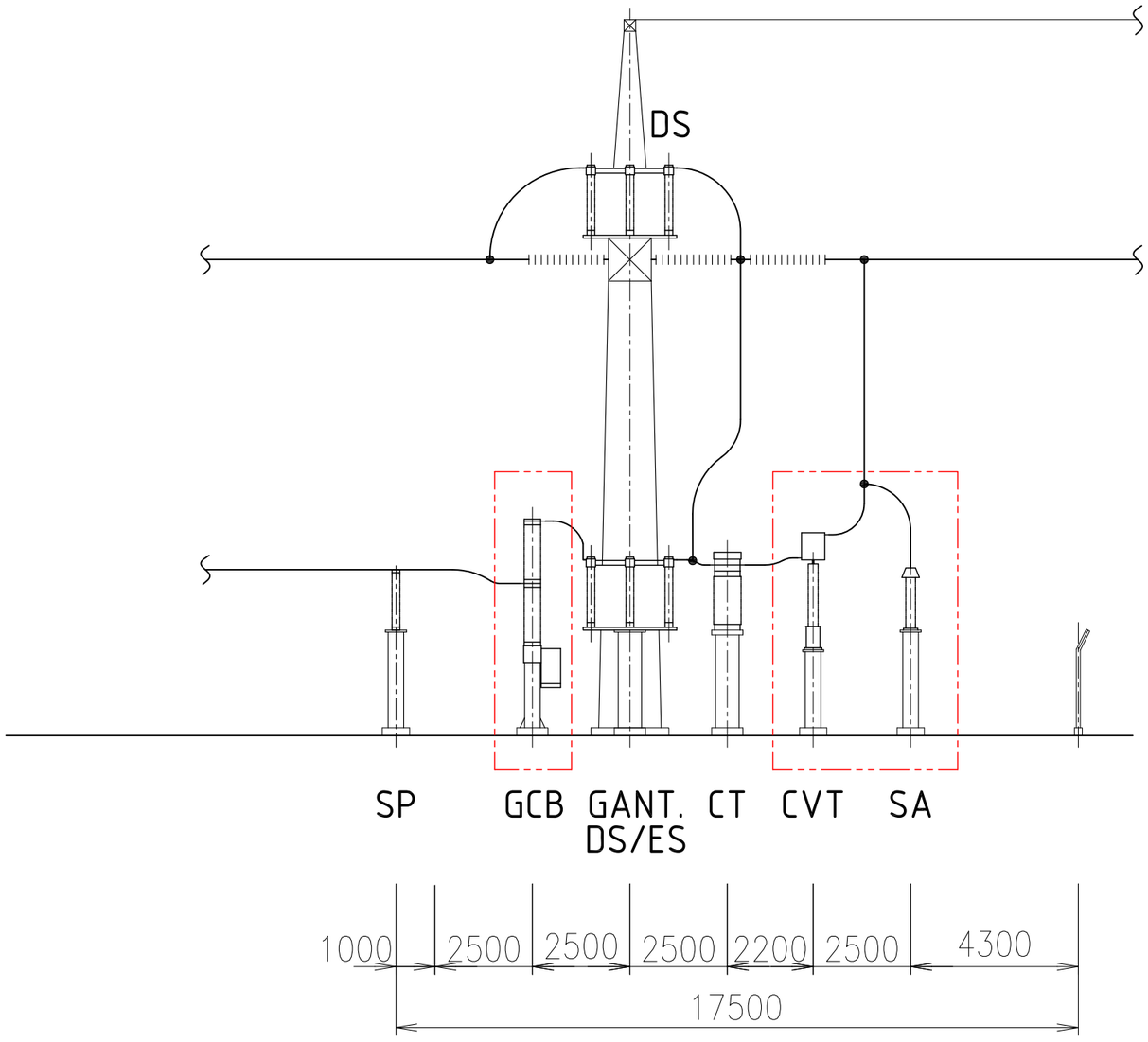
CONTROL BUILDING LAYOUT

NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_RM1_002			
DRAWING TITLE: LAYOUT DRAWING: 132 kV RAMU 1 SWITCHYARD			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

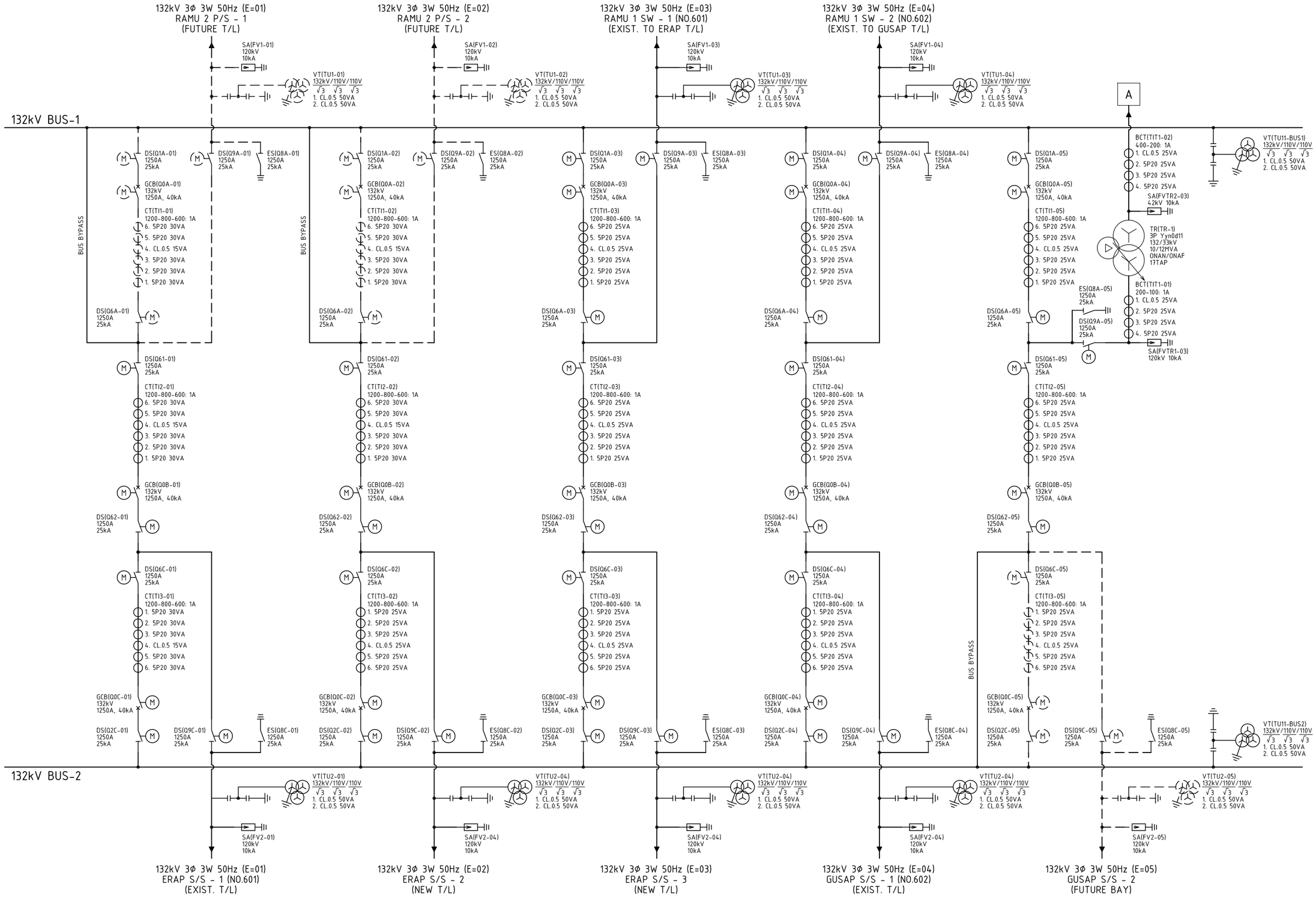


NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_RM1_003			
DRAWING TITLE: SECTION DRAWING: 132 kV RAMU 1 SWITCHYARD			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

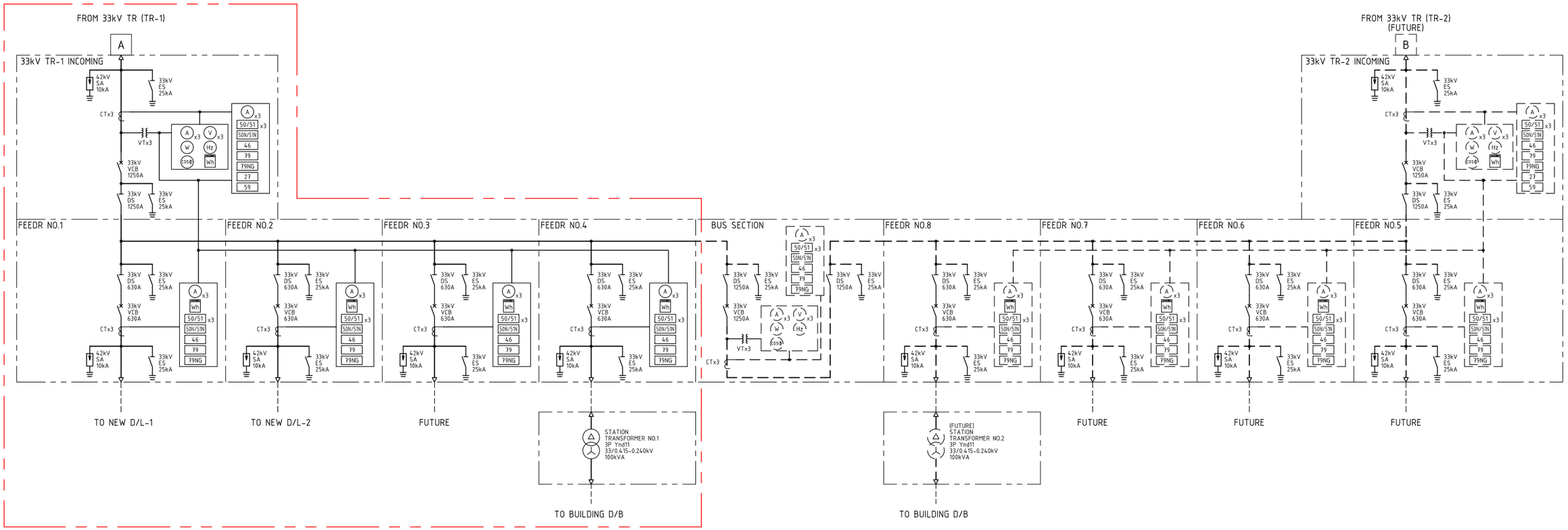


NOTE:

- - - - - - : PLANNED

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_SIS_001			
DRAWING TITLE: SINGLE LINE DIAGRAM: 132 kV SYSTEM OF SINGSING SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



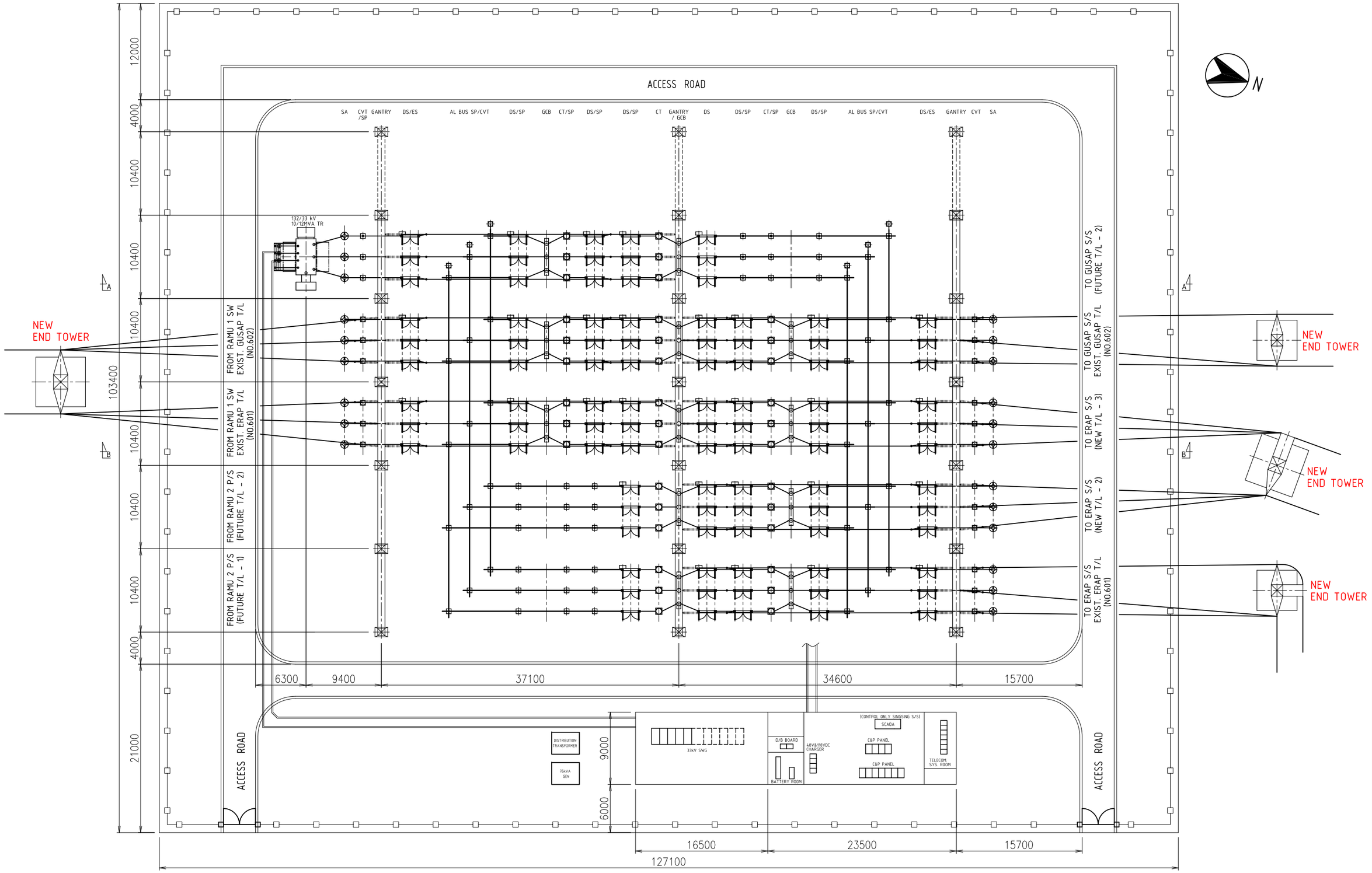
NOTE:

: UNDER THE PROJECT SCOPE

——————: PLANNED

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_SIS_002			
DRAWING TITLE: SINGLE LINE DIAGRAM: 33 kV SYSTEM OF SINGSING SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_SIS_003			
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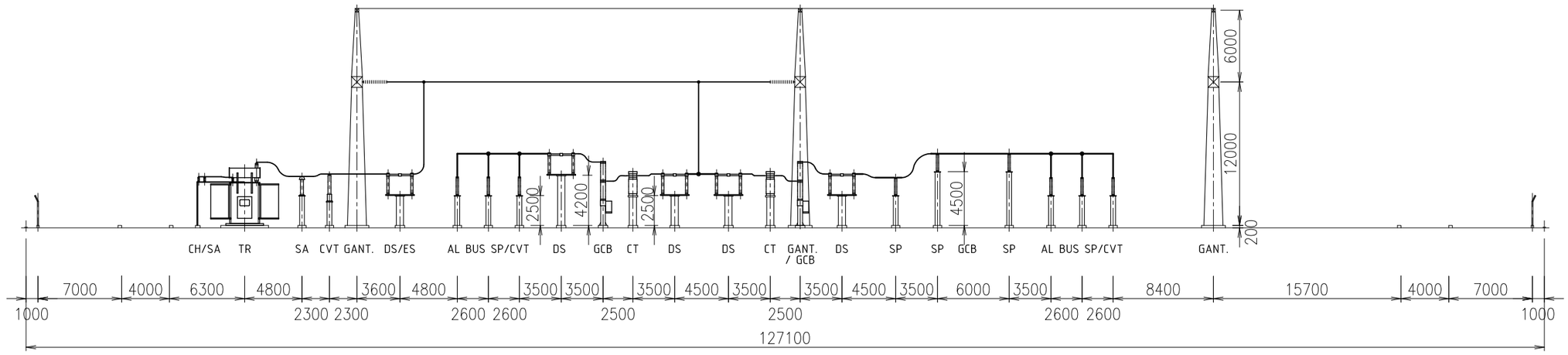
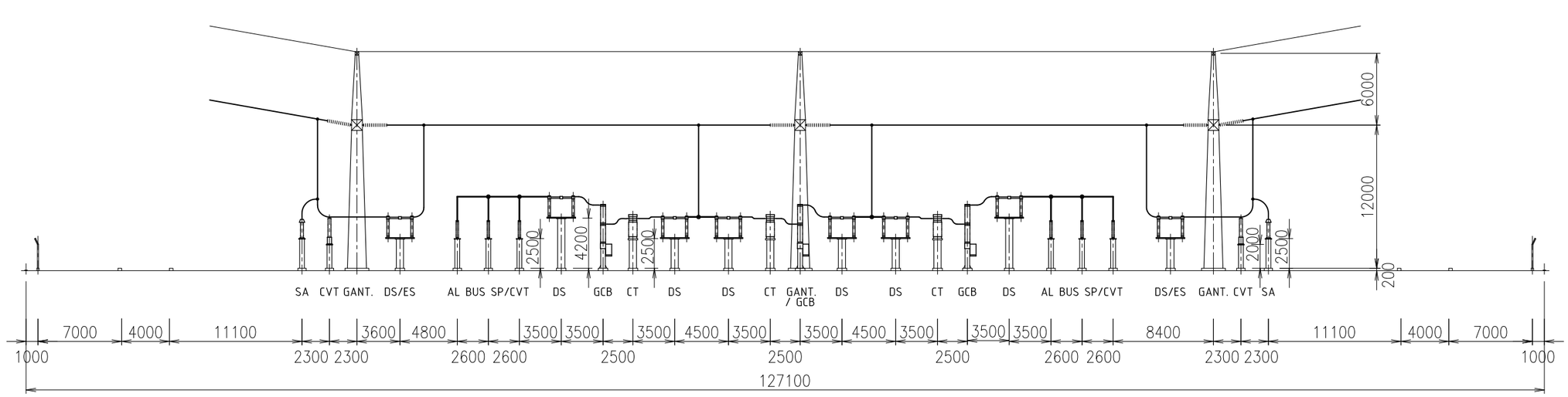
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



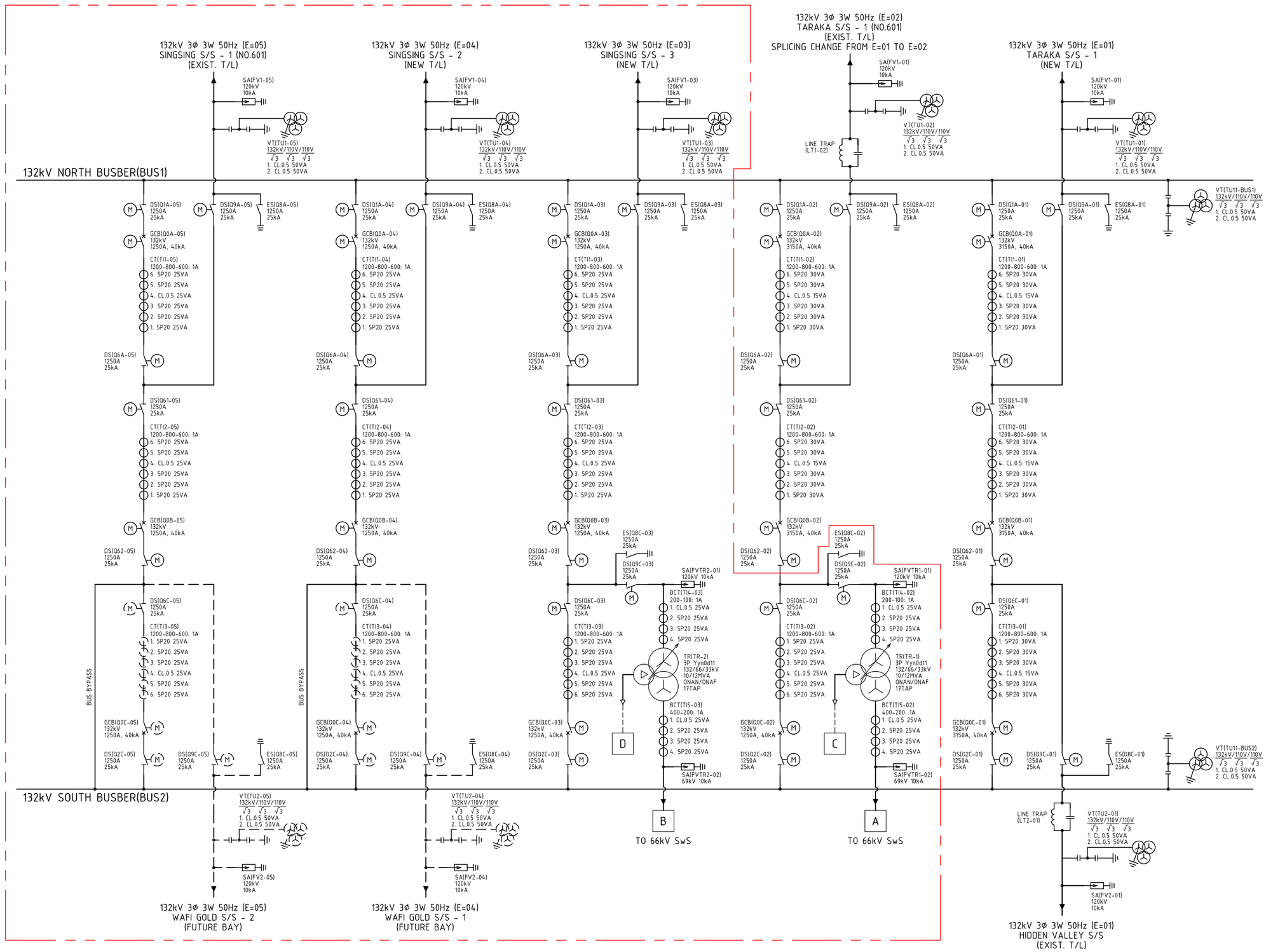
SECTION A - A



SECTION B - B

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_SIS_004			
DRAWING TITLE: SECTION DRAWING: SINGSING SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



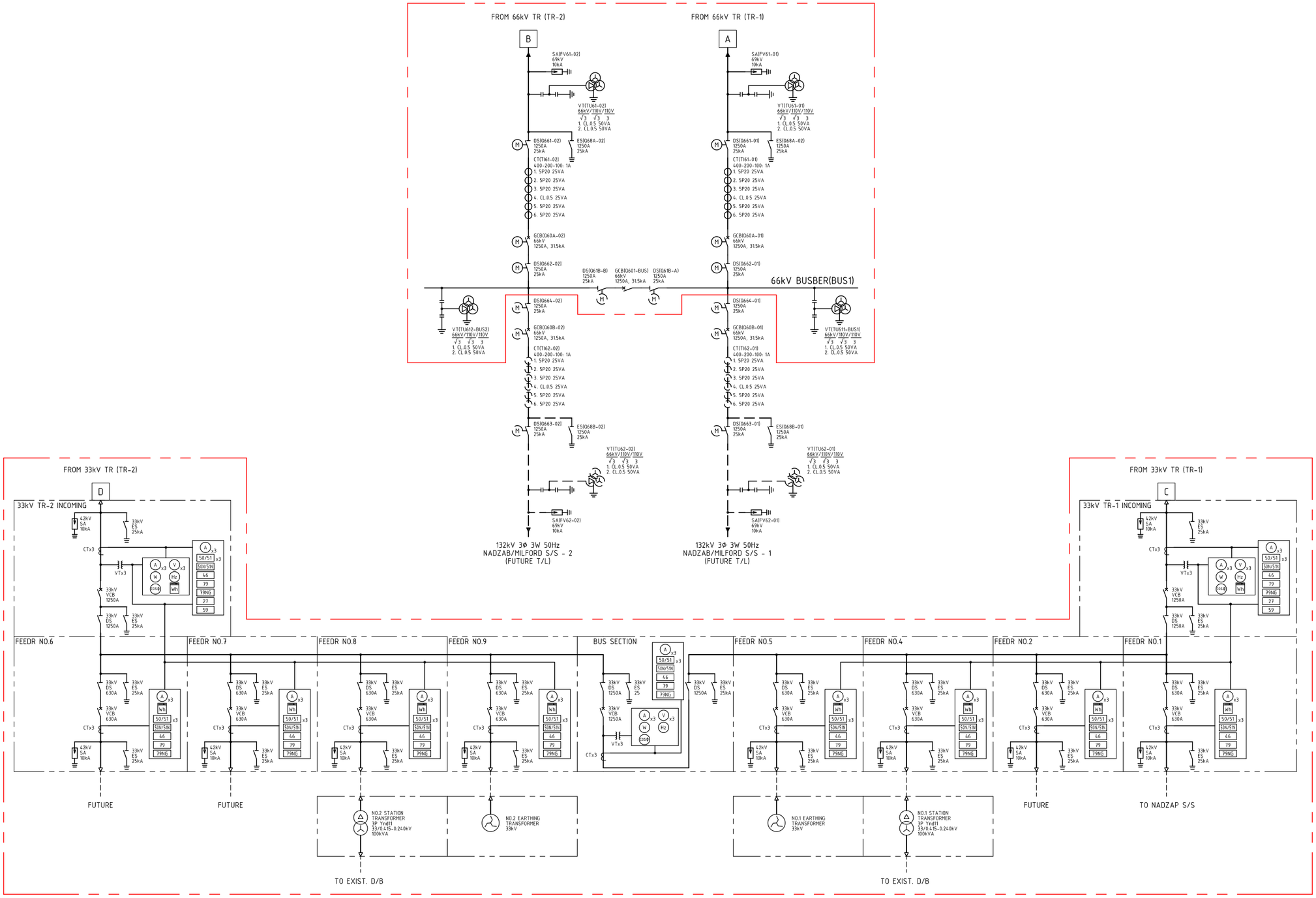
NOTE:

: UNDER THE PROJECT SCOPE

: PLANNED

REFERENCE ONLY

DRAWING NUMBER:	DWG NO. PNG_SS_ERP_001		
DRAWING TITLE:	SINGLE LINE DIAGRAM: 132 kV SYSTEM OF ERAP SUBSTATION		
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO: DATE: FEBRUARY. 2012



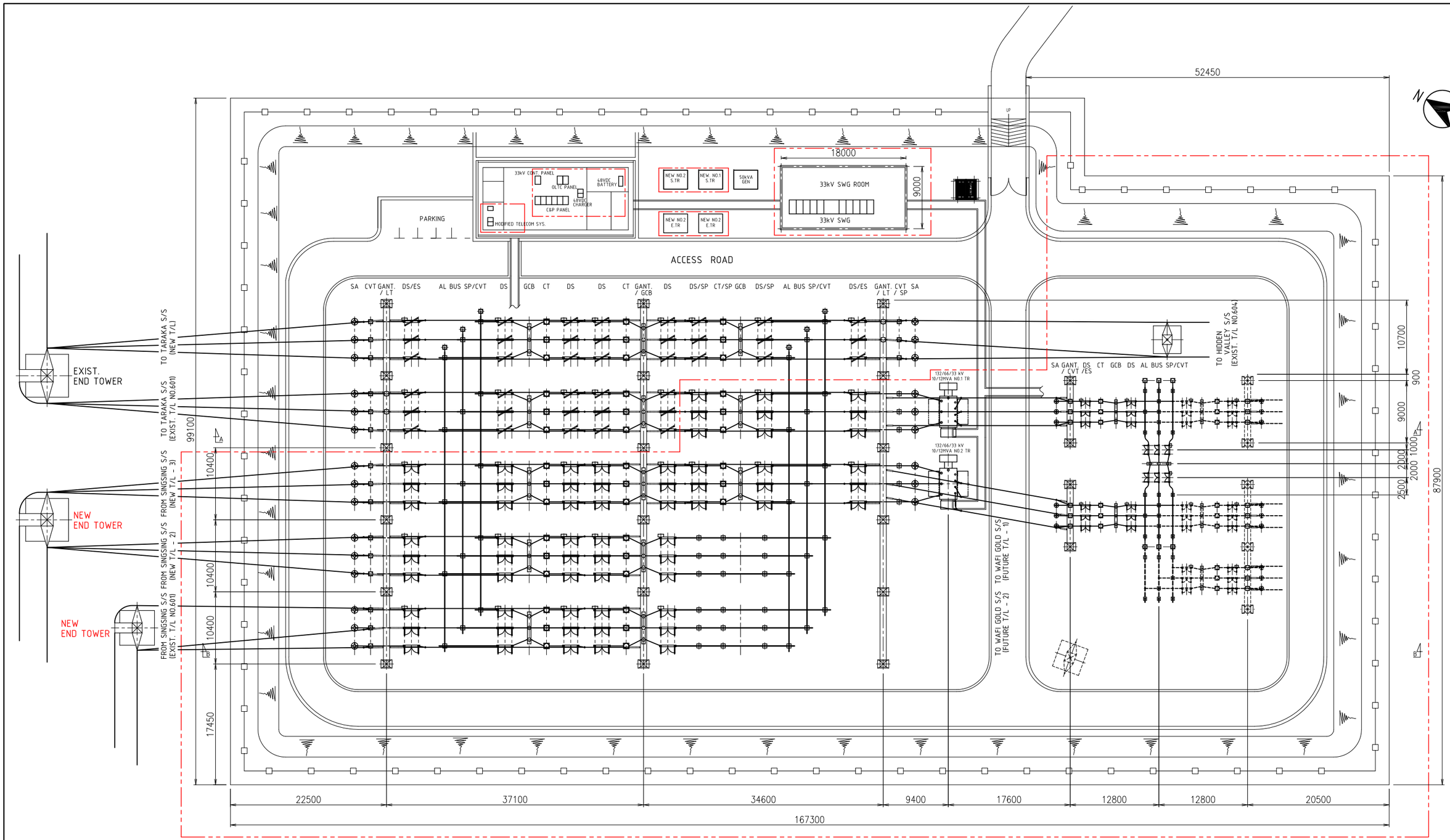
NOTE:

: UNDER THE PROJECT SCOPE

: PLANNED

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_ERP_002			
DRAWING TITLE: SINGLE LINE DIAGRAM: 66 kV & 33kV SYSTEM OF ERAP SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



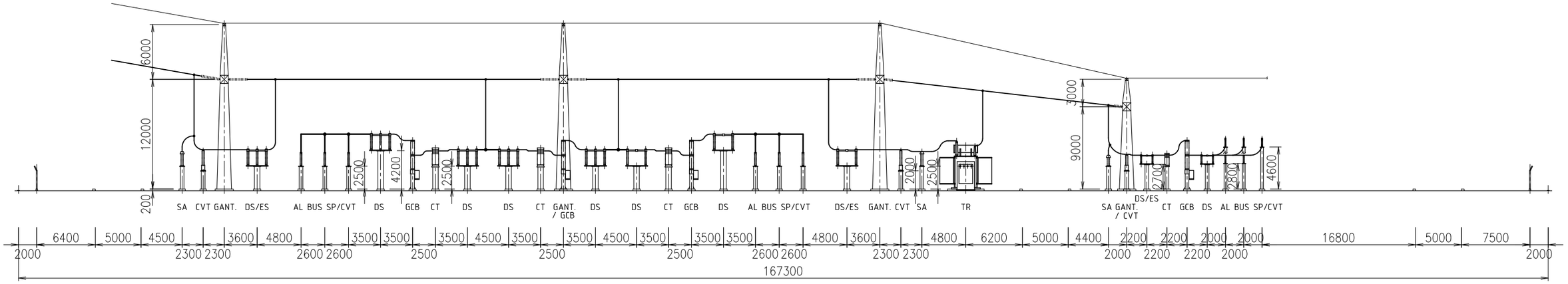
NOTE:

: UNDER THE PROJECT SCOPE

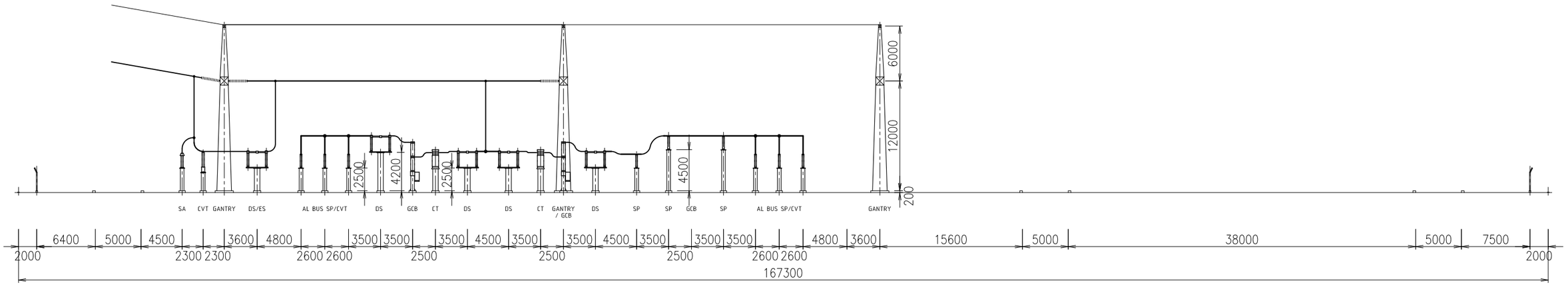
: PPL'S SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_ERP_003			
DRAWING TITLE: LAYOUT DRAWING: ERAP SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



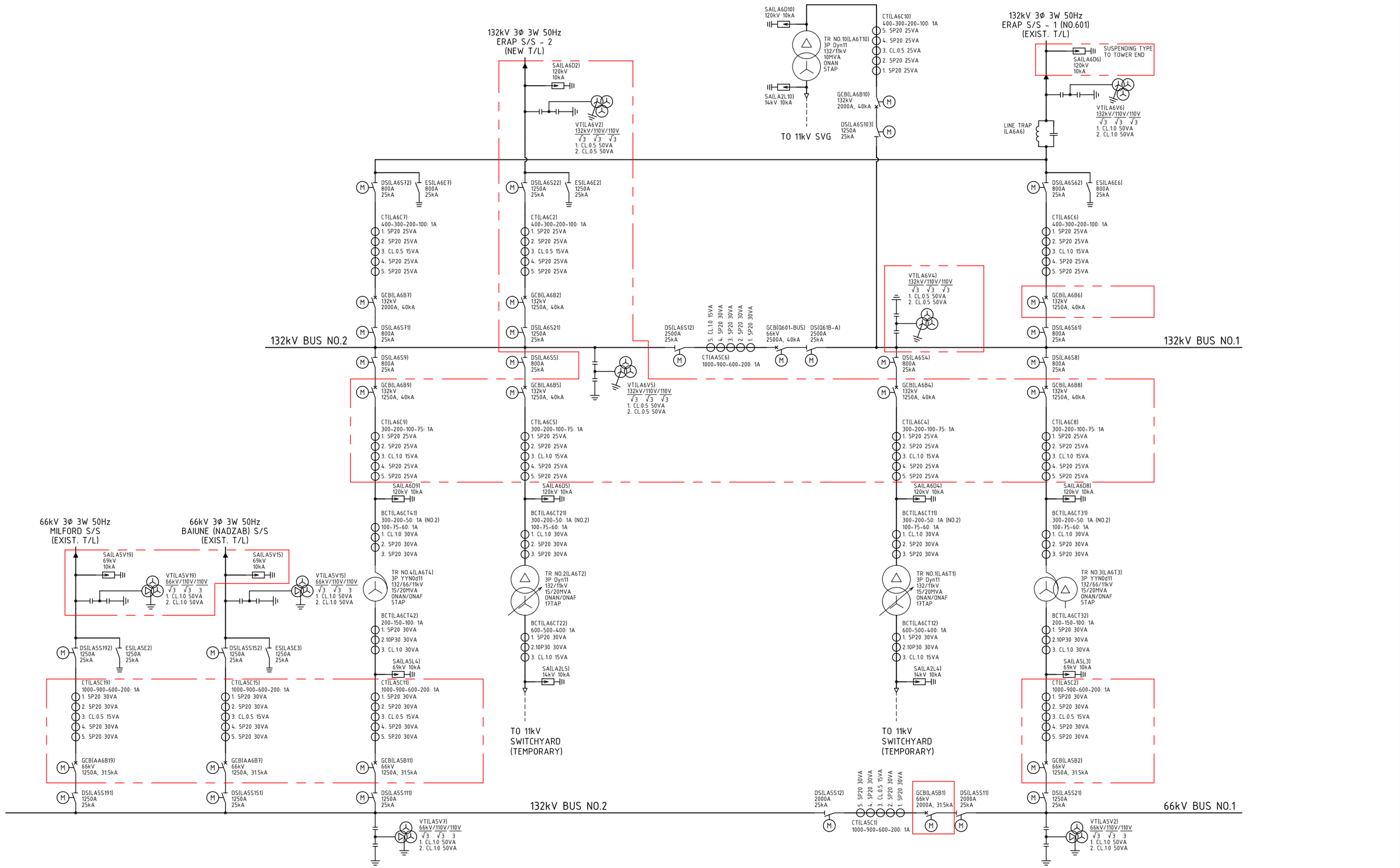
SECTION A - A



SECTION B - B

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_ERP_004			
DRAWING TITLE: SECTION DRAWING: ERAP SUBSTATION			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

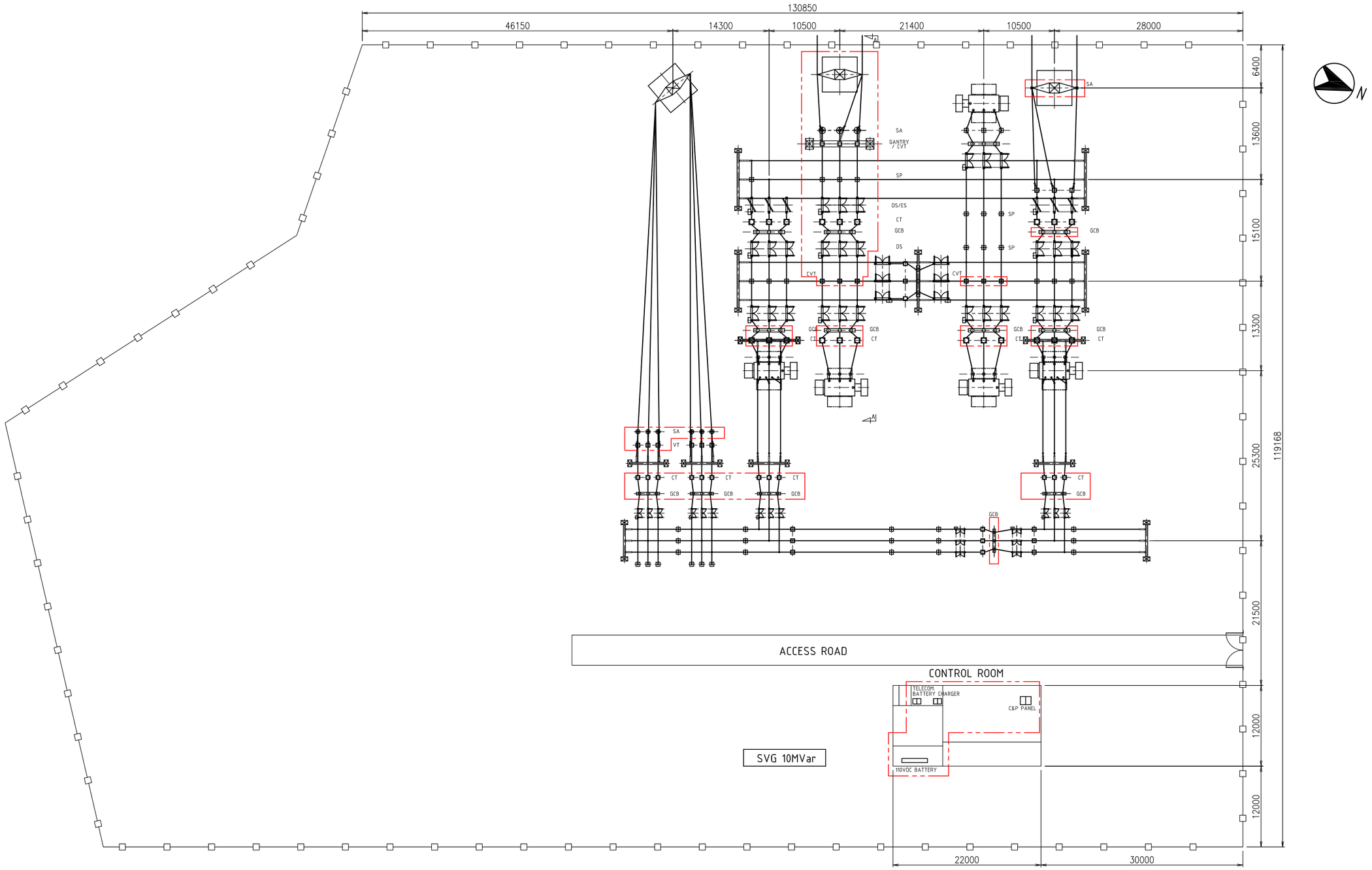


NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_001a			
DRAWING TITLE: SINGLE LINE DIAGRAM: TARAKA SUBSTATION (PLAN - A)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012

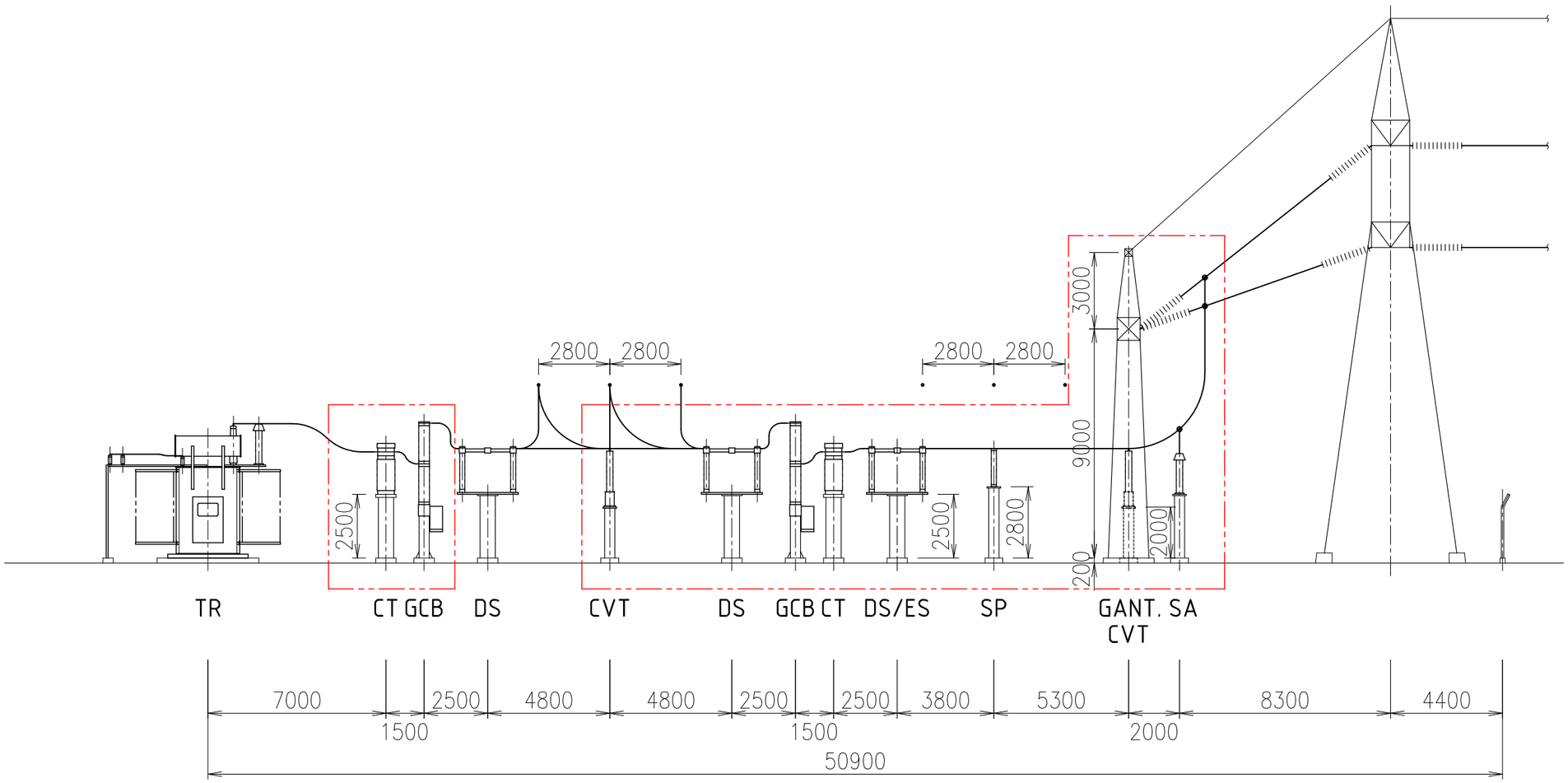


NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_002a			
DRAWING TITLE: LAYOUT DRAWING: TARAKA SUBSTATION (PLAN - A)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



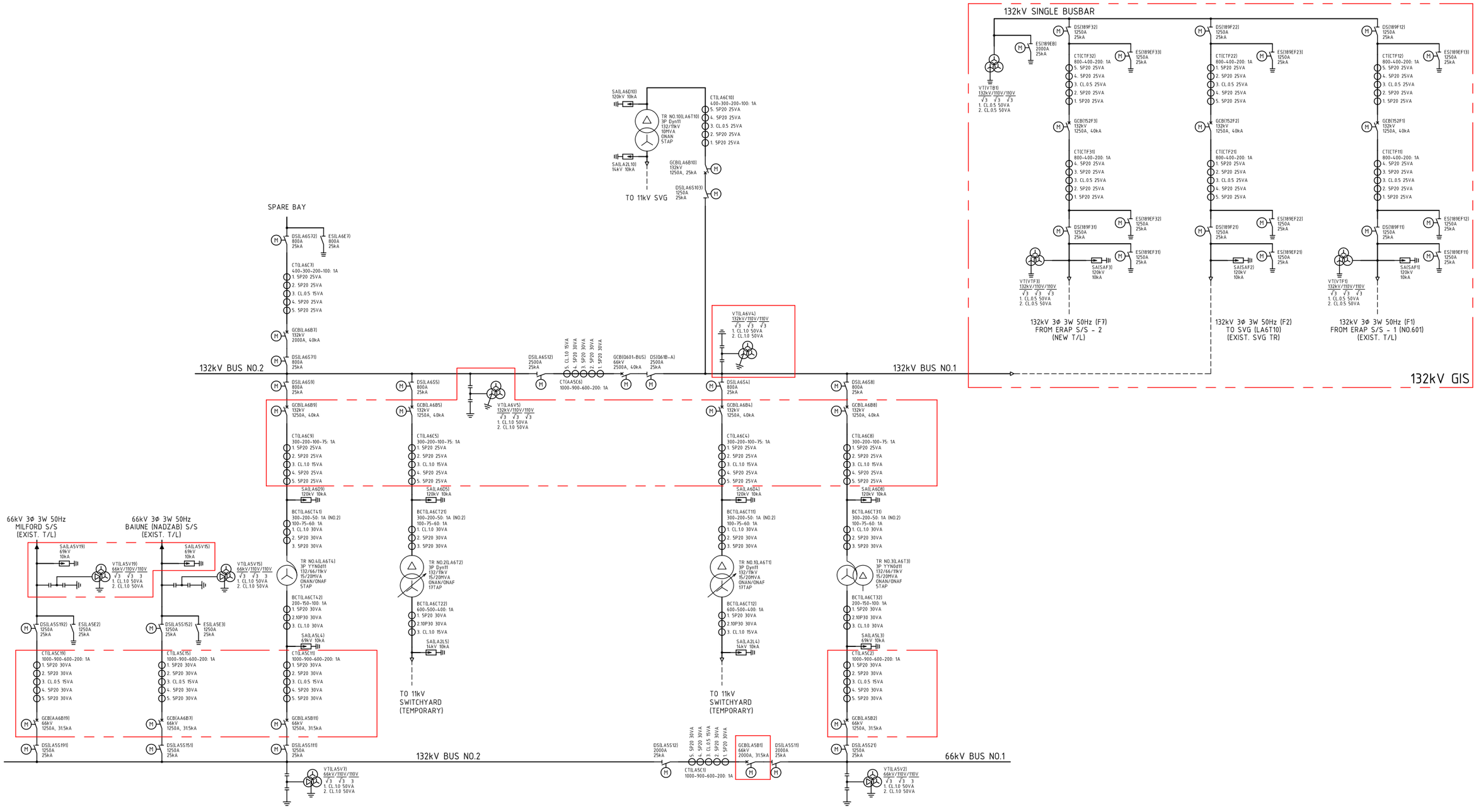
SECTION A - A

NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_003a			
DRAWING TITLE: SECTION DRAWING: TARAKA SUBSTATION (PLAN - A)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

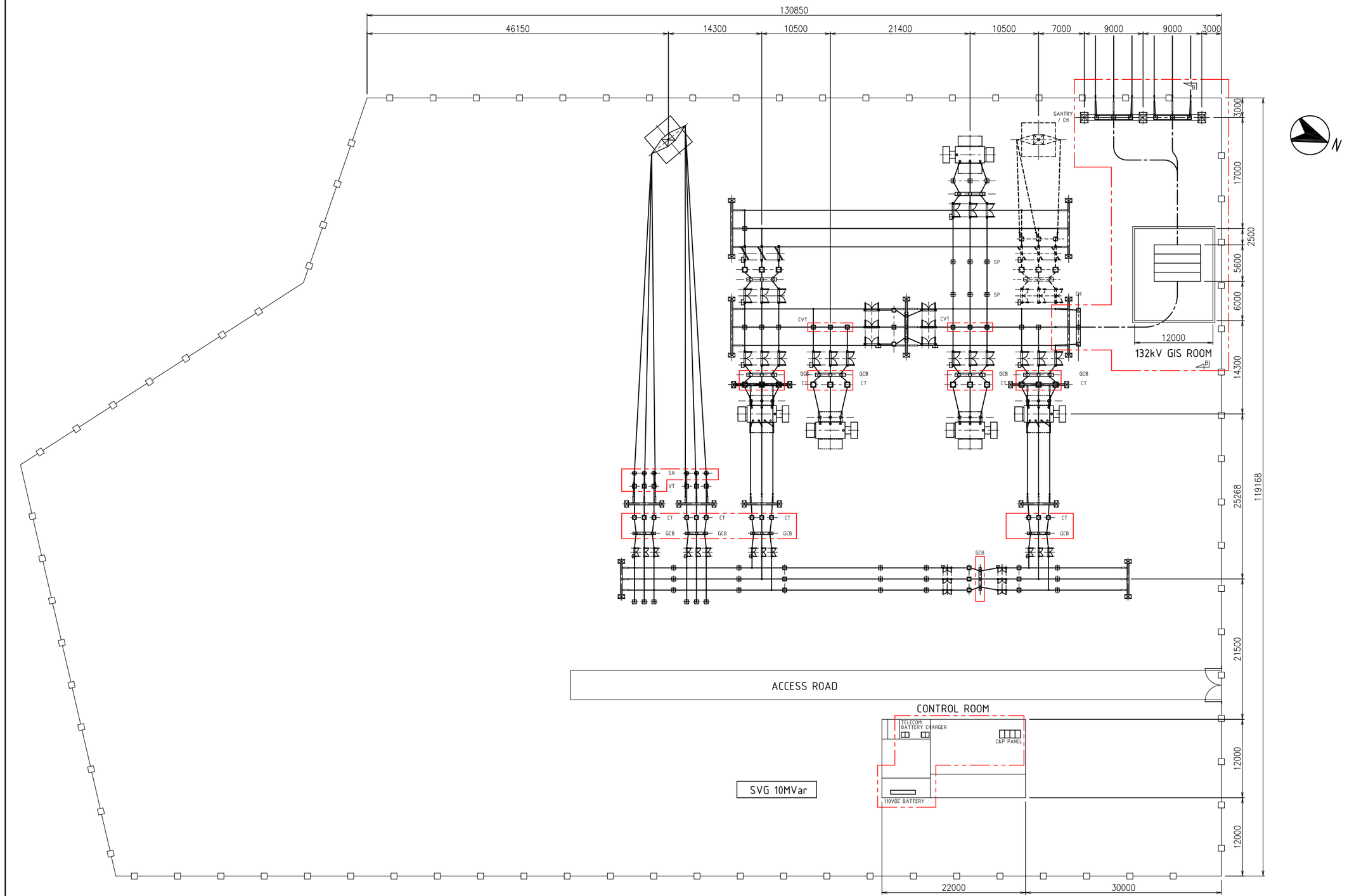


NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_001b			
DRAWING TITLE: SINGLE LINE DIAGRAM: TARAKA SUBSTATION (PLAN - B)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



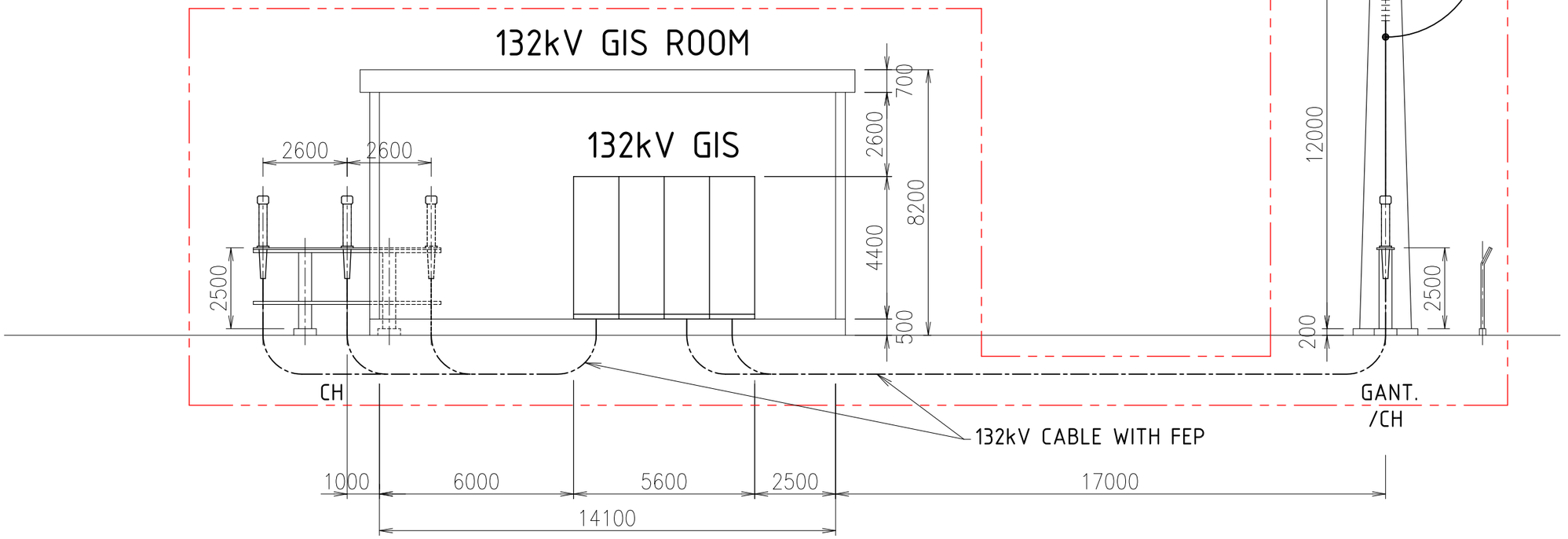
NOTE:

: UNDER THE PROJECT SCOPE

---------- : TO BE REMOVED BY PPL (OUT OF THE PROJECT SCOPE)

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_002b			
DRAWING TITLE: LAYOUT DRAWING: TARAKA SUBSTATION (PLAN - B)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



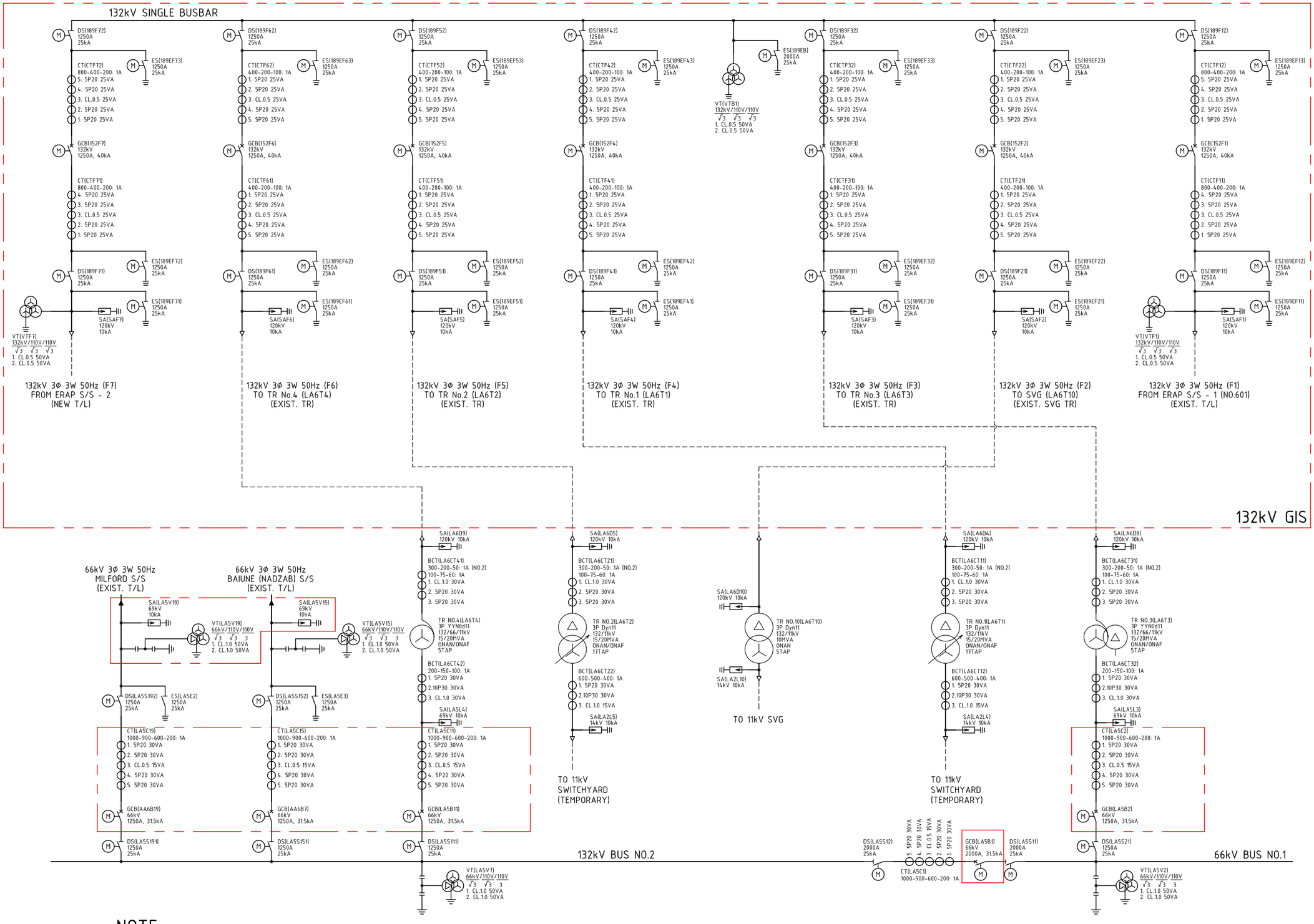
SECTION B - B

NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_003b			
DRAWING TITLE: SECTION DRAWING: TARAKA SUBSTATION (PLAN - B)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

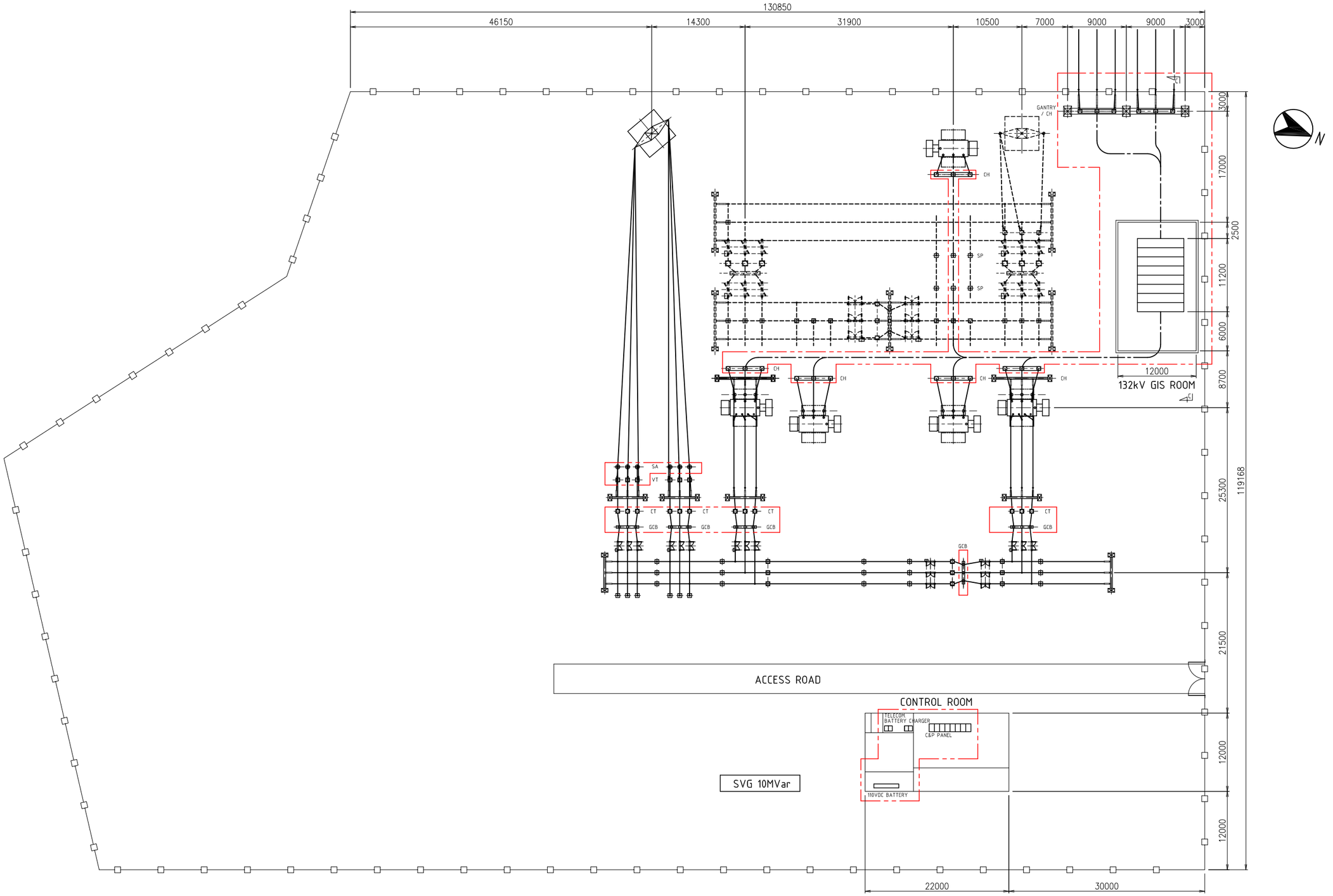


NOTE:

: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_001c			
DRAWING TITLE: SINGLE LINE DIAGRAM: TARAKA SUBSTATION (PLAN - C)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



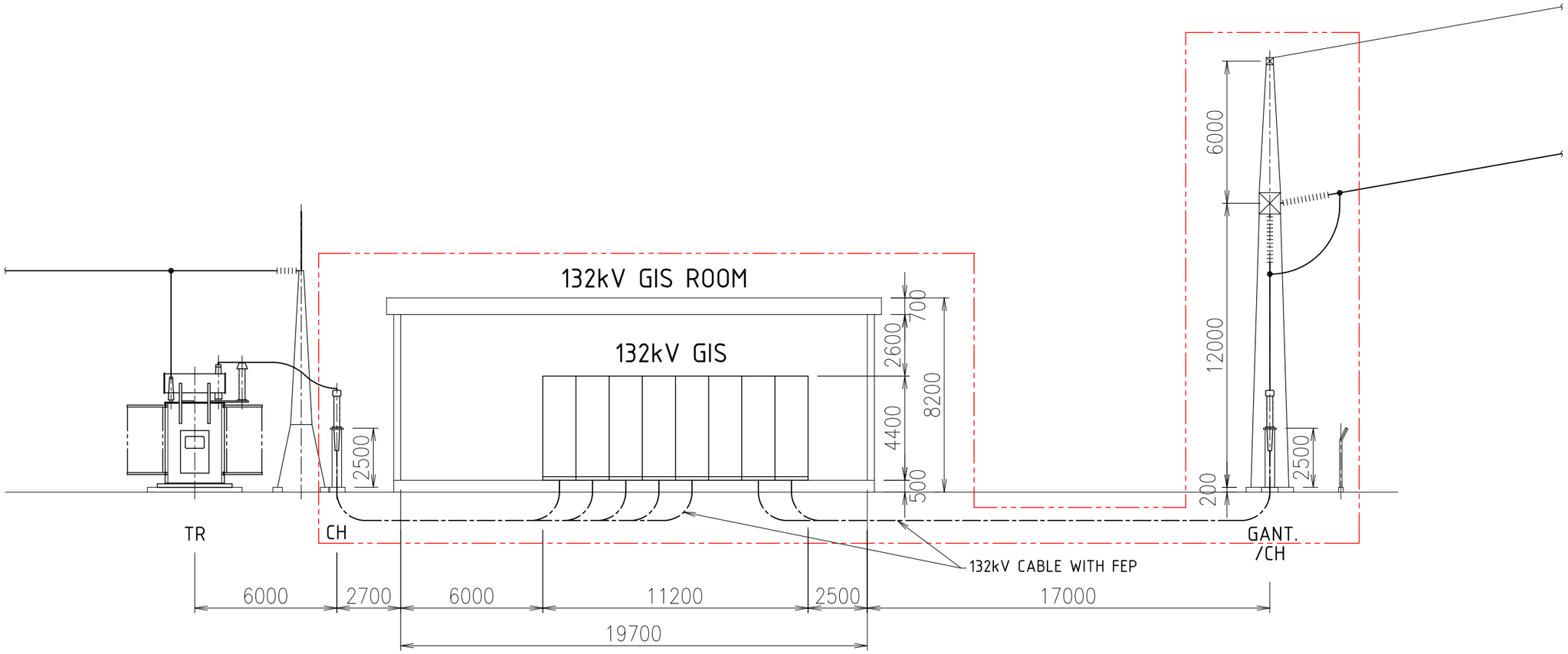
NOTE:

: UNDER THE PROJECT SCOPE

---------- : TO BE REMOVED BY PPL (OUT OF THE PROJECT SCOPE)

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_002c			
DRAWING TITLE: LAYOUT DRAWING: TARAKA SUBSTATION (PLAN - C)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: FEBRUARY. 2012



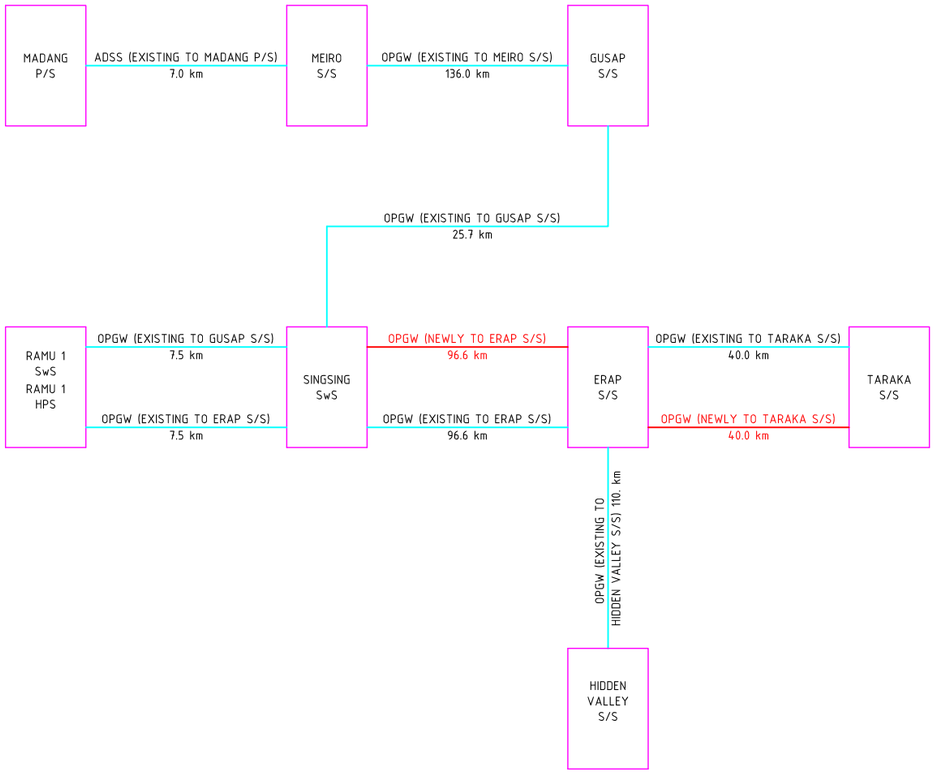
SECTION C - C

NOTE:

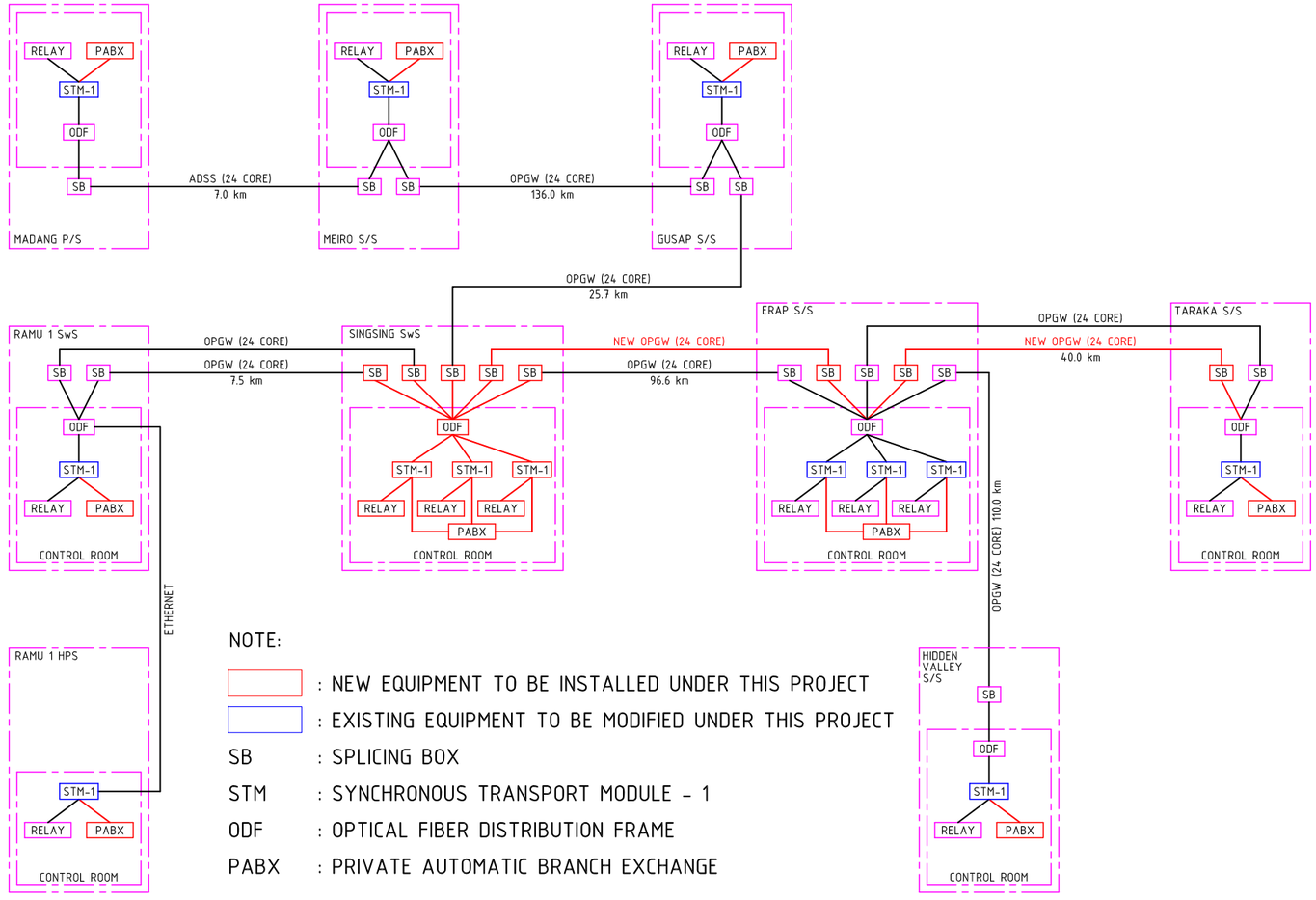
: UNDER THE PROJECT SCOPE

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_TRK_003c			
DRAWING TITLE: SECTION DRAWING: TARAKA SUBSTATION (PLAN - C)			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012



COMMUNICATION NETWORK DIAGRAM



NOTE:

	: NEW EQUIPMENT TO BE INSTALLED UNDER THIS PROJECT
	: EXISTING EQUIPMENT TO BE MODIFIED UNDER THIS PROJECT
SB	: SPLICING BOX
STM	: SYNCHRONOUS TRANSPORT MODULE - 1
ODF	: OPTICAL FIBER DISTRIBUTION FRAME
PABX	: PRIVATE AUTOMATIC BRANCH EXCHANGE

OPTICAL FIBER COMMUNICATION SYSTEM

REFERENCE ONLY

DRAWING NUMBER: DWG NO. PNG_SS_COM_001			
DRAWING TITLE: TELECOMMUNICATION SYSTEM			
PREPARED BY: MR. KOREZAWA	CHECKED BY: MR. MORITA	APPROVED BY: MR. FUKUNAGA	SHEET NO:
			DATE: JANUARY. 2012

ATTACHMENT-4 ENVIRONMENTAL SOCIAL CONSIDERATIONS

Attachment 4-1 Monitoring Form

Attachment 4-2 Environmental Checklist

Attachment 4-3 Minutes of Stakeholder Meetings

MONITORING FORM (Environment)

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

１．Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
ex.) Responses/Actions to Comments and Guidance from Government Authorities	

２．Mitigation Measures

- Air Quality（Emission Gas / Ambient Air Quality）

Item	Unit	Measured Value（Mean）	Measured Value（Max.）	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
SO_2						
NO_2						
CO						
O_3						
Soot and dust						
SPM						
Dust						

- Water Quality（Effluent/Wastewater/Ambient Water Quality）

Item	Unit	Measured Value（Mean）	Measured Value（Max.）	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS（Suspended Solid）						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
Heavy Metals						
Hydrocarbons / Mineral Oils						
Phenols						
Cyanide						
Temperature						

- Waste

Monitoring Item	Monitoring Results during Report Period

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level						
Vibration level						

- Odor

Monitoring Item	Monitoring Results during Report Period

３． Natural Environment

- Ecosystem

Monitoring Item	Monitoring Results during Report Period
ex.) Negative effects/Actions to Valuable species	

４． Social Environment

- Resettlement

Monitoring Item	Monitoring Results during Report Period

- Living / Livelihood

Monitoring Item	Monitoring Results during Report Period

MONITORING FORM (Land)

Land Acquisition for Erap			
Monitoring Activities	Monitoring Items	Result	Expected Date of Completion
Negotiation with landowner	Date of final negotiation		
	Size of land acquisition agreed	(ha)	
	Final price of land agreed	(kina)	
DLPP approval	Date of submission of Land Investigation Report		
	Date of approval by DLPP		
Completion of land acuisition	Date of payment		
	Amount of payment	(kina)	

Access Agreement for Transmission Line								
Monitoring Activities	Planned total	Unit	Progress in Quality			Progress in %		Expected Date of Completion
			During the Half-year period	Till the Last Half-year Period	Up to the Half-year Period	Till the Last Half-year Period	Up to the Half-year Period	
Access Agreement for Tower Sites "Deed of Release for Transmission Line Tower Sites"								
Progress of Access Agreement signing (Deed of Release for Transmission Line Tower Sites)		No. of towers						
* Land for eash tower site is ( ) square metres								
Progress of payment for Access Agreement (Deed of Release for Transmission Line Tower Sites)		No. of towers						
Amount of payment for tower sites		Kina				-	-	-
* Agreed amount for each tower site is ( ) square metres								

Access Agreement for Easement "Agreement to Regulate Entry and Access to Easement for Transmission Line Construction and Maintenance"								
Progress of Access Agreement signing (Agreement to Regulate Entry and Access to Easement for Transmission Line Construction and Maintenance)		meters (length)						
* Width of easement is ( ) metres								
Progress of payment for Compensation		No. of agreements						
Amount of payment for compensation	-	Kina				-	-	-

Attachment 4-2 Environmental Checklist: 6. Power Transmission and Distribution Lines（1）

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process?	(a) N	(a) The project has not been categorized by DEC as yet to determine the level of activity and hence the type and form of submission. If the project is officially categorized level 2B EIA report will not be required but an EPA (environment permit application) report will be required and submitted instead.
		(b) Have EIA reports been approved by authorities of the host country's government?	(b) N	(b) Notification for Environmental Permits was submitted to DEC on 5 January 2012 for its endoresement. PPL is preparing the environment permit application to be submitted by the end of January 2012.
		(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	(c) N	(c) No EIA has been submitted pending endorsement of the submitted Notificationand advise from DEC and no approvals have been given as yet
		(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(d) N	(d) No additional approval is needed.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders?	(a) Y	(a) Stakeholder meetings were held two times during the survey. Necessary explanations were given to the local stakeholders and shared opinions.
		(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(b) Y	(b) Comments from the stakeholders were reflected to the project design and the instration of transformers will be included in the project.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Examined
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) N	(a) N/A
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) N/A
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	(a) N	(a) N/A
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	(b) N	(b) N/A
		(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	(c) N	(c) N/A
		(d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock?	(d) N	(d) N/A
		(e) Is there any possibility that the project will cause the negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered?	(e) N	(e) N/A
		(f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	(f) N	(f) N/A
	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed?	(a) Y	(a)The route will be set to avoid the areas of vulnerability to slope failures and landslides.
		(b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides?	(b) Y	(b)Necessary adequate measures will be considered.
		(c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(c) Y	(c)Necessary adequate measures will be considered.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	(a) N	(a) The transmission line route was selected to avoid any involuntary resettlement. Any resettlement will be discussed with affected persons and in accordance with resettlement plan prior to effecting it.
		(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?	(b) Y	(b) The compensation plan was announced to affected people through stakeholder meetings during the feasibility study stage.
		(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	(c) Y	(c) The price of land to be acquired will be settled through negotiation and it will have to be fully agreed to by landowners prior to land acquisition or alienation.
		(d) Are the compensations going to be paid prior to the resettlement?	(d) N	(d) In consideration of traditions and customs of PNG, the amount of damage and compensation will be determined at the land clearing. The payment will be made afterward.
		(e) Are the compensation policies prepared in document?	(e) Y	(e) "Land Acquisition and Compensation Policy on the Project" was prepared
		(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	(f) Y	(f) Particular attention must be paid to the needs of the vulnerable groups on the project.
		(g) Are agreements with the affected people obtained prior to resettlement?	(g) Y	(g) Agreements will be obtained from the affected people prior to construction work.
		(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	(h) Y	(h) Institutional implementation framework has been established.
		(i) Are any plans developed to monitor the impacts of resettlement?	(i) Y	(i) Monitoring plan has been made.
		(j) Is the grievance redress mechanism established?	(j) Y	(j) The grievance mechanisms has been established according to the Land Disputes Settlement Act 2000.
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) N	(a) The project will not have significant negative impact on the living conditions.
		(b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?	(b) N	(b) There is possibility of diseases infection such as HIV however,PPL and contractor will conduct appropriate awaraness raising programs or faciliies during the construction to prevent increase of the diseases.
		(c) Is there any possibility that installation of structures, such as power line towers will cause a radio interference? If any significant radio interference is anticipated, are adequate measures considered?	(c) N	(c) No concern over radio interfernce
		(d) Are the compensations for transmission wires given in accordance with the domestic law?	(d) Y	(d) The compensation will be made according to the Compensation Schedule for Trees and Plants published by the government.

Attachment 4-2 Environmental Checklist: 6. Power Transmission and Distribution Lines（2）

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) N/A
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) N/A
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N	(a) N/A (b) N/A
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) All PNG labor laws and ordinances relating to working conditions will be observed (b) Consideration is given by Environmental Permit Application procedure and the Contractor will be required to provide a plan for the safe handling and management of any dangerous and hazardous materials. (c) Consideration is given by Environmental Permit Application procedure. The Contractor will be required to provide adequate training for its staff on health and safety issues under PPL supervision. (d) Consideration is given by Environmental Permit Application procedure. Both PPL and the Contractor will devise guidelines for the conduct of its security guards.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) Consideration is given by Environmental Permit Application procedure. Impacts are minimized through monitoring by PPL and DEC (b) Consideration is given by Environmental Permit Application procedure. Mitigation measure will be procided by PPL and contractor . Through the measures impacts are expected to minimized. (c) Consideration is given by Environmental Permit Application procedure. Mitigation measures will be provided by PPL and the contractor. Through the measures impacts are expected to be minimized.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) Consideration is given through the Environmental Permit Application procedure. PPL will devise and implement an Environmental Monitoring Plan. (b) Appropriate. However, the items, methods and frequencies should be reviewed regularly according to the conditions of the project site. (c) Consideration is given through Environemtal Permit Application procedure. PPL will conduct monitoring system under the supervision of DEC. (d) Consideration is given through Environemtal Permit Application procedure. PPL will conduct monitoring system under the supervision of DEC.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) -	(a)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) -	(a)

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

JICA Survey Team - Stakeholder Meeting

Meeting Minute 1

Project:	Ramu-Lae Transmission Line Expansion and Rehabilitation Project	Meeting No.:	01
Date:	Friday 11th Nov 2011	Chairperson:	Kyoko Harada
Start / End Time:	14:57-15:34 (37 minutes)	No of Attendees:	9
Location:	Huon District Office, Lae City	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
1	Tony ABE	Huon Gulf District Office	District Administrator
2	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
3	Kyoko HARADA	JICA Survey Team	Consultant
4	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
5	Akiko NISHINOMIYA	JICA Survey Team	Consultant
6	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
7	Titus TSIGESE	PNG Power Limited	Environmental Officer
8	Charlotte VADA	Douglas Environmental Services	Research Officer
9	Cliff WEMBNONG	Wampar Local Level Government	Patrol Officer

2. Formalities

2.1 Acknowledgements to the Huon Gulf District Administrator and all present were made by Kyoko Harada. Introductions of attendees were made by Steven Kerowa.

2.2 The project was briefly described by Kyoko Harada who further stated that JICA was pleased to be involved in the PNG Power project as the donor agency. She also stressed it was important to the donor agency that the stakeholder's expressed ownership of and a willingness to cooperate for the project. She further mentioned that the purpose of the survey was for the team to create awareness of the project to the Land Owners, as well as receive their feedback including any issues o concerns they may have

2.3 The District Administrator acknowledged JICA's support to the PNG Government, stating that although the project was addressing a basic need to the communities, the PNG Government simply did not have the resources to fund it and that any opportunity to amend for this shortfall or 'gap' was very much appreciated. He urged the team that this message be relayed to the stakeholders during the upcoming meetings, and conveyed his apologies as he would not be able to attend the meetings due to prior engagements.

3. Demarcation of District Borders

3.1 The District Administrator pointed out that the project area would span three (3) Districts in the Morobe Province, Lae, Huon Gulf and Markham. He then clarified the demarcation of District Borders.

3.1.1 The Huon Gulf District is bordered by the Lae and Markham Districts and begins after *West Taraka (bridge)* to *Leron Bridge*.

3.1.2 The Lae District includes the city area of *Lae* from the coast to *West Taraka (bridge).*

3.1.3 The Markham District begins at *Leron* and ends at *Sing Sing Creek*.

3.2 The District Administrator stated that while his officers would do their best to help with the stakeholder meetings in neighbouring districts, their official authority was limited to Huon Gulf District and any dealings with bordering district should be done in direct consultation with the respective District officers.

4. Environment and Social Issues of Project

Kyoko Harada stated that while, anticipated environment issues of the project were not particularly significant, it's social issues however were complex and an area of particular interest to JICA (the donor) and in need therefore of clarification.

The District Administrator agreed that social issues were complex and made the following recommendations to the JICA Survey Team for carrying out stakeholder meetings:

- Allow the meetings to be facilitated by the District Administration Officers and Steven Kerowa (a Port Moresby based PNG Power employee who was raised in Lae) who have experience working with the communities of interest and are familiar with all the existing issues.
- Allow the District Administration Officers and Steven Kerowa to explain the project to the Land Owners rather than the JICA Consultants. This was to avoid any wrong perceptions or expectations of Land Owners who might misinterpret information presented to them in English. He stated that the most suitable language in which to engage the Land Owners was the local vernacular 'Tok Pisin' (PNG Pidgin).

5. District Statistics and Planning data

Kyoko Harada asked the District Administration officers if any social statistics (such as Population, No. of Households etc.) could be made available to them. Aaron Ambang replied that he would supply the latest PNG Census data from 2011 along with other District Office planning and data and related documents on Monday 14th November. An agreement was made for the data to be collected at the office by JICA Survey Team on Monday morning.

6. Income Generating Activities in Huon Gulf District

The District Administration officers listed the following income generating activities practiced by the local Huon Gulf District communities:

- Selling of Agricultural crops such as Cacao, Vanilla, Coffee
- Selling of cash crops (at market places) such as Peanut, Beetle nut, Taro, Yam, Corn, Potato, Leafy Vegetables, Coconut, Banana, etc.
- Selling of poultry and cattle to locals and local businesses
- Formal Employment

The officers also briefly mentioned the following commercial activates that take place in the District and its neighbouring districts:

- Manufacturing
- Commodities
- Mining
- Agriculture
- Services

7. Other Donor-Funded Projects in Huon Gulf District

When asked about the Huon Gulf District's experience with other donor-funded projects, the District Administrator mentioned that there had been over the years quite a few. He outlined the following examples of such projects:

- New Zealand AID – Briz-Kanda Project which is a rural enterprise development program. The ten year project is now in it's 5th year, worth K10 million.
- ADB – SSSPP and economic project; Lae Port Development
- JICA – Construction of Umi Bridge (in Markham District), an important link in the Highway that Joins Morobe to Madang and Eastern Highlands Provinces.

8. District Administrator's final remarks

8.1 The District Administrator advised the District Administration Officers to mention the following at the stakeholder's meetings:

- Point out that this was the initial stage of the project and that JICA is only going to fund the project and to do that they need to know that there is adequate support from all stakeholders, including and especially Land Owners
- Describe potential advantages and disadvantages of project
- Impact on quality of life for the Land Owners and other locals
- Power as a basic requirement for development
- Foreseeable environmental impacts of the project
- Foreseeable social impacts of the project
- How the project is vital to achieving the goals in the Huon Gulf District 5 Year Development Plan

8.2 The District Administrator then re-iterated the importance of conveying information with clarity and simplicity and encouraged team work. He further assured the team that Huon Gulf District had a long history of working with local communities and expressed confidence that the Land Owners would support the project.

9. Schedule for stakeholder meetings

Because of the delayed flight and arrival time of the consultants and officers from Port Moresby, Steven announced that he would spend the rest of the afternoon re-scheduling meetings as follows:

- Huon Gulf District Land Owners – to be rescheduled to Saturday 12th November at 9 AM in Zifasing
- Markham District Administration – to be reschedule to Saturday 12th November at noon in the Markham District Administration Office
- Markham District Land Owners – to be rescheduled to Saturday 12 November in the afternoon Markham District Administration Office

10. Summary of Meeting

Kyoko and Steven briefly summarized the meeting:

- Allow PNG officers to facilitate meetings in Tok Pisin
- Huon Gulf District communities familiar with PNG Power projects and other donor funded projects.
- Aaron to provide data and information to JICA Consultants on Monday
- Steven to reschedule previously planned meetings

11. Meeting Close

JICA Survey Team - Stakeholder Meeting

Meeting Minute 2

Project:	Ramu-Lae Transmission Line Expansion and Rehabilitation Project	Meeting No.:	02
Date:	Saturday 12th Nov 2011	Chairperson:	Councilor Wayah Langim
Start / End Time:	10:30-11:59 (89 minutes)	No of Attendees:	20 + others
Location:	Zifasing, Wampar LLG	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
Survey Team			
1	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
2	Kyoko HARADA	JICA Survey Team	Consultant
3	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
4	Akiko NISHINOMIYA	JICA Survey Team	Consultant
5	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
6	Titus TSIGESE	PNG Power Limited	Environmental Officer
7	Charlotte VADA	Douglas Environmental Services	Research Officer
8	Charlie WINTAWA	Douglas Environmental Services	Senior Consultant - Social Scientist
Huon Gulf District Land Owners /Clan Leaders			
9	Chechep AUGUSTINE	Zifasing Village	Chuaif Clan Leader
10	Steven EFRON	Zifasing Village	Chuaif Clan Leader
11	Simon FENTONG	Zifasing Village	Orogwangin Clan Leader
12	Daniel GOI	Zifasing Village	Orogwangin Clan Member
13	John ICHIAN	Zifasing Village	Unspecified
14	Ben JOHN	Zifasing Village	Chuaif Clan Leader
15	Maijam JOLAS	Zifasing Village	Chuaif Clan Member
16	Wayah LANGIM	Zifasing Village	Village Councillor & Dep. President Wampar LLG
17	Darius MARTIN	Zifasing Village	Chuaif Clan Member
18	Sasa NONGOT	Zifasing Village	Owangrompon Clan Member
19	John PAN	Zifasing Village	Orogazog Clan Leader
20	Billy Go STEVEN	Tararan Village	Oroganchon Clan Leader
21	Geocka Steven	Tararan Village	Oroganchon Clan Leader

2. Formalities

2.1 Acknowledgements to the Land Owners / Clan Leaders, JICA Survey Team, Huon Gulf District Officers, PNG Power Officers and all others present were made by Councilor Wayah Langim who also pointed out that the Land Owners and Clan members present were representing four (4) clans of Wards 19 (Tararan) and 20 (Zifasing) of the Huon Gulf District.

2.2 Introductions of attendees were made by Kadum Tenia. Kadum then spoke of the inability of existing infrastructure to meet the demands of the developing districts and the government's recognition of this industrial region of Papua New Guinea as a development priority. He then mentioned that the Government of Japan, through its agency JICA, sought to help the Government in this respect. He continued that the purpose of the meeting was for the Land owners to express their views about the proposed PNG Power project in the presence of other stakeholders, particularly JICA; the donor agency - who wanted to hear firsthand accounts of their views.

3. Proposed Project Description

The proposed project works were described to the Land owners by Steven Kerowa who stressed the following key points:

- The pylon and towers to be erected under the new project would run parallel to existing lines, hence it is likely that all same Land Owner's from original project will be engaged.
- That PNG Power would do away with 'Outright Purchase' method of compensation for tower base land use utilized under 'ELCOM' (previous state-owned authority responsible for provision of electricity services. ELCOM installed the existing lines and implemented the original Land Owner contracts)
- That PNG Power Limited would engage a different method of compensation for tower base land use wherein the Land Owner would be party to an ongoing contract with PNG Power. The advantages of this new contract was that (1) it was not a one-off payment (2) it was permanent in nature (ongoing and renewable) and (3) it was transferable to the Land owner's next of kin and thus sustainable than previous contracts.
- PNG Power would engage Land Owners in other minor contracts for Land Clearing and maintenance of tower base vicinity.

4. Environment and Social responsibility requirements of the Government of PNG and JICA as a donor

Charlie Wintawa explained that both the Government of PNG and JICA required to carry out preliminary Environmental studies in order for planning decisions to be made, so that the money allocated or donated for projects were spent wisely and that the purpose of the projects came to fruition. He distinguished between the three components of the Environment – Physical, Biological and Social – and briefly outlined the work carried out by research officers when studying these three components.

5. Question and Answer Session

After the proposed project awareness was carried out, Councilor Langim announced the commencement of a Question and Answers session. He encouraged all Land owners and clan members to openly express their concerns so that an honest ongoing dialogue between stakeholders of the project could commence.

5.1 Questions

5.1.1 John Ichian, Zifasong Village (Comment)

The existing contracts between individuals and PNG Power for the clearing of the land were ineffective and this needed to be discussed with ward councilors.

5.1.2 John Pan , Orogazog Clan Leader (Comment & Question)

- There are no "services" in the areas where the land owners live. Although Land Owners agree that the project should proceed they are concerned over the contracts. PNG Power should increase in the value of contracts or "rate" for the contracts proposed under the new project.
- Can PNG Power give free power to the "papa graun" or Land Owners?

Steven's response:

- *PNG power would no longer carry out "Outright Purchasing" of land required for towers – this would only be done in cases where land would be bought for sub-stations. This was so the ownership of the land remained with the people.*
- *PNG Power would create new contracts with Land Owners that would allow them to maintain ownership of the Land.*

- *He would have to relay the information on increased rates to the PNG Power Management in Port Moresby for their consideration.*
- *As for free power, it would be highly unlikely that PNG Power would supply free power (electricity) to the Land Owners as it was a resource that although everybody is entitled to, is costly to produce and therefore a necessary fee is charged.*

Kadum's response:

- *The new PNG Power contracts were sustainable compared to previous contracts. Under this new contract the Land Owners would be less restricted in the use of land, that since they were the owner of the lands, they could use the surrounding areas of the tower to make their vegetable gardens. He also added that this new contract could be passed down from one generation to another, in effect creating a "permanent" source of revenue for Land Owners.*

5.1.3 Chechep Augutine, Chuaif Clan Leader (Comment & Question)

Nothing much had improved by way of services since the 70s when the first lines were developed, therefore the land owners could not give an outright "Yes" to the project unless a contract with improved "rates" was agreed upon.

5.1.4 Simon Fentong, Orogwangin Clan Leader

Can we work out an agreement to sign right now during this meeting? Can we also include in the agreement that Land Owners will get free power?

Steven's response:

- *Steven stated that they were there as representatives of PNG Power, and did not have the authority to draw up contracts with Land Owners, they would however relay the Land Owner's views to the PNG Power "Bosses" (Management). He further stressed that this was a genuine issue and what was left now was only a matter of following the "protocol".*
- *He added that the other stakeholders present sympathized with their views and agreed that the contract "rates" were to low and that he would therefore make recommendations to the management about this so that the Land Owners were compensated fairly for their contribution to the development of this province and the national as a whole.*
- *As for free power, he mentioned that it is not possible that PNG Power would supply free power to the Land Owners. This was because of the fact that although everybody was entitled to access to power, nobody (including Land owners and PNG Power employees like him), was entitled to free power as it was costly and that this was the convention or norm all over the world. He maintained that most of the money earned from the sale of electricity in PNG was used to maintain and operate the generation and distribution of electricity, which is expensive.*

5.1.5 Steven Efron, Chuaif Clan Leader (Comment and Question)

Among the Land Owners present that day, he identified himself as one of the Land Owner's who had signed the original contracts. PNG power or ELCOM as it was known back then, failed to provide services to them since the 70s.

5.1.6 Unidentified Land Owner from Zifasing (Question)

Can PNG power install MSK in the Land Owner's houses?

Steven's response:

Steven explained that the installation of MSK comes under the Rural Electrification (RE) Program that is implemented by the District Administration through it's Member of Parliament (MP), who also partially funds the RE program. He added that if the Land owners were interested in the MSK

installations, they had to go through the proper channels required by the program. This would mean they would have to organize meetings in their Wards or Local Level Governments – the Councilors of which could then take matters up to the District Level, from which matters could be further taken up to the Electorate Level for the Member of Parliament to address accordingly. He pointed out that Aaron, Kadum and Councilor Langim were resources they could utilize to "get things moving".

5.1.7 Darius Martin, Chuaif Clan Member (Comment and Question)

- What is PNG Power doing to ensure that contracts are made with the genuine Land Owners?
- The "rate" has to be increased before we give our consent to the project. We cannot say "Yes" to the project unless we are given good contracts!

Titus' response

Titus assure the Land Owners once again that he and Steven would take their views to the PNG Power Management adding that the project was important and that he was sure that they (the PNG Power Management) would come up with a contract that would meet the needs of the Land Owners. With regard to the provision of services, PNG Power could only provide electricity, for other services, he advised the Land Owners that they would have to consult with their MP, because he is the one who represents them in Parliament and is allocated funding for services in their area, along with the District Administration and LLG. MSK is one of the services that their member could provide. In terms of what PNG Power were doing to ensure that the rightful Land Owner's were compensated, Titus said that this meeting was the first of many meetings – and that they were there to create awareness and get feedback. They would then carry out studies in the project areas to ensure that the real Land Owner's are identified, he concluded by saying that in order to do this PNG power needed their cooperation.

Kadum's response

Kadum made mention that this meeting was a first step into addressing the concerns of the Land Owners. He said that the main thing required from them at this stage was their view on whether or not they wanted the project to proceed. To this many Land Owners replied that they did want the project to proceed, but only if some kind of proof was given that their contracts would have increased "rates".

5.1.8 John Pan, Orogazog Clan Leader (Comment and Question)

- The main concern was to increase the "rate" in the contract. Otherwise there is no problem and the contract can proceed as planned.
- To be absolutely sure, is there any way at all that PNG Power could bypass the MP and install MSK?

Steven's response:

- *Steven once again explained that the MSK and RE Program was implemented under the Electorate and that there was no way PNG Power would have resources to fund installation of MSK.*
- *Steven then stressed that they would take up their views on the contract to the PNG Power Management for their consideration. He said that this was a normal part of the project procedure and that other aspects of the pre-construction (planning) phase of the project could proceed in the meantime. He made a distinction between the planning and the construction phases and that no construction works would begin without the full consent of the Land Owners, which would be sought during the planning phase – hence this initial*

meeting. He and Titus assure the Land Owner's that they would that by the next meeting, they would provide PNG Power's response to their views and concerns.

5.1.9 Final Comments

Councilor Langim thanked the Survey Team and asked them to say a few words.

- Kyoko Harada addressed the Land Owners. She thanked them for their active participation in the discussions. She also said that the proposed project while potentially funded by JICA, belonged to them and that their participation in the project from start to finish was important.

- Charlie Wintawa added to what Kyoko said by saying that the Government of PNG had evolved since the 70s, that experienced had taught it to make the Social aspects of planning, including Land Owner consultation a necessary part in planning any project. He cited the Bougainville incident (where Land owner's revolted against the Government for not listening to their needs and how this incident had changed the way planning was carried out by the state.

- Aaron Ambang firstly conveyed the apologies of the District Administrator who was absent due to his attendance at a LLG meeting. He then explained the MSK and RE process to the Land Owners, saying that he would relay the message to the district Administrator so that the and Councilors could be called up for a meeting and the necessary protocol followed. He told the Land Owners to inform their Council Leaders and to prepare to be called up for meetings to further discuss MSK and RE. He also stated that he was there to represent the District Administration, which in turn represents the people of the District. He assured the Land Owners that as their administrative representatives the District Office would follow up with PNG Power with regard to the contracts.

6. Meeting Summary

Councilor Langim summarized the meeting, stating the two main areas of concern or issues were (1) increased "rates" for the tower base and land clearing contracts and (2) the provision of the MSK services by the MP and his Electorate. He said that the agreed course of action for issue (1) was for PNG Power Officers Steven and Titus to take up their views with the PNG Power Management while for issue (2) the Ward Councilors would have a meeting in the coming week with the District Administrator. He would expect to get updates on both issues from Aaron, as the representative of the District Administration. He also said that apart from the issues that needed to be addressed, the "door was open" for this project and that the people of the District greatly appreciated JICA concern and assistance to the project.

He then expressed gratitude to all who attended the meeting, in particular the Land Owners and JICA for being physically represented at their meeting in Zifasing.

7. Meeting Close

JICA Survey Team - Stakeholder Meeting

Meeting Minute 3

Project:	Ramu-Lae Transmission Line Expansion and Rehabilitation Project	Meeting No.:	03
Date:	Saturday 12th Nov 2011	Chairperson:	Kyoko Harada
Start / End Time:	13:17-13:38 (21 minutes)	No of Attendees:	7 + others
Location:	Markham District Office, Mutzing	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
1	Aaron AMBANG	Huon Gulf District Office	District Officer-In-Charge
2	Kyoko HARADA	JICA Survey Team	Consultant
3	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
4	Akiko NISHINOMIYA	JICA Survey Team	Consultant
5	Michael STEVEN	Markham District Administration Office	(Acting) District Administrator Patrol Officer - Lands
6	Titus TSIGESE	PNG Power Limited	Environmental Officer
7	Charlotte VADA	Douglas Environmental Services	Research Officer

2. Formalities

2.1 Acknowledgements to the (Acting) Markham District Administrator and all present were made by Kyoko Harada.

2.2 The project was briefly described by Kyoko Harada who further stated that JICA was pleased to be involved in the PNG Power project as the donor agency. She also stressed it was important to the donor agency that the stakeholder's expressed ownership of and a willingness to cooperate for the project. She further mentioned that the purpose of the survey was for the team to create awareness of the project to the Land Owners, as well as receive their feedback including any issues or concerns they may have.

2.3 The District Administrator acknowledged JICA's support to the PNG Government, adding that he supported the project which he believed was important to the people of Markham District. He then stated that the Markham District, a largely agricultural region was one of the largest in the country and that an upgrade in the power supply was long over due.

3. Environment and Social Impacts

- Kyoko Harada mentioned that the project will not have a significant environmental impact, adding that the most significant environmental impact would only occur during the Construction Phase due to the high level of agricultural activities.
- Akiko Nishinomiya added that it was important for people to have the understanding that the main impact would occur during the initial (and temporary) Construction Phase of t he project.
- Kyoko Harada added that while Environmental Impacts were not particularly significant, social issues however were complex and an area of particular interest to JICA (the donor).
- The District Administrator reiterated that the District Administration and its people were willing to support the project and agreed that during the project's Construction Phase some Environmental Impacts would occur and that this was mostly due to the fact that a lot of the existing power lines were surrounded by agricultural land, and that the proposed power lines running parallel to existing ones would inevitably have an impact – but one which could be mitigated to ensure minimal impact.

4. Brief Description of Markham District

- Kyoko Harada asked the Administrator how many people had access to power. The Administrator replied that the vast majority of the Markham District, in particular those living further away from the existing lines did not have access to power. He further added that Markham District was one of the most populace in the country and that previous government at District, Provincial and National levels had failed to properly plan this nationally significant agricultural district.
- When further asked if the lifestyle of the Markham people was similar to the Huon Gulf people, the administrator, supported by Aaron Ambang replied that the lifestyles of the two districts were highly similar. Aaron pointed out that the main difference was Markham's large population and higher level of agricultural activities. The Administrator mentioned that access to water on farms and villages was through windmill powered wells and regular wells.
- When asked what the agricultural activities of the district were, the Administrator listed the following: Enterprise - Cacao, Coffee, Rice, Cattle, Poultry and currently under development Oil Palm ventures. Much of the vast farming areas were either state or corporate owned, employing locals. In addition, many more locals were small-holder farmers who sold their produce to such enterprises. Cash crops – Peanut (mainly), banana, coconut, taro, selected fruits and vegetables.
- The Administrator pointed out that Markham District would be the first in Papua New Guinea to develop a clan-based Oil Palm estate for small-holder growers of oil palm. He went on that unlike in other established Oil Palm regions in PNG, the Oil Palm estate in Markham would not be state-owned land (leased to Oil Palm companies) but customary land that would be used by the owners themselves for growing Oil Palm who will sell their produce to Oil Palm Companies. The District Office would help with the management of the estate with the development of Oil Palm processing facilities. The first planting was proposed to take place in September 2012.

5. District Statistics and Planning data

Kyoko Harada asked the District Administration officers if any social statistics (such as Population, No. of Households etc.) could be made available to them. The Administrator replied that they would be able to supply data from the recent Census (conducted in mid-2011) and other related data. Steven made the suggestion to pick up the documents on Monday morning. Aaron pointed out that according to the latest data Markham District had a population exceeding 80 000 people, making it one of the largest Districts in the country.

6. Other Donor-Funded Projects in Markham District

When asked about the Markham District's experience with other donor-funded projects, the District Administrator outlined the following examples:

- JICA / Water PNG water supply project for the government owned Mutzing Hospital (situated just across the field from the meeting place). Plans were in place to upgrade the Hospital.
- There was also a local Aid Post that was set up through funding from Ramu Sugar and AusAID.

7. District Administrator's final remarks

The District Administrator advised the District Administration Officers that Land Owners from the Markham District have shown up in larger numbers in the morning but some had since due to postponement of meeting to afternoon and other commitments on their part. He said that the number of Land Owners present was sufficient to have a stakeholder meeting and that after this current meeting the stakeholder's meeting would proceed. He gave his assurance that the discussions and points raised in the stakeholder's meeting would be relayed to those who had left.

8. Summary of Meeting

- Steven to pick up the District data and information documents from the District Administrator on Monday.
- Meeting with Markham District Land Owners to proceed immediately after the meeting.

9. Meeting Close

JICA Survey Team - Stakeholder Meeting

Meeting Minute 4

Project:	Ramu-Lae Transmission Line Expansion and Rehabilitation Project	Meeting No.:	04
Date:	Saturday 12th Nov 2011	Chairperson:	a/ Administrator Steven
Start / End Time:	13:44-15:08 (84 minutes)	No of Attendees:	17 + others
Location:	Markham District Office Grounds, Mutzing LLG	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
Survey Team			
1	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
2	Kyoko HARADA	JICA Survey Team	Consultant
3	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
4	Akiko NISHINOMIYA	JICA Survey Team	Consultant
5	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
6	Titus TSIGESE	PNG Power Limited	Environmental Officer
7	Charlotte VADA	Douglas Environmental Services	Research Officer
8	Charlie WINTAWA	Douglas Environmental Services	Senior Consultant - Social Scientist
Markham District Land Owners /Clan Leaders			
9	Rob AWAI	Mampim Village	Mampim Clan Member
10	Noah BUSIL	Antiragen Village	Arifiwat Clan Chief
11	Martha GODFREY	Wampua Village	Taufugun Clan Member
12	Tom Jack MUNTUA	Dabu Village	Zumang Clan Leader , Ward 17 Councilor
13	Dickson MUSA	Mutzing STN	Ward Councilor
14	Michael STEVEN	Markham District Administration Office	(Acting) District Administrator Patrol Officer - Lands
15	S. Giwi WADA	Bagabuang Village	Ampuangbi Clan Member, Bagabuang Village Chariman
16	Elies Nimi WANTANG	Zumim Village	Abaing Clan Leader
17	Joe YAPET	Dabu Village	Dabu Clan Member

2. Formalities

2.1 The District Administrator made acknowledgements to the Land Owners / Clan Leaders, JICA Survey Team, Markham District Officers, PNG Power Officers and all others present. He apologized for the postponement and urged all Land Owners to relay the proceedings of the meeting to Land Owners who were not present, especially those from Umi-Wata who were not represented. Some Landowners pointed out that among the absent Land Owners were those who were Seventh Day Adventists and could not attend because it was their Sabbath day (religious day of rest).

2.2 The Administrator then described the project in brief. He mentioned that new power lines would be constructed 40 to 50 metres parallel to the existing lines. The new project was the PNG Government's response to the increasing demand in electricity in the area and that JICA, recognizing this genuine need of the people, had proposed to fund the project. He added that JICA was not new to the Markham area and pointed to the Mutzing Hospital water supply system across the field, a project of JICA. He further stated that the purpose of the meeting was therefore to create awareness of the project as well as collect the views of the Land Owners in presence of representatives of JICA and PNG Government representatives (PNG Power, District Administration Officers).

3. Proposed Project Description

3.1 Steven Kerowa mentioned the following points:

- The pylon and towers to be erected under the new project would run parallel to existing lines, hence it is likely that all same Land Owner's from original project will be engaged.
- That PNG Power would do away with 'Outright Purchase' method of compensation for tower base land use utilized under 'ELCOM' (previous state-owned authority responsible for provision of electricity services). ELCOM installed the existing lines and implemented the original Land Owner contracts.
- That PNG Power Limited would engage a different method of compensation for tower base land use wherein the Land Owner would be party to an ongoing contract with PNG Power. The advantages of this new contract was that (1) it was not a one-off payment (2) it was permanent in nature (ongoing and renewable) and (3) it was transferable to the Land Owner's next of kin and thus sustainable than previous contracts.
- PNG Power would engage Land Owners in other minor contracts for Land Clearing and maintenance of tower base vicinity.

3.2 Kadum added the following points:

- Access to power can greatly improve Quality of Life; kids can study at night and learn how to use computers, villagers can use fridges and rice cookers.

- The new PNG Power contracts were sustainable compared to previous contracts. Under this new contract the Land Owners would be less restricted in the use of land, that since they were the owner of the lands, they could use the surrounding areas of the tower to make their vegetable gardens. He also added that this new contract could be passed down from one generation to another, in effect creating a "permanent" source of revenue for Land Owners.

- This meeting was an opportunity for the land Owners to speak their mind.

4. <u>Question and Answer Session</u>

After the proposed project awareness was carried out, Steven announced the commencement of a Question and Answers session.

4.1 Questions

4.1.1 Noah Busil, Antiragen Village (Comment and Questions)

Thank you for coming out here to meet with us. The equipment on the tower where I live makes loud noises. We fear that it might explode or catch fire. Could PNG Power please look into this? The new contracts needed to be improved.

If Digicel can pay Land owner's K2000 for their towers, why can't PNG Power make similar payment?

Finally, why is the power supply in Markham low compared to Lae and even Hidden Valley, when the lines are running through Markham?

Stephen's response:

- Steven told them that they had to report incidents of potential damage to equipment to the PNG Power maintenance. You can report through the District Administration who will then contact PNG Power office in Lae.
- With the tower, PNG power is a state-owned enterprise compared to Digicel which is a large company. The Government of PNG therefore "protects" PNG Power with its laws because power production is expensive. Because of the production costs, PNG Power sells power to sustain itself. PNG power cannot afford to pay the same level of compensation paid by large companies, to do that it would have to increase the price of power.

Noah Busil:
People are in dispute over existing power line towers. We take the matter to the courts but they only tell us to sort it out through mediation – which seldom happens. How can PNG Power help us to settle these disputes once and for all instead of wasting time at the courts?

Stephen's response:
Mediation is the best way we have to address conflicts. Other methods previously employed only led to more conflicts. It is therefore best to have mediation.

4.1.2 Rob Awai, Mampim Village, (Comment)

Lae is being developed while we are being left behind. We have blackouts of up to 2 weeks duration. This is unacceptable.

4.1.3 Tom Jack, Mutzing, Ward 17 Councilor (Comment)

There are about 15 towers in the area I represent; we have had very little power supply let alone proper compensation for the towers. Our predecessors who signed the contract with ELCOM must have been "brainwashed" because nothing good has come out of it. The new contract has to be increased or else pay a larger amount upfront to buy off the land for the towers.

Steven's response:
Currently land is held under customary ownership. The Government doesn't allow PNG Power to buy off land for the tower it only allows for purchase of land for switching / sub-stations. Government Policy is to look after the land.

Tom Jack:
From our experience, nothing is happening. The Government does not look after the Land Owners.

Steven's response:
We now have a policy which will protect the Land Owners as opposed to before where no such arrangement existed. He also stated that he and his colleague Titus would make it known to the PNG Power Management of the Land Owner's view that old compensation arrangements used by ELCOM did not work.

District Administrator's response:
Under the new PNG Power arrangement Land Owners are given sustainable contracts. Previously under ELCOM, Land Owners did not have this kind of protection.

4.1.4 Oscar, unspecified village (Comment & Question)

We need services! The power supply is inadequate! We need a Sub-station here in Mutzing! Is it possible to include a substation in Mutzing in the project?

Steven's response:
Steven told the Land Owners that if they believed that they needed a sub-station, they should organize a meeting with their District Administrator and draft an Expression of Interest document to PNG Power. He added that if this was done quickly, he would be willing to take the EOI document to PNG Power Management in Port Moresby on Monday afternoon.

Kadum's response:

In support of the Land Owners' and Steven's suggestions, Kadum added that Markham was the biggest district in Morobe, an important agricultural area with major upcoming developments in Oil Palm and an important link in the Highlands Highway; he could not see any reason – apart

from funding constraints – why PNG Power would not accept the EOI. In addition to this, PNG power, unlike ELCOM, had a history of fulfilling its commitments.

District Administrator's Response

The District Administrator told the Land Owners that he wanted to meet first thing on Monday morning to draft the EOI and that it would be ready for pick up by Steven by mid-morning.

Land Owner's cheered and clapped. They also exchanged words of encouragement and support.

4.1.5 Final Comments

- *Aaron mentioned that it was good to see that the Landowner's were taking the initiative to address a serious issue through their District Administration. He also mentioned tat the Rural Electrification Program was also worth looking into with their District Administration, especially for areas that were more remote. He urged them to continue to do this and to also support PNG Power, and not hold any ill-will against the organization for the 'past sins' of its predecessor ELCOM.*
- *Kyoko Harada told the Land Owner's that it was their project and that JICA was only involved as a donor agency. Changes made in the project plans would be made by PNG Power, working under the currently proposed budget for the project.*
- *The District Administrator thanked the JICA Team, PNG Power Officers for taking time to meet with them.*

5. Meeting Summary

Steven summarized the meeting. He stated the two main areas of concern or issues were (1) improved contracts or compensation methods (from the old ELCOM methods) and (2) the proposal to construct a substation tin Mutzing. He said that the agreed course of action for issue (1) was for PNG Power Officers Steven and Titus to take up their views with the PNG Power Management while for issue (2) the Land Owners and the Administration would draft an expression of Interest for Steven to collect on Monday and take back to the PNG Power Management in Port Moresby.

He then expressed gratitude to all who attended the meeting, in particular the Land Owners.

6. Meeting Close

JICA Survey Team - Stakeholder Meeting (Second Trip)

Meeting Minute 1

Project:	Yonki-Taraka Transmission Line Expansion and Rehabilitation Project	Meeting No.:	01
Date:	Saturday 14th Jan 2012	Chairperson:	Kadum Tenia
Start / End Time:	11:22-12:00 (38 minutes)	No of Attendees:	20
Location:	Zifasing, Wampar LLG, Huon Gulf District, Morobe Province	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
Survey Team			
1	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
2	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
3	Akiko NISHINOMIYA	JICA Survey Team	Consultant
4	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
5	Titus TSIGESE	PNG Power Limited	Environmental Officer
6	Charlotte VADA	Douglas Environmental Services	Research Officer
7	Nathaniel	PNG Power	Technical Officer
Huon Gulf District Land owners /Clan Leaders			
8	Steven EFRON	Zifasing Village	Chuaif Clan Leader
9	Simon FENTONG	Zifasing Village	Orogwangin Clan Leader
10	Daniel GOI	Zifasing Village	Orogwangin Clan Member
11	Yatol KIFAS	Tararan Village	Clan Leader
12	Fetef JORAS	Tararan Village	Clan Leader
13	Robert MESAK	Tararan Village	Clan Leader
14	Oneg MURU	Tararan Village	Clan Leader
15	Samuel PAUL	Tararan Village	Clan Member
16	John PETER	Tararan Village	Clan Leader
17	Billy Go STEVEN	Tararan Village	Oroganchon Clan Leader
18	Onkon STEVEN	Tararan Village	Clan Member
19	Rhode STEVEN	Tararan Village	Clan Member
20	Peter VINCENT	Tararan Village	Clan Leader

2. Formalities

2.1 Acknowledgements to the land owners and all present were made by Kadum Tenia. He then apologized for the inconvenience of the short notice for the meeting and thanked the land owners for their understanding. The short notice was due to the Wampar LLG President's absence (due to duty travel) and consequent break-down in correspondence with PNG Power (through Steven Kerowa).

2.2 Kadum then explained that this meeting would be the follow-up meeting to the previously held meeting on Saturday 14th November 2011. He mentioned that the purpose was to give the land owners some feedback on the major points they raised in the prior meeting, and to get their views and possible agreement or consent for the project to proceed. He then invited Steven Kerowa to address the land owners.

3. Feedback from last meeting

Steven Kerowa briefly summarized the previous meeting adding that he and Titus had returned to Port Moresby and raised their concerns with the relevant authorities. He then addressed the 3 main points with respect to the outcomes or feedback that resulted. These were:

3.1 Access to free electricity

He stated that although this was addressed in the previous meeting, for clarity's sake he reiterated that PNG Power would not under any circumstance be able to provide free power to anybody.

3.2 Contract Rates for Land Clearing

Steven cited the previous land clearing contract rate of 1.20 per hour per head from an old 'Access Form' used by ELCOM. He informed the land owners that PNG Power had decided to do away with this rate as they felt it was not reasonable. He then announced the new PNG Power land clearing contract rate of K 3.85. The method for claiming this contract payment would be the same, using an updated version of the Access Form.

3.3 Tower Base Outright Purchase

The previous ELCOM rate for the tower bases was about K160.00 for the 4 x 4 m tower base. He said that under PNG Power, the new towers constructed would be 10 x 10 m. He informed the land owners that PNG Power had written to the Valuer General's Office to increase the rate to cater for the larger tower bases. He then told the land owners that the new price for the tower base acquisition could be K600 or more. He stressed that this was the amount that PNG Power hoped would be set, but that this was out of their hands and that the final amount would be set by the Valuer General's Office.

3.4 Damages

Steven informed the Land owners that the Valuer General's Office had a document that contained *fixed pricing* for damages to various plants and crops that result from the construction (or operations) works of development projects. He urged all land owners to get a copy of this document through their district and ward officers so they could familiarize themselves with the fixed prices. He said it was important to be physically present during the construction works so they could observe and record all the damages done to their plants or crops. He said that if they kept their own records, they would be in a position to fill out the Access Form supplied by PNG Power Officers and to verify the Officer's records with their own.

4. <u>Question and Answer Session</u>

4.1 Billy Go Steven, Oroganchon Clan Leader (Comment & Question)

For the tower base, I would like a payment to be made before I make my land available and for successive payments to be made on an ongoing basis as is the case with other projects in the Province. As for the land clearing contracts, thank you to PNG Power for increasing the rates – I will make a contract agreement.

Kadum's Response:

- The tower will be used to hold the transmission lines – they are government owned and will be used to roll out a service to PNG. They are not like the privately owned Digicel towers which hold the telecommunication lines that make profit, nor are they like the exploration infrastructure used by big mining companies. Therefore the government will only pay the outright purchase fee for the tower base.
- The payment for the tower bases was provided by ELCOM, however it was poorly implemented. PNG Power had decided to include this form of payment along with land clearing contracts and damages payments, as they believe there should at least be some form of compensation or for the tower base area.
- This information must be disseminated so all land owners are aware of what is happening.

Steven's Response:

- Steven agreed with Kadum in that there was a need for a district or ward level awareness campaign for land owners to give information from PNG Power Limited and the Valuer General's Office. He urged them to put pressure on their ward and district representatives to organize awareness

initiatives with locally-based PNG Power officers who could make presentations on the Valuer General's Rates as well as directions on how to use the access forms.

4.2 Simon Fentong, Zifaseng Village Clan Leader (Question)

Can you please clarify if the Tower Base will be under an ongoing contract like the land clearing?

Steven's Response:

- Steven replied 'no', explaining that the outright purchase is a one-off payment. As for the amount, PNG Power is not responsible for setting amounts or rates – this is the responsibility of the Valuer General's Office. He further stated that PNG Power wrote a letter to the Valuer General's Office requesting that an amount higher than the amount paid out by ELCOM be set for the outright purchase of the tower bases.
- If they did not agree with the existing rates – this was a matter for the Valuer General's Office and not PNG Power. He informed them that if they disagreed with the rates that they should raise their concerns with the Valuer General's Office.

Simon's response:

Thank you for your explanation. I now understand fully. Thank you PNG Power and the Huon Gulf District Administration Officers for your support and for taking the time to meet with us. Thank you for responding to the queries we put forward in the last meeting. This kind of communication has never been experienced with ELCOM.

Many thanks to JICA for their assistance in funding the project and facilitating the communication between land owners and PNG Power.

4.3 Nathaniel PNG POWER Officer

Nathaniel informed / reminded the land owners that the land clearing, damages and tower base payments were all tax deductible. He further stated that he was letting them know so that the after-tax payment did not come as a shock and that they wouldn't blame PNG Power for not informing them about the tax or wrongly accuse PNG Power Officers of stealing.

4 Summary of Meeting

Kadum briefly summarized the meeting:

- Tower bases - Land for tower bases would be bought outright by PNG Power using the Valuer General's revised rates – which is to be acknowledged. Steven would do the follow up on this when back in Port Moresby and inform Aaron accordingly who in turn will pass the message to Ward Councilors.
- Land Clearing Contract Rates – PNG Power has done away with ELCOM's land clearing rate of K1.20 per hour per head and will be using a new rate of K3.85 per hour per head and that this new rate exceeds the national minimum wage set up by the Minimum Wages Board.
- Damages to Plants and Crops - Compensation for damages to plants and crops was set by the Valuer General's Office and that all land owners should keep their own records during the project's land clearing process for their information and as well as to avoid discrepancies later on.
- Tax - That land owners should be aware of the tax charges on all the above.
- Awareness - That land owners should spread this information to their fellow land owners who were absent in the meeting.
- Awareness - That land owners should get their ward and district reps to organize (with local PNG POWER office) awareness on these matters.
- Kadum then explained that for the purpose of JICA's and PNG Power's records, he would asked them for their consent for the project should to proceed as planned. When asked, all land owners present agreed unanimously that the project should proceed as planned.

5 Meeting Close

JICA Survey Team - Stakeholder Meeting (Second Trip)

Meeting Minute 2

Project:	Yonki-Taraka Transmission Line Expansion and Rehabilitation Project	Meeting No.:	02
Date:	Saturday 14th Jan 2012	Chairperson:	Kadum Tenia
Start / End Time:	2:51-3:27 (36 minutes)	No of Attendees:	23
Location:	Zifasing, Wampar LLG, Huon Gulf District, Morobe Province	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
Survey Team			
1	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
2	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
3	Akiko NISHINOMIYA	JICA Survey Team	Consultant
4	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
5	Titus TSIGESE	PNG Power Limited	Environmental Officer
6	Charlotte VADA	Douglas Environmental Services	Research Officer
7	Nathaniel	PNG Power	Technical Officer
Kamkumung Land owners /Clan Leaders			
8	Anna SILAS	Kamkuming	Land Owner
9	Geseng SILAS	Kamkuming	Land Owner
10	Tabitha SILAS	Kamkuming	Land Owner
11	Giding SILAS	Kamkuming	Land Owner
12	Mercy WALA	Kamkuming	Land Owner
13	Henry ARUMOT	Kamkuming	Land Owner
14	Aring SILAS	Kamkuming	Land Owner
15	Scott ARING	Kamkuming	Land Owner
16	Michael ARING	Kamkuming	Land Owner
17	Jenner ARUMOT	Kamkuming	Land Owner
18	Tabitha ARUMOT	Kamkuming	Land Owner
19	Silas PAUL	Kamkuming	Land Owner
20	Aida ARING	Kamkuming	Land Owner
21	Nangitta ARING	Kamkuming	Land Owner
22	Molly ARUMOT	Kamkuming	Land Owner
23	Geseng GOARE	Kamkuming	Land Owner

2. Formalities

2.1 Acknowledgements to the land owners and all present were made by Kadum Tenia. He then apologized for not having had a meeting in Kamkumung with them earlier. He then introduced the JICA team, PNG Power Officers and the Huon Gulf District officers.

2.2 The landowners acknowledged JICA, PNG power and the district officers before briefly introduced themselves. They are a single extended family and are the land owners of a parcel of land on which stands 13 transmission towers. Their father (and grandfather), the patriarch of the family had been the original landowner with whom ELCOM signed contracts with.

3. Brief Description of the Project

Kadum described the project briefly, saying that due to the increasing demand in power of Morobe Province, and it's importance as the industrial province of PNG, that the government had sought funding to carry out an upgrade of the existing transmission lines. He added that JICA, recognizing this need, had agreed to fund the project, if all requirements were met including the consent of the landowners.

4. Discussion Session

Michael Aring, (Eldest male land owner) – Where will the transmission lines be built? And will they be the same size as the existing ones?

Steven's Response – They will run parallel to the existing line for which the tower bases measure 4 x 4 m. The new towers will measure 10 x 10 m.

A**nna Silas, land owner –** We have some grievances that we need to express. Since 1974 when the initial agreement was signed between my father and ELCOM, there have been no payments made. We want to enter a new contract for the 13 transmission towers, and for payments to be made on a monthly basis.

We actually aired out our concerns to some of your officer who came here a while back. They said they would get back to us but never did.

Kadum's Response – We were not aware that some officers had come to see you. Could you give us their names?

Henry Arumot – their names were Peter Joseph and a Papuan man named Kedea.

Steven – You will have to disregard what they have said to you as they are not authorized to make any statements on behalf of PNG Power regarding land issues or projects. They are technical officers who are responsible for maintaining the infrastructure. The meeting we are having now is your chance to air out your concerns because this is the proper channel. We will then relay your concerns to our management for their consideration.

Also bear in mind that ELCOM was established during the colonial period. The previous contracts were also drafted and signed during this period. Back then, there was not much done by the colonial powers by way of involving land owners in consultation processes whereby they could express concerns. However we cannot let the 'sins of the past' get in the way of opportunities we have before us now.

Michael Aring – Our terms are simple; we will not waste any more of your time. We want to be compensated for the period spanning from 1974 – 2012. We want all monies owed to us to be paid in full before the project can start.

Kadum's response – We do sincerely understand your grievances – we are all landowners ourselves. However we are not in a position to make any guarantees or comments about this issue. We can only advise you on what steps to take should you wish your grievance be heard by the PNG power management for their consideration.

Steven – I will write down the name of the appropriate PNG Power officer to whom you can address the letter. You can leave your letter at the Huon Gulf District Office or the PNG Power office and they will fax it across to me so I can deliver it to that officer. Thank you for your honesty in expressing how you truly feel.

Anna Silas – We will write the letter and drop it off at the Huon Gulf District Office. Thank you for coming by and we hope that something positive may come out of this.

Kadum – Thank you for having us.

5. Meeting Close

JICA Survey Team - Stakeholder Meeting (second Trip)

Meeting Minute 3

Project:	Yonki-Taraka Transmission Line Expansion and Rehabilitation Project	Meeting No.:	03
Date:	Sunday 15th Jan 2012	Chairperson:	Hon Dakie Mao, President, Uni Atzerall LLG
Start / End Time:	13:37-14:26 (49 minutes)	No of Attendees:	84
Location:	Markham District Office Grounds, Mutzing LLG	Minutes Taken By:	Charlotte Vada

1. Attendees

No.	Name	Organization / Company	Title / Position
Survey Team			
1	Aaron AMBANG	Huon Gulf District Office	District Officer In-Charge
2	Steven KEROWA	PNG Power Limited	Team Leader, Lands Projects & Acquisition
3	Akiko NISHINOMIYA	JICA Survey Team	Consultant
4	Kadum TENIA	Huon Gulf District Office	Former Patrol Officer
5	Titus TSIGESE	PNG Power Limited	Environmental Officer
6	Charlotte VADA	Douglas Environmental Services	Research Officer
7	Nathaniel	PNG Power	Technical Officer
8	JICA Engineer	JICA	Engineer
Markham District Land Owners /Clan Leaders			
9	John Orebut	Markham District Office	District Administrator
10	Hon Dakie MAO	Umi Atzera LLG	President / Land owner
11	Raphael KISANG	Afrifirang Village	Land Owner
12	Ben GIU	Antiragen Village	Land Owner
13	Benson GABREL	Antiragen Village	Land Owner
14	Chururua IGUANG	Antiragen Village	Land Owner
15	Guag BAYA	Antiragen Village	Land Owner
16	Iria UNING	Antiragen Village	Land Owner
17	Jimm MARAINUMP	Antiragen Village	Land Owner
18	Mathais FRANK	Antiragen Village	Land Owner
19	Noah BUSIL	Antiragen Village	Land Owner
20	Steven JOHN	Antiragen Village	Land Owner
21	Wasi JOEL	Antiragen Village	Land Owner
22	Willie CHIFANG	Antiragen Village	Land Owner
23	Yabob WASUB	Antiragen Village	Land Owner
24	Rafar AGISANG	Arifiran Vllage	Land Owner
25	Mathew AFFINO	Atsunas	Land Owner
26	Mathew WAKU	Atsunas	Land Owner
27	YANSAUM	Atsunas	Land Owner
Markham District Land Owners /Clan Leaders			
28	Awai AWAS	Dabu Village	Land Owner
29	Buga AMARANG	Dabu Village	Land Owner
30	Cr Tom JACK	Dabu Village	Land Owner / Ward 17 Councilor
31	Joe FRANCIS	Dabu Village	Land Owner
32	Kari MABAN	Dabu Village	Land Owner
33	Samson RINGA	Dabu Village	Land Owner
34	Tom FRANCIS	Dabu Village	Land Owner
35	Aigara APU	Marawasa Village	Land Owner
36	Igara APU	Marawasa Village	Land Owner

37	Jack JUAMO	Marawasa Village	Land Owner
38	Obe GAGAS	Marawasa Village	Land Owner
39	Obi GAGAS	Marawasa Village	Land Owner
40	Bama RIRI	Ngarutsaniang Village	Land Owner
41	Barnabas FAMF	Ngarutsaniang Village	Land Owner
42	Felis ATTA	Ngarutsaniang Village	Land Owner
43	Kenny BIRIWAT	Ngarutsaniang Village	Land Owner
44	Nick PAUL	Ngarutsaniang Village	Land Owner
45	Raka SARIA	Ngarutsaniang Village	Land Owner
46	Amos JEFFREY	Ragaimpun	Land Owner
47	Arisab JEFFERY	Ragaimpun	Land Owner
48	Iragin BAWARIA	Ragaimpun	Land Owner
49	Job SIYAM	Ragaimpun	Land Owner
50	John GAMP	Ragaimpun	Land Owner
51	Kelly PIRITZ	Ragaimpun	Land Owner
52	Kypa KEN	Ragaimpun	Land Owner
53	Mathew IGIS	Ragaimpun	Land Owner
54	Tonny IRAMP	Ragaimpun	Land Owner
55	Walter TIMOTHY	Ragaimpun	Land Owner
56	Gede WANTAP	Raoisaria	Land Owner
57	Muri SAGIANG	Raoisaria	Land Owner
58	David WARI	Sisino Creek	Land Owner
59	Maran UMPUNO	Sisino Creek	Land Owner
60	Bun SANGIANG	Tumua	Land Owner
61	John FRANCIS	Tumua	Land Owner
62	Bimaru MOI	Watarais	Land Owner
63	Kelven IRIA	Watarais	Land Owner
64	Soni TIMO MARABA	Watarais	Land Owner
65	Michael MARAN	Watuno	Land Owner
66	Joe TITIF	Zumim No1 Village	Land Owner
67	John MAIKEL	Zumim No1 Village	Land Owner
68	John NARIAN	Zumim No1 Village	Land Owner
69	Naso AGUAI	Zumim No1 Village	Land Owner
Markham District Land Owners /Clan Leaders			
70	Naso YAMBING	Zumim No1 Village	Land Owner
71	Yaling SASU	Zumim No1 Village	Land Owner
72	Abram JOESEPH	Zumim No2 Village	Land Owner
73	Ben GIU	Zumim No2 Village	Land Owner
74	David UTA	Zumim No2 Village	Land Owner
75	Gideon SASU	Zumim No2 Village	Land Owner
76	Joe TITIF	Zumim No2 Village	Land Owner
77	John MICHAEL	Zumim No2 Village	Land Owner
78	John NARIAN	Zumim No2 Village	Land Owner
79	Kieth ILUM	Zumim No2 Village	Land Owner
80	Lamuky YAPI	Zumim No2 Village	Land Owner
81	Sangi IRUM	Zumim No2 Village	Land Owner
82	Sonny RABUNI	Zumim No2 Village	Land Owner
83	Yambang AGUAI	Zumim No2 Village	Land Owner
84	Yambing FRANK	Zumim No2 Village	Land Owner

2. <u>Formalities</u>

2.1 Administrator John Orebut made an apology on behalf of the local Member of Parliament – who said he was aware of the meeting but due to a prior engagement would arrive late and asked that the meeting start without him. He then invited the JICA team and associates to introduce themselves.

2.2 Kadum Tenia introduced the JICA team, PNG Power Officers and Huon Gulf District Officers before giving acknowledgements to all present. He then gave a brief description of the project for the sake of those who did not attend the previous meeting held on Saturday 14th November, 2011, stating the following points:

- Morobe Province is the industrial province in PNG.
- The existing power supply from Yonki through to Lae and the mining sites was low and as the supply had increased over the years.
- JICA recognized the PNG Government's need in developing Morobe Province and became involved as the project donor.
- In order for the project to proceed, it was a requirement by JICA on the Government of PNG that proper project procedures - including engagement of land owners in discussions - were followed.
- That the new power line would run parallel to the existing ones from Yonki to Taraka.

Question from President *– Is that the big line (transmission) or the small line (distribution) line?*

Kadum *– The big line - transmission line.*

Land owner 1 *– Can you update us on the outcomes from the last meeting we had?*

Kadum *–Yes. I'll now hand over to Steven to give you the feedback on these points which you raised in the last meeting.*

3. <u>Feedback from last meeting</u>

Steven then proceeded to address the land owners on the feedback regarding the issues they had raised in the last meeting.

3.1 Substation in Mutzing:
The substation at Erap will be expanded, with another to be built at Sing Sing Creek. The substations will be able to supply the larger demand. Therefore the engineers have decided come to the conclusion that an additional substation in Mutzing is not necessary.

3.2 Contract Rates for Land Clearing:
Steven stated that the under the previous management of ELCOM, the land clearing contract rate of K 1.20 per hour per head, he then announced that the new PNG Power land clearing contract rate was at K 3.85. He explained that the method for claiming this contract payment would be the same, using an updated version of the Access Form. He further stated that this new amount was actually higher than what was set by the Minimum Wages Board.

President – it appears that the rate is alright. Now I will open up the floor for discussion.

4. <u>Open floor discussions</u>

4.1 Land owner 2 (Police Officer)
Thank you to the JICA, PNG Power and Huon Gulf District Administration Office for facilitating this meeting. We understand that you have had a previous meeting which most of us did not attend. Thank you for addressing those concerns. However now that we are here in numbers we, the land owners would like to present some points for your consideration. We ask that JICA take note of our concerns as we believe they need to be addressed before the project can proceed.

Form our experience with the water project, we have learned some lessons and want to avoid past mistakes. By this I refer to the JICA funded water project here in Mutzing. It was originally planned

for the entire community, however since PNG Water Board took over the project, the water is only going to the clinic and not the rest of the community. We want to make sure that PNG power does not make the same mistake with the power project. Here are our points:

4.1.1 Firstly, our fathers were the ones who made the initial agreements on the power pylons with ELCOM. Since those original contracts were signed, we have not had any payments made to us. Can we renew the terms of agreement for the power pylon/transmission lines?

4.1.2 Secondly the previous agreement only included payment for the transmission lines. Can we also in the new agreement include some percentage for the small lines (distribution lines)?

4.1.3 Compensation for damages for the loss of plants and crops was set at a low rate – which was hardly paid out. Can we make the agreement so the PNG Power Officers pay first before cutting anything?

4.1.4 Can PNG Power bring some development to our area, such as schools and clinic?

4.1.5 Finally, Can we draft an agreement based on the four points I have mentioned, between PNG Power, JICA and landowners and sign it today?

President *– Thank you for raising your concerns. Are there any more points you want to raise before we allow them (JICA PNG Power) to respond?*

Land Owner 3 *– I want to make a suggestion to PNG Power. Can you send your officers with bags of money when they come to assess the damages and/or land clearing? This would make things much more convenient.*

District Administrator's *– If you are going to talk, please talk about sensible things – let's not waste time.*

Councilor Tom *– Yes. Let's not drag this meeting or we'll only end up arguing.*

President *– Let's get to the point, do you agree that the project should proceed?*

Land owner 3 *– Only if they address all our points first.*

Land owner 5 *– Can PNG Power establish Incorporated Land Groups (ILGs) for the land owners?*

President *– The land issues will be dealt with by the District Offices – not PNG Power – they do not have the mandate for that.*

Land owner 2 *– We are wasting time! Let us just make the agreement so the project can proceed.*

Steven Kerowa *– It appears that most of the issues you are pointing out today are 'internal' issues either between land owners and PNG Power or landowners and District Offices.*

- *As for the development of other services, the current arrangements were done before independence, back when PNG was under a colonial power. This is why the agreements do not adequately address the needs of the land owners. PNG Power is under the PNG government which serves the people of Papua New Guinea. Once we get our basic services in running order, it is easier to plan for other developments like schools and clinics. In fact PNG Power now has a branch that was especially established to carry out small development projects in the rural areas and several projects are in the pipeline.*
- *Tower base – With regard to the tower bases, the new towers will be larger than the existing ones. The existing ones built by ELCOM measure 4 x 4 m and were bought outright at a flat*

rate of K160. The new larger towers proposed by PNG Power will be 10 x 10m. PNG Power has written a request to the Valuer General's Office to adjust this rate for the bigger tower. The new rate will therefore be greater than K160 – we are yet to be informed by the Valuer General as to the final amount but as soon as we are we will inform your District Office through our officers to notify you. As for the distribution lines, these are not paid for in any part of PNG – they are there to bring the power to the people.

- *With regard to compensation for damages to plants and crops – the rates for such payments are regulated by the Valuer General's Office. He has set the rates for all government departments and construction companies to use. PNG Power will refer to the Valuer General's rates when assessing your damages. It is important that you are present when the assessment is made or when the plants or crops are cut down so you can assess yourself and have a clear idea of what payment amount to expect.*

Land owner 6 *– Is the tower base a one-off payment or a continuous payment?*

Steven *– it's an outright purchase so it's a one-off payment.*

District Administrator *– As for the Land/ILG issue raised earlier, we will deal with that. We will identify the real land owners and pass the information on to PNG Power so that payments are made only to genuine land owners.*

Councilor Tom *– I think everything has been cleared up so let's just give our consent so the project can proceed.*

Land Owner 2 *– What about radiation? Can we have an agreement that covers compensation for radiation from the towers?*

Land owner 7 *– Can we review the contract agreement and make changes so that these issues are reflected?*

Steven *– Radiation and review of terms of agreement are issues that are beyond the scope of this meeting and those in attendance. So we will take your suggestions back to the main office in Port Moresby. One other thing, when PNG Power officers come around during to collect contract forms, they will take photos of the land owners and the records will be kept so when successive payments are made, the officers will use your data – including the photo to identify you. We will try to organize an awareness meeting for these procedures through your district administration officers.*

Councilor Tom *– Thank you. I think the majority of us just want the project to proceed smoothly without any hiccups. The project should proceed.*

Land Owner 2 *– I understand that we (land owners) have to meet with PNG Power and the district office to sort out these issues. Can JICA also be present in these meetings also?*

President *– No, they are the donors of the project. As Steven said these are internal matters for us to sort out.*

4.1.6 Final Comments

Councilor Tom urged all land owners to quickly get to the point and agree that the project should proceed. The LLG President then asked the land owners if they were in agreement for the project to proceed. They unanimously agreed that they want the project to proceed.

President then thanked all landowners, District officers, PNG Power officer and JICA.

5. **Meeting Close**

ATTACHMENT-5 PROJECT EVALUATION

Attachment 5-1a Economic and Financial Costs

Plan-A Rehabilitation of 132 kV switchgear with full air insulated switchgear (AIS) (US$)

Cost item		2014			2015			Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total
Estimated base cost for construction		21,506,155.56	16,176,368.89	37,682,524.44	12,228,044.44	11,355,091.11	23,583,135.56	33,734,200.00	27,221,020.00	60,955,220.00
(1) Transmission Line Component	Material	8,516,800.00	4,832,486.00	13,349,286.00	8,516,800.00	4,832,486.00	13,349,286.00	17,033,600.00	9,664,972.00	26,698,572.00
	Labour		3,973,214.00	3,973,214.00		3,973,214.00	3,973,214.00		7,946,428.00	7,946,428.00
(2) Substation Component	Material	12,989,355.56	3,011,788.89	16,001,144.44	3,711,244.44	860,511.11	4,571,755.56	16,700,600.00	3,872,300.00	20,572,900.00
	Labour		3,738,000.00	3,738,000.00		1,068,000.00	1,068,000.00		4,806,000.00	4,806,000.00
(3) Land & Right of Way Compensation	Properties	0.00	138,660.00	138,660.00	0.00	138,660.00	138,660.00	0.00	277,320.00	277,320.00
	Compensations		327,000.00	327,000.00		327,000.00	327,000.00		654,000.00	654,000.00
Physical Contingencies		1,720,492.44	1,294,109.51	3,014,601.96	978,243.56	908,407.29	1,886,650.84	2,698,736.00	2,202,516.80	4,901,252.80
Sub-total 1		23,226,648.00	17,470,478.40	40,697,126.40	13,206,288.00	12,263,498.40	25,469,786.40	36,432,936.00	29,423,536.80	65,856,472.80
Consulting Fee (1&2)		1,616,700.00	894,200.00	2,510,900.00	1,616,700.00	894,200.00	2,510,900.00	3,233,400.00	1,788,400.00	5,021,800.00
Consulting Fee (3)			25,000.00	25,000.00		25,000.00	25,000.00		50,000.00	50,000.00
Total Before Levies		24,843,348.00	18,389,678.40	43,233,026.40	14,822,988.00	13,182,698.40	28,005,686.40	39,666,336.00	31,211,936.80	70,878,272.80
Levies			496,866.96	496,866.96		296,459.76	296,459.76		793,326.72	793,326.72
Sub-total 2		24,843,348.00	18,886,545.36	43,729,893.36	14,822,988.00	13,479,158.16	28,302,146.16	39,666,336.00	32,005,263.52	71,671,599.52
Price Escalation		2,303,649.13	4,250,284.83	6,553,933.96	1,860,415.58	4,189,268.57	6,049,684.16	4,164,064.71	8,439,553.40	12,603,618.12
Grand Total		27,146,997.13	23,136,830.19	50,283,827.32	16,683,403.58	17,668,426.73	34,351,830.32	43,830,400.71	40,444,816.92	84,275,217.64
Financial Cost (Grand Total - Price Escalation)		24,843,348.00	18,886,545.36	43,729,893.36	14,822,988.00	13,479,158.16	28,302,146.16	39,666,336.00	32,005,263.52	71,671,599.52
Economic Cost		24,843,348.00	14,899,133.77	39,742,481.77	14,822,988.00	10,833,190.95	25,656,178.95	39,666,336.00	25,732,324.71	65,398,660.71

(Note)

1. Share rate of material and labour by work item:
   - (1) Transmission Line Component: 54.9 (%) Material; 45.1 (%) Labour
   - (2) Substation Component: 44.6 (%) Material; 55.4 (%) Labour

2. Allocated rate of FC and LC:
   - (1) Transmission Line Component: 49 (%) FC; 51 (%) LC
   - (2) Substation Component: 66 (%) FC; 34 (%) LC
   - (3) Land & Right of Way Compensation: 0 (%) FC; 100 (%) LC

3. Physical Contingencies: 8.0 (%)

4. Consulting Fee: 7.0 (%) Based on the estimation by Survey Team.

5. Income Tax of Labour: 25.0 (%) According to PNG Personal Income Tax Act

6. Net Profit: 10.0 (%) of the net offering amount of the works to be proposed by contractors.

7. Price escalation:
   - For FC Portion: 3.0 (%) Based on the similar projects in PPL.
   - For LC Portion: 7.0 (%) Based on the 2007 Annual Report by National Statistical Offiice PNG.

8. Standard conversion factor (SCF): 0.99142 Based on the data of external trade.

Attachment 5-1b Economic and Financial Costs

Plan-B Only 132 kV transmission line feeders are to be GIS and the other parts such as 132 kV busbar and main transformer bays are to be AIS (US$)

Cost item		2014			2015			Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total
Estimated base cost for construction		15,189,621.43	12,825,474.29	28,015,095.71	20,527,878.57	15,402,674.29	35,930,552.86	35,717,500.00	27,562,920.00	63,280,420.00
Transmission Line Component	Material	8,516,800.00	4,832,486.00	13,349,286.00	8,516,800.00	4,832,486.00	13,349,286.00	17,033,600.00	9,664,972.00	26,698,572.00
	Labour		3,973,214.00	3,973,214.00		3,973,214.00	3,973,214.00		7,946,428.00	7,946,428.00
Substation Component	Material	6,672,821.43	1,190,428.57	7,863,250.00	12,011,078.57	2,142,771.43	14,153,850.00	18,683,900.00	3,333,200.00	22,017,100.00
	Labour		2,031,071.43	2,031,071.43		3,655,928.57	3,655,928.57		5,687,000.00	5,687,000.00
Land & Right of Way Compensation	Properties	0.00	138,660.00	138,660.00	0.00	138,660.00	138,660.00	0.00	277,320.00	277,320.00
	Compensations		327,000.00	327,000.00		327,000.00	327,000.00		654,000.00	654,000.00
Physical Contingencies		1,215,169.71	1,026,037.94	2,241,207.66	1,642,230.29	1,232,213.94	2,874,444.23	2,857,400.00	2,258,251.89	5,115,651.89
Sub-total 1		16,404,791.14	13,851,512.23	30,256,303.37	22,170,108.86	16,634,888.23	38,804,997.09	38,574,900.00	29,821,171.89	68,396,071.89
Consulting Fee (1&2)		1,616,700.00	894,200.00	2,510,900.00	1,616,700.00	894,200.00	2,510,900.00	3,233,400.00	1,788,400.00	5,021,800.00
Consulting Fee (3)			25,000.00	25,000.00		25,000.00	25,000.00		50,000.00	50,000.00
Total Before Levies		18,021,491.14	14,745,712.23	32,767,203.37	23,786,808.86	17,529,088.23	41,315,897.09	41,808,300.00	31,609,571.89	73,417,871.89
Levies			360,429.82	360,429.82		475,736.18	475,736.18		836,166.00	836,166.00
Sub-total 2		18,021,491.14	15,106,142.05	33,127,633.19	23,786,808.86	18,004,824.41	41,791,633.26	41,808,300.00	32,445,737.89	74,254,037.89
Price Escalation		1,671,078.81	3,399,531.53	5,070,610.33	2,985,454.07	5,595,827.59	8,581,281.66	4,656,532.88	8,995,359.11	13,651,891.99
Grand Total		19,692,569.95	18,505,673.58	38,198,243.53	26,772,262.93	23,600,651.99	50,372,914.92	46,464,832.88	41,441,097.00	87,905,929.88
Financial Cost (Grand Total - Price Escalation)		18,021,491.14	15,106,142.05	33,127,633.19	23,786,808.86	18,004,824.41	41,791,633.26	41,808,300.00	32,445,737.89	74,254,037.89
Economic Cost		18,021,491.14	12,059,996.03	30,081,487.17	23,786,808.86	14,190,496.12	37,977,304.97	41,808,300.00	26,250,492.14	68,058,792.14

(Note)

1. Share rate of material and labour by work item:

Transmission Line Component	54.9 (%)	Material
	45.1 (%)	Labour
Substation Component	37.0 (%)	Material
	63.0 (%)	Labour

2. Allocated rate of FC and LC:

Transmission Line Component	49 (%)	FC
	51 (%)	LC
Substation Component	67 (%)	FC
	33 (%)	LC
Land & Right of Way Compensation	0 (%)	FC
	100 (%)	LC

3. Physical Contingencies: 8.0 (%)

4. Consulting Fee: 7.0 (%) Based on the estimation by Survey Team.

5. Income Tax of Labour: 25.0 (%) According to PNG Personal Income Tax Act

6. Net Profit: 10.0 (%) of the net offering amount of the works to be proposed by contractors.

7. Price escalation:

For FC Portion:	3.0 (%)	Based on the similar projects in PPL.
For LC Portion:	7.0 (%)	Based on the 2007 Annual Report by National Statistical Offiice PNG.

8. Standard conversion factor (SCF): 0.99142 Based on the data of external trade.

Attachment 5-1c Economic and Financial Costs

Plan-C Rehabilitation of 132 kV switchgear with full GIS (US$)

Cost item		2014			2015			Total		
		FC	LC	Sub-total	FC	LC	Sub-total	FC	LC	Sub-total
Estimated base cost for construction		10,132,969.23	10,371,972.31	20,504,941.54	27,910,830.77	18,144,487.69	46,055,318.46	38,043,800.00	27,728,420.00	65,772,220.00
Transmission Line Component	Material	8,516,800.00	4,832,486.00	13,349,286.00	8,516,800.00	4,832,486.00	13,349,286.00	17,033,600.00	9,664,972.00	26,698,572.00
	Labour		3,973,214.00	3,973,214.00		3,973,214.00	3,973,214.00		7,946,428.00	7,946,428.00
Substation Component	Material	1,616,169.23	218,184.62	1,834,353.85	19,394,030.77	2,618,215.38	22,012,246.15	21,010,200.00	2,836,400.00	23,846,600.00
	Labour		488,407.69	488,407.69		5,860,892.31	5,860,892.31		6,349,300.00	6,349,300.00
Land & Right of Way Compensation	Properties	0.00	138,660.00	138,660.00	0.00	138,660.00	138,660.00	0.00	277,320.00	277,320.00
	Compensations		327,000.00	327,000.00		327,000.00	327,000.00		654,000.00	654,000.00
Physical Contingencies		810,637.54	829,757.78	1,640,395.32	2,232,866.46	1,451,559.02	3,684,425.48	3,043,504.00	2,281,316.80	5,324,820.80
Sub-total 1		10,943,606.77	11,201,730.09	22,145,336.86	30,143,697.23	19,596,046.71	49,739,743.94	41,087,304.00	30,009,736.80	71,097,040.80
Consulting Fee (1&2)		1,616,700.00	894,200.00	2,510,900.00	1,616,700.00	894,200.00	2,510,900.00	3,233,400.00	1,788,400.00	5,021,800.00
Consulting Fee (3)			25,000.00	25,000.00		25,000.00	25,000.00		50,000.00	50,000.00
Total Before Levies		12,560,306.77	12,095,930.09	24,656,236.86	31,760,397.23	20,490,246.71	52,250,643.94	44,320,704.00	31,798,136.80	76,118,840.80
Levies			251,206.14	251,206.14		635,207.94	635,207.94		886,414.08	886,414.08
Sub-total 2		12,560,306.77	12,347,136.23	24,907,443.00	31,760,397.23	21,125,454.65	52,885,851.88	44,320,704.00	32,684,550.88	77,005,254.88
Price Escalation		1,164,679.57	2,778,636.58	3,943,316.14	3,986,209.66	6,565,707.02	10,551,916.68	5,150,889.23	9,344,343.59	14,495,232.82
Grand Total		13,724,986.34	15,125,772.81	28,850,759.14	35,746,606.89	27,691,161.67	63,437,768.56	49,471,593.23	42,028,894.47	91,500,487.70
Financial Cost (Grand Total - Price Escalation)		12,560,306.77	12,347,136.23	24,907,443.00	31,760,397.23	21,125,454.65	52,885,851.88	44,320,704.00	32,684,550.88	77,005,254.88
Economic Cost		12,560,306.77	10,037,454.73	22,597,761.50	31,760,397.23	16,360,197.69	48,120,594.93	44,320,704.00	26,397,652.42	70,718,356.42

(Note)

1. Share rate of material and labour by work item:

Transmission Line Component	54.9 (%)	Material	
	45.1 (%)	Labour	
Substation Component	30.9 (%)	Material	
	69.1 (%)	Labour	

2. Allocated rate of FC and LC:

Transmission Line Component	49 (%)	FC
	51 (%)	LC
Substation Component	70 (%)	FC
	30 (%)	LC
Land & Right of Way Compensation	0 (%)	FC
	100 (%)	LC

3. Physical Contingencies: 8.0 (%)

4. Consulting Fee: 7.0 (%) Based on the estimation by Survey Team.

5. Income Tax of Labour: 25.0 (%) According to PNG Personal Income Tax Act

6. Net Profit: 10.0 (%) of the net offering amount of the works to be proposed by contractors.

7. Price escalation:

For FC Portion:	3.0 (%)	Based on the similar projects in PPL.
For LC Portion:	7.0 (%)	Based on the 2007 Annual Report by National Statistical Offiice PNG.

8. Standard conversion factor (SCF): 0.99142 Based on the data of external trade.

Attachment 5-2 Comparison of Substation O&M Costs

(US$)

Plan-A Case of Full AIS	Unit cost	Man-Month	Yearly	Project Life	Total Cost of Project lif	Cost of each year
Engineer	168.3	12	12	30	726,866	24,228.9
Foreman	72.3	60	12	30	1,561,626	52,054.2
Electrician	48.6	60	12	30	1,050,624	35,020.8
Overhead (10% of Labour fee)					333,912	11,130.4
Spare parts & Temporary work cost	105,000.0			30	3,150,000	105,000.0
Sub-total					6,823,028	227,434.3
Total of 3 Substations (3 AISs)					20,469,083	682,302.8

Plan-B Case of Half AIS	Unit cost	Man-Month	Yearly	Project life	Total Cost of Project lif	Cost of each year
Engineer	168.26	7	12	30	424,005	14,134
Foreman	72.30	36	12	30	936,976	31,233
Electrician	48.64	36	12	30	630,374	21,012
Overhead (10% of Labour fee)					199,136	6,638
Spare parts & Temporary work cost (AIS)	75,000.0			30	2,250,000	75,000.0
Spare parts & Temporary work cost (GIS)	38,000.0			2	76,000	2,533.3
Sub-total					4,516,491	150,549.7
Total of 3 Substations (2 AISs & Half GIS)					18,162,546	605,418.2

Plan-C Case of Full GIS	Unit cost	Man-Month	Yearly	Project life	Total Cost of Project lif	Cost of each year
Engineer	168.26	2	12	30	121,144	4,038
Foreman	72.30	4	12	30	104,108	3,470
Electrician	48.64	4	12	30	70,042	2,335
Overhead (10% of Labour fee)					29,529	984
Spare parts & Temporary work cost (GIS)	126,000.0			2	252,000	8,400.0
Sub-total					576,824	19,227.5
Total of 3 Substations (2 AISs & Full GIS)					14,222,879	474,096.0

(Note)

1. Spare parts & Temporary work cost (GIS) is added each 15 years in a lump.

Attachment 5-3a Economic Evaluations

Plan-A Rehabilitation of 132 kV switchgear with full air insulated switchgear (AIS)

Year in order	Year	Cost (US$)				Benefit (US$)					Cash balance
		Construction economic cost		O&M cost	Total cost	Benefit due to gap of generation cost	External cost saving			Total benefit	
		FC	LC				Due to CO_2 reduction	Due to NOx reduction	Due to SOx reduction		
1	2014	24,843,348.0	14,899,133.8	1,066,715.3	40,809,197.1						-40,809,197.1
2	2015	14,822,988.0	10,833,190.9	1,371,491.1	27,027,670.1						-27,027,670.1
3	2016			1,371,491.1	1,371,491.1	7,632,193.8	1,868,059.9	280,209.0	1,436,969.2	11,217,431.9	9,845,940.8
4	2017			1,371,491.1	1,371,491.1	10,066,054.7	2,463,773.1	369,566.0	1,895,210.0	14,794,603.7	13,423,112.6
5	2018			1,371,491.1	1,371,491.1	12,499,915.6	3,059,486.2	458,922.9	2,353,450.9	18,371,775.6	17,000,284.5
6	2019			1,371,491.1	1,371,491.1	14,933,776.4	3,655,199.3	548,279.9	2,811,691.8	21,948,947.4	20,577,456.3
7	2020			1,391,491.1	1,391,491.1	17,367,637.3	4,250,912.4	637,636.9	3,269,932.6	25,526,119.2	24,134,628.1
8	2021			1,371,491.1	1,371,491.1	19,801,498.2	4,846,625.5	726,993.8	3,728,173.5	29,103,291.1	27,731,800.0
9	2022			1,371,491.1	1,371,491.1	21,482,691.1	5,258,115.2	788,717.3	4,044,704.0	31,574,227.7	30,202,736.6
10	2023			1,371,491.1	1,371,491.1	23,163,884.0	5,669,605.0	850,440.7	4,361,234.6	34,045,164.3	32,673,673.2
11	2024			1,371,491.1	1,371,491.1	24,845,077.0	6,081,094.7	912,164.2	4,677,765.1	36,516,100.9	35,144,609.8
12	2025			1,391,491.1	1,391,491.1	26,526,269.9	6,492,584.4	973,887.7	4,994,295.7	38,987,037.5	37,595,546.4
13	2026			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
14	2027			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
15	2028			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
16	2029			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
17	2030			1,391,491.1	1,391,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,066,483.0
18	2031			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
19	2032			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
20	2033			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
21	2034			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
22	2035			1,391,491.1	1,391,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,066,483.0
23	2036			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
24	2037			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
25	2038			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
26	2039			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
27	2040			1,391,491.1	1,391,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,066,483.0
28	2041			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
29	2042			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
30	2043			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
31	2044			1,371,491.1	1,371,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,086,483.0
32	2045			1,391,491.1	1,391,491.1	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,066,483.0
Total		39,666,336.0	25,732,324.7	43,702,939.8	109,101,600.5	742,468,254.0	181,726,936.7	27,259,040.5	139,789,951.3	1,091,244,182.5	982,142,582.0
In the condition of discount rate at:				10.0%							
Net present value (NPV):					70,146,775.5					233,205,562.5	163,058,787.0
Economic internal rate of return (EIRR):											26.74%
B/C ratio:											3.32

(Note)

1. Unit cost of generation

By Source	Cost per MWh
	(US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Unit price of emission gas

By gas	Ton per MWh	Price per ton	Price per MWh
	ton	(US$)	(US$)
CO_2	0.704	12.69	8.93
NOx	0.009	152.28	1.34
SOx	0.018	380.70	6.87

Based on the estimation by "Primary CDM Market of 2009" moving average issued by UN-FCCC.

Attachment 5-3b Economic Evaluations

Plan-B Only 132 kV transmission line feeders are to be GIS and the other parts such as 132 kV busbar and main transformer bays are to be AIS

Year in order	Year	Cost (US$)				Benefit (US$)					
		Construction economic cost		O&M cost	Total cost	Benefit due to gap of generation cost	External cost saving			Total benefit	Cash balance
		FC	LC				Due to CO_2 reduction	Due to NOx reduction	Due to SOx reduction		
1	2014	18,021,491.1	12,059,996.0	449,448.5	30,530,935.7						-30,530,935.7
2	2015	23,786,808.9	14,190,496.1	1,258,455.8	39,235,760.8						-39,235,760.8
3	2016			1,258,455.8	1,258,455.8	7,632,193.8	1,868,059.9	280,209.0	1,436,969.2	11,217,431.9	9,958,976.1
4	2017			1,258,455.8	1,258,455.8	10,066,054.7	2,463,773.1	369,566.0	1,895,210.0	14,794,603.7	13,536,148.0
5	2018			1,258,455.8	1,258,455.8	12,499,915.6	3,059,486.2	458,922.9	2,353,450.9	18,371,775.6	17,113,319.8
6	2019			1,258,455.8	1,258,455.8	14,933,776.4	3,655,199.3	548,279.9	2,811,691.8	21,948,947.4	20,690,491.6
7	2020			1,278,455.8	1,278,455.8	17,367,637.3	4,250,912.4	637,636.9	3,269,932.6	25,526,119.2	24,247,663.5
8	2021			1,258,455.8	1,258,455.8	19,801,498.2	4,846,625.5	726,993.8	3,728,173.5	29,103,291.1	27,844,835.3
9	2022			1,258,455.8	1,258,455.8	21,482,691.1	5,258,115.2	788,717.3	4,044,704.0	31,574,227.7	30,315,771.9
10	2023			1,258,455.8	1,258,455.8	23,163,884.0	5,669,605.0	850,440.7	4,361,234.6	34,045,164.3	32,786,708.5
11	2024			1,258,455.8	1,258,455.8	24,845,077.0	6,081,094.7	912,164.2	4,677,765.1	36,516,100.9	35,257,645.1
12	2025			1,278,455.8	1,278,455.8	26,526,269.9	6,492,584.4	973,887.7	4,994,295.7	38,987,037.5	37,708,581.8
13	2026			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
14	2027			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
15	2028			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
16	2029			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
17	2030			1,316,455.8	1,316,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,141,518.4
18	2031			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
19	2032			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
20	2033			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
21	2034			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
22	2035			1,278,455.8	1,278,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,179,518.4
23	2036			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
24	2037			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
25	2038			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
26	2039			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
27	2040			1,278,455.8	1,278,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,179,518.4
28	2041			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
29	2042			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
30	2043			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
31	2044			1,258,455.8	1,258,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,199,518.4
32	2045			1,316,455.8	1,316,455.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,141,518.4
Total		41,808,300.0	26,250,492.1	39,657,577.8	107,716,369.9	742,468,254.0	181,726,936.7	27,259,040.5	139,789,951.3	1,091,244,182.5	983,527,812.5
In the condition of discount rate at:				10.0%							
Net present value (NPV):					70,020,910.5					233,205,562.5	163,184,652.0
Economic internal rate of return (EIRR):											27.03%
B/C ratio:											3.33

(Note)

1. Unit cost of generation

By Source	Cost per MWh
	(US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Unit price of emission gas

By gas	Ton per MWh	Price per ton	Price per MWh
	ton	(US$)	(US$)
CO_2	0.704	12.69	8.93
NOx	0.009	152.28	1.34
SOx	0.018	380.70	6.87

Based on the estimation by "Primary CDM Market of 2009" moving average issued by UN-FCCC.

Attachment 5-3c Economic Evaluations

Plan-C Rehabilitation of 132 kV switchgear with full GIS

Year in order	Year	Cost (US$)				Benefit (US$)					Cash balance
		Construction economic cost		O&M cost	Total cost	Benefit due to gap of generation cost	External cost saving			Total benefit	
		FC	LC				Due to CO_2 reduction	Due to NOx reduction	Due to SOx reduction		
1	2014	12,560,306.8	10,037,454.7	80,125.2	22,677,886.7						-22,677,886.7
2	2015	31,760,397.2	16,360,197.7	1,041,627.8	49,162,222.7						-49,162,222.7
3	2016			1,041,627.8	1,041,627.8	7,632,193.8	1,868,059.9	280,209.0	1,436,969.2	11,217,431.9	10,175,804.1
4	2017			1,041,627.8	1,041,627.8	10,066,054.7	2,463,773.1	369,566.0	1,895,210.0	14,794,603.7	13,752,976.0
5	2018			1,041,627.8	1,041,627.8	12,499,915.6	3,059,486.2	458,922.9	2,353,450.9	18,371,775.6	17,330,147.8
6	2019			1,041,627.8	1,041,627.8	14,933,776.4	3,655,199.3	548,279.9	2,811,691.8	21,948,947.4	20,907,319.6
7	2020			1,061,627.8	1,061,627.8	17,367,637.3	4,250,912.4	637,636.9	3,269,932.6	25,526,119.2	24,464,491.5
8	2021			1,041,627.8	1,041,627.8	19,801,498.2	4,846,625.5	726,993.8	3,728,173.5	29,103,291.1	28,061,663.3
9	2022			1,041,627.8	1,041,627.8	21,482,691.1	5,258,115.2	788,717.3	4,044,704.0	31,574,227.7	30,532,599.9
10	2023			1,041,627.8	1,041,627.8	23,163,884.0	5,669,605.0	850,440.7	4,361,234.6	34,045,164.3	33,003,536.5
11	2024			1,041,627.8	1,041,627.8	24,845,077.0	6,081,094.7	912,164.2	4,677,765.1	36,516,100.9	35,474,473.1
12	2025			1,061,627.8	1,061,627.8	26,526,269.9	6,492,584.4	973,887.7	4,994,295.7	38,987,037.5	37,925,409.8
13	2026			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
14	2027			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
15	2028			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
16	2029			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
17	2030			1,187,627.8	1,187,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,270,346.4
18	2031			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
19	2032			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
20	2033			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
21	2034			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
22	2035			1,061,627.8	1,061,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,396,346.4
23	2036			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
24	2037			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
25	2038			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
26	2039			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
27	2040			1,061,627.8	1,061,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,396,346.4
28	2041			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
29	2042			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
30	2043			1,041,627.8	1,041,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,416,346.4
31	2044			996,627.8	996,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,461,346.4
32	2045			1,187,627.8	1,187,627.8	28,207,462.8	6,904,074.1	1,035,611.1	5,310,826.2	41,457,974.2	40,270,346.4
Total		44,320,704.0	26,397,652.4	32,697,586.3	103,415,942.7	742,468,254.0	181,726,936.7	27,259,040.5	139,789,951.3	1,091,244,182.5	987,828,239.8
In the condition of discount rate at:				10.0%							
Net present value (NPV):					69,415,424.5					233,205,562.5	163,790,138.0
Economic internal rate of return (EIRR):											27.23%
B/C ratio:											3.36

(Note)

1. Unit cost of generation

By Source	Cost per MWh
	(US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Unit price of emission gas

By gas	Ton per MWh	Price per ton	Price per MWh
	ton	(US$)	(US$)
CO_2	0.704	12.69	8.93
NOx	0.009	152.28	1.34
SOx	0.018	380.70	6.87

Based on the estimation by "Primary CDM Market of 2009" moving average issued by UN-FCCC.

Attachment 5-4a Financial Evaluations

Plan-A Rehabilitation of 132 kV switchgear with full air insulated switchgear (AIS)

Year in order	Year	Cost (US$)				Benefit (US$)			Cash balance
		Construction financial cost		O&M cost	Total cost	Benefit due to sales revenue	Benefit due to less power outage around Lae	Total benefit	
		FC	LC						
1	2014	24,843,348.0	18,886,545.4		43,729,893.4				-43,729,893.4
2	2015	14,822,988.0	13,479,158.2		28,302,146.2				-28,302,146.2
3	2016			1,371,491.1	1,371,491.1	7,632,193.8	101,326.4	7,733,520.2	6,362,029.1
4	2017			1,371,491.1	1,371,491.1	10,066,054.7	133,638.8	10,199,693.5	8,828,202.4
5	2018			1,371,491.1	1,371,491.1	12,499,915.6	165,951.2	12,665,866.7	11,294,375.6
6	2019			1,371,491.1	1,371,491.1	14,933,776.4	198,263.5	15,132,040.0	13,760,548.9
7	2020			1,391,491.1	1,391,491.1	17,367,637.3	230,575.9	17,598,213.2	16,206,722.1
8	2021			1,371,491.1	1,371,491.1	19,801,498.2	262,888.3	20,064,386.5	18,692,895.4
9	2022			1,371,491.1	1,371,491.1	21,482,691.1	285,208.1	21,767,899.3	20,396,408.1
10	2023			1,371,491.1	1,371,491.1	23,163,884.0	307,528.0	23,471,412.0	22,099,920.9
11	2024			1,371,491.1	1,371,491.1	24,845,077.0	329,847.8	25,174,924.7	23,803,433.6
12	2025			1,391,491.1	1,391,491.1	26,526,269.9	352,167.6	26,878,437.5	25,486,946.4
13	2026			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
14	2027			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
15	2028			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
16	2029			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
17	2030			1,391,491.1	1,391,491.1	28,207,462.8	374,487.4	28,581,950.2	27,190,459.1
18	2031			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
19	2032			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
20	2033			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
21	2034			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
22	2035			1,391,491.1	1,391,491.1	28,207,462.8	374,487.4	28,581,950.2	27,190,459.1
23	2036			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
24	2037			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
25	2038			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
26	2039			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
27	2040			1,391,491.1	1,391,491.1	28,207,462.8	374,487.4	28,581,950.2	27,190,459.1
28	2041			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
29	2042			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
30	2043			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
31	2044			1,371,491.1	1,371,491.1	28,207,462.8	374,487.4	28,581,950.2	27,210,459.1
32	2045			1,391,491.1	1,391,491.1	28,207,462.8	374,487.4	28,581,950.2	27,190,459.1
Total		39,666,336.0	32,365,703.5	41,264,733.3	113,296,772.9	742,468,254.0	9,857,144.3	752,325,398.3	639,028,625.4
In the condition of discount rate at:				10.0%					
Net present value (NPV):					73,855,240.0			160,776,543.4	86,921,303.5
Financial internal rate of return (FIRR):									19.58%
B/C ratio:									2.18

(Note)

1. Unit cost of generation

By Source	Cost per MWh (US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Estimation of less power outage

Initial MWh of power outage (MWh)
436.0

Based on the record of power outage caused around transmission line in Taraka SS grid in the first half of January 2012.

Attachment 5-4b Financial Evaluations

Plan-B Only 132 kV transmission line feeders are to be GIS and the other parts such as 132 kV busbar and main transformer bays are to be AIS

Year in order	Year	Cost (US$)				Benefit (US$)			Cash balance
		Construction financial cost		O&M cost	Total cost	Benefit due to sales revenue	Benefit due to less power outage around Lae	Total benefit	
		FC	LC						
1	2014	18,021,491.1	15,106,142.1		33,127,633.2				-33,127,633.2
2	2015	23,786,808.9	18,004,824.4		41,791,633.3				-41,791,633.3
3	2016			1,258,455.8	1,258,455.8	7,632,193.8	101,326.4	7,733,520.2	6,475,064.4
4	2017			1,258,455.8	1,258,455.8	10,066,054.7	133,638.8	10,199,693.5	8,941,237.7
5	2018			1,258,455.8	1,258,455.8	12,499,915.6	165,951.2	12,665,866.7	11,407,410.9
6	2019			1,258,455.8	1,258,455.8	14,933,776.4	198,263.5	15,132,040.0	13,873,584.2
7	2020			1,278,455.8	1,278,455.8	17,367,637.3	230,575.9	17,598,213.2	16,319,757.5
8	2021			1,258,455.8	1,258,455.8	19,801,498.2	262,888.3	20,064,386.5	18,805,930.7
9	2022			1,258,455.8	1,258,455.8	21,482,691.1	285,208.1	21,767,899.3	20,509,443.5
10	2023			1,258,455.8	1,258,455.8	23,163,884.0	307,528.0	23,471,412.0	22,212,956.2
11	2024			1,258,455.8	1,258,455.8	24,845,077.0	329,847.8	25,174,924.7	23,916,469.0
12	2025			1,278,455.8	1,278,455.8	26,526,269.9	352,167.6	26,878,437.5	25,599,981.7
13	2026			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
14	2027			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
15	2028			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
16	2029			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
17	2030			1,316,455.8	1,316,455.8	28,207,462.8	374,487.4	28,581,950.2	27,265,494.4
18	2031			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
19	2032			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
20	2033			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
21	2034			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
22	2035			1,278,455.8	1,278,455.8	28,207,462.8	374,487.4	28,581,950.2	27,303,494.4
23	2036			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
24	2037			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
25	2038			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
26	2039			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
27	2040			1,278,455.8	1,278,455.8	28,207,462.8	374,487.4	28,581,950.2	27,303,494.4
28	2041			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
29	2042			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
30	2043			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
31	2044			1,258,455.8	1,258,455.8	28,207,462.8	374,487.4	28,581,950.2	27,323,494.4
32	2045			1,316,455.8	1,316,455.8	28,207,462.8	374,487.4	28,581,950.2	27,265,494.4
Total		41,808,300.0	33,110,966.5	37,949,673.5	112,868,940.0	742,468,254.0	9,857,144.3	752,325,398.3	639,456,458.3
In the condition of discount rate at:				10.0%					
Net present value (NPV):					74,493,836.0			160,776,543.4	86,282,707.5
Financial internal rate of return (FIRR):									19.54%
B/C ratio:									2.16

(Note)

1. Unit cost of generation

By Source	Cost per MWh (US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Estimation of less power outage

Initial MWh of power outage (MWh)
436.0

Based on the record of power outage caused around transmission line in Taraka SS grid in the first half of January 2012.

Attachment 5-4c Financial Evaluations

Plan-C Rehabilitation of 132 kV switchgear with full GIS

Year in order	Year	Cost (US$)				Benefit (US$)			Cash balance
		Construction financial cost		O&M cost	Total cost	Benefit due to sales revenue	Benefit due to less power outage around Lae	Total benefit	
		FC	LC						
1	2014	12,560,306.8	12,347,136.2		24,907,443.0				-24,907,443.0
2	2015	31,760,397.2	21,125,454.7		52,885,851.9				-52,885,851.9
3	2016			1,041,627.8	1,041,627.8	7,632,193.8	151,757.2	7,783,951.0	6,742,323.2
4	2017			1,041,627.8	1,041,627.8	10,066,054.7	200,151.7	10,266,206.3	9,224,578.6
5	2018			1,041,627.8	1,041,627.8	12,499,915.6	248,546.1	12,748,461.7	11,706,833.9
6	2019			1,041,627.8	1,041,627.8	14,933,776.4	296,940.6	15,230,717.0	14,189,089.2
7	2020			1,061,627.8	1,061,627.8	17,367,637.3	345,335.0	17,712,972.4	16,651,344.6
8	2021			1,041,627.8	1,041,627.8	19,801,498.2	393,729.5	20,195,227.7	19,153,599.9
9	2022			1,041,627.8	1,041,627.8	21,482,691.1	427,158.1	21,909,849.2	20,868,221.4
10	2023			1,041,627.8	1,041,627.8	23,163,884.0	460,586.6	23,624,470.6	22,582,842.9
11	2024			1,041,627.8	1,041,627.8	24,845,077.0	494,015.1	25,339,092.1	24,297,464.3
12	2025			1,061,627.8	1,061,627.8	26,526,269.9	527,443.7	27,053,713.6	25,992,085.8
13	2026			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
14	2027			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
15	2028			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
16	2029			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
17	2030			1,187,627.8	1,187,627.8	28,207,462.8	560,872.2	28,768,335.0	27,580,707.3
18	2031			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
19	2032			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
20	2033			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
21	2034			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
22	2035			1,061,627.8	1,061,627.8	28,207,462.8	560,872.2	28,768,335.0	27,706,707.3
23	2036			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
24	2037			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
25	2038			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
26	2039			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
27	2040			1,061,627.8	1,061,627.8	28,207,462.8	560,872.2	28,768,335.0	27,706,707.3
28	2041			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
29	2042			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
30	2043			1,041,627.8	1,041,627.8	28,207,462.8	560,872.2	28,768,335.0	27,726,707.3
31	2044			996,627.8	996,627.8	28,207,462.8	560,872.2	28,768,335.0	27,771,707.3
32	2045			1,187,627.8	1,187,627.8	28,207,462.8	560,872.2	28,768,335.0	27,580,707.3
Total		44,320,704.0	33,472,590.9	31,575,833.3	109,369,128.2	742,468,254.0	14,763,108.3	757,231,362.3	647,862,234.1
In the condition of discount rate at:				10.0%					
Net present value (NPV):					74,519,673.3			161,824,978.0	87,305,304.6
Financial internal rate of return (FIRR):									19.61%
B/C ratio:									2.17

1. Unit cost of generation

By Source	Cost per MWh (US$)
Thermal	121.0
Hydro	84.5

Based on the estimation by "by Energy Information Administration, Annual Energy Outlook 2011" issued by U.S. Energy Information Administration (EIA).

2. Estimation of less power outage

Initial MWh of power outage (MWh)
653.0

Based on the record of power outage caused around transmission line in Taraka SS grid in the first half of January 2012.