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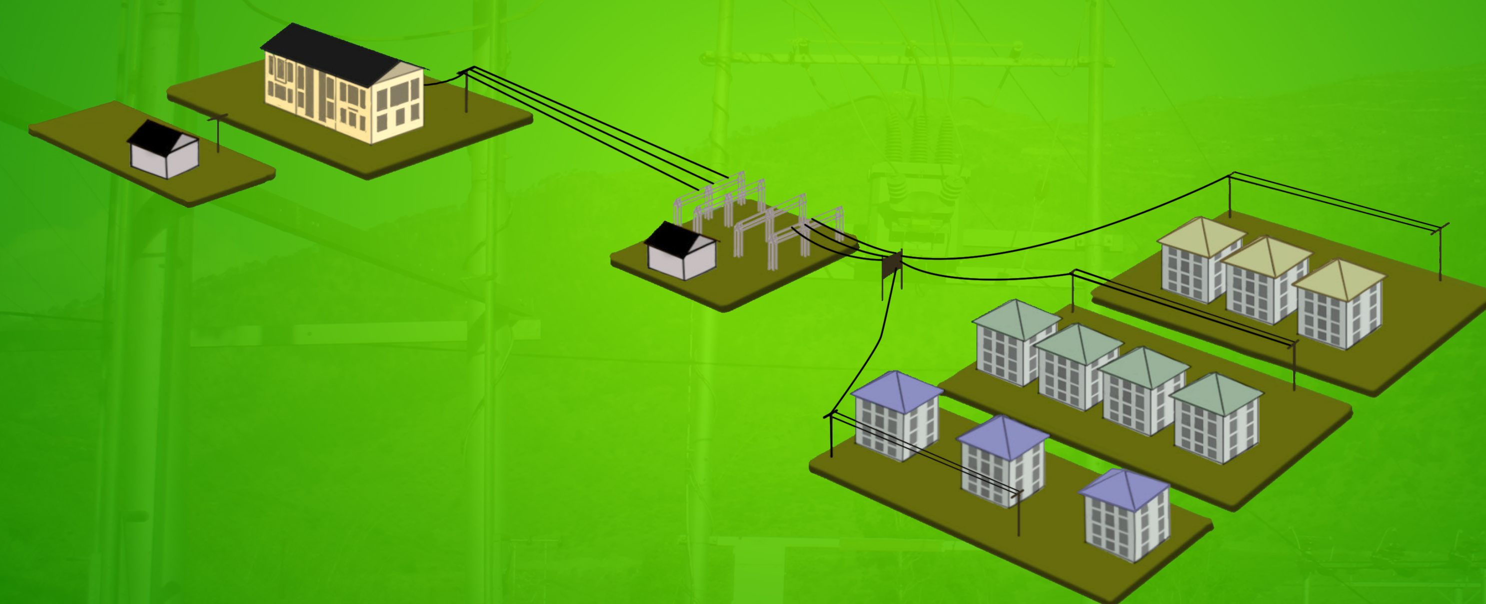
DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

ZHEMGANG DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2019

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FOREWORD

The Distribution System Master Plan (DSMP) identifies, prioritizes and opts for adequate and optimal distribution system expansion and augmentation programs to meet the expected electricity growth and demand development in the Country. This timely formulation of DSMP is in line with the stated corporate strategic objective of providing affordable, reliable and quality services to customers and will enable to traverse the changing technological, regulatory and social constraints for the time horizons considered.

The DSMP has been finalized after a series of consultative discussions with all the relevant stakeholders to obtain a shared outcome. In particular, adequate efforts have been taken to ensure that the DSMP aligns and integrates with the stated plans and programs of the Royal Government of Bhutan (RGoB) for the energy sector.

Based on the expected demand development for the time horizons considered, the DSMP outlines the road map for the implementation of optimized distribution network expansion programs and projects in stages with the expected investment required and financial commitments. The DSMP will be updated on a regular basis to incorporate changing business imperatives and contexts to ensure its relevance.

Appreciation goes to all the officials of the Distribution Services for formulating and coming out a comprehensive document that is timely which will serve as a blueprint for the Distribution Services to build a robust distribution system that will go a long way in contributing towards realization of BPC's objectives of providing a reliable electricity supply to its valued customers.

(Sonam Tobjey)
Chief Executive Officer

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Abbreviations

BPC: Bhutan Power Corporation Limited

ESD: Electricity Services Division

DSMP: Distribution System Master Plan

GIS: Geographical Information System

SLD: Single Line Diagram

ETAP: Electrical Transient and Analysis Program

IS: Indian Standard on Transformers

IEC: International Electro-Technical Commission

IP: Industrial Park

DT: Distribution Transformer

TSA: Time Series Analysis

LRM: Linear Regression Method

MV: Medium voltage (33kV, 11kV and 6.6kV)

DDCS: Distribution Design and Construction Standards

kVA: Kilo Volt Ampere

W: Watt

kWh: Kilo Watt Hour

RMU: Ring Main Unit

ARCB: Auto Recloser Circuit Breaker

ISD: Intelligent Switching Device

FPI: Fault Passage Indicator

ICT: Interconnecting Transform

Definitions

Asset Life: The period (or the total amount of activity) for which the asset will be economically feasible for use in a business.

Balanced system: A system is said to be balanced when all phase conductors carry approximately the same current. For delta systems, this applies to two-phase conductors, and for three-phase wye systems, this applies to three-phase conductors.

Contingency plan: Power that is needed when regularly used electric generating units are not in services, such as during short-term emergencies or longer unplanned outages, and during periods of scheduled maintenance when the units must be shut down. Short-term backup power is generally called emergency power. Long-range backup power is often provided for in reserve sharing agreements.

Capacity: Also known as the power or capability of an electric generating plant. 1) Facilities and places to serve electric customers. 2) The total amount of electrical energy a power line can transport at any given time (Measured in kVA).

Clearance: The clear distance between two objects measured surface to surface. For safety reasons, proper clearance must be maintained between power lines and the ground, buildings, trees, etc.

Critical Value: The value of the random variable at the boundary between the acceptance region and the rejection region in the testing of a hypothesis.

Distribution line: That part of the electrical supply system that distributes electricity at medium voltage (33kV, 11kV & 6.6kV) from a transformer substation to transformers or other step-down devices service customer premises, which finally supply power at the voltage required for customer use.

Distribution loss: Energy losses in the process of supplying electricity to consumers due to commercial and technical losses.

Distribution system: The portion of the transmission and facilities of an electric system that is dedicated to delivering electric energy to an end-user.

Energy: Delivered power measured in kilowatt-hours (kWh).

Generating station: A plant wherein electric energy is produced by conversion from some other forms of energy.

Grid: A system of high-voltage transmission and power-generating facilities that are interconnected with several other bulk power supply agencies on a regional basis. A grid enables power to be transmitted from areas having a surplus to areas experiencing a shortage. A grid also eliminates some duplication of costly facilities in a given region.

Investment: the action or process of investing money for certain activities with return and profit.

Lines (electrical supply) - Those conductors used to transmit or deliver electric energy and their necessary support or containing structures.

Linear Regression Method: In **statistical modeling**, regression analysis is a set of statistical processes for **estimating** the relationships between a **dependent variable** (often called the 'outcome variable') and one or more **independent variables.**

Load: 1) A device, or resistance of a device, to which power is delivered in a circuit. 2) The measure of electrical demand placed on an electric system at any given time.

Load forecasting: The methods used in determining a system's short and long-term growth in peak load and energy sales in kilowatt-hour.

Load Growth: The increase in the demand for power required over time.

Marginal Value: Just barely adequate or within a Lower Limit.

On line - Term generally used to indicate when a generating plant and transmission line is scheduled to be in operation. When an operational plant and line are not online, it is said to be "down."

Outage - Interruption of service to an electric consumer.

Overload - Operation of equipment over normal, full-load rating, or of a conductor above rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Optimization: the action of making the best or most effective use of a situation or resource.

Pad-mounted equipment- General term describing enclosed equipment, the exterior of which enclosure is at ground potential, positioned on a surface-mounted pad. Example: underground transformers and junction boxes.

Peak demand - The maximum amounts of electricity used by a utility customer at any given time during the year. The peak is used to measure the amount of electric transmission, distribution, and generating capacity required to meet that maximum demand, even if it occurs infrequently and only for very short durations.

Peak load - The greatest amount of electricity used during a time period by the consumers in a utility's system.

Power - The time rate of electric energy in a device or circuit, measured in watts.

Power factor - A measurement of efficiency in the use of electricity. For example, a 100% power factor would be like a horse pulling a wagon on rails directly forward with no resistance. If the horse turns and pulls at a right angle to the rails, he may pull just as hard, but his efforts will not move the car. This would be a zero percent power factor. Now, if he pulls at a 45-degree angle to the rails, he will pull the car, but not with as high efficiency as if he were pulling straight down the rails. In the use of electricity, not every kilowatt generated translates into equivalent horsepower efficiency.

Power grid - A network of generation, transmission, and distribution system that are interconnected

Power quality - The extent to which a utility system can maintain its delivery of electric energy within the tolerable limits of voltage and without outages or other problems that affect a customer's equipment use.

Power supply - Source of current and voltage.

Reliability - A measure of a utility's ability to deliver uninterrupted electric service to its customers.

Substation - An electrical facility containing switches, circuit breakers, buses, and transformers for switching power circuits and transforming power from one voltage to another, or from one system to another.

Time Series Analysis: The statistical techniques used when several years' data are available to forecast load growth.

1. Executive Summary

Bhutan Power Corporation Limited is mandated to provide affordable, adequate, reliable, and quality electricity services to the customers through transmission and distribution networks established across the country. Towards realizing the mission, vision, and destination statement of BPC as outlined in the Corporate Strategic Plan (2019-2030), there is a need to carry out comprehensive studies of the distribution system to address the system deficiencies as the ground realities are different triggered by technological advancement and economic growth.

The existing distribution networks are modeled and accordingly, the technical evaluation is carried out adopting the generally accepted load forecasting framework i.e. Time Series Analysis in conjunction with Linear Regression Method, the power requirement for the next ten (10) years are forecasted. Subsequently, the network capability and the system gaps are identified with proposed distribution system planning. The investments are proposed (based on the priority matrix) to address the system inadequacies with the intent to improve the Customer Services Excellence, Operational and Resource Optimization Excellence, Innovation and Technology Excellence, and Business Growth Excellence.

The single to three-phase distribution network conversion across the country is reproduced in this report based on the studies carried out by BPC "Technical and Financial Proposal on Converting Single Phase to Three-Phase Power Supply in Rural Areas".

The details on the distribution grid modernization are outlined in Smart Grid Master Plan2019 including the investment (2020-2027). The identification of the system deficiencies and qualitative remedial measures that would require system automation and remote control as per the existing and projected load is only outlined in this report. Similarly, the system study beyond the Distribution Transformers had to be captured during the annual rolling investment and budget approval.

The ETAP tool is used to carry out the technical evaluation and validate the system performance. Finally, necessary contingency plans, up-gradation, and reinforcement plans are proposed as annual investment plans based on the outcome of the simulation result.

2. Introduction

The system study is intended to improve the power distribution system in Bhutan by formulating a comprehensive, national level and district wise DSMP (2020-2030) till 2030 that provides measures for renewing and reinforcing power distribution facilities. BPC's distribution system has grown in size and complexity over the years. While many network additions and alterations carried out so far were as per the recommendations of the Druk Care Consultancy Study Report (2006), the ground realities are evermore different now than anticipated during the study. There is a need to explore opportunities for optimizing the available resources and develop a master plan for future investments.

Some of the prominent driving factors required for the development of the master plan include but not limited to a reliable power supply to the customers, reduction of distribution losses, network capability with the anticipated load growth, optimization of the resources and to develop an annual investment plan.

BPC has never carried out comprehensive system studies to improve the distribution system and optimize the available resources. The recurring investment plans (annual) are based on the on-site and field proposals without any technical evaluation being carried out which could have resulted in preventable and excessive investments. Therefore, proper planning is necessary to improve the system for optimal usage of resources.

It is also intended that this master plan is to provide general guidance in preparing long-range system planning. The analysis indicates where up-grades are most likely to be economical and provides insight into the development of a practical transition from the existing system to the proposed long-range system. Based on this analysis, recommendations are made for improving system performance and increasing system capacity for expansion. Periodic reviews of the master plan will be required to examine the applicability of the preferred plan considering actual system developments.

3. Objectives of the Master Plan

The objective(s) of the DSMP (are):

3.1 To carry out the system study of the existing distribution network, forecast and come out with the comprehensive ten (10) years strategic distribution plan;

3.2 To provide affordable and adequate electricity, reduce losses, improve power quality, reliability, optimize the resources and gear towards excellent customer services; and

3.3 To come out with annual investment plans.

4. Scope of the Distribution System Master Plan

Formulation of detailed DSMP (2020-2030) of the Dzongkhag for renewal, reinforcement, and extension of the power distribution system up to DT.

5. Methodology and Approach

To better understand the existing distribution system and postulate the credible investment plans; a standard framework and procedures had been adopted. However, in the absence of any standardized procedures in BPC for the planning of distribution system, the following customized procedures detailed in **Section 5.1** through **Section 5.5** and as shown in **Figure 1** are considered to suit BPC's requirement for developing the DSMP.

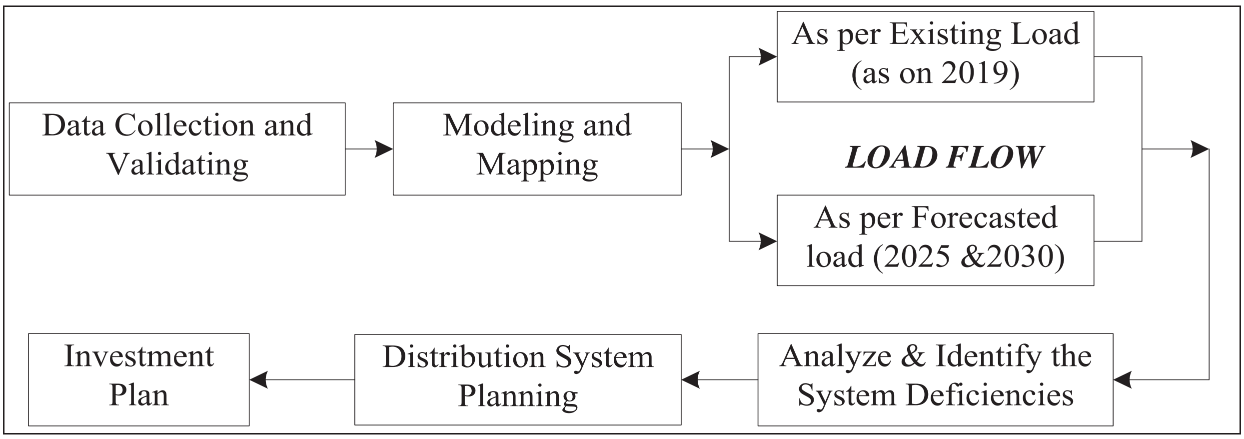


Figure 1: Block Diagram for Distribution System Planning for Thematic Studies

5.1 Data Collection and Validation

To carry out the detailed studies with greater accuracy, complete and reliable data of the existing distribution infrastructure is required. Therefore, an intensive field investigation was carried out during January and May 2020 to validate the information that was collected. The information required for the studies does not confine to the BPC's internal distribution network but also the developmental activities of the cross-governmental sectors. The power arrangement requirements from these developmental activities were also used to forecast the power demand. The data validation on the distribution system includes the review of all the power sources, medium voltage lines, and transformers with that of GIS data of Environment and GIS Division and SLD submitted by respective ESDs which is attached as **Annexure-1.**

5.2 Modeling and Mapping

The feeder wise distribution lines and transformers were modeled and mapped in the ETAP tool and the base case was developed for the existing distribution network. The technical parameters for the lines and transformers were considered based on IS 2026, IEC 60076 (Details attached as **Annexure-2**) to develop the base model. The modeling and Mapping detail is attached as **Annexure-1.**

5.3 Analysis and Identification of System Deficiencies

The existing distribution system model was analyzed in the ETAP involving balanced load flow to figure out the network capabilities against the set distribution standards. The load growth was projected using the commonly adopted methodology that is LRM in conjunction with TSA which is based on the historical data and accordingly the behavior of the distribution system was analyzed, and the system deficiencies were identified

5.4 Distribution System Planning

Necessary deterministic and probable distribution system planning methods are proposed to address the system gaps focusing on the reduction of losses, improving the reliability and power quality. Accordingly, any contingency plans, up-gradation, and reinforcement plans are proposed along with the investment plans incorporating best fit technology.

5.5 Investment Plan

The approved investment plans (from 2019 to 2024) have been validated based on the outcome of the system studies and accordingly, the yearly investment plans are outlined as per the priority matrix as detailed in **Section 9.**

6. Existing Electricity Distribution Network

6.1 Overview of Power Supply Sources

The power supply to Zhemgang Dzongkhag is fed from the 132/33/11 kV Tingtibi substation. The power supply to the Tingtibi substation comes from a 60 MW Kurichu hydropower plant, channeled through 132 kV transmission lines from 220kV Jigmeling substation and 132/33/11kV Nanglam substation. Additionally, Zhemgang Dzongkhag has a 2x100 kW mini-hydropower plant at Tingtibi. The generation from the mini hydel is synchronized and injected into the grid. Further, a 33kV feeder (Panbang Feeder) is constructed from the Nanglam substation which forms a ring system and supplies power to Panbang Dungkhag. The overall power distribution network of the Dzongkhag is illustrated in the schematic diagram shown in **Figure 2**.

As can be seen from the figure, a transformation capacity of 2x3 MVA, 132/33kV, and 2x1.5 MVA, 33/11kV is available at the Tingtibi substation. The substation has three (3) number of 33kV outgoing feeders (i.e. 33kV Zhemgang, 33kV Gomphu, and 33kV Dakpai feeders) and one (1) number of 11kV feeder (11kV Tama feeder).

The 33kV Zhemgang feeder supplies power to the customers of the Zhemgang town area. The line is further extended and caters to the power requirement of Nobji and Korphu gewogs under Trongsa Dzongkha.

The power generated from the 2x100 kW Tingtibi power plant is step up to 6.6 kV and distributed to the Yebilaptsa and Tingtibi communities. The generation is also interconnected with a 33 kV Zhemgang feeder through a 33/6.6 kV, 1.5 MVA Inter-Connecting Transformer (ICT).

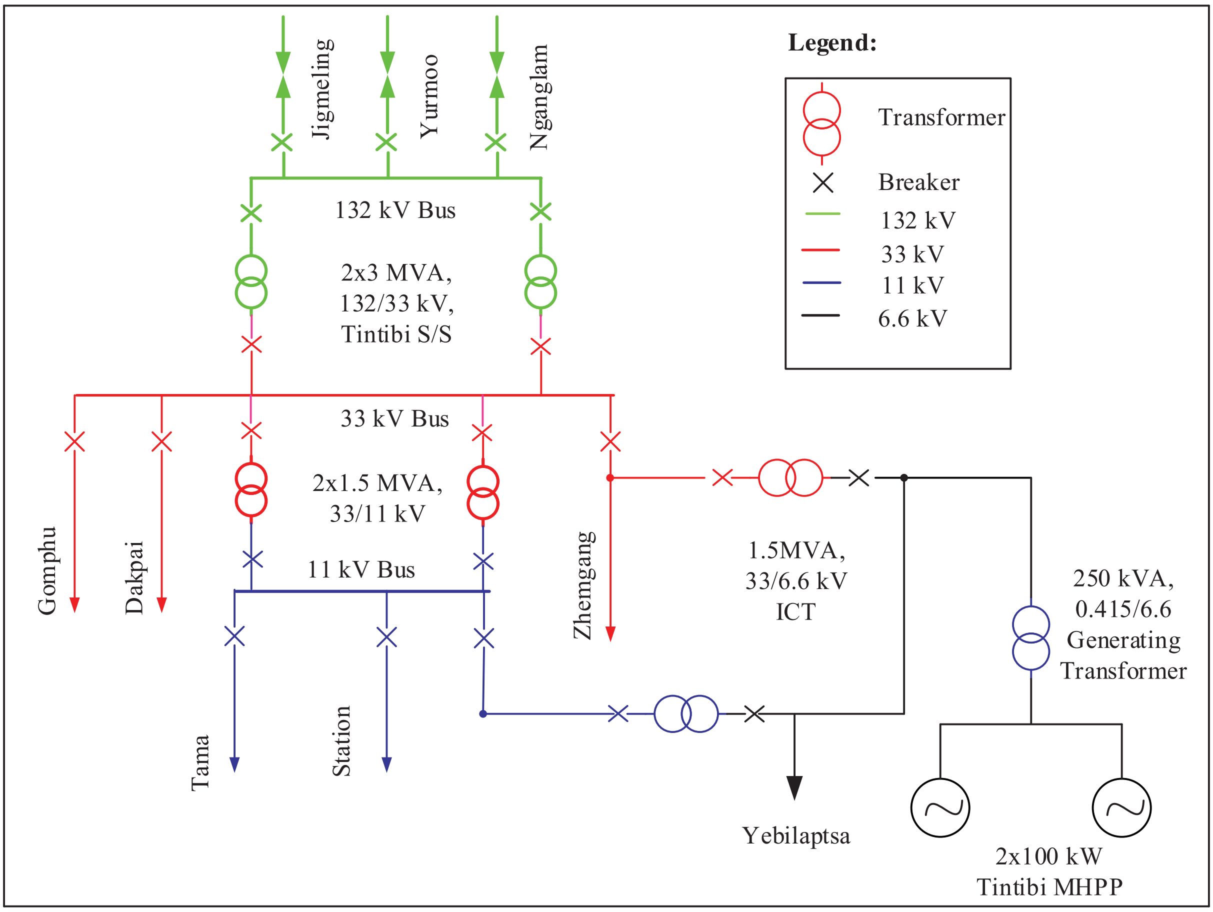


Figure 2: Electricity distribution schematic of Zhemgang Dzongkha

6.2 Electricity Distribution Lines

The quantity of MV and LV lines infrastructure operated and maintained by ESD Zhemgang is summarized in **Table 1**.

Table 1: MV and LV line infrastructure details

Sl. No.	33 kV (km)		11 kV (km)		6.6kV (km)		Total MV line (km)	LV lines (km)		Total LV length (km)
	OH	UG	OH	UG	OH	UG		OH	UG	
1	314.115	-	10.34	-	20.228	0.292	**344.974**	315.746	1.361	**317.107**

The total MV line length is 344.974 km and the total LV line length is 317.107 km. The ratio of LV to MV line length is 1:1.10 which reflects an almost equal proportion of the distribution network in the Dzongkhag. While the ratio of LV to MV line length would vary according to the site conditions, as a general rule, the ratio of 1.2:1 should be maintained which would balance the initial capex and optimize the running and maintenance costs. The MV distribution network is mainly through 33 kV and11 kV overhead lines.

6.3 Distribution Transformers

The number of distribution transformers at various kVA rating levels operated and maintained by the ESD Zhemgang is tabulated in **Table 2.**

Table 2: Total numbers of transformers & installed capacity & customers

Source	Capacity (MVA)	Feeder	Feeder Length (km)	DTs (Nos.)	Connected (kVA)	Customers connected (Nos.)
132/33/11kV Tingtibi Substation	2x3	33kV Zhemgang	27.1	43	4318	1041
		33kV Gomphu	175.298	96	2965	2019
		33kV Dakpai	116.298	66	2663	1184
	2x1.5	11kV Tama	10.340	6	264	139
		Station/Colony Feeder	0.07	2	200	
200kW Tingtibi Micro-Hydel	0.25	6.6kV Yebilaptsa	15.938	12	1110	366
Total			**345.044**	**225**	**11,520.00**	**4,749.00**

Till July 2020, there are 225 distribution transformers with a total capacity of 11,520kVA. As can be inferred from **Table 2,** the installed capacity of the transformer per customer is 2.43 kVA (4,749 customers as of July 2020 including 260 customers of Trongsa).

7. Analysis of Distribution System

Based on the model developed in ETAP for the existing feeder wise distribution network, analysis of the system was carried out by considering the forecasted load growth from 2020-2030. The quality of power, reliability, and energy loss of the existing network was assessed, and accordingly, the augmentation and reinforcement works are proposed which shall be an integral part of the investment plan. The assessment of MV lines, DTs, power sources, reliability of the power supply, and energy & power consumption pattern are presented from **Section 7.1** through **Section 7.4**.

7.1 Assessment of Power Sources

The assessments of the capabilities of the power sources were exclusively done based on the existing and forecasted load. The source capability assessment had to be carried out to ascertain the adequacy of the installed capacity against the existing load and the forecasted load. The assessment had been carried out bifurcating HV and MV substations as detailed below.

7.1.1 HV Substation (132/33/11kV)

Tingtibi substation is the primary power source to Zhemgang Dzongkhag. To assess the capacity of the substation, the peak power consumed has been compiled based on the historical data. The details on the installed capacity of substations, existing peak load, and anticipated load in the future are tabulated in **Table 3.**

Table 3: Peak load of Tingtibi Substation

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW	2019	2025	2030
1	Tingtibi Substation	132/33	2x3	5.1	2.52	3.486	4.04
		33/11	2x1.5	2.55	0.57	0.723	0.941

As seen from **Table 3,** the recorded peak load at the Tingtibi substation in the year 2019 is 2.52 MW and 0.57MW at 33kV and 11kV voltage levels respectively. The time series forecast projected a load of 4.04MW at 33kV voltage level and 0.941MW at 11kV voltage level against its installed capacity of 5.1MW and 2.55MW (@ 0.85 pf), respectively. Hence it is evident that the substation would be adequate to cater to the present and forecasted electricity demand.

7.1.2 MV Substation (33/11 kV)

No MV substation is available under the administration of the Dzongkhag.

7.2 Assessment of MV Feeder

Feeder wise planning is necessary to ensure that the power delivery capacity, power quality, and reliability requirements of the customers are met. In a distribution system, capacity assessment of existing MV feeders is important to ensure that feeders are adequate to transmit the peak demand of the load connected to the feeders. Particularly, the capacity assessment of the feeders enables the identification of feeders that require reinforcement and reconfiguration works.

The behavior of the MV feeders is assessed based on the existing and forecasted load, feeder wise energy loss, reliability, and single to three-phase line conversions which are outlined vividly in **Section 7.2.1** through **Section 7.2.4**. Further, recognizing that the asset life of the distribution system is thirty years (30), our system should be able to handle the load growth (peak demand) for the next 30 years. Therefore, it is equally important to consider the asset life of the system in addition to the assessment of the system at different time horizons.

7.2.1 Assessment of MV Feeder Capacity

The load profile of MV feeders emanating from the Tingtibi substation had been compiled based on the historical data. The array of daily and monthly peak demand was sorted to obtain the annual peak demand. The feeder-wise peak demand recorded at the source is presented in **Table 4** and the corresponding feeder-wise annual load curve is presented in **Figures 3.**

Table 4: Historical feeder wise peak power demand of ESD Zhemgang.

Sl.No.	Power Source	Feeder Name	Peak Load (MW)			
			2016	2017	2018	2019
1	132/33/11kV, 2x3MVA, Tingtibi Substation & 0.415/6.6kV, 250kVA, Tingtibi Micro-Hydel	33kV Zhemgang Feeder	0.9	0.83	0.7	0.828
		33kV Gomphu Feeder	0.856	0.7	0.88	0.689
		33kV Dakpai Feeder	0.9	0.815	0.933	1.003
		11kV Tama Feeder	0.134	0.066	0.096	0.173
		6.6kV Yebilaptsa Feeder	0.409	0.185	0.48	0.377
		Station/Colony feeder	-	-	-	0.02

From **Figure 3**, it is noted that there is a lot of anomalies in the recorded peak load of the feeders. Although the reason for the inconsistency in the data could not be ascertained, the peak load data had been normalized and forecasted the energy demand for the next ten (10) years.

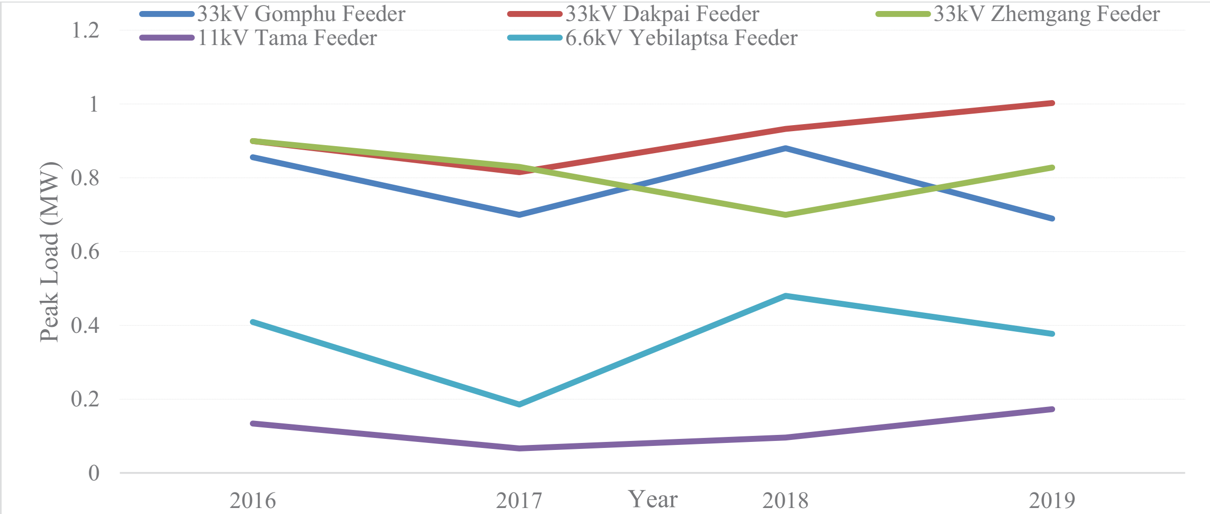


Figure 3: Peak load (MW) of Tingtibi substation outgoing feeders

The load carrying capacity of a feeder is determined by the line length and degree of load connected in addition to other parameters like ampacity capability. As evident from **Table 2,** the power distribution in the Dzongkhag is through 33kV and 11kV system. The types of conductors used are mostly ACSR-Rabbit and Dog. **Table 5** exhibits the ampacity capability of the conductors at different voltage levels. Ampacity capability (thermal loading) of the lines have been calculated based on IS 398 (Part-II): 1996 for maximum conductor temperature 85°C for ACSR conductors considering an ambient temperature of 40°C.

Table 5: Thermal loading of ACSR conductor at different voltage levels

Sl. No.	ACSR Conductor Type	Ampacity of Conductor	MVA rating corresponding to the Ampacity
33 kV Voltage Level			
1	RABBIT	193	11.031
2	DOG	300	17.146
3	WOLF	398	22.748
11 kV Voltage Level			
1	RABBIT	193	3.677
2	DOG	300	5.715
3	WOLF	398	7.582

The distribution network is developed using the ETAP software based on the existing and the forecasted load for the assessment. The assessment is then carried out for the following case scenarios. The upcoming LAPs, bulk load/industrial load sanctioned by DCSD, BPC is also being considered. These power demands are added to the peak load forecast of that year when the load is anticipated to come in subsequent years.

a) System Study with Existing System
b) System Study with future load: 2025 scenario
c) System Study with future load: 2030 scenario
d) System Study when Tingtibi Mini Hydropower Plant is down

a) System Study with Existing Load

A load flow analysis of the existing system was carried out considering the 2019-20 peak load. From the simulation results, it shows that all the feeders would experience an optimal voltage drop (within ±10%) at the substation bus as well as at the end of feeders. Hence, it is evident that the distribution network has adequate capacity to deliver the power to the customers without any additional investment.

b) Assessment of MV Feeder Capacities with the Forecasted Load

The peak power demand presented in **Table 4** has been considered to forecast the power demand for the next 10 years (2020-2030). Linear Regression Method (LRM) in conjunction with Time Series Analysis (TSA) is adopted to forecast the load as detailed in **Annexure- 3**. The summary of the forecasted load for the feeders is tabulated in **Table 6.**

Table 6: Feeder wise load forecast of ESD Zhemgang.

Feeder Name	Forecasted Load Growth (MW)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Zhemgang Feeder	0.95	0.97	0.99	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17
33kV Gomphu Feeder	0.96	1.01	1.05	1.10	1.15	1.19	1.24	1.29	1.33	1.38	1.42
33kV Dakpai Feeder	1.02	1.06	1.10	1.15	1.19	1.23	1.28	1.32	1.36	1.40	1.45
11kV Tama Feeder	0.11	0.13	0.14	0.16	0.17	0.19	0.20	0.22	0.23	0.24	0.26
6.6kV Yebilaptsa Feeder	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59	0.61
Station/Colony Feeder	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.06	0.07

From the power flow analysis of the 2025 and 2030 loading scenarios, the 6.6 kV feeder would experience marginal voltage which can be improved by changing the transformer tap position. No abnormality was observed in the rest of the feeders. **Table 7** exhibits the voltage profile of the feeders at 2025 and 2030 loading.

Table 7: Voltage profile of the feeders (2025 & 2030 Loading)

Feeder Name	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage (%)		
	Load	Bus	End	Load	Bus	End
Tingtibi SS(132/33kV)	3.022	100	98.17	3.697	100	97.65
Tingtibi SS(33/11kV)	0.406	98.17	97.53	0.498	97.65	96.86
33kV Gomphu	0.869	98.17	96.80	1.100	97.65	95.96
33kV Dakpai	0.777	98.17	96.93	0.979	97.65	95.99
33kV Zhemgang	0.370	98.17	97.41	0.411	97.65	96.78
6.6kV under Zhemgang	0.560	97.49	93.99	0.646	96.87	92.78
11kV Station/Colony	0.024	97.53	96.46	0.024	96.86	95.80
11kV Tama	0.145	97.53	97.21	0.201	96.86	96.42
11kV Yebilaptsa	Connected ICT to 6.6kV	97.53	97.42	Connected ICT to 6.6kV	96.86	96.74
6.6kV under Yebilaptsa	0.470	97.47	94.41	0.551	96.74	93.27

c) System Study when the Tingtibi Mini Hydropower Plant is down

11 kV Yebilaptsa feeder emanating from the Tingtibi substation is synchronized and interconnected with the Tingtibi power plant through 500 kVA, 11/6.6 kV ICT. When the power plant is up and running, the generation is injected into the grid and caters to the customer of Yebilaptsa and Tingtibi town. However, when the power plant is down, the entire load should be catered by an 11 kV Yebilaptsa feeder. A power flow study shows that critical voltage drop would be experienced by the end customer which can be improved by changing the tap of the transformer. No additional investment is required. **Table 8** below shows the voltage profile of the Yebilaptsa feeder before and after the improvement.

It is also important for BPC to explore the best fit technology (e.g. installing AVR/voltage boosters) to improve the voltage profile rather than proposing to up-grade the entire conductor size which would be inconvenient to implement as it will involve frequent power interruptions. The detailed simulation results for all the case studies are attached as **Annexure- 4.**

Table 8: Voltage Profile of the Feeder

Sl. No.	Feeder Name	2025			2030		
		Load (MW)	Bus V (%)	End V (%)	Load (MW)	Bus V (%)	End V (%)
1	11 kV Yebilaptsa	0.453	96.93	90.03	0.526	96.08	87.9
Voltage profile after transformer tap changing							
2	11 kV Yebilaptsa	0.453	-	95.53	0.526	-	95.27

7.2.2 Energy Loss Assessment of MV Feeders

Energy losses in the distribution network are inherent as the power transmission and distribution system are associated with the transformer and line loss. However, it is crucial to maintain the energy loss at an optimal level by engaging in timely improvement of the distribution infrastructures and not reacting to the localized system deficiencies. The objective of the energy loss assessment is to single out the feeder (s) with maximum loss (es) and put in additional corrective measures to minimize to the acceptable range. **Table 9** below shows the energy sales, purchase, and loss profile of Zhemgang**.**

Table 9: Energy Sales-Purchase-Loss Trend

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
1	**Energy Requirement (MU)**						
i)	Purchase from GenCos as per TD bill	3.72	4.31	4.47	4.56	4.72	
ii)	Mini/Micro Hydel Generation	0.02	0.12	0.35	0.64	0.47	
iii)	Diesel Generation	0.00	0.00	0.00	0.00	0.00	
iv)	Import from Pema Gatshel	0.92	0.69	0.54	0.82	0.89	
v)	Export to Trongsa	0.16	0.16	0.17	0.18	0.18	
	Total	**4.5**	**4.95**	**5.18**	**5.83**	**5.9**	
	% growth over previous year	-1.21%	10.03%	4.57%	12.63%	1.1%	5.424%
2	**Energy Sales (MU)**						
i)	**LV Total**	**4.29**	**4.59**	**4.8**	**5.37**	**5.42**	
ii)	Medium Voltage	0.00	0.00	0.00	0.00	0.00	

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
iii)	High Voltage	0.00	0.00	0.00	0.00	0.00	
	Total Energy Sales	**4.29**	**4.59**	**4.8**	**5.37**	**5.42**	
	% growth over previous year	5.34%	7.16%	4.42%	12.03%	1.0%	5.99%
	Energy Loss (1-2)	**0.21**	**0.36**	**0.38**	**0.46**	**0.48**	**0.378**
	Total Loss (%)	**4.67%**	**7.27%**	**7.34%**	**7.89%**	**8.14%**	**7.062%**

Source: Adapted from Power Data Book 2019, BPC

Note:

LV Customer: Domestic (Rural & Urban), Rural Cooperatives, Rural Micro-Trades, Rural Community Lhakhangs, Religious Institutions, Commercial, Industrial, Agriculture, Institutions, Street Lighting, Powerhouse auxiliaries, and Temporary connections.

The plot of the energy requirement data presented in Table 7 yields the trend graphs shown in Figure 4. The energy requirement has increased steadily over the year @ 5.42 % and so is the energy consumed @ 5.99 % on the average from the year 2015-2019.

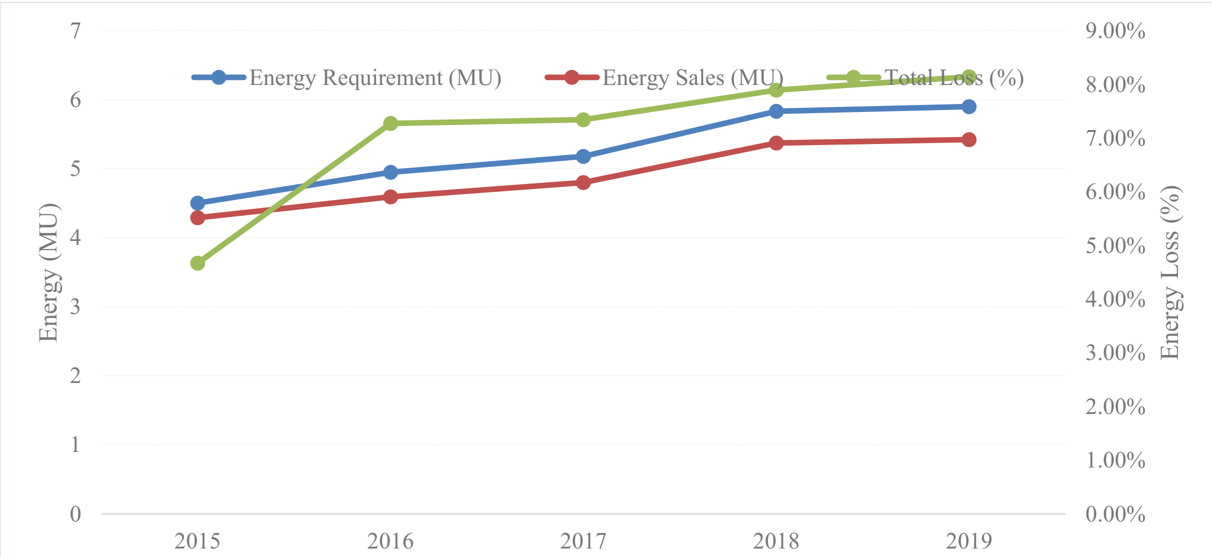


Figure 4: *Energy requirement trend of ESD Zhemgang*

Generally, the technical loss is 8.9% for the distribution network and any loss more than this range is due to commercial loss. An independent study carried out by 19 ESDs for 38 feeders in 2017 (two feeders each in ESD with more loss) showed that an average of 6.84% is due to technical loss. The study also showed that the loss pattern was never consistent because of variant characteristics of a distribution network and loading pattern. The average loss index of Zhemgang (2015-2019) is 7.062% (0.378 million units on average) which is commendable and acceptable. To better understand the loss profile, the aggregate technical and commercial loss (AT&C) which is accounted for based on the difference of energy purchase from the Transmission Department and energy sale for the year 2019 is worked out as presented in **Table 10** and **Figure 5.**

Table 10: Feeder wise energy loss

Sl No.	Feeder Name	2019		
		Energy Purchase (MU)	Energy Sales (MU)	Energy Loss (%)
1	33kV Gomphu Feeder	1.58	1.51	4.80%
2	33kV Zhemgang Feeder	1.05	0.90	13.74%
3	33kV Dakpai Feeder	0.77	0.65	14.94%
4	11kV Tama Feeder	0.09	0.08	17.69%
5	6.6kV Yebilaptsa Feeder	0.63	0.58	6.75%
	Total	4.12	3.72	9.71%

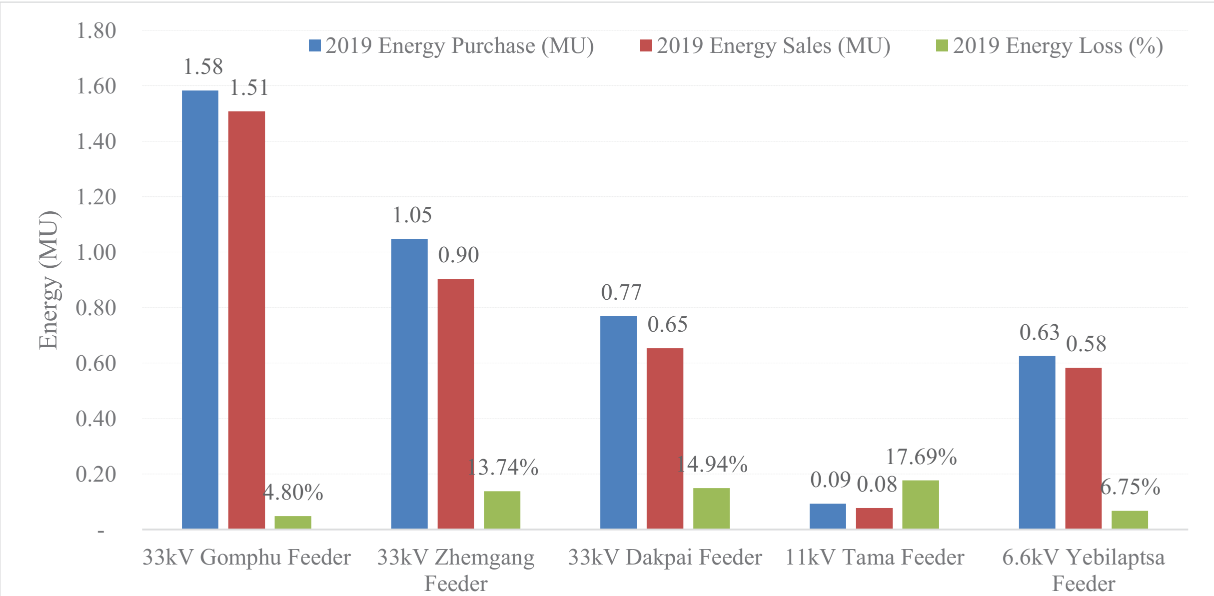


Figure 5: Feeder wise energy loss of ESD, Zhemgang

From **Figure 5,** it is inferred that the 11kV Tama Feeder has the highest loss in terms of percentage followed by a 33 kV Dakpai and 33 kV Zhemgang feeder. The high proportion of loss for the Tama feeder is due to fewer energy sales and purchases which will not have a significant impact on the overall loss of the Dzongkhag as the loss is just 16,475 kWh (0.016MU). The high losses in Dakpai and Zhemgang feeders could be due to long LV lines resulting in high line resistance and therefore high I^2R losses.

The ETAP software was used to compute the technical loss of the system, however, as the system study is till DT, the technical loss obtained through the ETAP does not account for the loss due to the LV network and transmission system. The simulation result shows that only 2.60% constitute MV technical loss. The remaining (4.462%) is due to LV and commercial loss. The feeder wise MV and DT technical loss is as shown in **Table 11.**

Table 11: Technical loss from ETAP simulation

Sl.No.	Feeder Name	Power Demand (MW)	Apparent Loss (MW)	Loss (%)
1	33kV Gomphu	0.44	0.018	4.09%
2	33kV Dakpai	0.299	0.003	1.00%
3	33kV Zhemgang	0.332	0.004	1.20%
4	11kV Tama	0.047	0	0.00%
5	11kV Yebiblaptsa	0.207	0.005	2.42%
6	11kV Station-Colony	0.024	0	0.00%
Overall system Losses		**1.346**	**0.035**	**2.60%**

7.2.3 Reliability Assessment of the MV Feeders

Today's emphasis in the power sector has shifted to providing reliable power supply as electricity itself is positioned as one of the essential needs. However, improving reliability comes with its inherent costs as it involves embracing additional preventive and corrective measures leading to substantial up-front capital investment. Any major reliability improvement strategies need to be adopted only after carefully understanding the costs involved and the benefits that will be accrued from implementing such strategies. Failure rate, repair time, and restoration time are some important parameters defining reliability. Reducing the values of one or more of the above parameters can improve reliability considerably.

In addition to ensuring that the MV feeders have the required capacity, it is also very important to ensure that the MV feeders are reliable. The yearly average feeder reliability assessment (2017-2019) is summarized in **Table 12.** The individual feeder reliability details used to derive the summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered to compute the actual representation of the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2018-2019 are 19.98 & 53.16 respectively.

Table 12: Feeder wise reliability indices of ESD Zhemgang for 2018 & 2019

Sl. No.	Feeder	2018		2019		Total	
		SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
1	33kV Zhemgang Feeder	7.48	33.47	17.05	40.46	24.53	73.93
2	33kV Gomphu Feeder	16.92	64.74	35.10	77.48	52.02	142.22
3	33kV Dakpai Feeder	8.00	15.85	13.48	30.91	21.48	46.76
4	11kV Tama Feeder	0.36	1.55	0.12	0.03	0.48	1.58
5	6.6kV Yebilaptsa Feeder	0.58	0.71	0.80	0.59	1.38	1.30
Average SAIFI and SAIDI						**19.98**	**53.16**

Source: Adapted from monthly system performance report of DCSD, BPC
Notes:

(a) ***SAIFI*** *(System Average Interruption Frequency Index) = (Total no. of customer interruption per year)/ (Total no. of customers served)*
(b) ***SAIDI*** *(System Average Interruption Duration Index) = Σ (Total interruption duration per year)/ (Total no. number of customers served)*

(c) The interruption due to scheduled outages, momentary outages less than five minutes, and outages due to failure of the grid are not taken into account.

Plotting the reliability indices data presented in **Table 12** above yields the bar graph as shown in **Figure 5** which indicates that the 33 kV Gomphu has the highest values of both the indices followed by 33 kV Zhemgang and Dakpai feeders. The high interruption frequency and the duration index of the Gomphu feeder could be due to the feeder passing through a thick forest and also it comprises multiple spur lines. The feeder has a total circuit line length of around 175 km from Tingtibi to the end of the Namrigang border of Mongar Dzongkhag. The feeder caters the electricity to Panbang Dungkhag consisting of seven Gewogs (Trong, Phangkhar, Goshing, Nangla, Dungmang, Bardo, and Bjoka) consisting of 1346 customers. Additionally, the extension of new lines for the Off-Grid RE electrification program will be tapped and extended from this feeder which is further expected to worsen the situation. Therefore, to resolve the power quality and reliability issues, the construction of a 132/33 kV substation at Panbang would be inevitable as a long-term measure. The 132kC tower line passes through the Dungkhag.

The construction of a substation would not only improve the reliability of the Panbang Dungkhag but reduces the circuit line length and losses (I^2R loss). Further, it has the following additional benefits:

a) Constructional power supply to the Chamkhar Chhu project can be arranged from the new substation
b) Can be used as an alternative source for Pemagatshel Dzongkhag in the event of the power interruption in Nganglam substation.

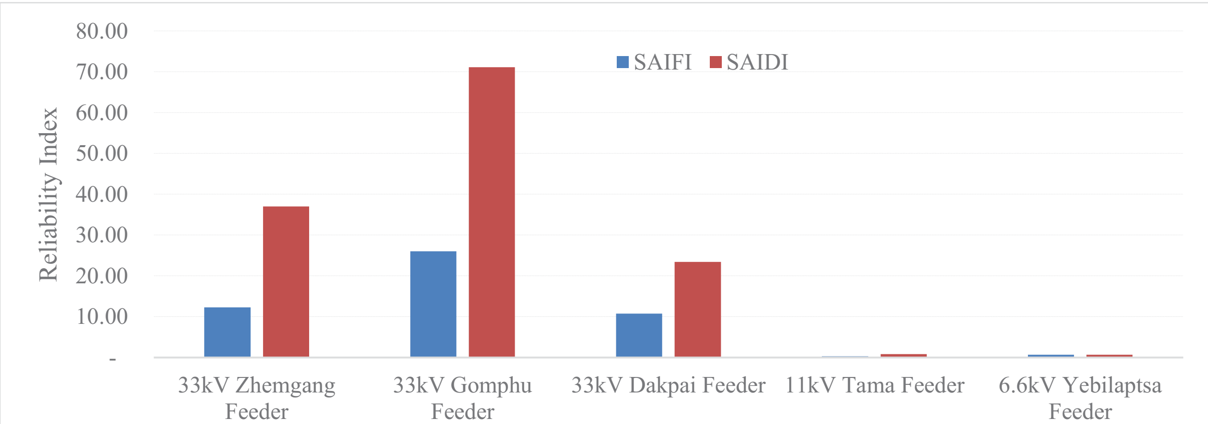


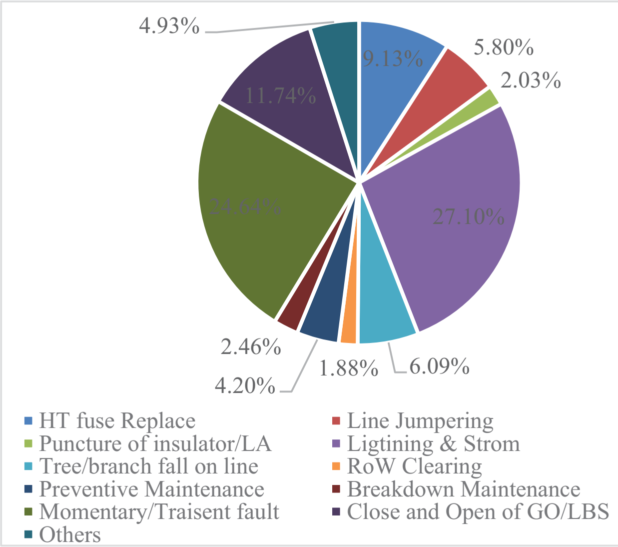
Figure 6: Average Feeder Wise Rebialility Indices

To get a better understanding of the reliability index, the detailed root cause outages of the feeders had been computed in **Table 13**.

It is noted that while exploring the tripping data of the previous years, most of the causes are due to lightning & storm followed by a momentary/transient fault which is caused by trees and branches touching the line. Further, trees and branches are blown in by the heavy wind on the lines and poles leading to the snapping of the conductor and damaging the structures. This is directly related to the right of way clearing along the line. Therefore, as mandated in the O&M manual, ESD Zhemgang is recommended to increase the frequency of RoW clearing, non-working ARCBs should be made functional, installation of communicable FPI to identify the fault, and early restoration. Additional line lightning arrestors (LA) could also be installed at critical locations where maximum faults occur due to lightning and storm.

Table 13: The Root Cause Outages

Cause of Outages	Freq. (Nos.)	Interruption (%)
HT fuse Replace	32	9.13%
Line Jumpering	20	5.80%
Puncture of insulator/LA	7	2.03%
Ligthning & Strom	94	27.10%
Tree/branch fall on line	21	6.09%
RoW Clearing	7	1.88%
Preventive Maintenance	15	4.20%
Breakdown Maintenance	9	2.46%
Momentary/Transient fault	85	24.64%
Close and Open of GO/LBS	41	11.74%
Others	17	4.93%



The reliability of the power supply can be further enhanced through training of linemen to equip them with the knowledge, skills, and confidence to operate and maintain the distribution infrastructure. For instance, the linemen of the ESDs need to develop the confidence to change DO fuses online using hot sticks instead of the usual practice of taking shut down of the whole feeder. However, having the right tools, equipment, and especially spares (of appropriate specifications) is a prerequisite.

7.2.4 Single Phase to Three Phase Conversion

BPC during the RE expansion programs considered for low-load remote and rural homes with two of the three phases of the MV designed with single phase transformers. However, with the adoption of mechanized agricultural machinery, the requirement of three phase power to cater to these loads is gaining importance even in the rural areas. Therefore, R&DD, BPC in 2017 has carried out the "Technical and Financial Proposal on Converting Single Phase to Three Phase Supply" to come out with the alternatives for providing three-phase power supply where there are single phase power supplies. It was reported that while all the alternatives required the third conductor of the

MV system to be extended on the existing poles following three proposals along with the financial impact were proposed:

a) Alternative -I

It was proposed to replace all the single-phase with three-phase transformers and this option as contemplated as not feasible as a replacement by three phase transformers and distribution boards will lead to idle storage of single phase transformers of BPC.

b) Alternative -II

It was proposed to utilize the existing single-phase transformers to form three-phase transformations along with the additional purchase of three-phase transformers and additional pole structures. Further, single phase transformers of identical make, type, and rating can be only used to make three phase power available.

c) Alternative -III

Option 3 is found to be a techno-commercially viable alternative as the lines can be easily upgraded to three phase by constructing a third conductor on existing pole structures. The transformer can be upgraded from single phase to three phase as and when the demand for 3-phase supply comes. The line up-gradation across the country would amount to Nu. 79 million (Detail in **Annexure-6**) excluding the cost of three-phase transformers which have to be procured on need-basis, rather than one-time conversion in general.

The total single phase line length in the Dzongkhag is 66.79 km (33 kV). The estimated cost for the conversion of such is Nu. 8.24 million.

As the single phase to three network conversions is demand-driven planning, conversion works shall be carried out based on the demand from the customers which would be more techno-commercially viable alternatives. Therefore, considering the anticipatory conversion requirement, the conversion of networks is proposed in the later stage of the DSMP.

7.3 Assessment of the Existing Distribution Transformers

7.3.1 Distribution Transformer Loading

The DTs are one of the most critical equipment of the distribution network and assessment of existing loading pattern along with the remaining asset life are crucial to ascertain the capability of the transformers for the future. The capability evaluation is based on the historical peak load loading pattern and forecasted peak load growth of the feeder.

Some of the existing transformer capacities would not be adequate to cater to the forecasted load growth for the next ten (10) years. Accordingly, the capacities of the transformers need to be upgraded and such a proposal is tabulated **in Table 14.** The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Assuming that the load growth of the rural homes is not expected to grow similar to that of urban dwellings, it is strongly recommended to closely monitor the actual load growth and accordingly plan remedial measures for those transformers. Nevertheless, considering the actual site-specific growth rate and cross-swapping of the existing transformers, it is recommended that arrangements be made for the procurement of only 16 new transformers from the 30 overloaded transformers.

Table 14: List of Overloaded Distribution Transformers

DT Location Name	Capacity (kVA)	Existing Loading 2019		Loading (%)		Remarks
		(kVA)	(%)	2025	2030	
Dangkhar Pokto	50	28.75	57.50%	181%	199%	Upgrade to 100kVA within 2025
DVH	125	37.28	29.82%	94%	103%	Upgrade to higher capacity between 2025 & 2030
BHU	125	33.07	26.46%	83%	92%	As it is BHU area, developmental activities are anticipated. Needs to be upgraded to higher capacity between 2025 and 2030
Korphu-IV	10	3.705	37.05%	116%	129%	Upgrade to 25kVA within 2025
Korphu-VII	25	8.56	34.24%	108%	119%	Upgrade to 63kVA within 2025
Goling Wangdra	63	13.899	22.06%	62%	101%	Upgrade to 125kVA between 2025 & 2030
Goling Village	63	19.648	31.19%	71%	111%	Upgrade to 125kVA between 2025 & 2030
Pangtang A	25	5.36	21.44%	101%	121%	Upgrade to 63kVA within 2025

DT Location Name	Capacity (kVA)	Existing Loading 2019		Loading (%)		Remarks
		(kVA)	(%)	2025	2030	
Pantang B	25	5.69	22.76%	107%	128%	Upgrade to 63kVA within 2025
Duenmang village I	25	16.78	67.12%	107%	147%	Upgrade to 63kVA within 2025
Duenmang village II	25	11.97	47.88%	78%	108%	Upgrade to 63kVA between 2025 & 2030
Gangdar BHU Bjoka	10	5.41	54.10%	255%	304%	Upgrade to 63kVA within 2025
Dunmang Tshachhu	10	8.98	89.80%	115%	140%	Upgrade to 25kVA wihtin 2025
Tama village	63	23.98	38.06%	79%	119%	Upgrade to 125kVA between 2025 & 2030
Berti	63	21.87	34.71%	135%	188%	Upgrade to 125kVA within 2025
Buli A	63	23.7	37.62%	77%	117%	Upgrade to 125kVA between 2025 & 2030
Buli C	125	25.04	20.03%	82%	97%	Developing area. Needs to be upgraded to 250kVA between 2025 to 2030
Lower Nimshong	25	6.57	26.28%	66%	106%	Upgrade to 63kVA between 2025 & 2030
Middle Nimshong	25	5.08	20.32%	60%	100%	Upgrade to 63kVA between 2025 & 2030
Lower Tshaidang	25	14.27	57.08%	87%	117%	Upgrade to 63kVA between 2025 & 2030
Kikhar	25	12.54	50.16%	80%	110%	Upgrade to 63kVA between 2025 & 2030
Anim Dratshang	10	10.05	100.50%	414%	485%	Upgrade to 25kVA within 2025
Upper Wamling A	25	5.48	21.92%	90%	106%	Upgrade to 63kVA between 2025 & 2030
Middle Wamling	25	5.41	21.64%	89%	105%	Upgrade to 63kVA between 2025 & 2030
Lower Wamling A	25	5.51	22.04%	91%	106%	Upgrade to 63kVA between 2025 & 2030
PWD Mangdichu	50	33.09	66.18%	159%	189.9%	Upgrade to 70kVA within 2025
Yebilaptsha A (School)	50	19.12	38.24%	92%	109.7%	Upgrade to 70kVA between 2025 & 2030
Yebilaptsha B (Hospital)	50	36.54	73.08%	176%	209.7%	Upgrade to 250kVA within 2025. 250kVA is recommended as this is a hospital area. Development is anticipated.
Tingtibi town A	50	31.47	62.94%	151%	180.6%	Upgrade to 70kVA within 2025
Tingtibi main town B	125	51.92	41.54%	100%	119.2%	Upgrade to 250kVA within 2025.

7.3.2 Asset life of Distribution Transformers

The assessment of the existing loading pattern together with the remaining asset life is crucial to ascertain its capabilities to transmit the projected load growth. The life cycle of the transformer and its mapping provides clear information for its optimal utilization and development of an asset replacement framework.

Although, as listed in **Table 15**, the DTs had already outlived the asset life, proper evaluation and testing should be required to find out the actual performance of the DTs and informed decisions can be made on the continuous use of the transformers. The life of the asset has been calculated from the year transformer is put into use.

Table 15: List of outlived Distribution Transformers

Asset Code	DT Location Name	Transformer Ratio	Capacity	MFD	2019	2025	2030
Private	BT Churmulung	33/.415kV	25	1996	23	29	34
1503061	Tingtibi Power House	0.415/6.6kV	250	1978	41	47	52
1503063	PWD Mangdichu	6.6/.415kV	50	1978	41	47	52
1503066	Tingtibi Town BoD	6.6/.415kV	75	1978	41	47	52
1503064	Yebilaptsha A	6.6/.415kV	50	1978	41	47	52
1503065	Yebilaptsha B	6.6/.415kV	50	1978	41	47	52
1503068	Pemala sawmill	6.6/.415kV	30	1991	28	34	39
1503067	Telecom Zhemgang	6.6/.415kV	30	1991	28	34	39
1503070	KD sawmill	6.6/.415kV	75	1986	33	39	44

7.3.3 Replacement of Single Phase Transformer

As discussed in the "Single Phase to Three Phase Conversion" of the distribution network it will be more economical and technically feasible to convert the single to three phase transformers on a need basis. A sum of Nu.186 million is estimated for replacing the entire single transformer including the distribution board across the country. The detailed work out is produced as **Annexure-8.**

There are around 91 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu. 7.36 million.

As the conversion from single to three-phase transformer is demand base, the plan has been distributed in ten year-span.

7.4 Power Requirement for Urban Areas by 2030

The Zhemgang Thromde stretches from BoC to Dangkhar pokto area. As the town is located on steep slopes, the Ministry of Work and Human Settlements had planned only for light structural construction and other smaller recreational activities. Therefore, depending upon the degree of activities planned, the town would not require huge electrical infrastructure and power. The existing 500kVA Dzong substation and 500kVA RDTC substations are loaded only 6% and 3%, respectively. Any additional load can be catered to from these substations. **Figure 6** depicts the overview of the Zhemgang town.

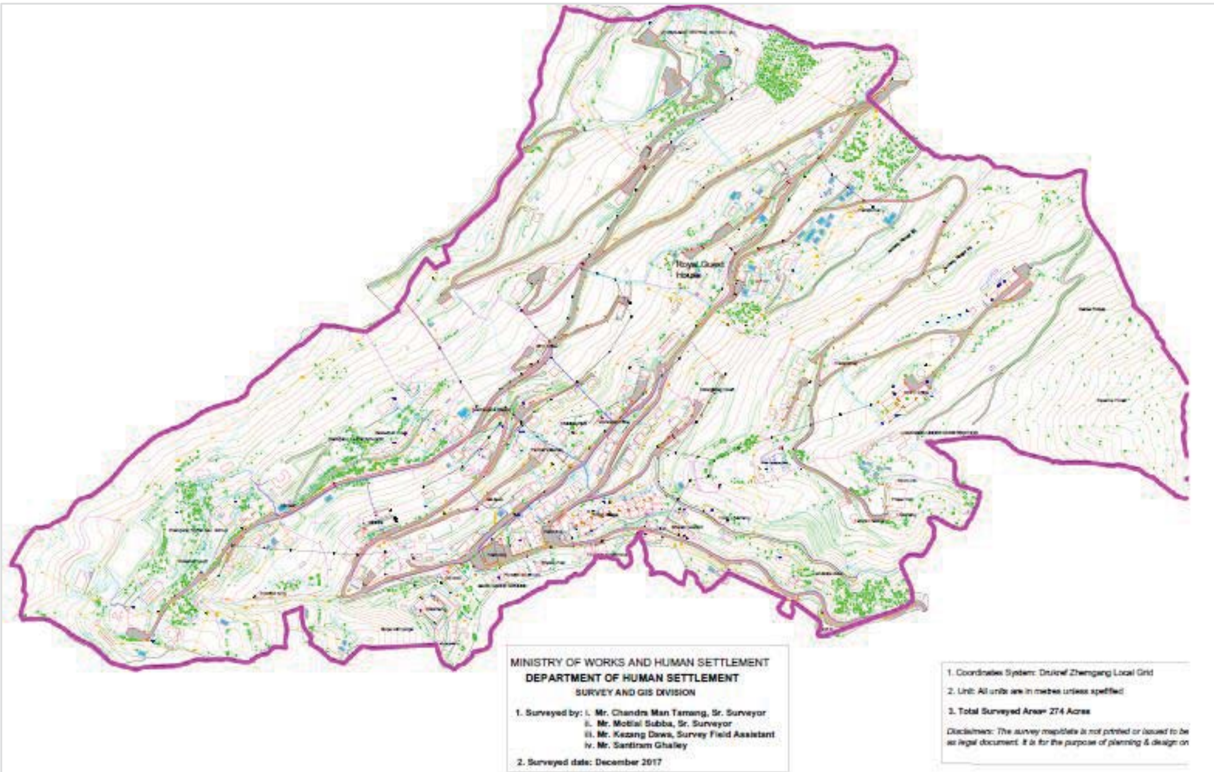


Figure 7: Overview of Zhemgang town

8. Distribution System Planning until 2030

The distribution network of Zhemgang Dzongkhag has a radial topology with a significant risk of high interruptions (fault in one location would mean that the entire customer in the network would experience the outage). Having alternate routes, sources or any contingency plan would significantly improve the reliability and power quality. To have a robust and hard-lined distribution network, there is a need for good contingency plans with adequate sources to reduce the downtime. However, any provision to improve the power system would incur an additional capital cost in addition to recurring additional preventive and corrective costs.

Therefore, to meet the system shortfalls against the set standard and to keep abreast with the forecasted load growth, proper distribution system planning is required which is detailed from **Section 8.1** through **Section 8.4.**

8.1 Power Supply Source

8.1.1 HV substation

The 132/33/11kVA Tingtibi substation with installed 2x3MVA, 132/33kV, and 2x1.5MVA, 33/11kV has adequate capacity to deliver the present and forecasted electricity demand without having to invest. However, after the detailed assessment as reflected in **section 7.2, the** construction of a 132/33 kV substation at Panbang Dungkhag is recommended to improve the power supply reliability.

8.1.2 MV Substation

ESD Zhemgang has no MV substation under its jurisdiction.

8.2 MV Lines

The detailed MV line assessment made in **section 7.2** shows that the MV distribution lines would be adequate to cater to the existing as well as the future load till 2030.

8.3 Distribution Transformers

As detailed in **Section 7.3.1,** the DTs of urban areas might get overloaded as forecasted, the following are the list of DTs which would require up-gradation.

a) Upgrade 125 kVA, 6.6/0.415 transformer at DVH to 250 kVA.
b) Upgrade 125 kVA, 6.6/0.415 transformer at BHU to 250 kVA.
c) Upgrade 63 kVA, 33/0.415 transformer at Goling village to 125 kVA.

d) Upgrade 25 kVA, 33/0.415 transformer at Panbang A village to 63 kVA.
e) Upgrade 25 kVA, 33/0.415 transformer at Panbang B village to 63 kVA.
f) Upgrade 25 kVA, 33/0.415 transformer at Dungmang village-I to 63 kVA.
g) Upgrade 25 kVA, 33/0.415 transformer at Dungmang village-II to 63 kVA.
h) Upgrade 10 kVA, 33/0.240 transformer at Gangdra BHU to 63 kVA.
i) Upgrade 63 kVA, 11/0.415 transformer at Tama village to 125 kVA.
j) Upgrade 63 kVA, 11/0.415 transformer at Berti village to 125 kVA.
k) Upgrade 63 kVA, 33/0.415 transformer at Buli A to 125 kVA.
l) Upgrade 125 kVA, 33/0.415 transformer at Buli C to 250 kVA.
m) Upgrade 25 kVA, 33/0.415 transformer at Kikhar to 63 kVA.
n) Upgrade 25 kVA, 33/0.415 transformer at Upper Wamling A to 63 kVA.
o) Upgrade 50 kVA, 6.6/0.415 transformer at Yebilaptsa hospital to 250 kVA.
p) Upgrade 125 kVA, 6.6/0.415 transformer at Tintibi town to 250 kVA.

8.4 Switching and Control

Switching and control system is required to take care of the system during faulty situations which ultimately is going to take care of the failure rate, repair, and restoration time. This, in turn, would improve the reliability, safety of the equipment and online staff, optimize resource usage, and more importantly, the revenue generation will be enhanced. Similarly, to capture real-time data and information, it is inevitable to have an automated and smart distribution system. The feeders which are more susceptible to faults are identified with proposed restorative measures through the studies. Except for the tripping of breakers in the sending end substations, the existing distribution network is neither automated nor smart to detect the faults and respond in a real-time manner. Therefore, the automation and smart grid components are detailed in the Smart Grid Master Plan 2019.

8.4.1 Intelligent Switching Devices

As per the detailed reliability assessment of individual feeders in **Section 7.2.3**, the 33 kV Zhemgang, Gomphu and, Dakpai feeders are more susceptible to power interruptions. Therefore, additional preventive and corrective measures for these feeders need to be put in place. To improve the reliability and power quality of these feeders, it is proposed to have technology in place to respond to a fault and clear it accordingly rather than through an ex post facto approach. Therefore, it is proposed to enhance the existing switching and control system by having the latest suitable and user-friendly technology (automatic). The coordinated arrangement of Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers, and FPIs would significantly improve the control and operation mechanism of the network.

However, the quantum and the location of the devices to be installed shall be based on the Smart Grid Master Plan 2019. **Table 16,** shows the existing and proposed switching devices to be installed in the respective feeders.

Table 16: List of switching equipment

Sl. No.	Name of Feeder	ARCBs		FPIs		LBS/GO	
		Existing (nos.)	Proposed (Nos.)	Existing (nos.)	Proposed (Nos.)	Existing (nos.)	Proposed (Nos.)
1	33kV Zhemgang Feeder	1	1	1	2	8	-
2	33kV Gomphu Feeder	4	1	-	6	27	-
3	33kV Dakpai Feeder	2	2	2	4	18	3
4	11kV Tama Feeder	0	-	-	-	3	-
5	6.6kV Yebilaptsa Feeder	0	-	-	-	1	-
	Total	**7**	**4**	**3**	**12**	**57**	**3**

8.4.2 Distribution System Smart Grid

The distribution grid modernization is outlined in Smart Grid Master Plan 2019 including the investment (2020-2027). The DMS, ADMS, DSCADA features along with their components and functionalities, the timeline for the programs, and the cost estimates of the smart grid are lucidly reflected. Therefore, this report exclusively entails the identification of the system deficiencies and qualitative remedial measures that would require system augmentation and reinforcement as per the existing and projected load.

9. Investment Plan

Following the above-mentioned contingency plans targeted to improve the power quality, reduce losses, and improve reliability indices of the Dzongkhag, an investment proposal is developed.

The investment plan has been confined to power supply sources, MV lines, DTs, switching and control equipment, and RoW. The proposed/approved (2019-2023) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 8.**

How important is the task?			
	Highly Important	Action: Do First **I**	Action: Do Next **II**
	Important	**Action: Do Later III**	No Action: Don't Do **IV**
		More Urgent	**Urgent**
How urgent is the task?			

Figure 8: Priority Matrix

The matrix gives us the basis on the prioritization of the investments to be made in the ten-year schedule as every activity cannot be carried out at a time. The activities which have to be carried out due to load growth, developmental activities, and retrofitting of obsolete/defective switchgear and equipment will have the highest level of importance and urgency. These activities have to be prioritized and invested in the initial years which are grouped in the first quadrant (Do First).

Similarly, there are certain activities although might be very important but not so urgent can be planned in the later stage of the year (Do Next). These activities can be but are not limited to improving the reliability, reducing losses, and reconfiguration of lines and substations to reduce the losses and improving the power quality. The activities which are not so important but are highly urgent have to be also planned in a later stage of the period.

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 17** as an investment plan. The cost estimates have been worked out based on the BPC ESR-2015 and annual inflation is cumulatively applied to arrive at the actual investment cost for the following years.

In the span of the next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Zhemgang Dzongkhag is Nu. 224.62 million.

Table 17: Investment Plan until 2030

Sl.No.	Project Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1	**Distribution Transformers**	-	-	-	-	-	-	-	-	-	-	-	-
1.1	Up-grade 6.6/0.415kV, 125kVA DVH transformer to 250kVA	-	-	-	-	-	-	-	-	-	-	0.70	**0.70**
1.2	Up-grade 6.6/0.415kV, 125kVA BHU transformer to 250kVA	-	-	-	-	-	-	-	-	-	-	0.70	**0.70**
1.3	Up-grade 33/0.415kV, 63kVA Goling Wangdra transformer to 125kVA	-	-	-	-	-	-	0.43	-	-	-	-	**0.43**
1.4	Up-grade 33/0.415kV, 25kVA Pantang-A transformer to 63kVA	-	-	-	0.32	-	-	-	-	-	-	-	**0.32**
1.5	Up-grade 33/0.415kV, 25kVA Pantang-B transformer to 63kVA	-	-	0.32	-	-	-	-	-	-	-	-	**0.32**
1.6	Up-grade 33/0.415kV, 25kVA Dunmang Village-I transformer to 63kVA	-	-		0.32	-	-	-	-	-	-	-	**0.32**
1.7	Up-grade 33/0.415kV, 25kVA Dunmang Village-II transformer to 63kVA	-	-	0.32		0.32	-	-	-	-	-	-	**0.64**
1.8	Up-grade 33/0.240kV, 10kVA Gangdar BHU Bjoka transformer to 63kVA	-	-	-	0.33	-	-	-	-	-	-	-	**0.33**
1.9	Up-grade 33/0.415kV, 63kVA Buli-A transformer to 125kVA	-	-	-	-	-	-	-	0.43		-	-	**0.43**
1.10	Up-grade 33/0.415kV, 125kVA Buli-c transformer to 250kVA	-	-	-	-	-	-	-		0.89	-	-	**0.89**
1.11	Up-grade 33/0.415kV, 25kVA Kikhar transformer to 63kVA	-	-	-	-	-	-	-	0.32	-	-	-	**0.32**
1.12	Up-grade 33/0.240kV, 25kVA Upper Wamling-A transformer to 63kVA	-	-	-	-	-	0.32	-		-	-	-	**0.32**
1.13	Up-grade 11/0.415kV, 63kVA Tama Village transformer to 125kVA	-	-	-	-	-	-	-	0.50	-	-	-	**0.50**
1.14	Up-grade 11/0.415kV, 63kVA Berti transformer to 125kVA	-	-	-	-	0.50	-	-	-	-	-	-	**0.50**

Sl.No.	Project Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1.15	Up-grade 6.6/0.415kV, 50kVA Yebilaptsa-B(hospital) transformer to 250kVA	-	-	0.70	-	-	-	-	-	-	-	-	**0.70**
1.16	Up-grade 6.6/0.415kV, 125kVA Tingtibi Town-B transformer to 250kVA	-	-	0.70	-	-	-	-	-	-	-	-	**0.70**
2	**Conversion**	-	-	-	-	-	-	-	-	-	-	-	-
2.1	Conversion of single to three-phase line	-	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	**8.24**
2.2	Replacement of single phase by three phase transformers	-	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	**7.36**
3	**Switching and control**	-	-	-	-	-	-	-		-	-	-	-
3.1	Installation of LBS	-	-	0.28	0	-	0.30	-	0.3	-	-	-	**0.88**
4	**Power Supply Source**	-	-	-	-	-	-	-		-	-	-	-
4.1	Construction of 132/33 kV substation at Panbang Dungkhag	-	-	-	-	-	-	-	200.00	-	-	-	**200.00**
	Total	-	**1.56**	**3.88**	**2.53**	**2.38**	**2.18**	**1.99**	**203.12**	**2.45**	**1.56**	**2.96**	**224.62**

10. Conclusion

Based on the inputs from the division office, validated data, assessment of the existing distribution network, and the reliability analysis, recommendations are made for system modifications and improvements. Costs associated with each recommendation and presented in several phases so that work may continue at a pace that is determined by fund availability and the capacity of the office to execute the work. An attempt is made to prioritize the recommendations; however, there will undoubtedly be adjustments in the order and priority by which the investments will be implemented.

The third option which would be the least-cost alternatives for converting the single to three-phase distribution network where all the MV lines will have to be converted to three phase and replacing the single phase by three phase transformers on need basis.

Although the report entails the identification of system deficiencies and reinforcement required, for automation and smart operation of the distribution network, the smart grid infrastructure development with functionalities is detailed in “Smart Grid Master Plan 2019”. Therefore, the DSMP-Smart Grid Master Plan-Hybrid is necessary which can be amalgamated during the rolling out of annual investment and budget approvals.

The proportion of LV is higher in comparison to MV line length, accordingly the independent study carried out by BPC in 2017 showed that a large portion of the loss is due to LV and DT. Therefore, a similar system study beyond DT has to be carried out to capture the entire network and strategize to develop the blueprint.

11. Recommendation

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	HV substation has adequate capacity to cater to the present and forecasted energy demand.
2	MV Substations	No MV substations under the administration of Zhemgang.
B. MV Lines		
1		
C. Distribution Transformers		
1	Distribution Transformers	As reflected in **Section 7.3.1** of this report, it is proposed to regularly monitor the loading pattern especially of the urban transformers. It is desired to load the transformers less than 85% to ensure that transformer is operated at maximum efficiency. The system study is restricted to DTs, the loads need to be uniformly distributed amongst the LV feeders to balance the load.
2	Single to Three Phase Transformers	As reported in the "Technical and Financial Proposal on Converting Single Phase Power Supply to Three Phase in Rural Areas", it is recommended to replace the single to three phase transformers on a need basis.
D. Switching and Control Equipment		
1	Switching and Control Equipment	It is recommended to install Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers, and FPIs as proposed which would reduce the downtime for clearing faults. 1) Install FPI, Sectionalizes, and ARCBs at various identified locations. 2) Installation of 11kV& 33kV RMUs at various identified locations.
E. others		
1	Investment Plan	As reflected in **Section 9** of this report, the overall investment plan as proposed is recommended.

Sl. No.	Parameters	Recommendations
2	Review of the DSMP	Practically the projections will hold only true in the nearest future therefore, it is strongly recommended to review the DSMP in 2025 (after five years) or if need be as and when the situation demands.
3	System Studies beyond DT	It is observed that the distribution of electricity is more through LV than MV & HV and the scope of DSMP terminates at DT. However, it is equally important to carry out similar system studies for LV networks till meter point. Due to the time constraint and non-availability of required LV data, it is recommended to carry out the studies on the LV network including the DTs. Nevertheless, with the entire distribution network captured in the GIS and ISU, the system studies should be carried out including the LV network in the future.
4	Customer Mapping	One of the important parameters required especially for reaffirming the capability of the DTs is by examining customer growth patterns. Therefore, it is recommended to consistently update the customers via the customer mapping process carried out annually.
5	Right of Way	RoW should be maintained as per the DDCS 2016. However, an increased frequency of Row clearing in the problematic sections of the line and fast growth sub-tropical forest is recommended.
6	Asset life of DTs	The asset life of DTs needs to be gathered to enable the development of an asset replacement framework. However, it is recommended to regularly monitor the health of the transformers which have already outlived their lives.
7	Overloading of DTs	As per the load forecast, some of the rural DTs might overload. While the probability of realizing such an event is quite low. It is, however, recommended that the DTs that have already exhausted its statutory life (25 years and above) be regularly monitored.
8	New extension through 33kV network	The power carrying capacity of the 33kV system is almost 3-fold compared to that of the 11kV system. Therefore, any new extension of lines may be done through a 33kV system (based on fund availability and practical convenience).
9	Reliability	To improve the reliability of the feeder/network, it is recommended either that fault should be located within a short period of time thereby reducing the restoration time and the number of customers affected. In this regard, the following initiatives are recommended:

Sl. No.	Parameters	Recommendations
		1) To install ISDs (communicable FPIs, Sectionalizers & ARCBs); 2) To explore the construction of feeders with customized 11kV & 33kV towers; and 3) To increase the frequency of Row clearing in a year.

12. Annexure

1. Annexure-1: MV Line Details and Single Line Diagram
2. Annexure-2: IS 2026, IEC 60076 (Technical parameters for Distribution Lines and Transformers)
3. Annexure-3: The details on the load forecast methodology.
4. Annexure-4: Detailed Simulation Results
5. Annexure-5: Feeder Wise Reliability Indices
6. Annexure-6: Material Cost of Upgrading single phase (11 kV and 33 kV) Lines to three-phase
7. Annexure-7: Distribution Transformer Loading
8. Annexure-8: Material Cost of three-phase (3Φ) Transformers

13. References

1. The FWPL and CPL from TD, BPC as of 2018.
2. BPC Power Data Book 2018.
3. BPC Distribution Design and Construction Standards (DDCS)-2016.
4. BPC Smart Grid Master Plan (2019-2027).
5. BPC National Transmission Grid Master Plan (2020 & 2030).
6. BPC Operation and Maintenance Manual for Distribution System (2012).
7. BPC Corporate Strategic Plan (2019-2030).
8. Population and Housing Census of Bhutan 2019.
9. The Structural Plan (2004-2027) for every Dzongkhag.
10. Industrial Parks (Department of Industry).
11. BPC Electrical Schedule of Rates 2015.

14. Assumptions

1. All the distribution network was considered as Balanced System (Restriction with the existing ETAP Key);
2. All DTs considered as lump load and depending upon the type of load connected to the feeder, a ratio of 80% (static load) to 20% (industrial feeders) were assumed;
3. The voltage level of ±10% is given as a critical value which is indicated by red color while simulating and a voltage level of ±5% is given as a marginal value which is indicated by pink color while simulating.
4. The typical inbuilt value of X/R ratio of the ETAP tool was considered for all the transformers;
5. Dimensions and parameters of some cables/UG cables are customized in the library as per the requirement;
6. The technical parameters which are required for analysis of the distribution network have been considered as per the set standard of DDCS.

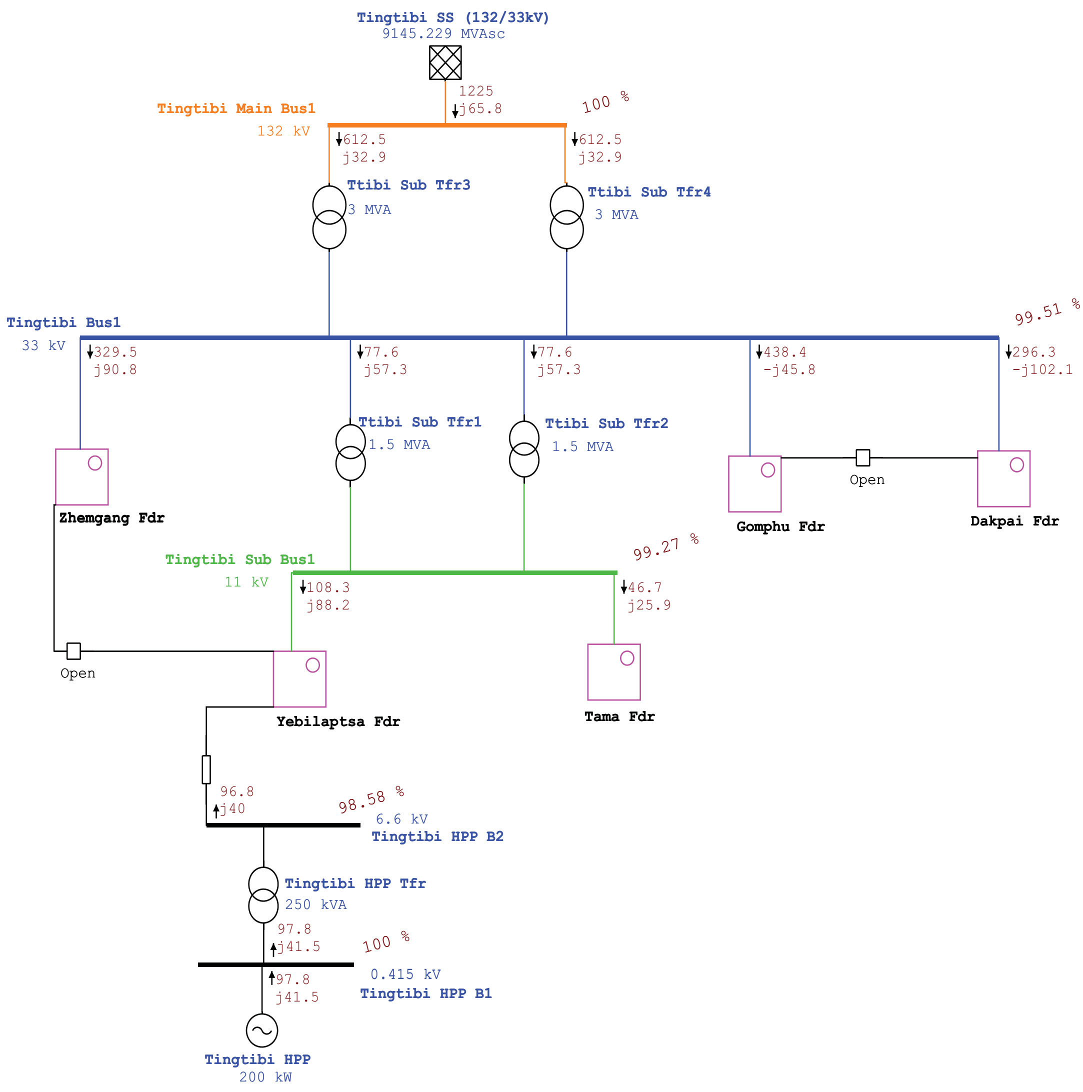
15. Challenges

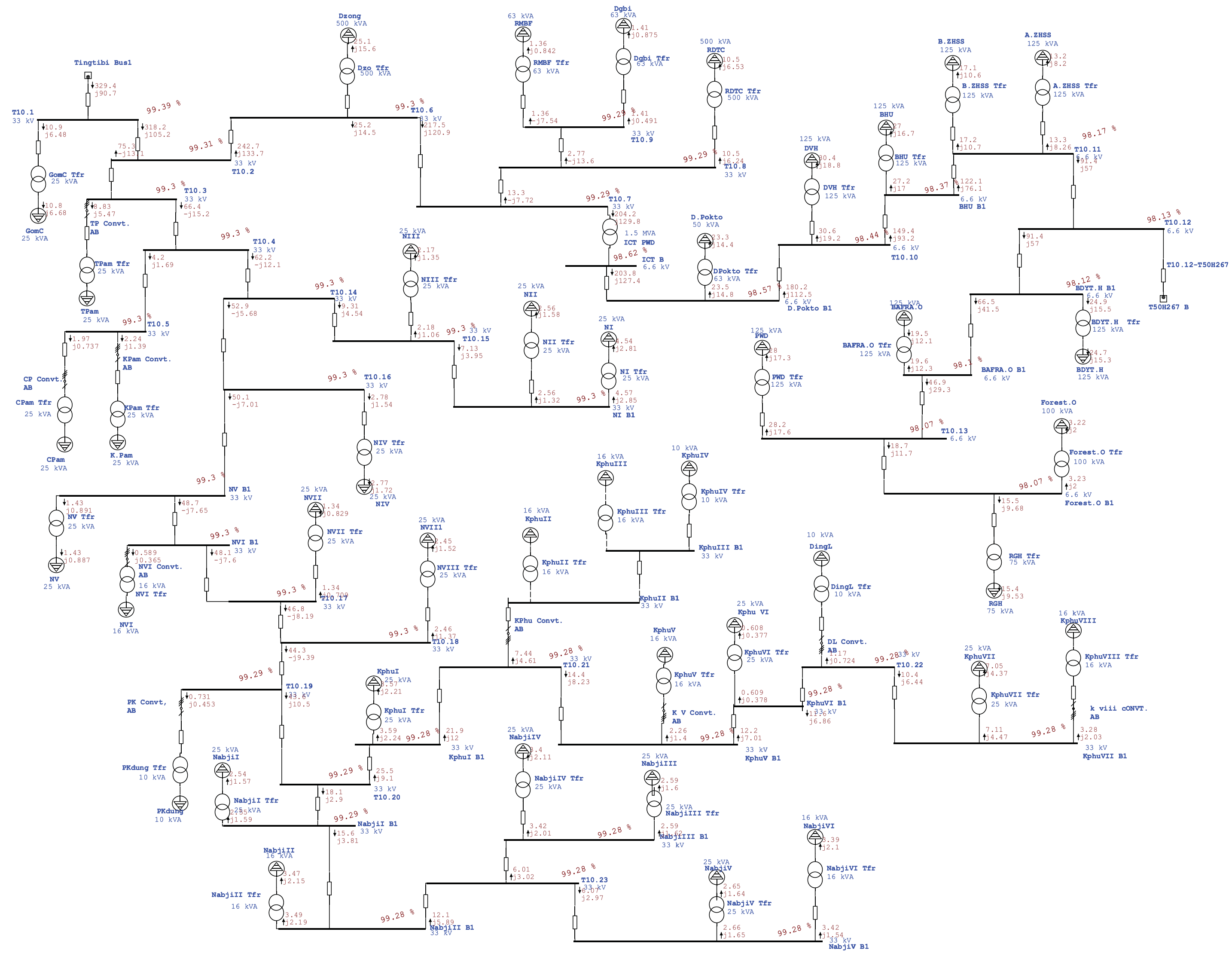
Sl. No.	Parameters	Challenges	Opportunities/Proposals
1	Software Tool (ETAP)	a) Only one key & offline Key b) Balanced Load Flow c) Limitations of No. of buses (1000)	a) Can opt for on line key with fewer more modules especially to carry out the technical evaluation of an unbalanced load flow system. This would be more applicable and accrue good results for LV networks.
2	Data	a) No recorded data (reliability & energy) on the out-going feeders of MV SS	a) Feeder Meters could be installed for outgoing feeders of MV substations to record actual data (reliability & energy)

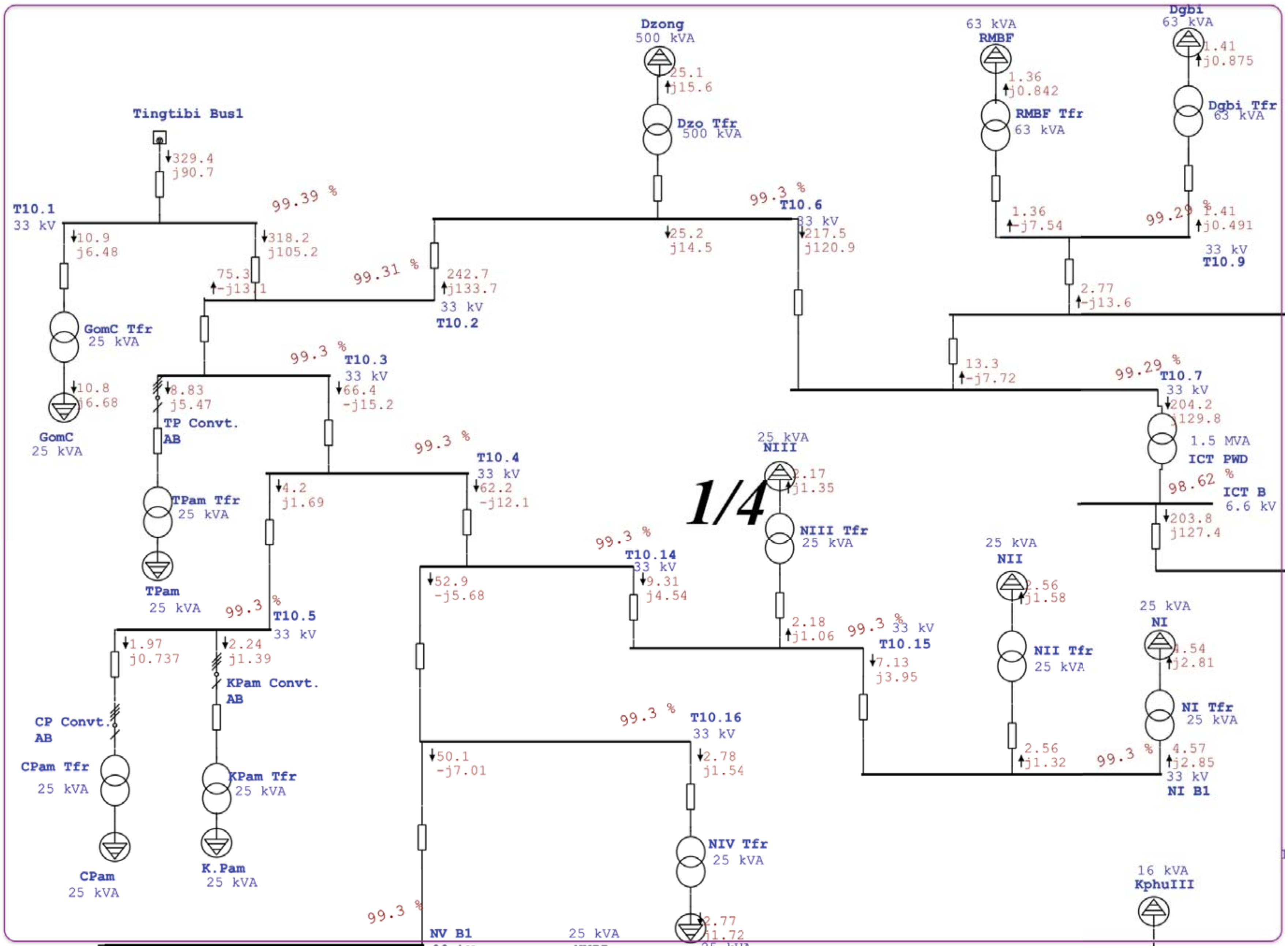
Sl. No.	Parameters	Challenges	Opportunities/Proposals
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to timing and number of DTs.	b) To get the accurate Transformer Load Management (TLM)/loading, it is proposed to install DT meters which could also have additional features to capture other required information.
		c) No proper feeder and DT wise Customer Mapping recorded	c) Customer Information System (CIS) of the feeder/DT would enable us to have a proper TLM and replacement framework.
3	Manpower	a) Resource gap in terms of trained (ETAP) and adequate engineers (numbers)	a) Due to the lesser number of trained engineers in the relevant fields (software), engineers from other areas were involved.

Annexure-1: MV Line Details and Single Line Diagram

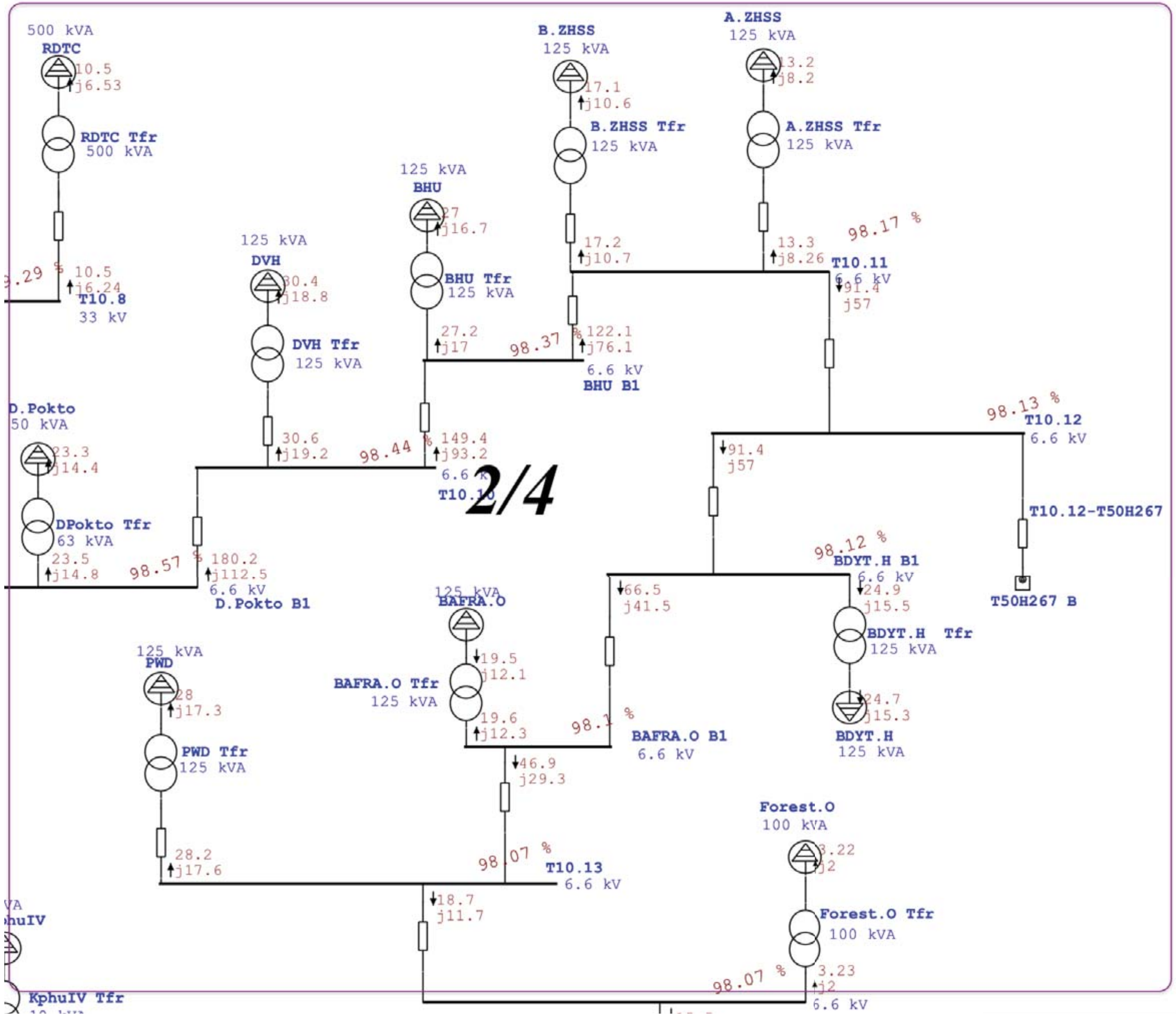
One-Line Diagram - OLV1 (Load Flow Analysis)

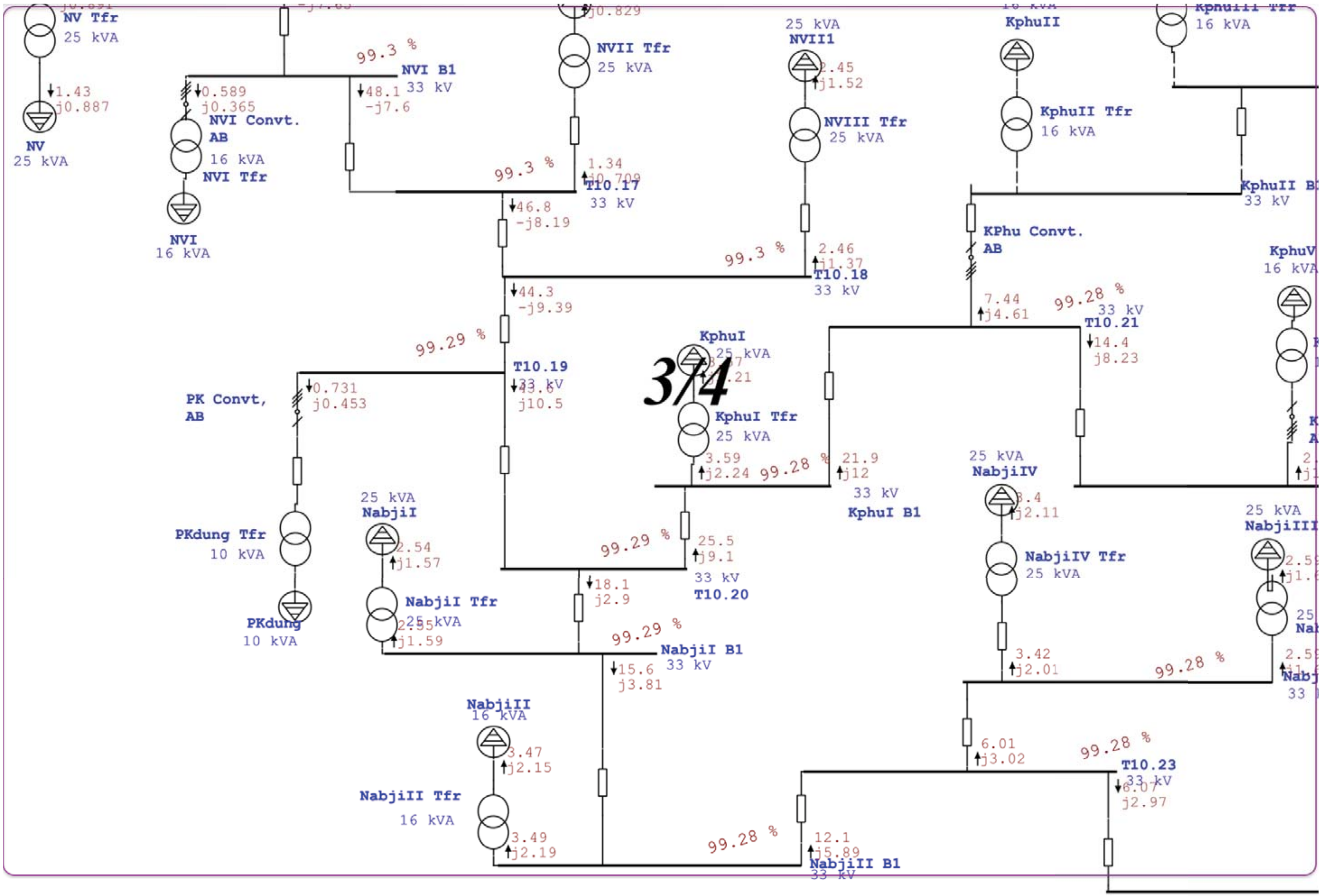




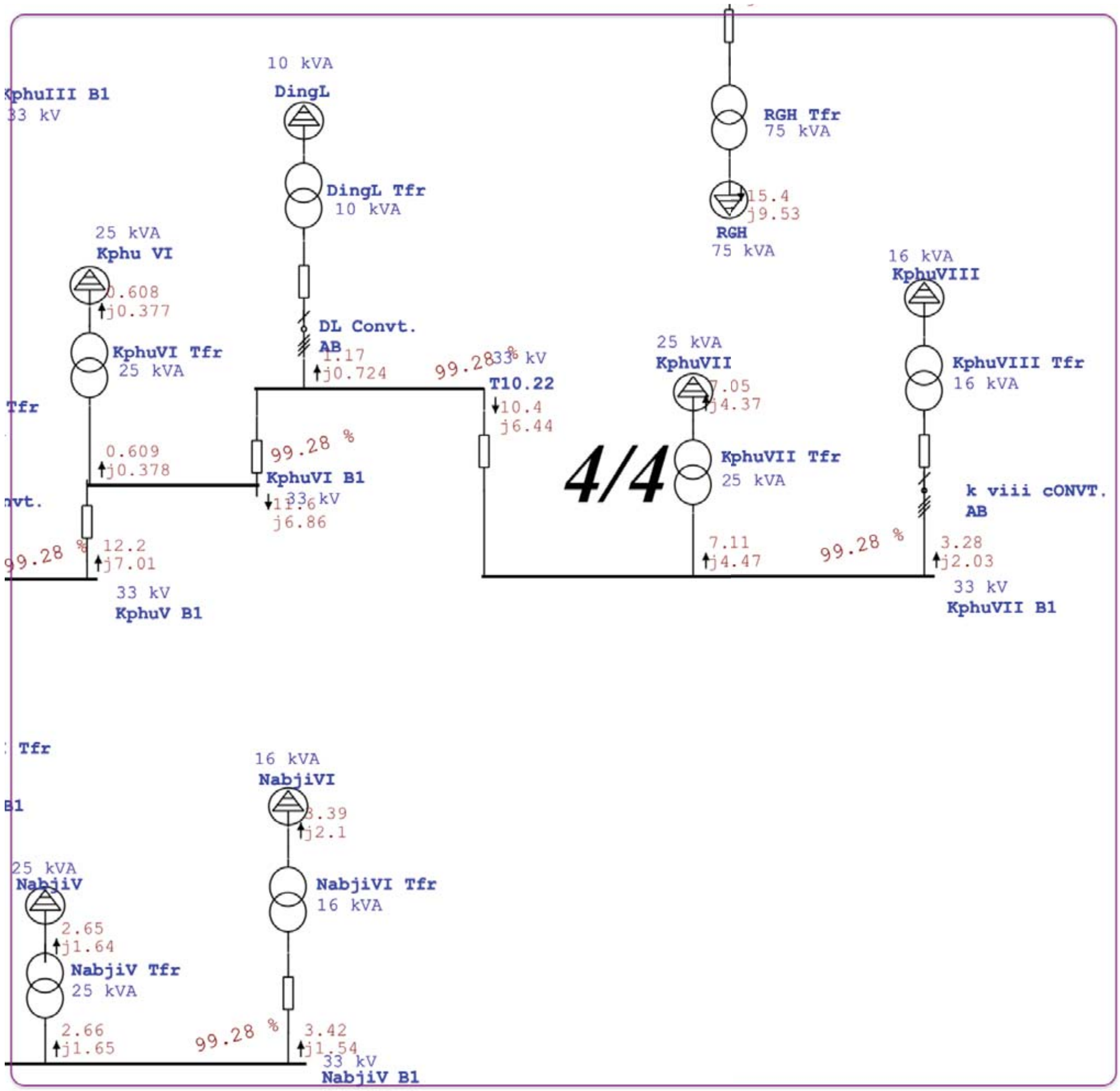


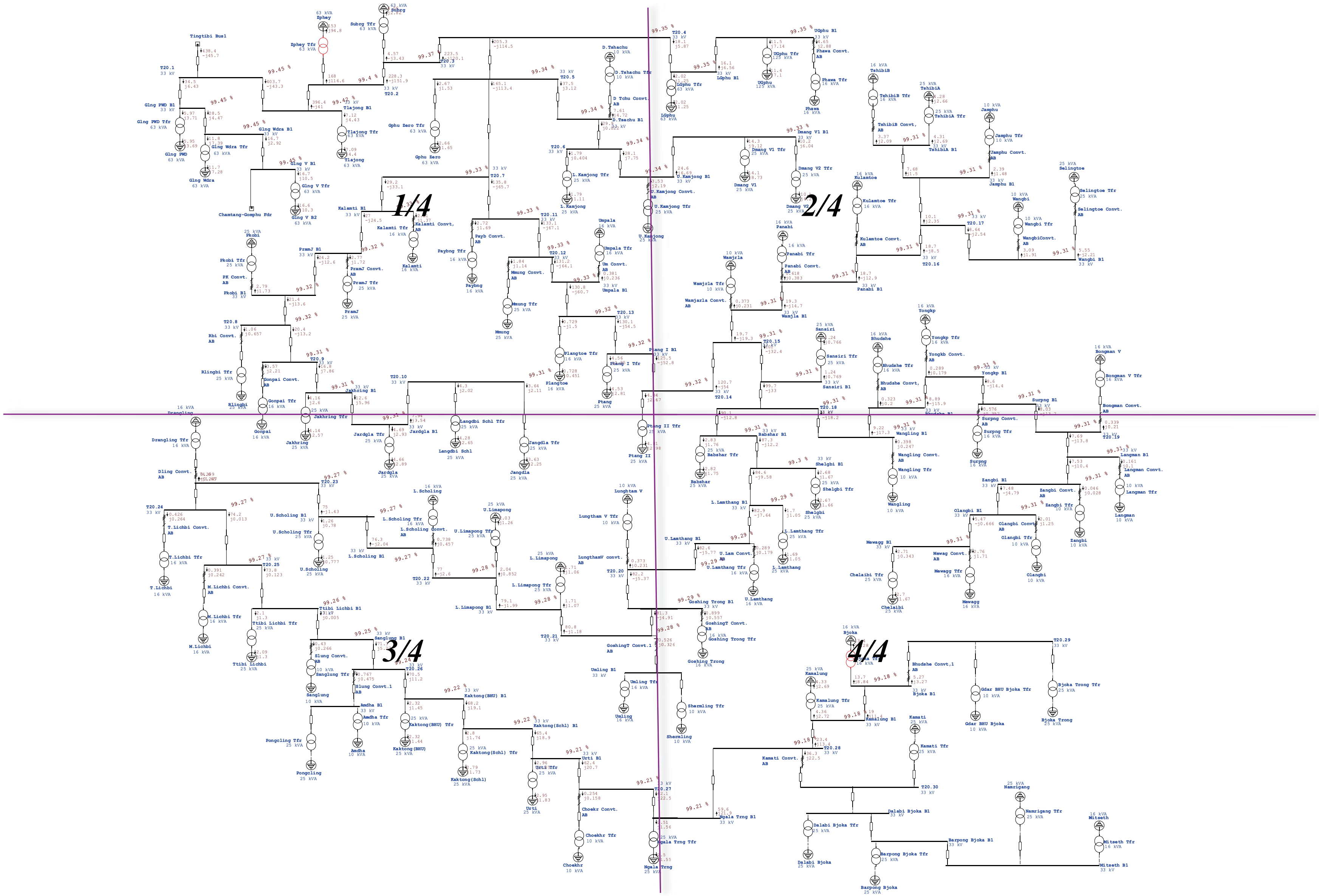
Tingtibi Bus1
329.4
j90.7
T10.1
33 kV
10.9
j6.48
GomC Tfr
25 kVA
10.8
j6.68
GomC
25 kVA
99.39 %
318.2
j105.2
75.3
-j13.1
99.31 %
242.7
j133.7
33 kV
T10.2
Dzong
500 kVA
25.1
j15.6
Dzo Tfr
500 kVA
25.2
j14.5
99.3 %
T10.6
33 kV
217.5
j120.9
99.3 %
T10.3
33 kV
8.83
j5.47
66.4
-j15.2
TP Convt.
AB
TPam Tfr
25 kVA
TPam
25 kVA
99.3 %
T10.4
33 kV
4.2
j1.69
62.2
-j12.1
99.3 %
T10.5
33 kV
1.97
j0.737
2.24
j1.39
KPam Convt.
AB
CP Convt.
AB
CPam Tfr
25 kVA
KPam Tfr
25 kVA
CPam
25 kVA
K.Pam
25 kVA
52.9
-j5.68
99.3 %
T10.14
33 kV
9.31
j4.54
25 kVA
NIII
2.17
j1.35
NIII Tfr
25 kVA
2.18
j1.06
1/4
99.3 %
33 kV
T10.15
7.13
j3.95
99.3 %
T10.16
33 kV
50.1
-j7.01
2.78
j1.54
NIV Tfr
25 kVA
2.77
j1.72
99.3 %
NV B1
25 kVA
63 kVA
RMBF
1.36
j0.842
RMBF Tfr
63 kVA
1.36
-j7.54
Dgbi
63 kVA
1.41
j0.875
Dgbi Tfr
63 kVA
99.29 %
1.41
j0.491
33 kV
T10.9
2.77
-j13.6
13.3
-j7.72
99.29 %
T10.7
33 kV
204.2
j129.8
1.5 MVA
ICT PWD
98.62 %
ICT B
6.6 kV
203.8
j127.4
25 kVA
NII
2.56
j1.58
NII Tfr
25 kVA
2.56
j1.32
25 kVA
NI
4.54
j2.81
NI Tfr
25 kVA
99.3 %
4.57
j2.85
33 kV
NI B1
16 kVA
KphuIII

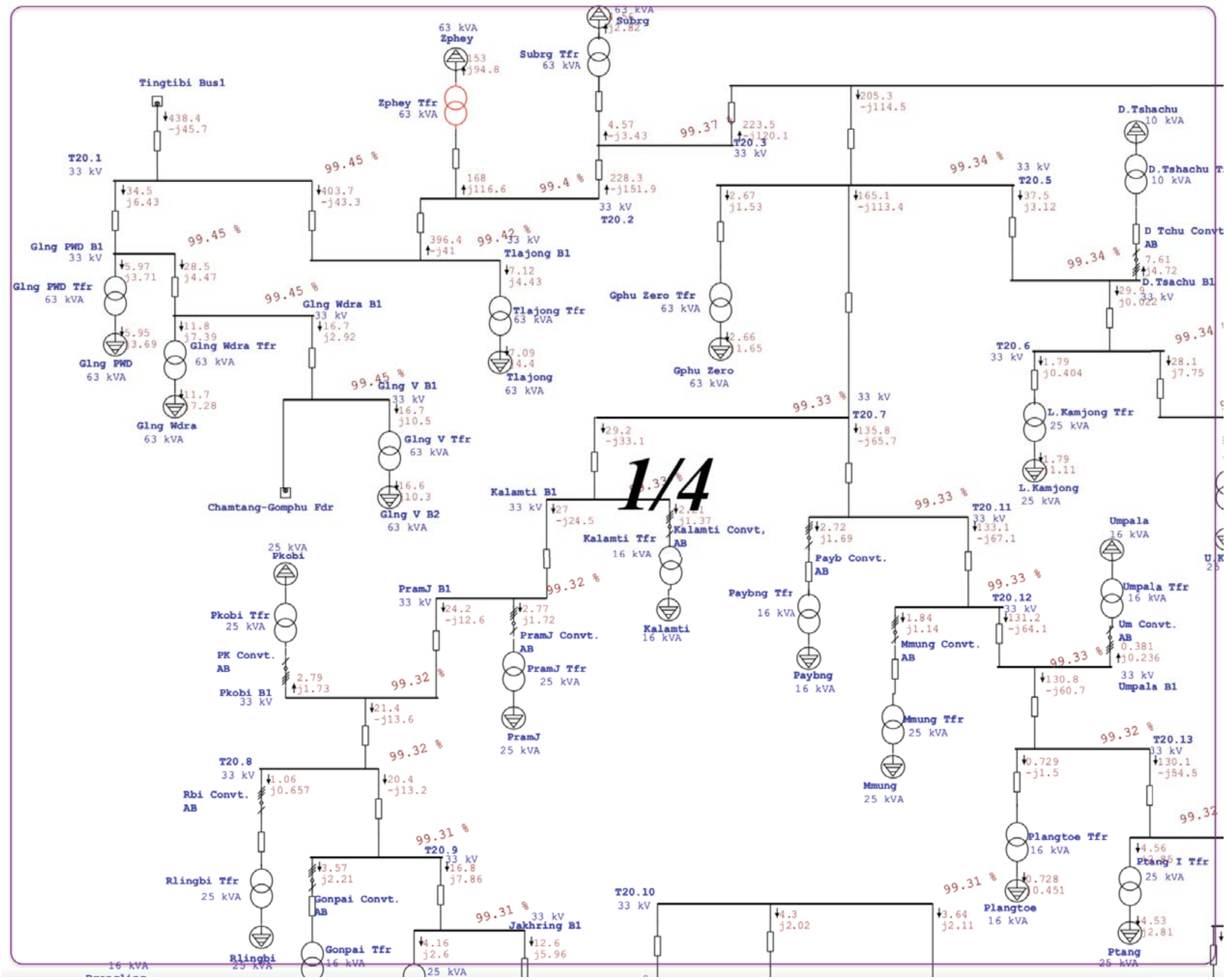

RDTC
500 kVA
10.5
j6.53
RDTC Tfr
500 kVA
10.5
j6.24
T10.8
33 kV
B.ZHSS
125 kVA
17.1
j10.6
B.ZHSS Tfr
125 kVA
17.2
j10.7
A.ZHSS
125 kVA
13.2
j8.2
A.ZHSS Tfr
125 kVA
13.3
j8.26
98.17 %
T10.11
6.6 kV
91.4
j57
BHU
125 kVA
27
j16.7
BHU Tfr
125 kVA
27.2
j17
98.37 %
122.1
j76.1
6.6 kV
BHU B1
DVH
125 kVA
30.4
j18.8
DVH Tfr
125 kVA
30.6
j19.2
98.44 %
149.4
j93.2
6.6 kV
T10.10
2/4
D.Pokto
50 kVA
23.3
j14.4
DPokto Tfr
63 kVA
23.5
j14.8
98.57 %
180.2
j112.5
6.6 kV
D.Pokto B1
98.13 %
T10.12
6.6 kV
91.4
j57
T10.12-T50H267
T50H267 B
98.12 %
BDYT.H B1
6.6 kV
24.9
j15.5
BDYT.H Tfr
125 kVA
24.7
j15.3
BDYT.H
125 kVA
66.5
j41.5
BAFRA.O
125 kVA
19.5
j12.1
BAFRA.O Tfr
125 kVA
19.6
j12.3
98.1 %
BAFRA.O B1
6.6 kV
46.9
j29.3
PWD
125 kVA
28
j17.3
PWD Tfr
125 kVA
28.2
j17.6
98.07 %
T10.13
6.6 kV
18.7
j11.7
Forest.O
100 kVA
3.22
j2
Forest.O Tfr
100 kVA
3.23
j2
98.07 %
6.6 kV
KphuIV Tfr

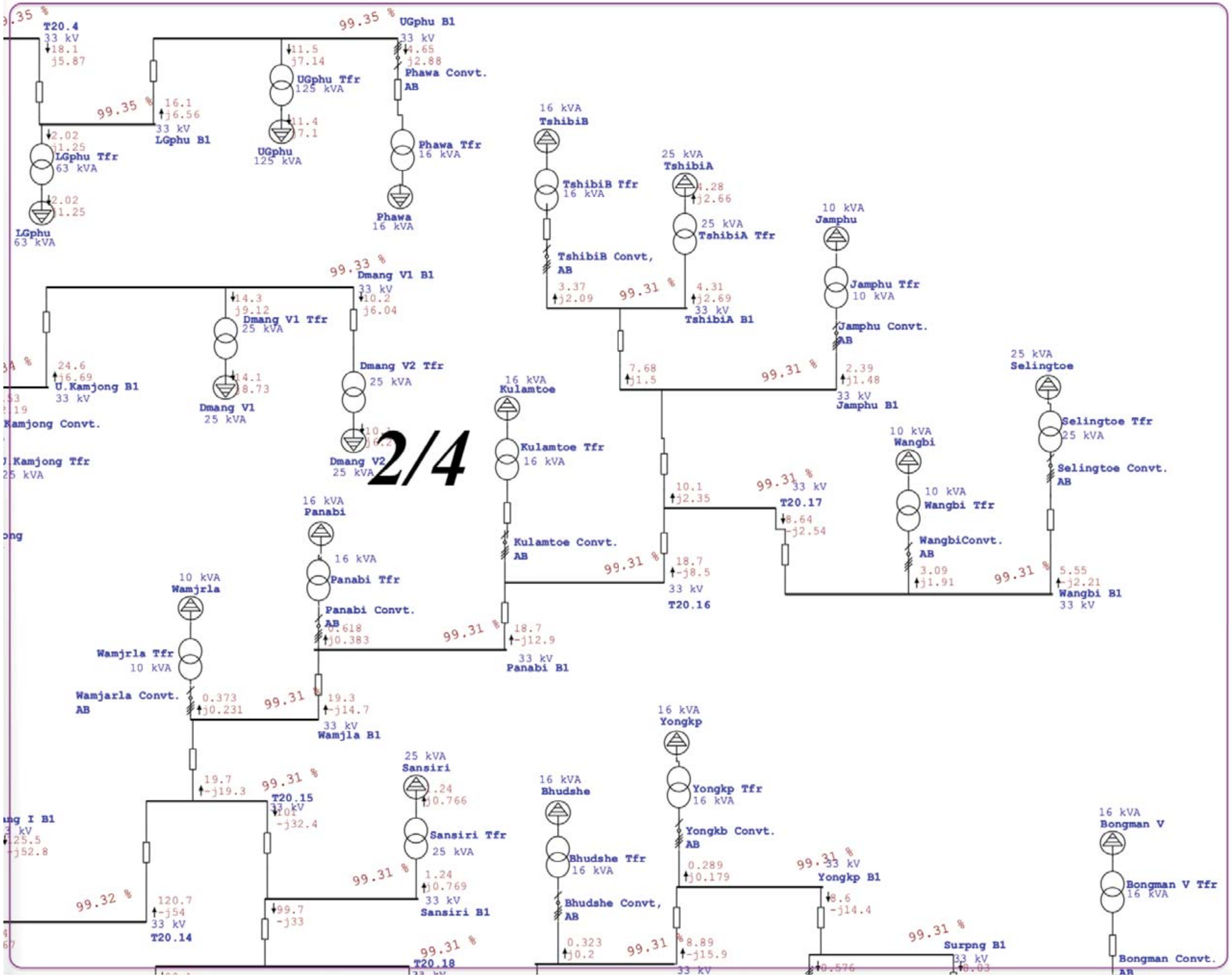


NV Tfr
25 kVA
1.43
j0.887
NV
25 kVA
0.589
j0.365
NVI Convt.
AB
16 kVA
NVI Tfr
NVI
16 kVA
99.3 %
NVI B1
33 kV
48.1
-j7.6
NVII Tfr
25 kVA
j0.829
99.3 %
1.34
j0.709
T10.17
33 kV
46.8
-j8.19
25 kVA
NVII1
2.45
j1.52
NVIII Tfr
25 kVA
99.3 %
2.46
j1.37
T10.18
33 kV
44.3
-j9.39
99.29 %
T10.19
33 kV
43.6
j10.5
PK Convt,
AB
0.731
j0.453
PKdung Tfr
10 kVA
PKdung
10 kVA
25 kVA
NabjiI
2.54
j1.57
NabjiI Tfr
25 kVA
2.55
j1.59
99.29 %
18.1
j2.9
25.5
j9.1
33 kV
T10.20
99.29 %
NabjiI B1
33 kV
15.6
j3.81
NabjiII
16 kVA
3.47
j2.15
NabjiII Tfr
16 kVA
3.49
j2.19
99.28 %
12.1
j5.89
NabjiII B1
33 kV
KphuI
25 kVA
3.37
j2.21
3/4
KphuI Tfr
25 kVA
3.59
j2.24
99.28 %
21.9
j12
33 kV
KphuI B1
KphuII
KphuII Tfr
16 kVA
KphuIII Tfr
16 kVA
KphuII B1
33 kV
KPhu Convt.
AB
7.44
j4.61
99.28 %
33 kV
T10.21
14.4
j8.23
KphuV
16 kVA
25 kVA
NabjiIV
3.4
j2.11
NabjiIV Tfr
25 kVA
3.42
j2.01
99.28 %
25 kVA
NabjiIII
6.01
j3.02
99.28 %
T10.23
33 kV
6.07
j2.97

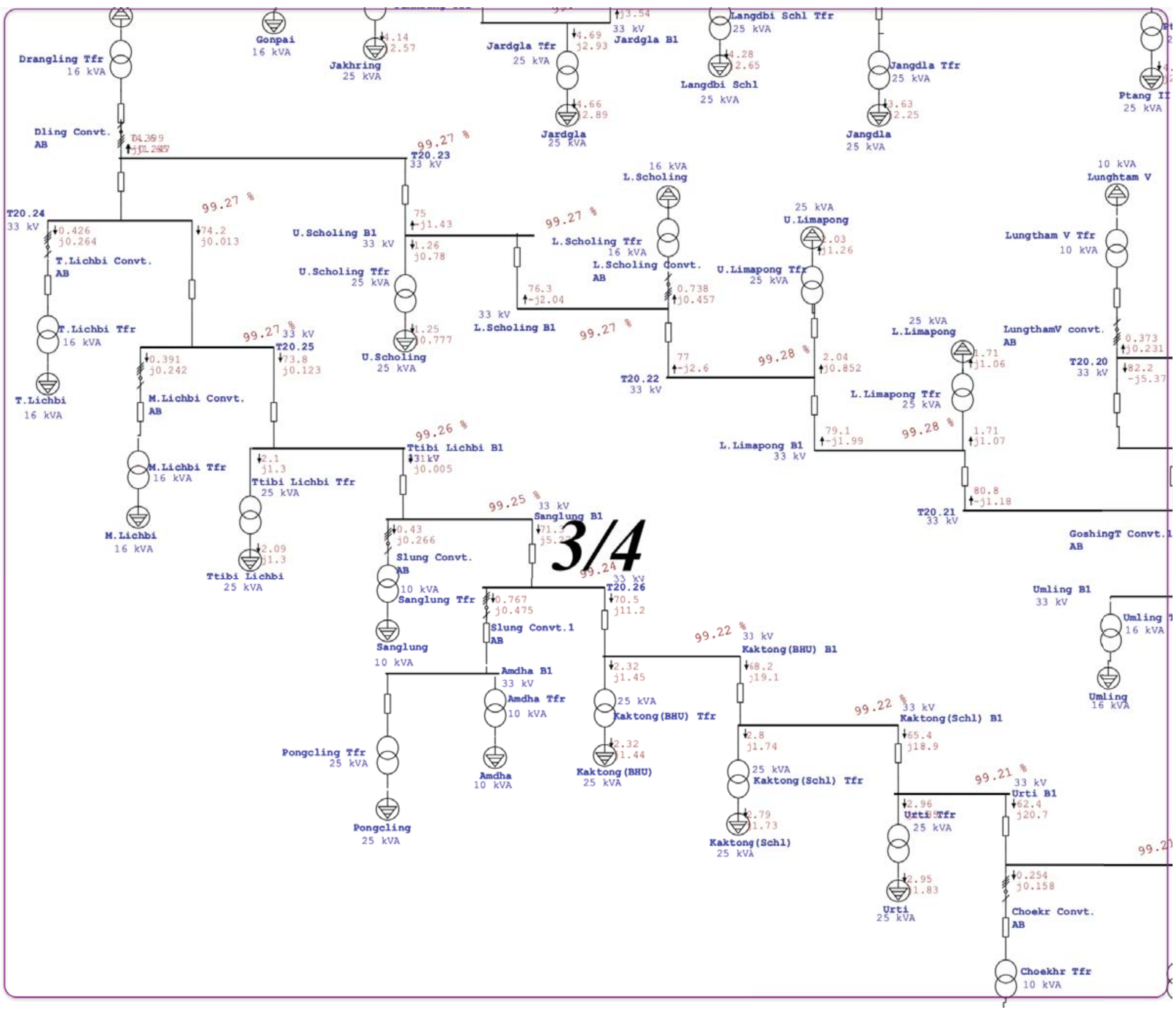

10 kVA
DingL
DingL Tfr
10 kVA
RGH Tfr
75 kVA
15.4
j9.53
RGH
75 kVA
KphuIII B1
33 kV
25 kVA
Kphu VI
0.608
j0.377
KphuVI Tfr
25 kVA
DL Convt.
AB
1.17
j0.724
99.28 %
33 kV
T10.22
10.4
j6.44
16 kVA
KphuVIII
KphuVIII Tfr
16 kVA
25 kVA
KphuVII
7.05
j4.37
KphuVII Tfr
25 kVA
4/4
Tfr
0.609
j0.378
99.28 %
KphuVI B1
33 kV
11.6
j6.86
k viii cONVT.
AB
99.28 %
12.2
j7.01
33 kV
KphuV B1
7.11
j4.47
99.28 %
3.28
j2.03
33 kV
KphuVII B1
Tfr
B1
16 kVA
NabjiVI
3.39
j2.1
NabjiVI Tfr
16 kVA
25 kVA
NabjiV
2.65
j1.64
NabjiV Tfr
25 kVA
2.66
j1.65
99.28 %
3.42
j1.54
33 kV
NabjiV B1


1/4
2/4
3/4
4/4

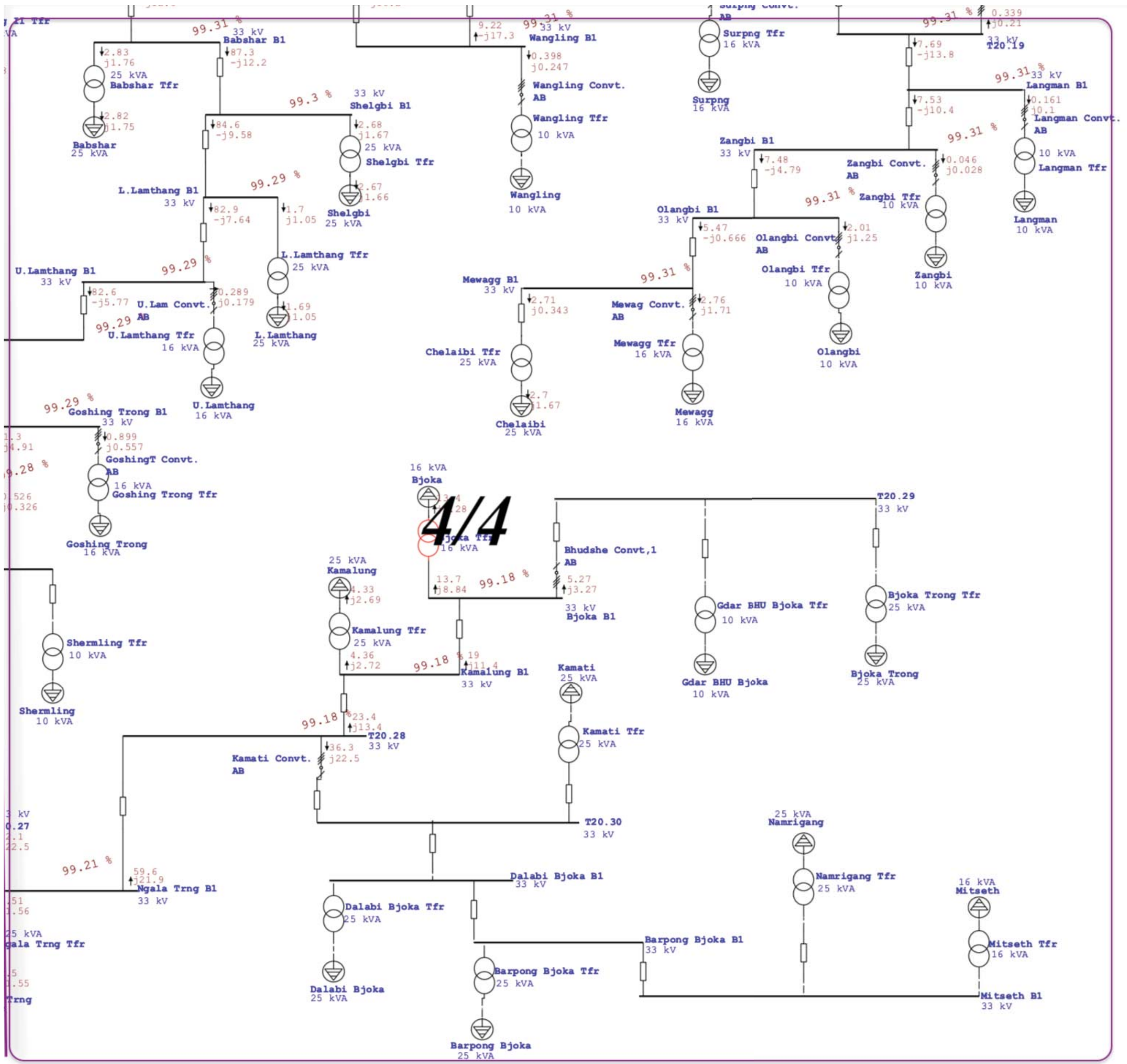

1/4
Tingtibi Bus1
T20.1
33 kV
Glng PWD B1
Glng PWD Tfr
63 kVA
Glng PWD
Glng Wdra B1
Glng Wdra Tfr
Glng Wdra
Glng V B1
Glng V Tfr
Glng V B2
Chamtang-Gomphu Fdr
Zphey
Zphey Tfr
Subrg
Subrg Tfr
T20.2
T20.3
Tlajong B1
Tlajong Tfr
Tlajong
Gphu Zero Tfr
Gphu Zero
T20.5
T20.6
T20.7
D.Tshachu
D.Tshachu Tfr
10 kVA
D Tchu Convt.
AB
D.Tsachu B1
L.Kamjong Tfr
L.Kamjong
25 kVA
Kalamti B1
Kalamti Tfr
Kalamti Convt.
Kalamti
16 kVA
T20.11
Payb Convt.
Paybng Tfr
Paybng
T20.12
Mmung Convt.
Mmung Tfr
Mmung
Umpala
Umpala Tfr
Um Convt.
Umpala B1
T20.13
Plangtoe Tfr
Plangtoe
Ptang I Tfr
Ptang
PramJ B1
PramJ Convt.
PramJ Tfr
PramJ
Pkobi
Pkobi Tfr
PK Convt.
Pkobi B1
T20.8
Rbi Convt.
Rlingbi Tfr
Rlingbi
T20.9
Gonpai Convt.
Gonpai Tfr
Jakhring B1
T20.10
99.45 %
99.4 %
99.42 %
99.37 %
99.34 %
99.33 %
99.32 %
99.31 %



2/4
T20.4
33 kV
LGphu B1
LGphu Tfr
63 kVA
LGphu
63 kVA
UGphu B1
UGphu Tfr
125 kVA
UGphu
125 kVA
Phawa Convt.
AB
Phawa Tfr
16 kVA
Phawa
16 kVA
Dmang V1 B1
Dmang V1 Tfr
25 kVA
Dmang V1
25 kVA
Dmang V2 Tfr
25 kVA
Dmang V2
25 kVA
U.Kamjong B1
TshibiB
16 kVA
TshibiB Tfr
16 kVA
TshibiB Convt,
AB
TshibiA
25 kVA
TshibiA Tfr
25 kVA
TshibiA B1
Jamphu
10 kVA
Jamphu Tfr
10 kVA
Jamphu Convt.
AB
Jamphu B1
Kulamtoe
16 kVA
Kulamtoe Tfr
16 kVA
Kulamtoe Convt.
AB
T20.16
T20.17
Wangbi
10 kVA
Wangbi Tfr
10 kVA
WangbiConvt.
AB
Selingtoe
25 kVA
Selingtoe Tfr
25 kVA
Selingtoe Convt.
AB
Wangbi B1
33 kV
Panabi
16 kVA
Panabi Tfr
16 kVA
Panabi Convt.
AB
Panabi B1
Wamjrla
10 kVA
Wamjrla Tfr
10 kVA
Wamjarla Convt.
AB
Wamjla B1
T20.15
T20.14
T20.18
Sansiri
25 kVA
Sansiri Tfr
25 kVA
Sansiri B1
Bhudshe
16 kVA
Bhudshe Tfr
16 kVA
Bhudshe Convt,
AB
Yongkp
16 kVA
Yongkp Tfr
16 kVA
Yongkb Convt.
AB
Yongkp B1
Surpng B1
Bongman V
16 kVA
Bongman V Tfr
16 kVA
Bongman Convt.
99.35 %
99.33 %
99.31 %
99.32 %

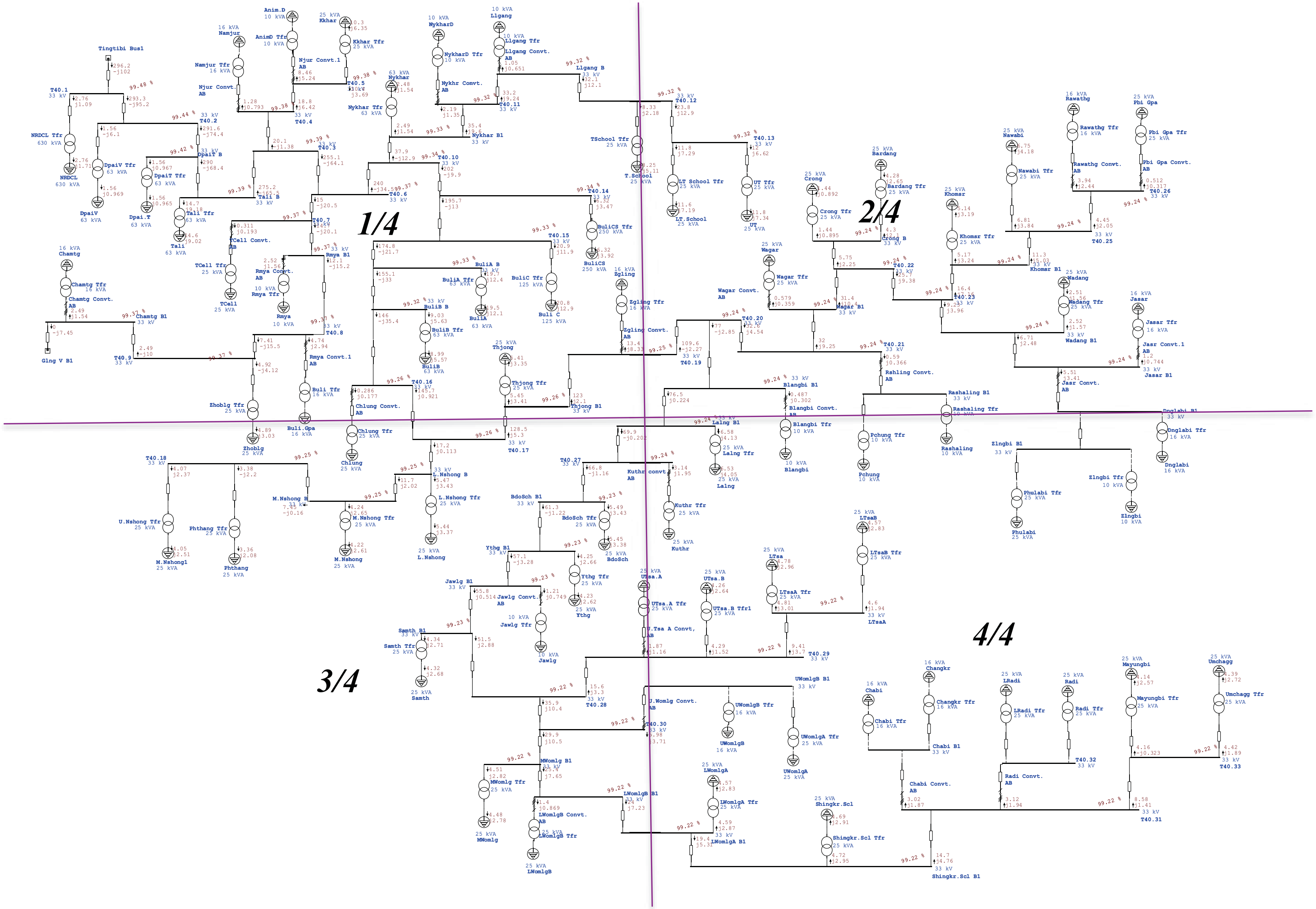


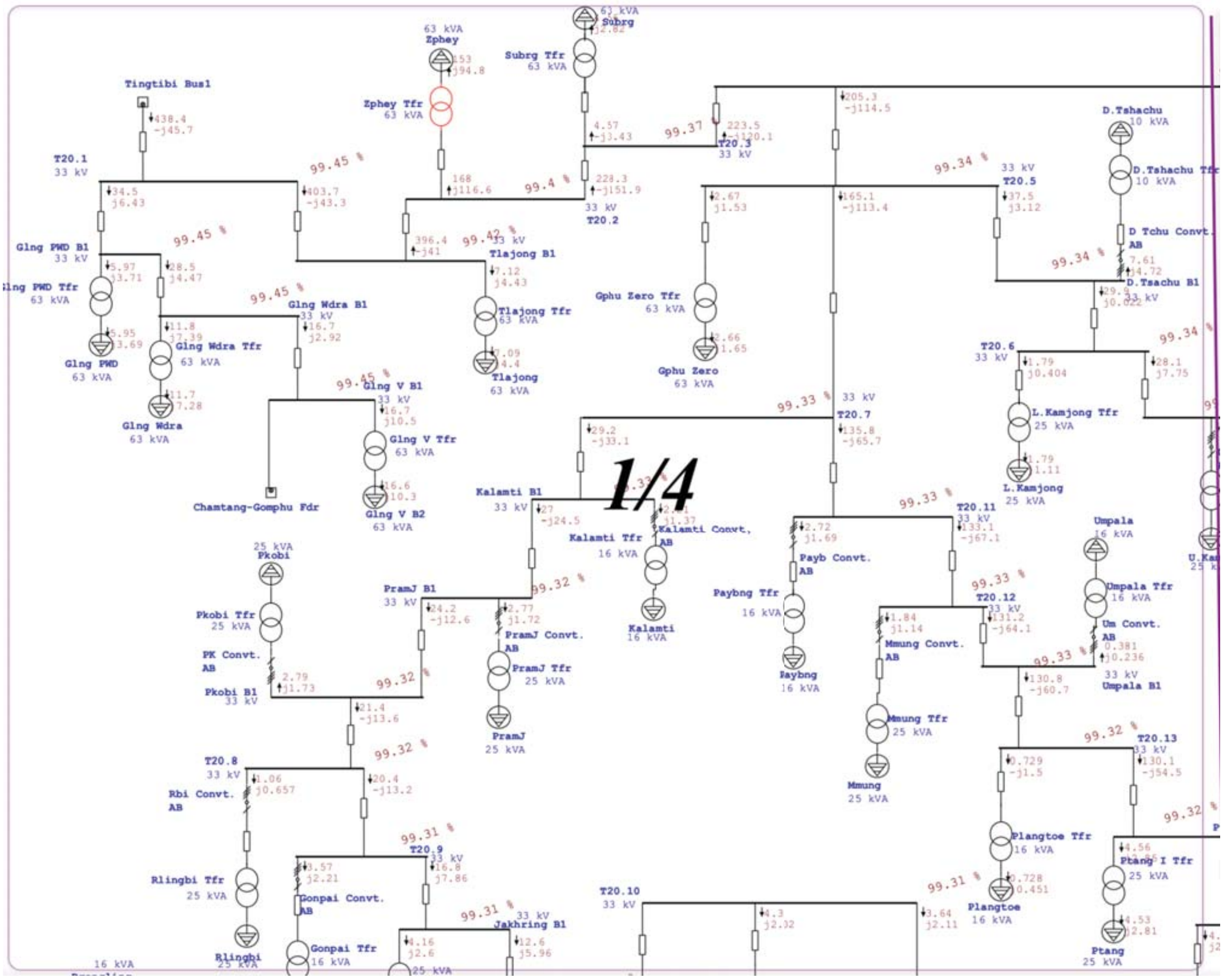
Drangling Tfr
16 kVA
Gonpai
16 kVA
Jakhring
25 kVA
Jardgla Tfr
25 kVA
Jardgla
25 kVA
33 kV
Jardgla B1
Langdbi Schl Tfr
25 kVA
Langdbi Schl
25 kVA
Jangdla Tfr
25 kVA
Jangdla
25 kVA
Ptang II
25 kVA
Dling Convt.
AB
99.27 %
T20.23
33 kV
T20.24
33 kV
0.426
j0.264
T.Lichbi Convt.
AB
74.2
j0.013
T.Lichbi Tfr
16 kVA
T.Lichbi
16 kVA
U.Scholing B1
33 kV
75
-j1.43
1.26
j0.78
U.Scholing Tfr
25 kVA
1.25
j0.777
U.Scholing
25 kVA
16 kVA
L.Scholing
L.Scholing Tfr
16 kVA
L.Scholing Convt.
AB
0.738
j0.457
76.3
-j2.04
33 kV
L.Scholing B1
25 kVA
U.Limapong
2.03
j1.26
U.Limapong Tfr
25 kVA
10 kVA
Lungtham V
Lungtham V Tfr
10 kVA
LungthamV convt.
AB
0.373
j0.231
T20.20
33 kV
82.2
-j5.37
99.27 %
0.391
j0.242
M.Lichbi Convt.
AB
33 kV
T20.25
73.8
j0.123
M.Lichbi Tfr
16 kVA
M.Lichbi
16 kVA
99.27 %
77
-j2.6
T20.22
33 kV
99.28 %
2.04
j0.852
25 kVA
L.Limapong
1.71
j1.06
L.Limapong Tfr
25 kVA
L.Limapong B1
33 kV
79.1
-j1.99
99.28 %
1.71
j1.07
80.8
-j1.18
T20.21
33 kV
99.26 %
Ttibi Lichbi B1
31 kV
j0.005
2.1
j1.3
Ttibi Lichbi Tfr
25 kVA
2.09
j1.3
Ttibi Lichbi
25 kVA
GoshingT Convt.1
AB
99.25 %
33 kV
Sanglung B1
0.43
j0.266
Slung Convt.
AB
10 kVA
Sanglung Tfr
Sanglung
10 kVA
3/4
99.24
33 kV
T20.26
70.5
j11.2
0.767
j0.475
Slung Convt.1
AB
Amdha B1
33 kV
Amdha Tfr
10 kVA
Amdha
10 kVA
Pongcling Tfr
25 kVA
Pongcling
25 kVA
Umling B1
33 kV
Umling Tfr
16 kVA
Umling
16 kVA
99.22 %
33 kV
Kaktong(BHU) B1
68.2
j19.1
2.32
j1.45
25 kVA
Kaktong(BHU) Tfr
2.32
j1.44
Kaktong(BHU)
25 kVA
99.22 %
33 kV
Kaktong(Schl) B1
65.4
j18.9
2.8
j1.74
25 kVA
Kaktong(Schl) Tfr
2.79
j1.73
Kaktong(Schl)
25 kVA
99.21 %
33 kV
Urti B1
62.4
j20.7
2.96
Urti Tfr
25 kVA
2.95
j1.83
Urti
25 kVA
0.254
j0.158
Choekr Convt.
AB
Choekhr Tfr
10 kVA



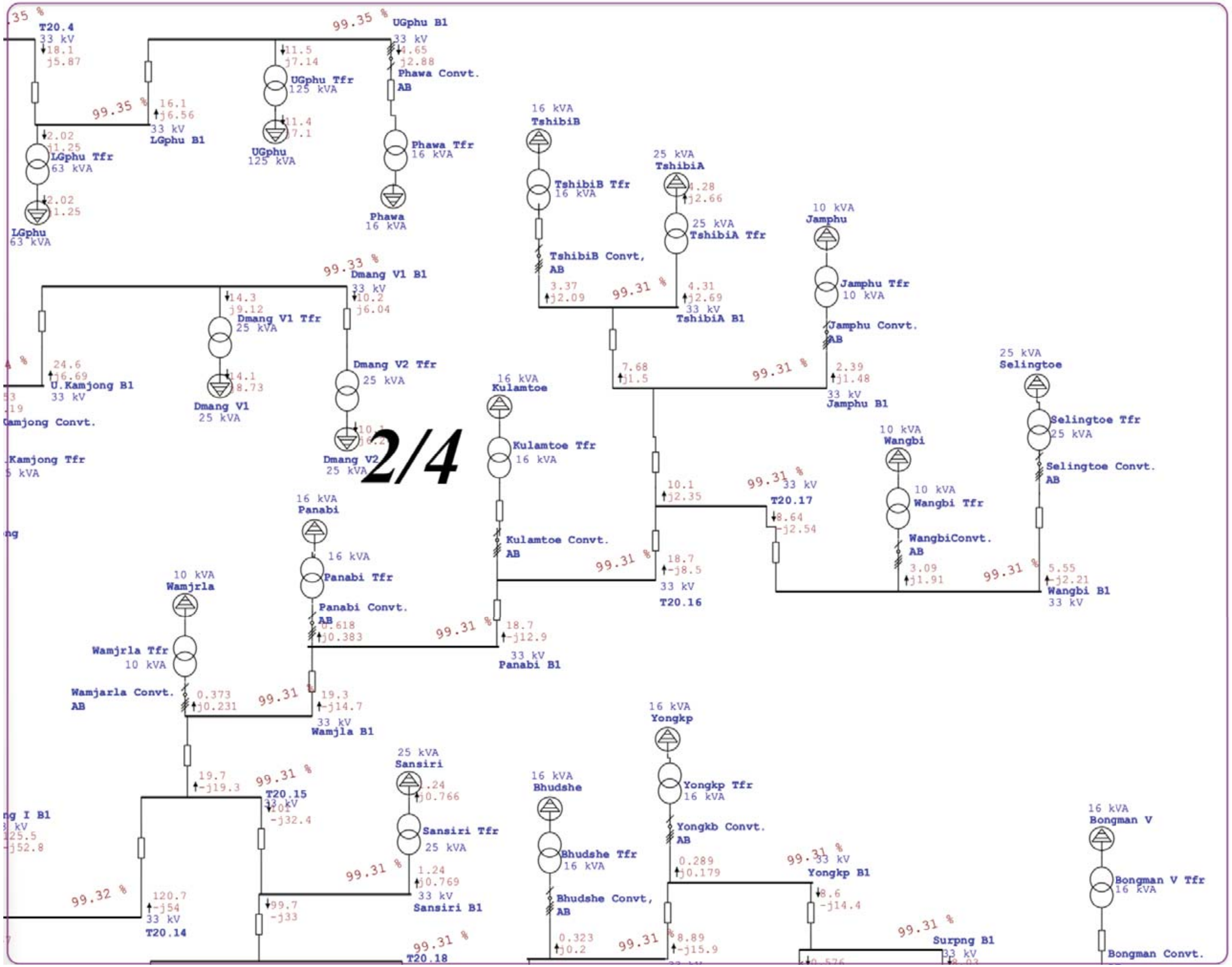
4/4
Babshar B1
33 kV
Babshar Tfr
25 kVA
Babshar
Shelgbi B1
Shelgbi Tfr
Shelgbi
L.Lamthang B1
L.Lamthang Tfr
L.Lamthang
U.Lamthang B1
U.Lam Convt.
AB
U.Lamthang Tfr
16 kVA
U.Lamthang
Goshing Trong B1
GoshingT Convt.
Goshing Trong Tfr
Goshing Trong
Shermling Tfr
10 kVA
Shermling
Wangling B1
Wangling Convt.
Wangling Tfr
Wangling
Surpng Tfr
Surpng
T20.19
Langman B1
Langman Convt.
Langman Tfr
Langman
Zangbi B1
Zangbi Convt.
Zangbi Tfr
Zangbi
Olangbi B1
Olangbi Convt
Olangbi Tfr
Olangbi
Mewagg B1
Mewag Convt.
Mewagg Tfr
Mewagg
Chelaibi Tfr
Chelaibi
Bjoka
Bjoka Tfr
Bhudshe Convt,1
Bjoka B1
T20.29
Gdar BHU Bjoka Tfr
Gdar BHU Bjoka
Bjoka Trong Tfr
Bjoka Trong
Kamalung
Kamalung Tfr
Kamalung B1
Kamati
Kamati Tfr
T20.28
Kamati Convt.
T20.30
Ngala Trng B1
Dalabi Bjoka B1
Dalabi Bjoka Tfr
Dalabi Bjoka
Barpong Bjoka B1
Barpong Bjoka Tfr
Barpong Bjoka
Namrigang
Namrigang Tfr
Mitseth
Mitseth Tfr
Mitseth B1

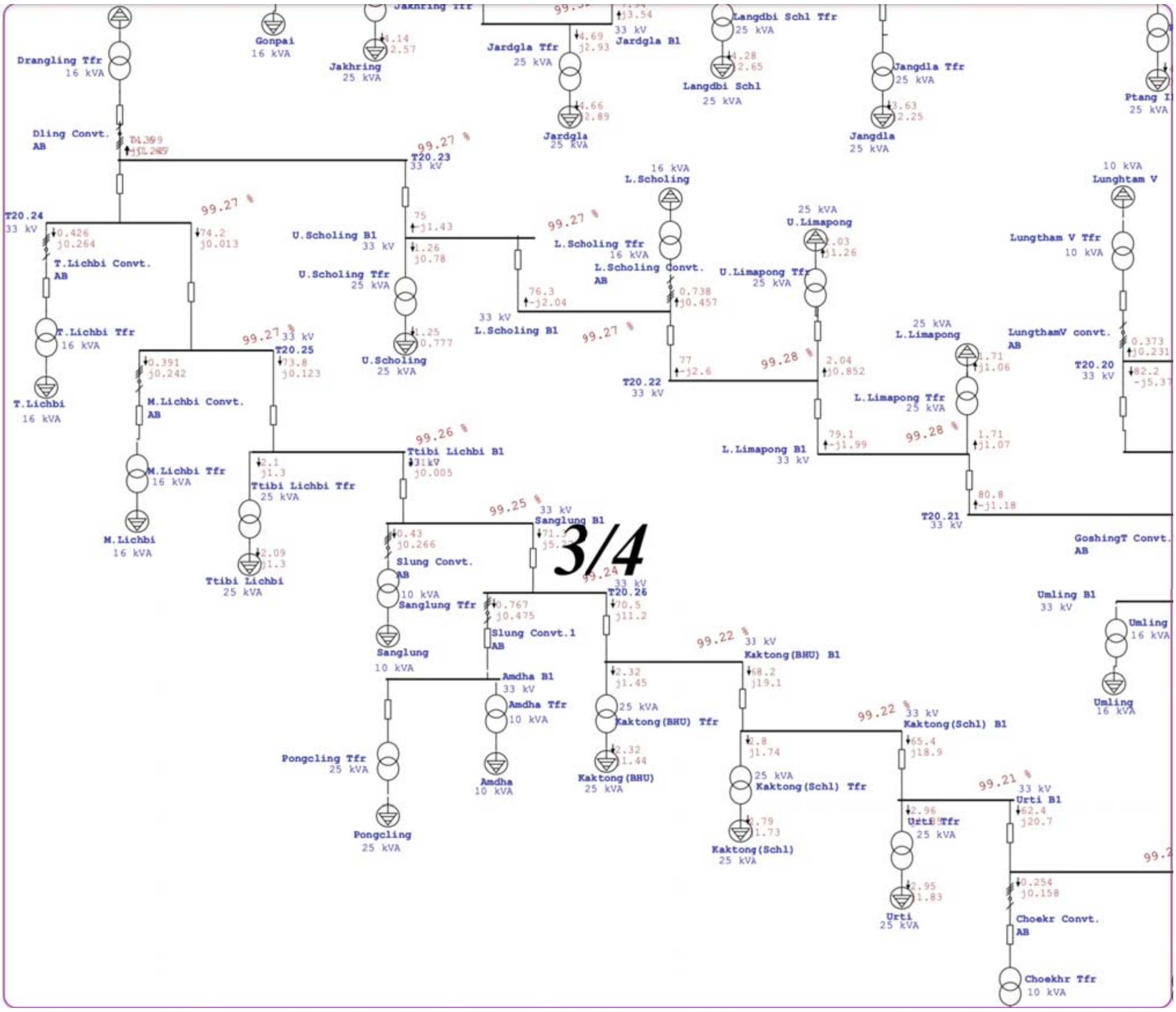
One-Line Diagram - OLV1=>Dakpai Fdr (Load Flow Analysis)

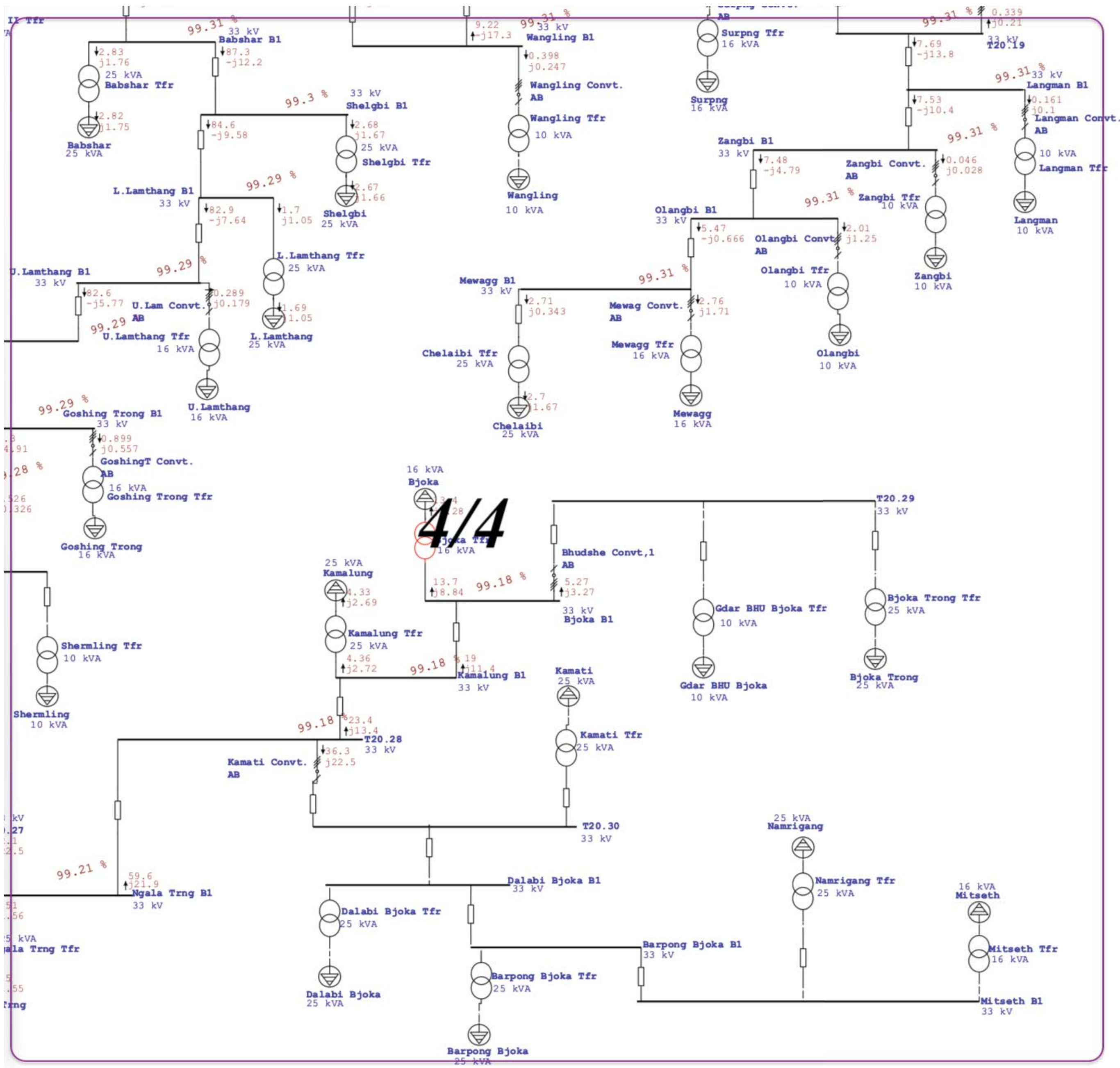




1/4
Tingtibi Bus1
T20.1
33 kV
Zphey
63 kVA
Zphey Tfr
63 kVA
Subrg
Subrg Tfr
63 kVA
T20.2
T20.3
T20.5
T20.6
T20.7
T20.8
T20.9
T20.10
T20.11
T20.12
T20.13
D.Tshachu
10 kVA
D.Tshachu Tfr
D Tchu Convt.
AB
D.Tsachu B1
Glng PWD B1
Glng PWD Tfr
Glng PWD
Glng Wdra B1
Glng Wdra Tfr
Glng Wdra
Glng V B1
Glng V Tfr
Glng V B2
Chamtang-Gomphu Fdr
Tlajong B1
Tlajong Tfr
Tlajong
Gphu Zero Tfr
Gphu Zero
L.Kamjong Tfr
L.Kamjong
25 kVA
Kalamti B1
Kalamti Tfr
Kalamti Convt.
Kalamti
16 kVA
Paybng Tfr
Payb Convt.
Paybng
Umpala
Umpala Tfr
Um Convt.
Umpala B1
Pkobi
Pkobi Tfr
PK Convt.
Pkobi B1
PramJ B1
PramJ Convt.
PramJ Tfr
PramJ
Mmung Convt.
Mmung Tfr
Mmung
Rbi Convt.
Rlingbi Tfr
Rlingbi
Gonpai Convt.
Gonpai Tfr
Jakhring B1
Plangtoe Tfr
Plangtoe
Ptang I Tfr
Ptang
99.45 %
99.4 %
99.37 %
99.34 %
99.42 %
99.33 %
99.32 %
99.31 %


2/4
T20.4
33 kV
18.1
j5.87
99.35 %
LGphu B1
33 kV
16.1
j6.56
LGphu Tfr
63 kVA
LGphu
63 kVA
UGphu B1
33 kV
99.35 %
UGphu Tfr
125 kVA
UGphu
125 kVA
Phawa Convt.
AB
Phawa Tfr
16 kVA
Phawa
16 kVA
Dmang V1 B1
33 kV
99.33 %
Dmang V1 Tfr
25 kVA
Dmang V1
25 kVA
Dmang V2 Tfr
25 kVA
Dmang V2
25 kVA
U.Kamjong B1
33 kV
24.6
j6.69
TshibiB
16 kVA
TshibiB Tfr
16 kVA
TshibiB Convt,
AB
TshibiA
25 kVA
TshibiA Tfr
25 kVA
TshibiA B1
33 kV
99.31 %
Jamphu
10 kVA
Jamphu Tfr
10 kVA
Jamphu Convt.
AB
Jamphu B1
33 kV
Selingtoe
25 kVA
Selingtoe Tfr
25 kVA
Selingtoe Convt.
AB
Wangbi
10 kVA
Wangbi Tfr
10 kVA
WangbiConvt.
AB
Wangbi B1
33 kV
T20.17
33 kV
T20.16
33 kV
Kulamtoe
16 kVA
Kulamtoe Tfr
16 kVA
Kulamtoe Convt.
AB
Panabi
16 kVA
Panabi Tfr
16 kVA
Panabi Convt.
AB
Panabi B1
33 kV
Wamjrla
10 kVA
Wamjrla Tfr
10 kVA
Wamjarla Convt.
AB
Wamjla B1
33 kV
T20.15
33 kV
T20.14
33 kV
99.32 %
Sansiri
25 kVA
Sansiri Tfr
25 kVA
Sansiri B1
33 kV
T20.18
Bhudshe
16 kVA
Bhudshe Tfr
16 kVA
Bhudshe Convt,
AB
Yongkp
16 kVA
Yongkp Tfr
16 kVA
Yongkb Convt.
AB
Yongkp B1
33 kV
Surpng B1
33 kV
Bongman V
16 kVA
Bongman V Tfr
16 kVA
Bongman Convt.


Drangling Tfr
16 kVA
Gonpai
16 kVA
Jakhring
25 kVA
Jardgla Tfr
25 kVA
Jardgla B1
33 kV
Jardgla
25 kVA
Langdbi Schl Tfr
25 kVA
Langdbi Schl
25 kVA
Jangdla Tfr
25 kVA
Jangdla
25 kVA
Ptang
25 kVA
Dling Convt.
AB
T20.23
33 kV
99.27 %
T20.24
33 kV
0.426
j0.264
74.2
j0.013
T.Lichbi Convt.
AB
T.Lichbi Tfr
16 kVA
T.Lichbi
16 kVA
U.Scholing B1
33 kV
75
-j1.43
1.26
j0.78
U.Scholing Tfr
25 kVA
U.Scholing
25 kVA
1.25
0.777
L.Scholing Tfr
16 kVA
L.Scholing
16 kVA
L.Scholing Convt.
AB
0.738
j0.457
76.3
-j2.04
33 kV
L.Scholing B1
U.Limapong
25 kVA
U.Limapong Tfr
25 kVA
j1.26
Lunghtam V
10 kVA
Lungtham V Tfr
10 kVA
LungthamV convt.
AB
0.373
j0.231
T20.20
33 kV
82.2
-j5.37
T20.25
33 kV
0.391
j0.242
73.8
j0.123
M.Lichbi Convt.
AB
M.Lichbi Tfr
16 kVA
M.Lichbi
16 kVA
T20.22
33 kV
77
-j2.6
99.28 %
2.04
j0.852
L.Limapong
25 kVA
1.71
j1.06
L.Limapong Tfr
25 kVA
L.Limapong B1
33 kV
79.1
-j1.99
1.71
j1.07
80.8
-j1.18
T20.21
33 kV
99.26 %
Ttibi Lichbi B1
33 kV
j0.005
2.1
j1.3
Ttibi Lichbi Tfr
25 kVA
Ttibi Lichbi
25 kVA
2.09
j1.3
99.25 %
Sanglung B1
33 kV
0.43
j0.266
Slung Convt.
AB
10 kVA
Sanglung Tfr
Sanglung
10 kVA
3/4
99.24 %
T20.26
33 kV
0.767
j0.475
70.5
j11.2
Slung Convt.1
AB
Amdha B1
33 kV
Amdha Tfr
10 kVA
Amdha
10 kVA
Pongcling Tfr
25 kVA
Pongcling
25 kVA
GoshingT Convt.
AB
Umling B1
33 kV
Umling
16 kVA
99.22 %
Kaktong(BHU) B1
33 kV
2.32
j1.45
68.2
j19.1
25 kVA
Kaktong(BHU) Tfr
2.32
1.44
Kaktong(BHU)
25 kVA
Kaktong(Schl) B1
33 kV
2.8
j1.74
65.4
j18.9
25 kVA
Kaktong(Schl) Tfr
2.79
1.73
Kaktong(Schl)
25 kVA
99.21 %
Urti B1
33 kV
2.96
62.4
j20.7
Urti Tfr
25 kVA
2.95
1.83
Urti
25 kVA
0.254
j0.158
Choekr Convt.
AB
Choekhr Tfr
10 kVA


Babshar B1
33 kV
Babshar Tfr
25 kVA
Babshar
25 kVA
Shelgbi B1
33 kV
Shelgbi Tfr
25 kVA
Shelgbi
25 kVA
L.Lamthang B1
33 kV
L.Lamthang Tfr
25 kVA
L.Lamthang
25 kVA
U.Lamthang B1
33 kV
U.Lam Convt.
AB
U.Lamthang Tfr
16 kVA
U.Lamthang
16 kVA
Goshing Trong B1
33 kV
GoshingT Convt.
AB
Goshing Trong Tfr
16 kVA
Goshing Trong
16 kVA
Shermling Tfr
10 kVA
Shermling
10 kVA
Wangling B1
33 kV
Wangling Convt.
AB
Wangling Tfr
10 kVA
Wangling
10 kVA
Surpng Tfr
16 kVA
Surpng
16 kVA
T20.19
33 kV
Langman B1
33 kV
Langman Convt.
AB
Langman Tfr
10 kVA
Langman
10 kVA
Zangbi B1
33 kV
Zangbi Convt.
AB
Zangbi Tfr
10 kVA
Zangbi
10 kVA
Olangbi B1
33 kV
Olangbi Convt.
AB
Olangbi Tfr
10 kVA
Olangbi
10 kVA
Mewagg B1
33 kV
Mewag Convt.
AB
Mewagg Tfr
16 kVA
Mewagg
16 kVA
Chelaibi Tfr
25 kVA
Chelaibi
25 kVA
4/4
Bjoka
16 kVA
Bjoka Tfr
16 kVA
Bjoka B1
33 kV
Bhudshe Convt,1
AB
T20.29
33 kV
Gdar BHU Bjoka Tfr
10 kVA
Gdar BHU Bjoka
10 kVA
Bjoka Trong Tfr
25 kVA
Bjoka Trong
25 kVA
Kamalung
25 kVA
Kamalung Tfr
25 kVA
Kamalung B1
33 kV
Kamati
25 kVA
Kamati Tfr
25 kVA
T20.28
33 kV
Kamati Convt.
AB
T20.30
33 kV
Ngala Trng B1
33 kV
Ngala Trng Tfr
Dalabi Bjoka B1
33 kV
Dalabi Bjoka Tfr
25 kVA
Dalabi Bjoka
25 kVA
Barpong Bjoka B1
33 kV
Barpong Bjoka Tfr
25 kVA
Barpong Bjoka
25 kVA
Namrigang
25 kVA
Namrigang Tfr
25 kVA
Mitseth
16 kVA
Mitseth Tfr
16 kVA
Mitseth B1
33 kV
99.31 %
99.3 %
99.29 %
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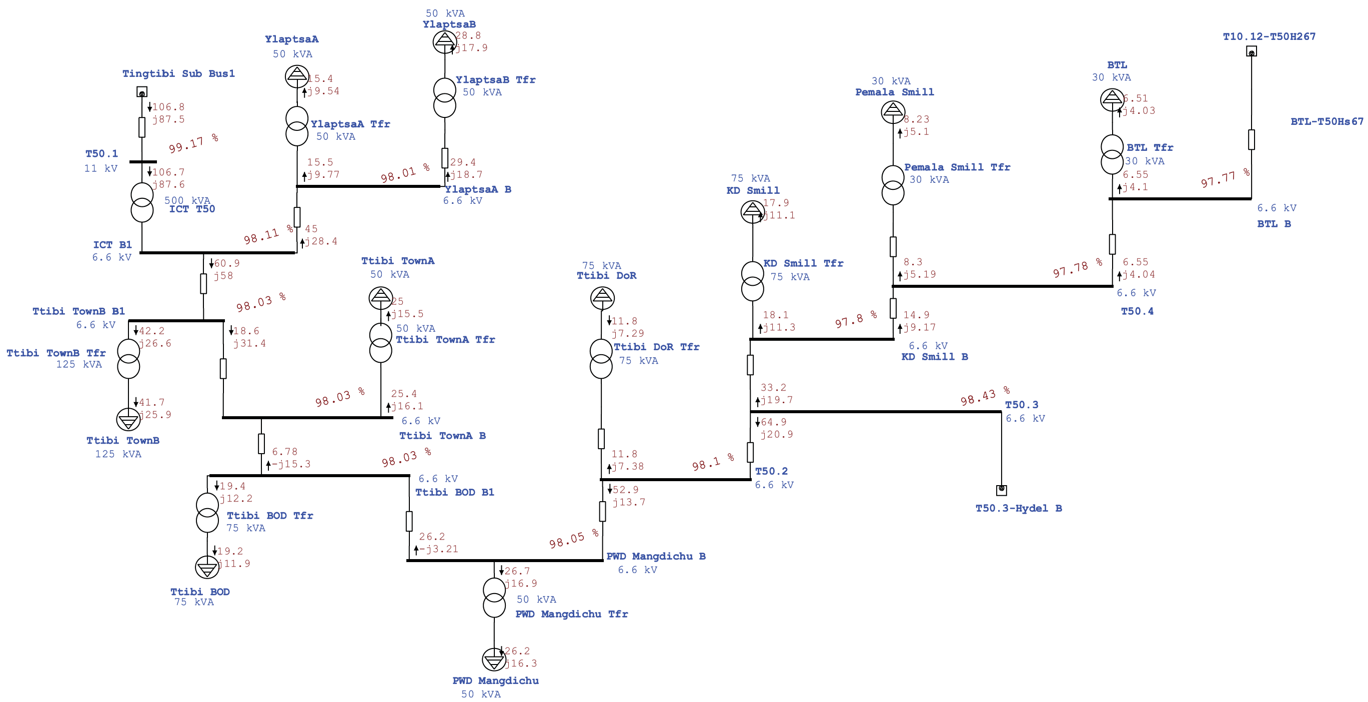
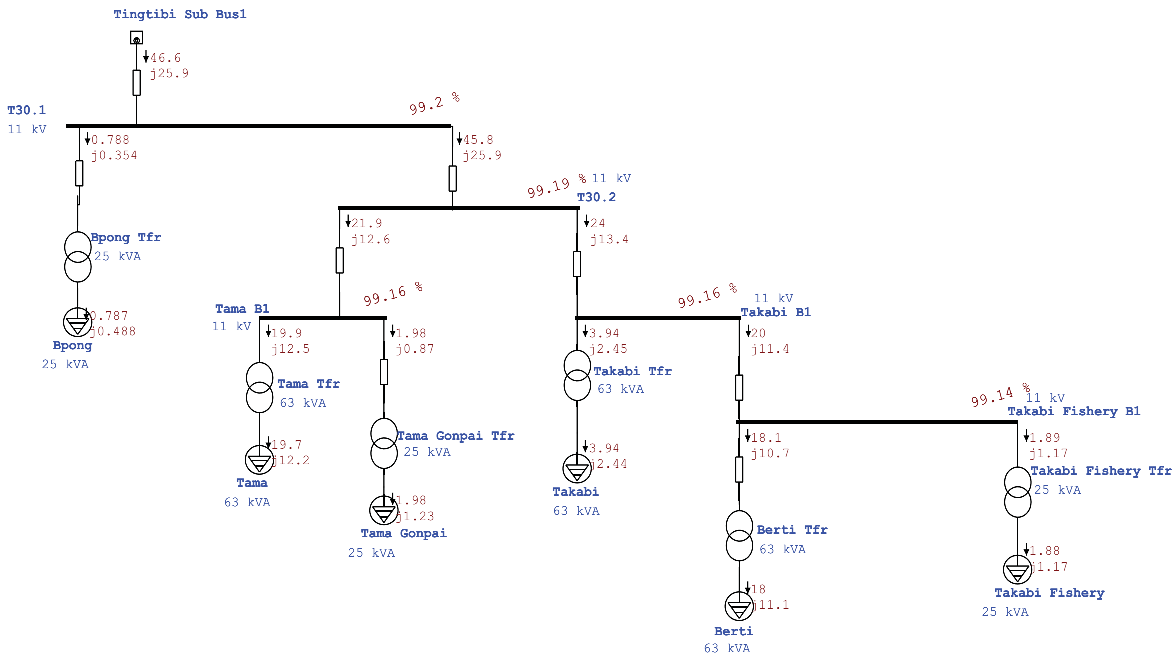
One-Line Diagram - OLV1=>Yebilaptsa Fdr (Load Flow Analysis)



One-Line Diagram - OLV1=>Tama Fdr (Load Flow Analysis)



Section		CONDUCTOR	Conductor type & Line Length					Length (km)		
From	To		300 UG	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
33kV Zhemgang feeder										
T10H001	T10H110	DOG			6,816.00			6.82	6.82	3
T10H110	T10H167	DOG			5,018.68			5.02	5.02	3
T20H167	T10H172	DOG			520.41			0.52	0.52	3
T10H172	T10H178	DOG			375.20			0.38	0.38	3
T20H167	T10H276	AAAC					1,112.33	1.11	1.11	
T10H276	T10H317	AAAC					387.91	0.39	0.39	3
T10H276	T10H294	AAAC					1,531.71	1.53	1.53	3
T10H294	T10H311	AAAC					1,770.54	1.77	1.77	3
T10H294	T10H312	RABBIT				146.61		0.15	0.15	3
T10H312	T10H314	RABBIT				164.17		0.16	0.16	3
T10H312	T10H325	RABBIT				1,547.46		1.55	1.55	
T10H172	T10H185	DOG			400.34			0.40	0.40	
T10H185	T10H188	RABBIT				233.59		0.23	0.23	
T10H185	T10H190	RABBIT				125.69		0.13	0.13	
T10H190	T10H220	RABBIT				2,237.81		2.24	2.24	
T10H220	T10H222	RABBIT				130.63		0.13	0.13	
			-	-	13,130.63	4,585.97	4,802.49	22.52	22.52	
33kV Gomphu Feeder										
T20H001	T20H016	DOG			917.85			0.92	0.92	
T20H016	T20H040	DOG			1,982.93			1.98	1.98	
T20H040	T20H069	DOG			2,191.18			2.19	2.19	
T20H069	T20H091	DOG			1,875.68			1.88	1.88	
T20H091	T20H256	DOG			9,200.85			9.20	9.20	
T20H256	T20H336	DOG			5,241.02			5.24	5.24	
T20H336	T20H351	DOG			1,858.30			1.86	1.86	
T20H351	T20H463	DOG			4,708.42			4.71	4.71	
T20H463	T20H465	DOG			108.69			0.11	0.11	
T20H465	T20H482	DOG			1,308.33			1.31	1.31	
T20H482	T20H494	DOG			1,186.42			1.19	1.19	
T20H494	T20H508	DOG			1,529.28			1.53	1.53	
T20H508	T20H532	DOG			1,461.01			1.46	1.46	
T20H532	T20H538	DOG			470.06			0.47	0.47	
T20H538	T20H546	DOG			720.91			0.72	0.72	
T20H546	T20H547	DOG			56.83			0.06	0.06	
T20H547	T20H809	DOG			638.04			0.64	0.64	
T20H809	T20H875	RABBIT				788.33		0.79	0.79	
T20H875	T20H889	RABBIT				1,453.94		1.45	1.45	
T20H889	T20H898	RABBIT				1,018.71		1.02	1.02	
T20H898	T20H903	RABBIT				697.86		0.70	0.70	
T20H903	T20H906	RABBIT				215.35		0.22	0.22	
T20H906	T20H923	RABBIT				347.16		0.35	0.35	
T20H923	T20H934	RABBIT				1,381.74		1.38	1.38	
T20H934	T20H959	RABBIT				85.22		0.09	0.09	
T20H959	T20H960	RABBIT				98.42		0.10	0.10	
T20H960	T20H963	RABBIT				343.75		0.34	0.34	
T20H963	T20H966	RABBIT				475.46		0.48	0.48	
T20H966	T20H967	RABBIT				95.45		0.10	0.10	
T20H967	T20H979	RABBIT				656.07		0.66	0.66	
T20H979	T20H981	RABBIT				119.91		0.12	0.12	
T20H981	T20H984	RABBIT				403.66		0.40	0.40	
T20H984	T20H997	RABBIT				1,880.90		1.88	1.88	
T20H997	T20H1011	RABBIT				2,194.22		2.19	2.19	
T20H1011	T20H1051	RABBIT				3,170.99		3.17	3.17	
T20H1051	T20H1056	RABBIT				535.48		0.54	0.54	
T20H1056	T20H1065	RABBIT				1,249.27		1.25	1.25	
T20H1065	T20H1070	RABBIT				642.87		0.64	0.64	
T20H1070	T20H1085	RABBIT				334.46		0.33	0.33	
T20H1085	T20H1118	RABBIT				4,763.20		4.76	4.76	
T20H1118	T20H1144	RABBIT				2,512.17		2.51	2.51	
T20H1144	T20H1158	RABBIT				2,625.64		2.63	2.63	
T20H1158	T20H1186	RABBIT				3,557.15		3.56	3.56	
T20H1186	T20H1202	RABBIT				1,656.69		1.66	1.66	
T20H1202	T20H1213	RABBIT				974.84		0.97	0.97	
T20H016	T20H208	DOG			247.40			0.25	0.25	
T20H040	T20H101	DOG			562.96			0.56	0.56	
T20H101	T20H129	DOG			1,872.11			1.87	1.87	
T20H129	T20H165	DOG			2,426.21			2.43	2.43	
T20H091	T20H092	DOG			229.39			0.23	0.23	
T20H256	T20H284	RABBIT				2,126.86		2.13	2.13	
T20H336	T20H361	DOG			659.37			0.66	0.66	
T20H361	T20H376	RABBIT				1,178.10		1.18	1.18	
T20H376	T20H423	RABBIT				1,244.21		1.24	1.24	
T20H351	T20H352	DOG			39.19			0.04	0.04	
T20H351	T20H392	RABBIT				375.89		0.38	0.38	
T20H392	T20H207	RABBIT				33.00		0.03	0.03	
T20H392	T20H404	RABBIT				2,764.39		2.76	2.76	

Section		CONDUCTOR	Conductor type & Line Length					Length (km)		
From	To		300 UG	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
T20H404	T20H409	RABBIT				241.49		0.24	0.24	
T20H404	T20H407	RABBIT				383.72		0.38	0.38	
T20H407	T20H701	RABBIT				2,878.60		2.88	2.88	
T20H701	T20H702	RABBIT				745.60		0.75	0.75	
T20H463	T20H718	RABBIT				3,388.99		3.39	3.39	
T20H718	T20H735	RABBIT				4,657.48		4.66	4.66	
T20H735	T20H737	RABBIT				228.96		0.23	0.23	
T20H737	T20H740	RABBIT				368.14		0.37	0.37	
T20H740	T20H748	RABBIT				1,021.13		1.02	1.02	
T20H740	T20H793	RABBIT				7,914.45		7.91	7.91	
T20H793	T20H797	RABBIT				475.63		0.48	0.48	
T20H793	T20H799	RABBIT				238.27		0.24	0.24	
T20H799	T20H801	RABBIT				175.30		0.18	0.18	
T20H801	T20H802	RABBIT				199.57		0.20	0.20	
T20H802	T20H803	RABBIT				226.90		0.23	0.23	
T20H802	T20H804	RABBIT				54.37		0.05	0.05	
T20H465	T20H469	RABBIT				384.25		0.38	0.38	
T20H482	T20H485	RABBIT				355.26		0.36	0.36	
T20H508	T20H515	AAAC					634.13	0.63	0.63	
T20H538	T20H540	DOG			115.45			0.12	0.12	
T20H546	T20H562	DOG			1,564.66			1.56	1.56	
T20H562	T20H570	DOG			714.34			0.71	0.71	
T20H570	T20H582	DOG			1,402.88			1.40	1.40	
T20H582	T20H583	DOG			78.40			0.08	0.08	
T20H582	T20H607	DOG			2,673.59			2.67	2.67	
T20H607	T20H608	DOG			202.63			0.20	0.20	
T20H608	T20H616	AAAC					1,062.53	1.06	1.06	
T20H616	T20H618	AAAC					292.55	0.29	0.29	
T20H607	T20H625	DOG			723.80			0.72	0.72	
T20H625	T20H642	DOG			1,817.03			1.82	1.82	
T20H642	T20H686	DOG			5,292.00			5.29	5.29	
T20H809	T20H812	RABBIT				411.14		0.41	0.41	
T20H812	T20H818	RABBIT				547.62		0.55	0.55	
T20H818	T20H822	RABBIT				564.36		0.56	0.56	
T20H822	T20H824	RABBIT				347.71		0.35	0.35	
T20H824	T20H825	RABBIT				42.25		0.04	0.04	
T20H825	T20H828	RABBIT				369.64		0.37	0.37	
T20H825	T20H837	RABBIT				1,183.92		1.18	1.18	
T20H837	T20H848	RABBIT				1,930.07		1.93	1.93	
T20H848	T20H859	RABBIT				1,824.93		1.82	1.82	
T20H859	T20H866	RABBIT				926.22		0.93	0.93	
T20H866	T20H869	RABBIT				455.62		0.46	0.46	
T20H906	T20H920	RABBIT				1,605.69		1.61	1.61	
T20H934	T20H946	RABBIT				2,132.52		2.13	2.13	
T20H946	T20H958	RABBIT				1,603.79		1.60	1.60	
T20H960	T20H961	RABBIT				140.60		0.14	0.14	
T20H967	T20H973	RABBIT				701.82		0.70	0.70	
T20H979	T20H980	RABBIT				279.39		0.28	0.28	
T20H981	T20H982	RABBIT				119.91		0.12	0.12	
T20H1011	T20H1012	RABBIT				61.92		0.06	0.06	
T20H1012	T20H1029	RABBIT				2,597.54		2.60	2.60	
T20H1070	T20H1081	RABBIT				1,567.14		1.57	1.57	
T20H1118	T20H1120	RABBIT				246.70		0.25	0.25	
T20H1120	T20H1122	RABBIT				254.62		0.25	0.25	
T20H1122	T20H1125	RABBIT				426.26		0.43	0.43	
T20H1125	T20H1129	RABBIT				205.13		0.21	0.21	
T20H1125	T20H1127	RABBIT				287.20		0.29	0.29	
T20H1144	T20H1147	RABBIT				260.50		0.26	0.26	
			-	-	56,077.23	87,033.68	1,989.22	145.10	145.10	
11kV Tama feeder										
Substation	T30H16	DOG			897.52			0.90	0.90	
T30H16	T30H25	DOG			363.48			0.36	0.36	
T30H25	T30H66	DOG			2,806.67			2.81	2.81	
T30H66	T30H145	RABBIT				1,114.30		1.11	1.11	
T30H16	T30H22	DOG			393.23			0.39	0.39	
T30H25	T30H83	RABBIT				1,267.01		1.27	1.27	
T30H83	T30H107	RABBIT				1,655.38		1.66	1.66	
T30H107	T30H131	RABBIT				1,842.54		1.84	1.84	
			-	-	4,460.91	5,879.23	-	10.34	10.34	
33kV Dakpai feeder										
Substation	T40H000	WOLF		41.44				0.04	0.04	
T40H000	T40H038	DOG			2,562.23			2.56	2.56	
T40H038	T40H124	DOG			4,776.26			4.78	4.78	
T40H124	T40H150	DOG			2,267.90			2.27	2.27	
T40H150	T40H204	DOG			3,748.55			3.75	3.75	
T40H204	T40H698	DOG			14.57			0.01	0.01	
T40H698	T40H244	DOG			2,949.52			2.95	2.95	
T40H244	T40H290	DOG			3,801.85			3.80	3.80	

Section		CONDUCTOR	Conductor type & Line Length					Length (km)		
From	To		300 UG	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
T40H290	T40H291	DOG			118.95			0.12	0.12	
T40H291	T40H306	DOG			1,034.84			1.03	1.03	
T40H306	T40H311	DOG			362.64			0.36	0.36	
T40H311	T40H316	DOG			348.48			0.35	0.35	
T40H316	T40H1020	DOG			11,782.16			11.78	11.78	
T40H1020	T40H430	DOG			1,450.99			1.45	1.45	
T40H430	T40H431	DOG			65.57			0.07	0.07	
T40H431	T40H715	DOG			1,279.40			1.28	1.28	
T40H715	T40H743	DOG			1,279.40			1.28	1.28	
T40H743	T40H848	DOG			1,087.70			1.09	1.09	
T40H848	T40H858	DOG			1,194.81			1.19	1.19	
T40H858	T40H861	DOG			319.03			0.32	0.32	
T40H861	T40H870	DOG			281.33			0.28	0.28	
T40H870	T40H871	DOG			191.32			0.19	0.19	
T40H871	T40H881	DOG			1,466.44			1.47	1.47	
T40H881	T40H895	DOG			1,637.20			1.64	1.64	
T40H895	T40H922	DOG			3,503.19			3.50	3.50	
T40H922	T40H949	DOG			1,204.80			1.20	1.20	
T40H949	T40H963	DOG			145.58			0.15	0.15	
T40H963	T40H967	DOG			699.97			0.70	0.70	
T40H967	T40H968	DOG			304.49			0.30	0.30	
T40H968	T40H972	DOG			774.21			0.77	0.77	
T40H972	T40H973	DOG			154.97			0.15	0.15	
T40H973	T40H974	DOG			51.57			0.05	0.05	
T40H974	T40H985	DOG			942.45			0.94	0.94	
T40H124	T40H127	DOG			2,267.90			2.27	2.27	
T40H698	T40H618	RABBIT				2,919.43		2.92	2.92	
T40H618	T40H619	RABBIT				109.58		0.11	0.11	
T40H618	T40H627	RABBIT				852.62		0.85	0.85	
T40H627	T40H634	RABBIT				975.45		0.98	0.98	
T40H627	T40H644	RABBIT				1,015.84		1.02	1.02	
T40H244	T40H647	DOG			204.64			0.20	0.20	
T40H647	T40H1025	DOG			2,049.59			2.05	2.05	
T40H1025	T40H666	DOG			87.64			0.09	0.09	
T40H666	T40H678	RABBIT				1,262.48		1.26	1.26	
T40H666	T40H680	DOG			415.52			0.42	0.42	
T40H680	T40H697	RABBIT				2,446.31		2.45	2.45	
T40H680	T40H708	DOG			1,326.20			1.33	1.33	
T40H708	T20H165	DOG			2,395.00			2.40	2.40	
T40H290	T40H546	DOG			7,723.40			7.72	7.72	
T40H546	T40H549	DOG			320.84			0.32	0.32	
T40H549	T40H582	RABBIT				686.37		0.69	0.69	
T40H549	T40H558	DOG			1,116.94			1.12	1.12	
T40H558	T40H584	DOG			956.60			0.96	0.96	
T40H584	T40H571	DOG			984.94			0.98	0.98	
T40H584	T40H574	DOG			337.58			0.34	0.34	
T40H574	T40H575	DOG			54.73			0.05	0.05	
T40H574	T40H577	DOG			320.18			0.32	0.32	
T40H306	T40H319	DOG			362.64			0.36	0.36	
T40H430	T40H447	RABBIT				1,814.96		1.81	1.81	
T40H447	T40H451	RABBIT				159.65		0.16	0.16	
T40H451	T40H453	RABBIT				58.68		0.06	0.06	
T40H453	T40H469	RABBIT				1,466.41		1.47	1.47	
T40H715	T40H732	DOG			2,831.36			2.83	2.83	
T40H743	T40H754	DOG			1,635.92			1.64	1.64	
T40H754	T40H768	RABBIT				1,853.97		1.85	1.85	
T40H754	T40H772	DOG			483.34			0.48	0.48	
T40H772	T40H776	DOG			399.20			0.40	0.40	
T40H776	T40H778	DOG			240.69			0.24	0.24	
T40H778	T40H780	DOG			187.92			0.19	0.19	
T40H776	T40H786	DOG			559.28			0.56	0.56	
T40H786	T40H799	RABBIT				27.75		0.03	0.03	
T40H799	T40H802	RABBIT				542.27		0.54	0.54	
T40H802	T40H817	RABBIT				2,868.57		2.87	2.87	
T40H817	T40H831	RABBIT				3,440.52		3.44	3.44	
T40H831	T40H836	RABBIT				1,229.38		1.23	1.23	
T40H786	T40H788	DOG			357.17			0.36	0.36	
T40H788	T40H790	DOG			277.83			0.28	0.28	
T40H790	T40H792	DOG			137.59			0.14	0.14	
T40H790	T40H793	DOG			240.90			0.24	0.24	
T40H793	T40H794	RABBIT				60.95		0.06	0.06	
T40H793	T40H796	RABBIT				704.10		0.70	0.70	
T40H861	T40H868	DOG			1,009.10			1.01	1.01	
T40H922	T40H931	DOG			992.14			0.99	0.99	
T40H931	T40H932	RABBIT				334.21		0.33	0.33	
T40H931	T40H936	DOG			372.73			0.37	0.37	
T40H931	T40H937	DOG			197.31			0.20	0.20	
T40H937	T40H938	RABBIT				225.69		0.23	0.23	

Section		CONDUCTOR	Conductor type & Line Length					Length (km)		
From	To		300 UG	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
T40H938	T40H940	RABBIT				318.71		0.32	0.32	
T40H949	T40H951	RABBIT				436.25		0.44	0.44	
T40H951	T40H961	RABBIT				1,423.87		1.42	1.42	
T40H973	T40H1012	RABBIT				2,576.69		2.58	2.58	
T40H1012	T40H1014	RABBIT				306.14		0.31	0.31	
T40H1012	T40H1016	RABBIT				434.11		0.43	0.43	
T40H973	T40H987	DOG			511.92			0.51	0.51	
T40H987	T40H991	RABBIT				885.95		0.89	0.89	
T40H991	T40H997	RABBIT				1,377.86		1.38	1.38	
T40H974	T40H978	DOG			280.34			0.28	0.28	
			-	41.44	83,441.45	32,814.74	-	116.30	116.30	
6.6kV Yebilaptsa feeder										
TMH01	T50H001		0.00					0.00	0.00	
T50H001	T50H097							0.59	0.59	
T50H097	T50H044							2.33	2.33	
T50H044	T50H051							0.44	0.44	
T50H051	T50H059							0.39	0.39	
T50H059	T50H060							0.07	0.07	
T50H060	T50H063							0.20	0.20	
T50H063	T50H268							0.01	0.01	
T50H268	T50H064							0.02	0.02	
T50H064	T50H073							0.45	0.45	
T50H073	T50H089							0.89	0.89	
T50H089	T50H095							0.37	0.37	
T50H097	T50H229							7.70	7.70	
T50H229	T50H238							0.57	0.57	
T50H238	T50H240							0.15	0.15	
T50H238	T50H260							1.32	1.32	
T50H260	T50H267							0.40	0.40	
T50H044	T50H212							0.02	0.02	
			0.00	-	-	-	-	15.94	15.94	
33kV Panbang feeder										
T70H001	T70H004	DOG			0.62			0.62	0.62	
T70H004	T70H029	DOG			3.34			3.34	3.34	
T70H029	T70H042	DOG			1.25			1.25	1.25	
T70H042	T70H052	DOG			1.05			1.05	1.05	
T70H052	T70H066	DOG			0.72			0.72	0.72	
T70H066	T70H082	DOG			0.72			0.72	0.72	
T70H082	T70H87	DOG			0.38			0.38	0.38	
T70H87	T70H093	DOG			0.77			0.77	0.77	
T70H093	T70H105	DOG			1.61			1.61	1.61	
T70H105	T70H122	DOG			2.12			2.12	2.12	
T70H122	T70H125	DOG			0.18			0.18	0.18	
T70H125	T70H150	DOG			2.63			2.63	2.63	
T70H150	T70H158	DOG			0.73			0.73	0.73	
T70H004	T70H006	DOG			0.18			0.18	0.18	
T70H029	T70H031	RABBIT				0.05		0.05	0.05	
T70H052	T70H059	DOG			0.53			0.53	0.53	
T70H052	T70H055	DOG			0.19			0.19	0.19	
T70H066	T70H076	RABBIT				1.04		1.04	1.04	
T70H082	T70H084	DOG			0.09			0.09	0.09	
T70H076	T70H248	DOG			0.02			0.02	0.02	
T70H087	T70H213	AAAC					7.19	7.19	7.19	
T70H213	T70H216	RABBIT				0.41		0.41	0.41	
T70H216	T70H225	AAAC					1.33	1.33	1.33	
T70H225	T70H012	XLPE						-	-	
T70H125	T70H129	DOG			0.50			0.50	0.50	
T70H150	T70H236	RABBIT				0.61		0.61	0.61	
T70H236	T70H247	RABBIT				1.92		1.92	1.92	
			0	0	17.64	4.04	8.52	30.20	30.20	

Annexure-2: IS 2026, IEC 60076 (Technical parameters for Distribution Lines and Transformers)

Sl. No.	Parameter	Requirement
1	Applicable standard	IS 2026, IEC 60076
2	Type	Oil filled[1] / two winding
3	Winding material	Copper
4	Core Material	CRGO silicon steel/Amorphous Metal
5	Cooling	Oil natural air natural (ONAN)
6	Terminations	
	· Primary	Outdoor Bushing or cable box[2]
	· Secondary	Outdoor Bushing or Cable box
7	Rated no load voltage	
	· Primary	33 kV or 11 kV
	· Secondary	415/240 V
8	% Impedance	
	10 kVA-24 kVA (1phase/3phase)	3%
	25 kVA-630 kVA	4%
	631 kVA-1250 kVA	5%
9	Vector group	Dyn11
10	Tap changer	
	· Type	Off load
	· Range	+5% to -5%
	· Step value	2.50%
11	Insulation Class (IEC-76)	A
12	Permissible Temperature rise	
	· Maximum winding temperature	55ºC
	· Max. Top oil temperature	50°C
13	Insulation levels	
	· Primary	170 kVp-70 kV/75 kVp-28 kV
	· Secondary	7500 Vp-3000 V

Annexure-3: The details on the load forecast methodology.

1. Load Forecast

1.1 Type of Load Forecast and Power System Planning

One of the power system planning element is the load forecast. Although, there are no documented standards specifying the type of planning however, the power system planning can be short-term planning (STP) (less than one year), medium-term planning (MTP) (1-3 years) and long-term planning (LTP) (3-10 years and even higher). It is necessary to predict the power requirement for a specified time-horizon which is referred to as load (power) forecasting based on the historical consumption pattern for better planning and optimizing the available resources. Analogy to power system planning, the load forecast can be also short-term load forecasting (STLF), medium-term load forecasting (MTLF) and long-term load forecasting (LTLF) and accordingly the distribution network expansion programs are proposed[1] for distributing the electricity.

There are number of driving factors which are listed below affecting the forecasted load.

a) Time
   - Hours of the day (day or night)
   - Day of the week (weekdays or weekend)
   - Time of the year (winter or summer season)
b) Weather conditions (temperature and humidity)
c) Type of customers (residential, commercial, industries etc.)
d) Population
e) Economic indicators (per capita income, Gross Domestic Product (GDP) etc.)
f) Prices of the electricity

As the DSMP is being developed for 10-year period, the load forecast has to be done for same time horizon. Therefore, some of the driving factors as listed above which affects the LTLF may not impact the accuracy as daily, weekly and monthly time factors and weather conditions will have minimum contribution to the load variance.

1.2 Methods of Load (LTLF) Forecast

The LTLF methods are generally the trend analysis or time series analysis, economic modelling, end-use analysis and hybrid analysis. As the DSMP is for 10-year period, the methods of LTFL is being outlined for forecasting the load[1].

1.2.1 Trend Analysis

In the trend analysis, the historical data (power) is used to forecast the load. The details on load forecast adopting power consumption trend is reflected in **Section 1.3.** Typical load forecast is as shown in **Figure 1.**

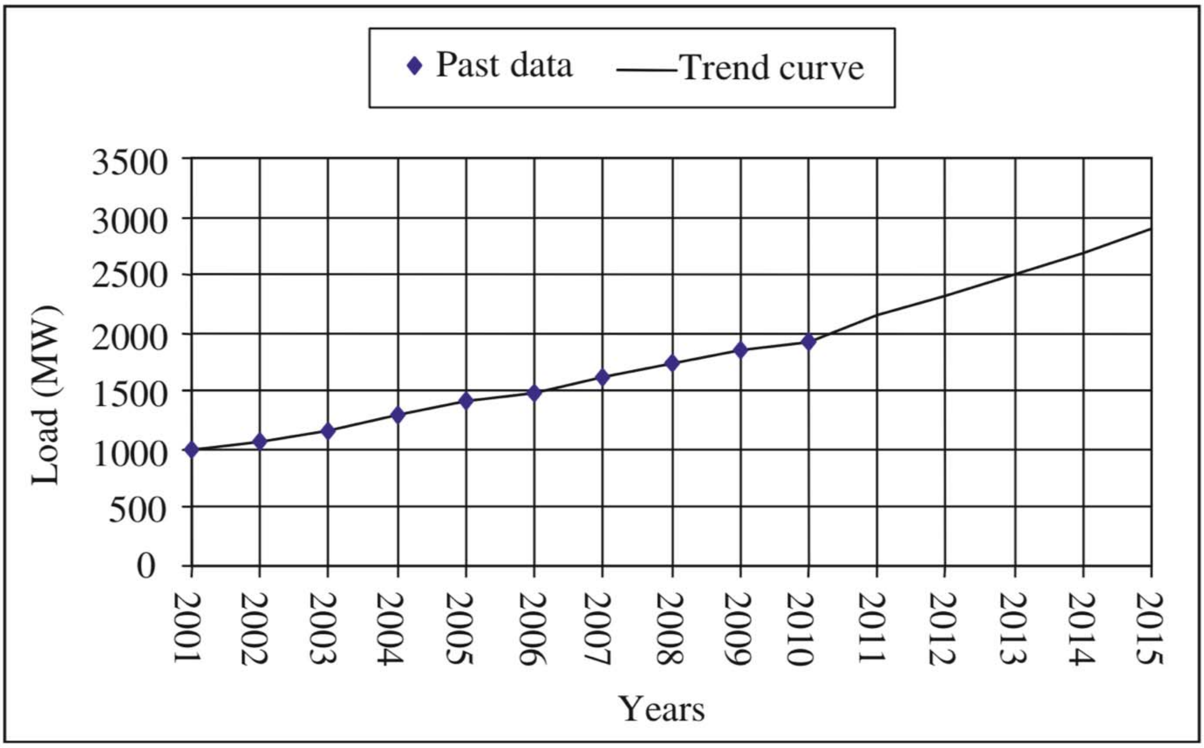


Figure 1: Typical trend curve[1]

1.2.2 Economic Modelling

In this method, the relationship between the load and the driving parameters are established and accordingly the future values of the driving factors are projected. Although, this approach is widely being used, as most of the data for driving factors are not available and for simplicity the trend analysis is adopted to forecast the load.

1.2.3 End-use Analysis

This approach is exclusively used for residential loads which is forecasted in terms of energy and therefore, it requires some methods to convert the predicted energy consumption to load (power demand). There is uncertainty in the accuracy of the predicted load and is also confined to residential customers. Therefore, end-use analysis approach is not adopted to predict the load.

1.2.4 Hybrid Analysis

Although, the end-use and econometric methods may be simultaneously used to forecast the load, it is not widely used as it has advantages and disadvantages of both the approaches.

1.3 Trend Line Analysis

The LTLF is carried out using the trend analysis approach and accordingly for planning the distribution system network. In order to forecast the load, the peak power demand prior to 2020 was considered and the power requirement trend is obtained. Load requirement is then predicted for next ten-year period (2020-2030) by extrapolating the trend line considering the load of 2019 as a base data. The case study of Punakha Dzongkhag is chosen to get insight of actual load forecast.

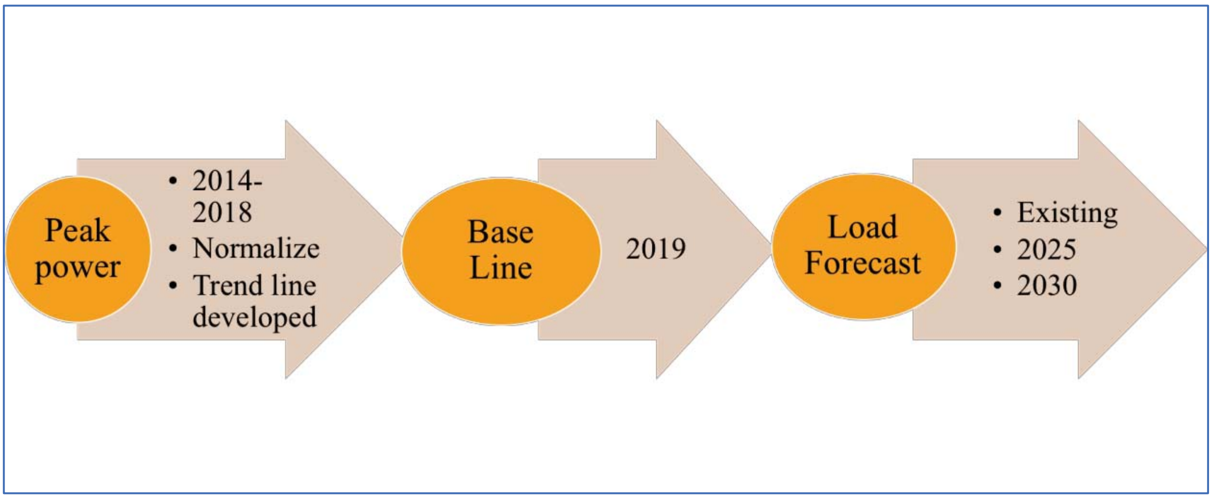


Figure 2: Flow diagram for load forecast

1.3.1 Normalizing the Data

Some of the distribution network do have ring feeders and multiple sources for better reliability and contingency. This in turn has resulted in abnormality in the power consumption data (recordings). Further, in the absence of meters or malfunctioning of the reading equipment or recorded data, some of the feeders have unreliable data for some of the years. Therefore, data is normalized by omitting the outliers or by taking the average of the past data (or average of preceding and future load if a year's data is missing). Such exercise is carried out for all the feeders and substation loads.

Table 1: Actual power data of Punakha Dzongkhag

Sl.No.	Name of Feeder	Consumption Pattern (MW)						
		2013	2014	2015	2016	2017	2018	2019
1	Feeder A	1.85	2.01	0.90	0.22	2.45	2.64	2.63
2	Feeder B	0.48	0.51	4.86	0.50	0.49	0.74	0.72
3	Feeder C	1.35	1.60	1.60	1.80	2.10	1.76	2.40
4	Feeder D	0.96	1.02	1.47	1.48	1.80	2.24	1.89
	Total	**4.64**	**5.14**	**8.83**	**4.00**	**6.84**	**7.37**	**7.64**

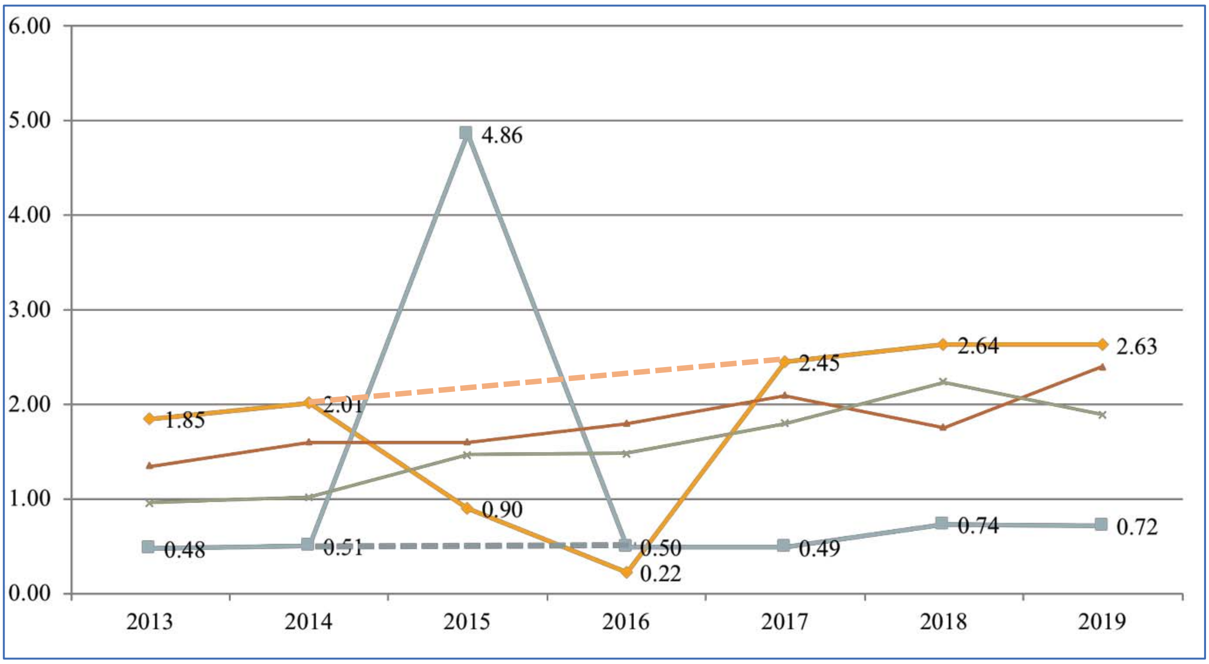


Figure 3: Actual data of Punakha Dzongkhag

$$x = \left(\frac{x_1 + x_2}{2}\right)$$

$Where:$
$x \text{ is the normalized data}$

$x_1 and\ x_2\ are\ the\ data\ for\ two\ years$

Table 2: Normalized power data of Punakha Dzongkhag

Sl.No.	Name of Feeder	Consumption Pattern (MW)						
		2013	2014	2015	2016	2017	2018	2019
1	Feeder A	1.85	2.01	1.93	1.97	2.45	2.64	2.63
2	Feeder B	0.48	0.51	0.49	0.50	0.49	0.74	0.72
3	Feeder C	1.35	1.60	1.60	1.80	2.10	1.76	2.40
4	Feeder D	0.96	1.02	1.47	1.48	1.80	2.24	1.89
	Total	**4.64**	**5.14**	**8.83**	**4.00**	**6.84**	**7.37**	**7.64**

1.3.2 Trend Line and Load Forecast

Based on the power data, the trend line is added to portray the power consumption pattern which gets generated as per the linear regression equation[1]. The trend line added is then extrapolated to forecast the load for next ten years which is as shown in **Figure 4.**

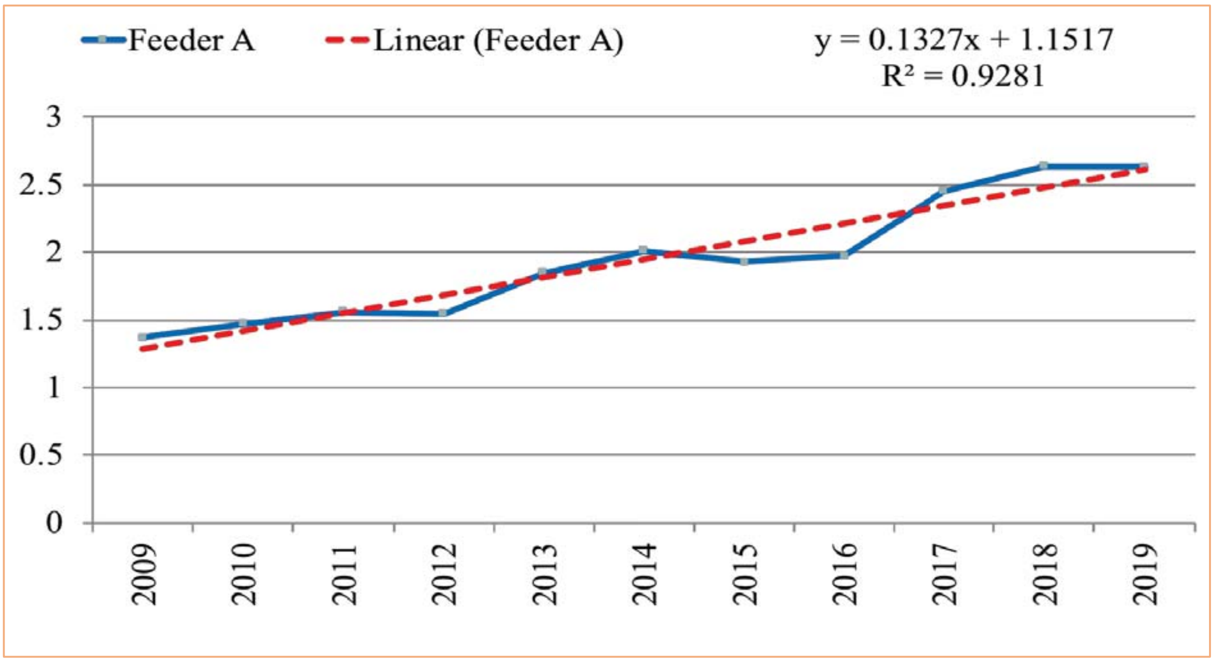


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$$y = ax + b$$

$Where:$

$y -$ $Dependent\ variable\ or\ forecasted\ load$

$a - Slope\ which\ is\ the\ average\ change\ in\ y\ for\ every\ increment\ of\ x\ (increase\ in\ year)$

$It\ also\ gives\ how\ dependent\ variable\ changes\ when\ indepemended\ variable\ increases.$

$x - is\ the\ independent\ variable\ or\ time\ in\ year$

$b - is\ the\ intercept\ which\ is\ the\ predicted\ value\ of\ y\ when\ x\ is\ zero\ (time\ is\ zero)$

The Pearson correlation coefficient *'r',* which can take values between -1 & 1 corresponds to the linear relationship between variables x & y. If the r value is either -1 or 1, dependent variable can be perfectly explained by a linear function of the other.

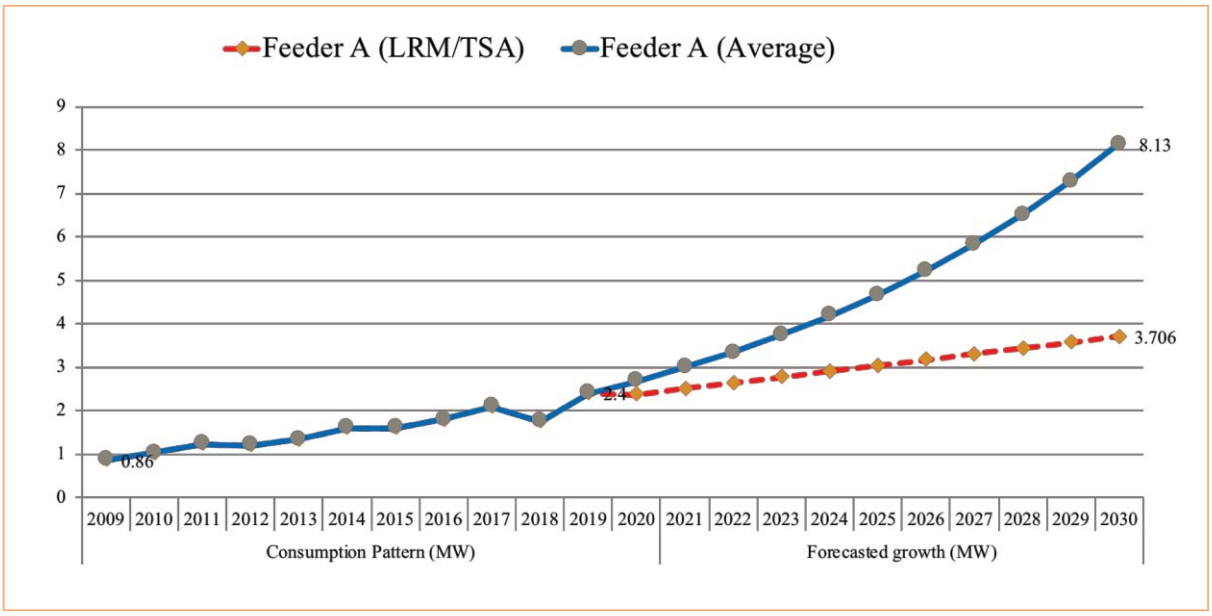


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

2. Electrical Transient Analyser Program (ETAP) –Modelling and Load Flow Analysis

2.1 ETAP Software

"**ETAP** is an analytical engineering solution tool specializing in the simulation, design, monitoring, control, operator training, optimizing, and automating power systems[3]. ETAP's integrated digital platform offers the best comprehensive suite of enterprise solutions."

ETAP software is used in DSMP for modelling/designing, network simulation and to carry out the technical evaluation for distribution power system. The modelled network is fed with the essential data (such as specifications, constraints and parameters for network components) and the simulation results are assessed and analysed. Conclusively, different measures are considered and performed in ETAP for improving the efficiency of a system.

2.2 Load Flow Analysis (ETAP)

Load Flow Analysis (LFA) is a major tool to study and analyse the operation of a power system and determines voltage drops and power flow throughout the electrical system. Using network parameters (Input) for power sources, lines, transformers and connected loads, LFA provides voltages magnitude, real/reactive power, currents, and power losses as a result from the load flow simulation. The study also allows for swing, voltage regulated, and unregulated power sources with multiple power grids and generator connections and the analysis can be performed on both radial and loop systems.

Numerical analysis method such as Adaptive Newton-Raphson, Newton-Raphson, Fast Decoupled, & Accelerated Gauss Seidel methods are accessible in ETAP and can be used for solving the load flow analysis problems.

In this analysis, Adaptive Newton-Raphson method is used for load flow study of distribution networks and the study is carried out under 3-time horizon: present (2019), 2025 and 2030 (forecast load). The results (total generation, loading, system losses, and critical report of load flow) obtained under the scenarios are analysed and corresponding corrective measures are proposed.

2.2.1 Creating the Library

Although, the electrical parameters and specifications are inbuilt, to suit the requirements of the study, the missing electrical parameters are customized by creating a library. The units are set to metric system and accordingly the network is modelled and the relative data for network components such as transformers, line types, power sources and load details are fed in which are detailed as follows:

a) Transmission Cable

- Library-Transmission Line-Phase Conductor-Add-Transmission line library
- In transmission line library: change unit system into Metric, conductor type into ACSR and frequency into 50HZ, and Source name as BPC.
- Click BPC and click edit properties.
- In edit properties add the required conductor parameter by referring the Excel sheet (technical parameters.)
- For AAAC use the source name "Pirelli" and select the required size.

b) UG cable (Since 33kV Al UG Cable is not available):

- Library- Cable- Add-change the source name to BPC and make the necessary changes especially type of conductor to Aluminium and installation into non-magnetic.
- Change insulation type to XLPE.
- Select BPC from the Cable library table and click edit properties
- In edit properties add the required UG cable parameters referring the Excel sheet as shown in Pictures below.

c) Set Loading and Generation Categories.

- Go to Project- Settings- Loading and generation categories
- In Generation Category, set 3 categories as Maximum, Normal and Minimum.
- In AC Load, set 3 categories as 2019, 2025 and 2030.
- Keep the DC Load Empty.

2.2.2 Network Modelling and Load Flow Analysis

a) Draw Distribution Network (SLD).

b) Enter the height=8 and spacing =1.25 in the Transmission line table.

c) Enter the electrical parameters (kW, kVA, kV, etc.) ratings for power sources, transformers, line type, bus kV and loading details.

d) Under the Lump Load, in "Nameplate" edit and enter DT % loading and forecasted % loading details for 2019,2025,2030. Set the load type (80% as constant impedance and 20% as constant KVA) as most of the loads are impedance load.
e) Make sure to run the load flow for each composite network before you continue with other network. This is to avoid numerous errors at the end.
f) After completing the SLD, study case for different load scenarios needs to be created.
g) Switch to "Load Flow Analysis" mode in Mode Toolbar. Go to "Study Case," select present Case 1 as 2019 and select "Prompt" in "Output Report"
h) Edit the "Load Flow Study Case [Brief Case Symbol]." Go to "Loading" and set to "2019" under Loading Category and set "Normal" under Generation Category. Check the Margins set under Alerts and set "Marginal (±5% for Over and Under Voltage Category)" and set "Critical (±10% for Over and Under Voltage Category)"
i) Close "Load Flow Study Case" and run "Run Load Flow" and save the result as 2019.
j) Similarly, follow step b), c) and d) for 2025 and 2030.
k) To generate the report (SLD drawings) in PDF, go to print preview- set up- change the printer name "Microsoft print to PDF".

2.3 Consideration/Assumptions made while simulating in ETAP software

a) All Network is considered as balanced system as there is limitation of unbalanced system in ETAP Key.
b) The voltage level of ±10% is assigned as critical value which is indicated by red colour while simulating and voltage level of ±5% is given as marginal value which is indicated by pink colour while simulating.
c) The typical value of X/R ratio from ETAP inbuilt system is taken for all the power transformers for the simulation.
d) Some of the types of transmission cables /underground cables used in BPC are not available in ETAP library therefore, a new source is created in ETAP library by inserting all the parameters of those unavailable cables/transmission lines.
e) There are three cases created in ETAP simulation depending on the load forecast namely the 2019, 2025 and 2030 where the forecasted loads are given respectively and simulated/analysed accordingly.

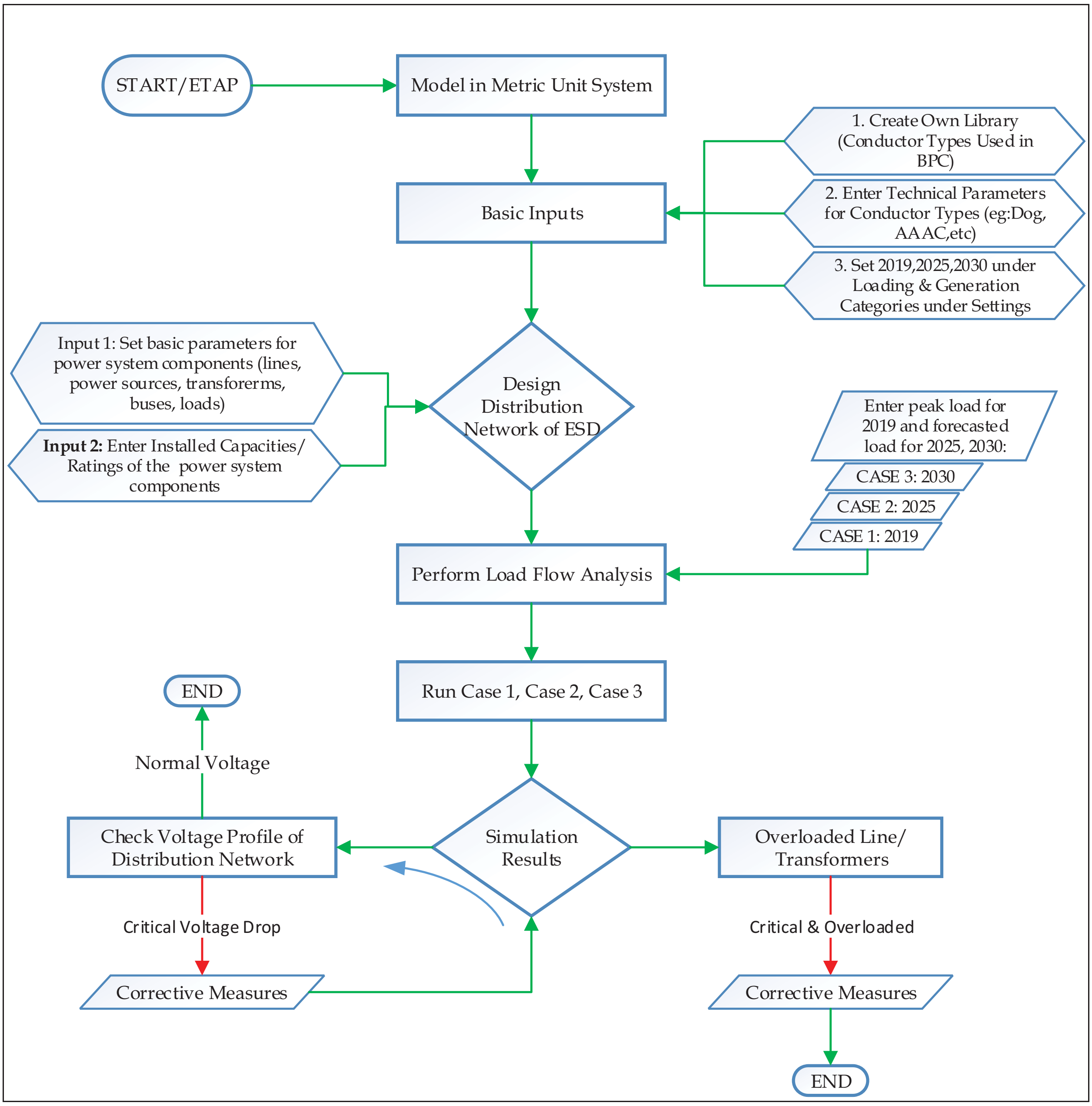


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

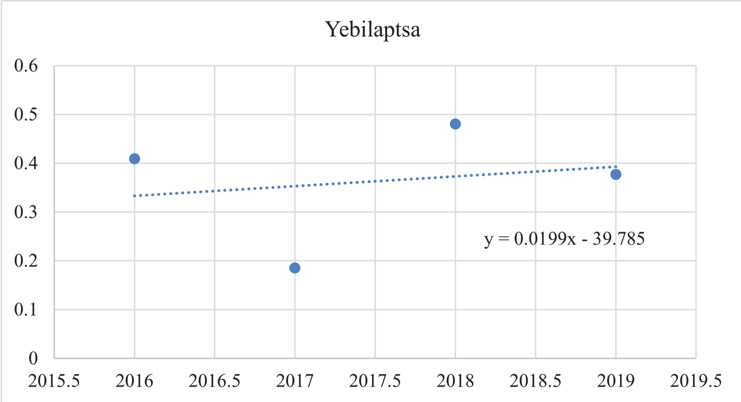
[1]Electric Power System Planning Issues, Algorithms and Solutions by Hossein Seifi Mohammad Sadegh Sepasian

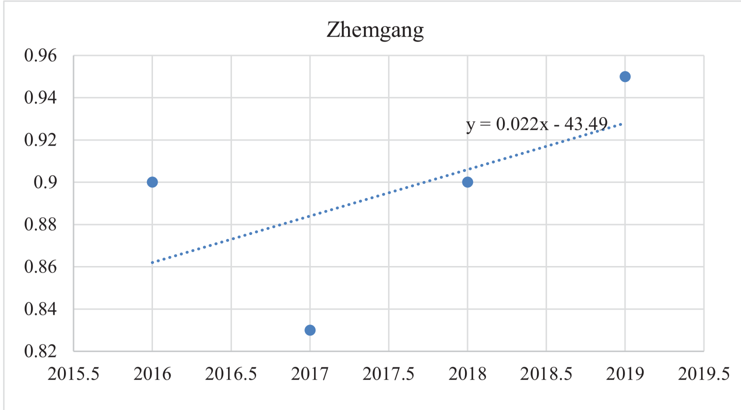
[2]http://sites.utexas.edu/sos/guided/inferential/numeric/bivariate/cor/: dated September 29, 2020

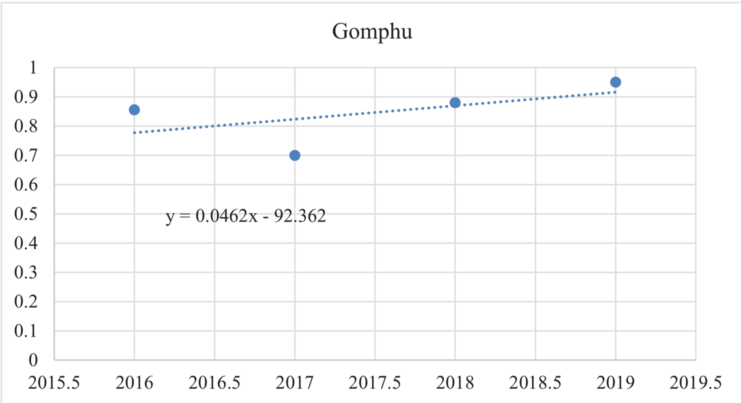
[3]http://www.powerqualityworld.com/2011/05/etap-tutorials-load-flow-analysis.html dated September 30, 2020

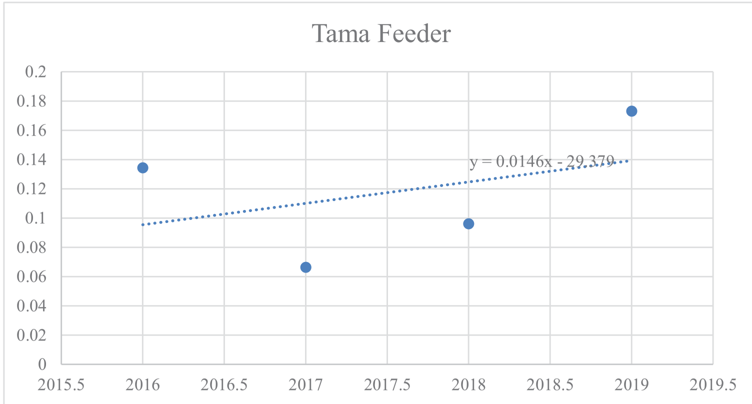
33kV Gomphu feeder		33kv Dakpai feeder		33kV Zhemgang feeder		11kV Tama feeder		6.6kV Yebilaptsha feeder	
Year	Load	Year	Load	Year	Load	Year	Load	Year	Load
2016	0.856	2016	0.9	2016	0.9	2016	0.1342	2016	0.409
2017	0.7	2017	0.815	2017	0.83	2017	0.0662	2017	0.1854
2018	0.88	2018	0.933	2018	0.07	2018	0.096	2018	0.4804
2019	0.6894	2019	1.003	2019	0.828	2019	0.173	2019	0.377

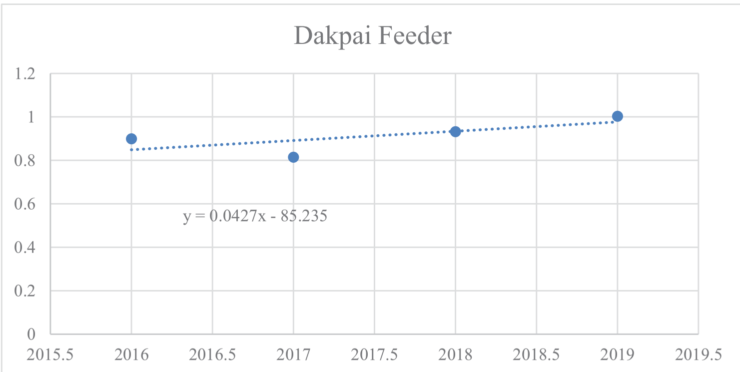
33kV Gomphu feeder		33kv Dakpai feeder		33kV Zhemgang feeder		11kV Tama feeder		6.6kV Yebilaptsha feeder	
Year	Load	Year	Load	Year	Load	Year	Load	Year	Load
2016	0.856	2016	0.9	2016	0.9	2016	0.1342	2016	0.409
2017	0.7	2017	0.815	2017	0.83	2017	0.0662	2017	0.1854
2018	0.88	2018	0.933	2018	0.9	2018	0.096	2018	0.4804
2019	0.95	2019	1.003	2019	0.95	2019	0.173	2019	0.377
0.0462x - 92.362		0.0427x - 85.235		0.2492x - 502.1		0.0146x - 29.379		0.0199x - 39.785	
2020	**0.962**	2020	**1.019**	2020	**0.95**	2020	**0.113**	2020	**0.413**
2021	**1.0082**	2021	**1.0617**	2021	**0.972**	2021	**0.1276**	2021	**0.4329**
2022	**1.0544**	2022	**1.1044**	2022	**0.994**	2022	**0.1422**	2022	**0.4528**
2023	**1.1006**	2023	**1.1471**	2023	**1.016**	2023	**0.1568**	2023	**0.4727**
2024	**1.1468**	2024	**1.1898**	2024	**1.038**	2024	**0.1714**	2024	**0.4926**
2025	**1.193**	2025	**1.2325**	2025	**1.06**	2025	**0.186**	2025	**0.5125**
2026	**1.2392**	2026	**1.2752**	2026	**1.082**	2026	**0.2006**	2026	**0.5324**
2027	**1.2854**	2027	**1.3179**	2027	**1.104**	2027	**0.2152**	2027	**0.5523**
2028	**1.3316**	2028	**1.3606**	2028	**1.126**	2028	**0.2298**	2028	**0.5722**
2029	**1.3778**	2029	**1.4033**	2029	**1.148**	2029	**0.2444**	2029	**0.5921**
2030	**1.424**	2030	**1.446**	2030	**1.17**	2030	**0.259**	2030	**0.612**

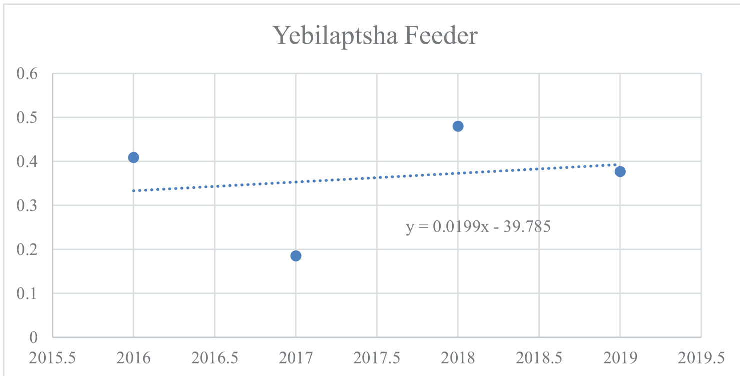

Yebilaptsa
y = 0.0199x - 39.785


Zhemgang
y = 0.022x - 43.49


Gomphu
y = 0.0462x - 92.362


Tama Feeder
y = 0.0146x - 29.379


Dakpai Feeder
y = 0.0427x - 85.235


Yebilaptsha Feeder
y = 0.0199x - 39.785

Annexure-4: Detailed Simulation Results

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
A.ZHSS B1	6.600										0.053	84.6	5.0	
A.ZHSS B2	0.415		0.010	0.006	0.034	0.021					0.052	85.0	79.3	
B.ZHSS B1	6.600										0.068	84.4	6.4	
B.ZHSS B2	0.415		0.013	0.008	0.044	0.027					0.067	85.0	102.2	
Babshar B1	33.000										0.314	92.4	5.7	
Babshar B2	0.415		0.014	0.008	0.003	0.002					0.019	85.0	29.1	
BAFRA.O B1	6.600										0.226	84.4	21.3	
BAFRA.O B2	0.415		0.015	0.009	0.049	0.031					0.076	85.0	116.6	
Bardang B1	33.000										0.019	84.3	0.3	
Bardang B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	27.1	
BdoSch B1	33.000										0.304	89.5	5.5	
BdoSch B2	0.415		0.004	0.002	0.013	0.008					0.019	85.0	28.7	
BDYT.H B1	6.600										0.324	84.3	30.5	
BDYT.H B2	0.415		0.019	0.012	0.062	0.038					0.095	85.0	147.3	
Berti B1	11.000										0.114	83.3	6.2	
Berti B2	0.415		0.021	0.013	0.069	0.042					0.106	85.0	164.6	
BHU B1	6.600										0.558	84.2	52.0	
BHU B2	0.415		0.021	0.013	0.068	0.042					0.105	85.0	160.9	
Bhudshe B1	33.000		0.002	0.001	0.000	-					0.046	98.3	0.8	
Bjoka B1	33.000		0.024	0.015	0.005	0.003					0.034	85.0	0.6	
Bjoka B2	0.415													
Blangbi B1	33.000		0.000	0.000	0.002	0.001					0.342	89.8	6.2	
Bpong B1	11.000										0.005	84.8	0.3	
Bpong B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.5	
BTL B	6.600										0.020	84.3	1.9	
BTL B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.4	
BuliA B	33.000										0.648	91.8	11.7	
BuliA B2	0.415		0.013	0.008	0.043	0.027					0.065	85.0	98.1	
BuliB B	33.000										0.582	92.4	10.5	
BuliB B2	0.415		0.009	0.006	0.031	0.019					0.047	85.0	70.0	
BuliC B1	33.000										0.113	84.1	2.0	
BuliC B2	0.415		0.021	0.013	0.072	0.044					0.109	85.0	162.0	
BuliCS B1	33.000										0.035	84.9	0.6	
BuliCS B2	0.415		0.006	0.004	0.024	0.015					0.035	85.0	51.0	
Chamtg B1	33.000		0.002	0.002	0.009	0.006					0.014	85.0	0.2	
Chelaibi B1	33.000										0.019	84.3	0.3	
Chelaibi B2	0.415		0.013	0.008	0.003	0.002					0.019	85.0	27.6	
CPam B1	33.000		0.001	0.001	0.006	0.003					0.008	85.0	0.2	
Crong B	33.000										0.026	85.3	0.5	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Crong B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.1	
D.Pokto B1	6.600										0.762	84.1	70.6	
D.Tsachu B1	33.000		0.010	0.006	0.002	0.001					0.107	91.0	1.9	
Dgbi B1	33.000										0.006	84.9	0.1	
Dgbi B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.6	
Dmang V1 B1	33.000										0.065	84.0	1.2	
Dmang V1 B2	0.415		0.025	0.015	0.005	0.003					0.035	85.0	54.3	
Dmang V2 B1	33.000										0.027	84.0	0.5	
Dmang V2 B2	0.415		0.018	0.011	0.004	0.002					0.026	85.0	39.4	
DpaiT B	33.000										1.022	93.2	18.4	
DpaiT B2	0.415		0.001	0.001	0.006	0.003					0.008	85.0	12.0	
DpaiV B1	33.000										0.008	84.9	0.2	
DpaiV B2	0.415		0.001	0.001	0.006	0.003					0.008	85.0	12.0	
DPokto B2	0.415		0.018	0.011	0.057	0.035					0.088	85.0	137.9	
DVH B1	6.600										0.107	84.1	9.9	
DVH B2	0.415		0.020	0.013	0.067	0.042					0.103	85.0	157.9	
Dzo B1	33.000										0.104	84.8	1.9	
Dzo B2	0.415		0.019	0.012	0.069	0.043					0.103	85.0	149.5	
Forest.O B1	6.600										0.073	84.3	6.9	
Forest.O B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	18.6	
Glng PWD B1	33.000										0.172	87.3	3.1	
Glng PWD B2	0.415		0.029	0.018	0.006	0.004					0.041	85.0	60.6	
Glng Tfr B2	0.415		0.048	0.029	0.010	0.006					0.068	85.0	101.6	
Glng V B1	33.000										0.071	83.9	1.3	
Glng Wdra B1	33.000										0.132	86.4	2.4	
Glng Wdra B2	0.415		0.043	0.027	0.009	0.006					0.062	85.0	92.2	
GomC B1	33.000										0.022	84.2	0.4	
GomC B2	0.415		0.004	0.003	0.014	0.009					0.022	85.0	32.2	
Goshing Trong B1	33.000		0.004	0.003	0.001	0.001					0.262	92.5	4.8	
Gphu Zero B1	33.000										0.019	84.7	0.3	
Gphu Zero B2	0.415		0.013	0.008	0.003	0.002					0.019	85.0	27.0	
ICT B	6.600										0.764	84.1	70.6	
ICT B1	6.600										0.336	78.8	31.2	
Jakhring B1	33.000										0.059	85.8	1.1	
Jakhring B2	0.415		0.010	0.006	0.002	0.001					0.015	85.0	21.7	
Jamphu B1	33.000		0.005	0.003	0.001	0.001					0.040	87.9	0.7	
Jangdla B1	33.000										0.014	84.5	0.3	
Jangdla B2	0.415		0.010	0.006	0.002	0.001					0.014	85.0	20.6	
Jardgla B1	33.000										0.044	85.8	0.8	
Jardgla B2	0.415		0.011	0.007	0.002	0.001					0.015	85.0	22.4	
Jasar B1	33.000		0.006	0.004	0.023	0.014					0.035	85.0	0.6	
Jawlg B1	33.000		0.001	0.001	0.005	0.003					0.268	89.4	4.9	

Bus			**Directly Connected Load**								**Total Bus Load**			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Kaktong(BHU) B1	33.000										0.194	89.4	3.5	
Kaktong(BHU) B2	0.415		0.011	0.007	0.002	0.001					0.016	85.0	23.6	
Kaktong(Schl) B1	33.000										0.178	89.5	3.2	
Kaktong(Schl) B2	0.415		0.013	0.008	0.003	0.002					0.019	85.0	28.7	
Kalamti B1	33.000		0.011	0.007	0.002	0.002					0.119	96.1	2.2	
Kamalung B1	33.000										0.049	85.5	0.9	
Kamalung B2	0.415		0.010	0.006	0.002	0.001					0.015	85.0	22.1	
KD Smill B	6.600										0.102	84.3	9.6	
KD Smill B2	0.415		0.011	0.007	0.035	0.022					0.055	85.0	83.9	
Khomsr B1	33.000										0.057	85.9	1.0	
Khomsr B2	0.415		0.004	0.002	0.013	0.008					0.019	85.0	28.4	
Kihar B2	0.415		0.005	0.003	0.016	0.010					0.025	85.0	36.7	
Kkhar B1	33.000										0.026	84.0	0.5	
KphuI B1	33.000										0.105	85.3	1.9	
KphuI B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	21.2	
KphuV B1	33.000		0.002	0.001	0.006	0.004					0.059	84.9	1.1	
KphuVI B1	33.000										0.050	84.7	0.9	
KphuVI B2	0.415		0.000	0.000	0.002	0.001					0.003	85.0	3.7	
KphuVII B1	33.000		0.002	0.002	0.009	0.006					0.043	84.3	0.8	
KphuVII B2	0.415		0.005	0.003	0.018	0.011					0.028	85.0	41.9	
L.Kamjong B1	33.000										0.012	84.5	0.2	
L.Kamjong B2	0.415		0.009	0.005	0.002	0.001					0.012	85.0	18.0	
L.Lamthang B1	33.000										0.278	92.5	5.0	
L.Lamthang B2	0.415		0.008	0.005	0.002	0.001					0.012	85.0	17.3	
L.Limapong B1	33.000										0.254	92.1	4.6	
L.Limapong B2	0.415		0.008	0.005	0.002	0.001					0.012	85.0	17.3	
L.Nshong B	33.000										0.060	87.7	1.1	
L.Nshong B2	0.415													
L.Scholing B1	33.000		0.003	0.002	0.001	-					0.229	92.6	4.2	
Lalng B1	33.000										0.340	89.4	6.2	
Lalng B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.7	
Langdbi Schl B1	33.000										0.015	84.4	0.3	
Langdbi Schl B2	0.415		0.010	0.006	0.002	0.001					0.015	85.0	21.7	
Langman B1	33.000		0.001	0.000	0.000	-					0.038	97.2	0.7	
LGphu B1	33.000										0.109	85.9	2.0	
LGphu B2	0.415		0.010	0.006	0.002	0.001					0.014	85.0	20.7	
Llgang B	33.000		0.001	0.001	0.004	0.002					0.070	88.9	1.3	
LT School B2	0.415		0.005	0.003	0.017	0.011					0.026	85.0	38.9	
LT.School B1	33.000										0.027	84.0	0.5	
LTsaA	33.000										0.042	85.1	0.8	
LTsaA B2	0.415		0.004	0.002	0.014	0.008					0.021	85.0	31.0	
LTsaB B1	33.000										0.021	84.2	0.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
LTsaB B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.6	
LWomlgA B1	33.000										0.117	86.8	2.1	
LWomlgA B2	0.415		0.005	0.003	0.015	0.010					0.023	85.0	35.2	
LWomlgB B1	33.000		0.001	0.001	0.005	0.003					0.124	87.0	2.3	
M.Nshong B	33.000										0.060	87.4	1.1	
M.Nshong B2	0.415		0.004	0.003	0.015	0.009					0.022	85.0	33.3	
Mayungbi B1	33.000										0.021	84.2	0.4	
Mayungbi B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.0	
Mewagg B1	33.000		0.009	0.006	0.002	0.001					0.032	86.3	0.6	
MWomlg B1	33.000										0.148	86.6	2.7	
MWomlg B2	0.415		0.004	0.003	0.015	0.009					0.023	85.0	34.9	
N1 B2	0.415		0.003	0.002	0.012	0.008					0.018	85.0	27.2	
NabjiI B1	33.000										0.072	87.8	1.3	
NabjiI B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.2	
NabjiII B1	33.000										0.064	85.5	1.1	
NabjiII B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.8	
NabjiIII B1	33.000										0.025	84.7	0.4	
NabjiIII B2	0.415		0.002	0.001	0.007	0.004					0.011	85.0	15.5	
NabjiIV B1	33.000										0.014	84.5	0.3	
NabjiIV B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.2	
NabjiV B1	33.000										0.025	85.4	0.4	
NabjiV B2	0.415		0.002	0.001	0.007	0.004					0.011	85.0	15.9	
NabjiVI B1	33.000										0.014	84.2	0.3	
NabjiVI B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.1	
Nawabi B1	33.000										0.021	84.2	0.4	
Nawabi B2	0.415		0.004	0.002	0.014	0.008					0.021	85.0	31.0	
Ngala Trng B1	33.000										0.139	89.2	2.5	
Ngala Trng B2	0.415		0.012	0.007	0.003	0.002					0.017	85.0	25.8	
NI B1	33.000										0.029	84.8	0.5	
NII B1	33.000										0.011	84.6	0.2	
NII B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.2	
NIII B1	33.000										0.009	84.7	0.2	
NIII B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.9	
NIV B1	33.000										0.012	84.6	0.2	
NIV B2	0.415		0.002	0.001	0.008	0.005					0.011	85.0	16.6	
NRDCL B1	33.000										0.018	85.0	0.3	
NRDCL B2	0.415		0.003	0.002	0.012	0.008					0.018	85.0	25.9	
NV B1	33.000										0.191	92.0	3.4	
NV B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.5	
NVI B1	33.000		0.000	0.000	0.002	0.001					0.185	92.1	3.3	
NVII B1	33.000										0.006	84.8	0.1	
NVII B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
NVIII B1	33.000										0.010	84.6	0.2	
NVIII B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	14.5	
Nykhar B1	33.000										0.089	89.9	1.6	
Nykhar B2	0.415		0.002	0.002	0.009	0.006					0.014	85.0	19.7	
Olangbi B1	33.000		0.007	0.004	0.002	0.001					0.040	88.7	0.7	
Panabi B1	33.000		0.003	0.002	0.001	-					0.067	96.6	1.2	
Pemala Smill B1	6.600										0.026	84.1	2.4	
Pemala Smill B2	0.415		0.005	0.003	0.016	0.010					0.025	85.0	38.4	
Phthang B	33.000										0.018	84.3	0.3	
Pkobi B1	33.000		0.013	0.008	0.003	0.002					0.090	95.0	1.6	
Plangtoe B1	33.000										0.005	84.7	0.1	
Plangtoe B2	0.415		0.003	0.002	0.001	-					0.005	85.0	7.3	
PramJ B1	33.000		0.013	0.008	0.003	0.002					0.108	93.8	2.0	
Ptang B2	0.415		0.022	0.013	0.005	0.003					0.031	85.0	47.1	
Ptang I B1	33.000										0.500	93.8	9.1	
Ptang II B1	33.000										0.035	83.7	0.6	
Ptang II B2	0.415		0.023	0.014	0.005	0.003					0.033	85.0	50.2	
Pthang B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	26.1	
PWD B1	6.600										0.074	84.4	7.0	
PWD B2	0.415		0.014	0.009	0.047	0.029					0.073	85.0	111.7	
PWD Mangdichu B	6.600										0.162	91.8	15.1	
PWD Mangdichu B2	0.415		0.016	0.010	0.049	0.031					0.077	85.0	122.6	
RDTC B1	33.000										0.043	84.9	0.8	
RDTC B2	0.415		0.008	0.005	0.029	0.018					0.043	85.0	61.3	
RGH B1	6.600										0.061	84.2	5.7	
RGH B2	0.415		0.012	0.007	0.038	0.024					0.059	85.0	91.2	
RMBF B1	33.000										0.005	84.9	0.1	
RMBF B2	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.7	
Rmya B1	33.000		0.001	0.000	0.002	0.001					0.043	99.2	0.8	
Samth B1	33.000										0.263	88.8	4.8	
Samth B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	27.1	
Sanglung B1	33.000		0.002	0.001	0.000	-					0.196	92.1	3.6	
Sansiri B1	33.000										0.368	93.8	6.7	
Sansiri B2	0.415		0.006	0.004	0.001	0.001					0.009	85.0	12.6	
Selingtoe B1	33.000		0.015	0.009	0.004	0.002					0.022	85.0	0.4	
Shelgbi B1	33.000										0.295	92.4	5.4	
Shelgbi B2	0.415		0.013	0.008	0.003	0.002					0.019	85.0	27.6	
Shingkr.Scl B1	33.000										0.094	86.4	1.7	
Shingkr.Scl B2	0.415		0.004	0.002	0.014	0.008					0.021	85.0	31.0	
Station/Colony B1	0.415		0.005	0.003	0.019	0.012					0.028	85.0	40.7	
Subrg B1	33.000										0.032	84.5	0.6	
Subrg B2	0.415		0.022	0.014	0.005	0.003					0.032	85.0	46.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Surpng B1	33.000		0.003	0.002	0.001	-					0.043	97.9	0.8	
T10.1	33.000										1.215	86.7	21.9	
T10.2	33.000										1.196	86.2	21.6	
T10.3	33.000		0.004	0.002	0.014	0.009					0.271	92.3	4.9	
T10.4	33.000										0.252	92.2	4.6	
T10.5	33.000		0.002	0.001	0.006	0.004					0.017	86.2	0.3	
T10.6	33.000										0.931	83.9	16.8	
T10.7	33.000										0.828	83.6	14.9	
T10.8	33.000										0.051	90.0	0.9	
T10.9	33.000										0.011	88.3	0.2	
T10.10	6.600										0.666	84.2	62.0	
T10.11	6.600										0.446	84.3	41.9	
T10.12	6.600										0.324	84.3	30.5	
T10.13	6.600										0.148	84.3	13.9	
T10.14	33.000										0.239	90.9	4.3	
T10.15	33.000										0.038	85.4	0.7	
T10.16	33.000										0.202	91.7	3.6	
T10.17	33.000										0.183	92.2	3.3	
T10.18	33.000										0.177	92.3	3.2	
T10.19	33.000		0.001	0.000	0.002	0.001					0.175	88.4	3.2	
T10.20	33.000										0.173	88.1	3.1	
T10.21	33.000		0.006	0.003	0.021	0.013					0.090	85.0	1.6	
T10.22	33.000		0.001	0.001	0.003	0.002					0.048	84.4	0.9	
T10.23	33.000										0.049	85.8	0.9	
T20.1	33.000										1.167	94.1	20.9	
T20.2	33.000										0.952	95.1	17.1	
T20.3	33.000										0.898	94.7	16.2	
T20.4	33.000										0.871	94.5	15.8	
T20.5	33.000										0.766	95.1	13.9	
T20.6	33.000										0.097	88.6	1.8	
T20.7	33.000										0.645	95.2	11.7	
T20.8	33.000		0.005	0.003	0.001	0.001					0.071	96.4	1.3	
T20.9	33.000		0.010	0.006	0.002	0.001					0.073	86.0	1.3	
T20.10	33.000										0.029	85.6	0.5	
T20.11	33.000		0.010	0.006	0.002	0.001					0.529	94.4	9.6	
T20.12	33.000		0.009	0.005	0.002	0.001					0.516	94.4	9.3	
T20.13	33.000										0.503	94.1	9.1	
T20.14	33.000										0.468	94.3	8.5	
T20.15	33.000										0.435	94.7	7.9	
T20.16	33.000										0.064	95.4	1.2	
T20.17	33.000										0.067	91.4	1.2	
T20.18	33.000										0.360	93.8	6.5	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
T20.19	33.000		0.002	0.001	0.000	-					0.039	98.5	0.7	
T20.20	33.000		0.002	0.001	0.000	-					0.265	92.5	4.8	
T20.21	33.000		0.003	0.002	0.001	-					0.258	92.1	4.7	
T20.22	33.000										0.242	92.4	4.4	
T20.23	33.000		0.002	0.001	0.000	-					0.216	92.8	3.9	
T20.24	33.000		0.002	0.001	0.000	-					0.214	92.6	3.9	
T20.25	33.000		0.002	0.001	0.000	-					0.211	92.6	3.8	
T20.26	33.000		0.004	0.002	0.001	0.001					0.195	91.0	3.6	
T20.27	33.000		0.001	0.001	0.000	-					0.140	89.4	2.6	
T20.28	33.000		0.054	0.034	0.012	0.008					0.127	85.4	2.3	
T30.1	11.000										0.238	84.3	12.9	
T30.2	11.000										0.233	84.3	12.6	
T40.1	33.000										1.042	93.8	18.7	
T40.2	33.000										1.028	93.4	18.5	
T40.3	33.000										0.964	93.2	17.4	
T40.4	33.000		0.001	0.001	0.005	0.003					0.059	88.3	1.1	
T40.5	33.000		0.005	0.003	0.019	0.012					0.053	86.8	1.0	
T40.6	33.000										0.911	92.9	16.5	
T40.7	33.000		0.000	0.000	0.001	0.001					0.045	100.0	0.8	
T40.8	33.000		0.003	0.002	0.010	0.006					0.041	98.2	0.7	
T40.9	33.000										0.028	99.1	0.5	
T40.10	33.000										0.872	91.7	15.8	
T40.11	33.000		0.001	0.001	0.005	0.003					0.076	90.3	1.4	
T40.12	33.000										0.066	87.4	1.2	
T40.13	33.000										0.049	85.1	0.9	
T40.14	33.000										0.793	90.8	14.3	
T40.15	33.000										0.759	90.9	13.7	
T40.16	33.000		0.000	0.000	0.001	0.001					0.546	90.7	9.9	
T40.17	33.000										0.546	90.4	9.9	
T40.18	33.000										0.038	88.9	0.7	
T40.19	33.000										0.470	90.2	8.6	
T40.20	33.000										0.472	89.9	8.6	
T40.21	33.000		0.001	0.000	0.002	0.001					0.134	87.8	2.4	
T40.22	33.000										0.128	87.1	2.3	
T40.23	33.000										0.104	86.6	1.9	
T40.25	33.000										0.038	85.8	0.7	
T40.26	33.000		0.003	0.002	0.011	0.007					0.017	85.0	0.3	
T40.27	33.000		0.003	0.002	0.011	0.007					0.320	89.6	5.8	
T40.28	33.000										0.249	87.4	4.5	
T40.29	33.000		0.002	0.001	0.007	0.004					0.072	86.2	1.3	
T40.30	33.000		0.006	0.004	0.022	0.013					0.180	86.4	3.3	
T40.31	33.000		0.006	0.004	0.022	0.014					0.073	86.8	1.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
T40.33	33.000										0.040	88.0	0.7	
T50.1	11.000										0.345	78.3	18.7	
T50.2	6.600										0.199	90.7	18.5	
T50.3	6.600										0.304	88.8	28.0	
T50.4	6.600										0.046	84.3	4.3	
T50H267 B	6.600													
Takabi B1	11.000										0.151	83.9	8.2	
Takabi B2	0.415		0.005	0.003	0.017	0.010					0.025	85.0	36.6	
Takabi Fishery B1	11.000										0.126	83.6	6.9	
Takabi Fishery B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.5	
Tali B	33.000										1.016	92.9	18.3	
Tali B2	0.415		0.010	0.006	0.034	0.021					0.052	85.0	76.8	
Tama B1	11.000										0.082	84.2	4.5	
Tama B2	0.415		0.013	0.008	0.044	0.027					0.066	85.0	99.7	
Tama Gonpai B1	11.000										0.013	84.5	0.7	
Tama Gonpai B2	0.415		0.002	0.001	0.008	0.005					0.013	85.0	18.5	
Thjong B1	33.000										0.488	90.3	8.9	
Thjong B2	0.415		0.004	0.002	0.013	0.008					0.019	85.0	28.7	
Tingtibi Bus1	33.000										4.009	90.7	71.8	
Tingtibi HPP B1	0.415										0.320	87.6	445.0	
Tingtibi HPP B2	6.600										0.305	88.8	28.0	
Tingtibi Main Bus1	132.000										4.105	90.1	18.0	
Tingtibi Sub Bus1	11.000										0.611	81.1	33.1	
Tlajong B1	33.000										0.999	94.8	18.0	
Tlajong B2	0.415		0.034	0.021	0.008	0.005					0.049	85.0	71.8	
TSchool B1	33.000										0.019	84.3	0.3	
TSchool B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	26.8	
TshibiA B1	33.000		0.009	0.006	0.002	0.001					0.034	84.5	0.6	
TshibiA B2	0.415		0.014	0.008	0.003	0.002					0.019	85.0	29.1	
Ttibi BOD B1	6.600										0.086	92.5	8.0	
Ttibi BOD B2	0.415		0.012	0.007	0.038	0.024					0.059	85.0	89.9	
Ttibi DoR B1	6.600										0.037	84.5	3.5	
Ttibi DoR B2	0.415		0.007	0.004	0.024	0.015					0.036	85.0	55.0	
Ttibi Lichbi B1	33.000										0.209	92.5	3.8	
Ttibi LichbiB2	0.415		0.010	0.006	0.002	0.001					0.014	85.0	21.3	
Ttibi Town B2	0.415		0.025	0.016	0.082	0.051					0.126	85.0	195.0	
Ttibi TownA B	6.600										0.088	75.0	8.2	
Ttibi TownA B2	0.415		0.015	0.010	0.047	0.029					0.074	85.0	116.8	
Ttibi TownB B1	6.600										0.196	75.2	18.3	
U.Kamjong B1	33.000		0.017	0.010	0.004	0.002					0.085	88.3	1.5	
U.Lamthang B1	33.000		0.001	0.001	0.000	-					0.266	92.5	4.8	
U.Limapong B1	33.000										0.014	84.5	0.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
U.Limapong B2	0.415		0.010	0.006	0.002	0.001					0.014	85.0	20.6	
U.Nshong B1	33.000										0.022	84.2	0.4	
U.Nshong B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	31.3	
U.Scholing B1	33.000										0.224	92.5	4.1	
U.Scholing B2	0.415		0.006	0.004	0.001	0.001					0.009	85.0	12.6	
UGphu B1	33.000		0.010	0.006	0.002	0.001					0.096	84.5	1.7	
UGphu B2	0.415		0.055	0.034	0.012	0.008					0.079	85.0	117.2	
Umchagg B1	33.000										0.021	84.2	0.4	
Umchagg B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.3	
Umpala B1	33.000		0.002	0.001	0.000	-					0.504	94.4	9.1	
Urti B1	33.000										0.160	89.2	2.9	
Urti B2	0.415		0.014	0.009	0.003	0.002					0.020	85.0	30.2	
UT B1	33.000										0.023	84.1	0.4	
UT B2	0.415		0.004	0.003	0.014	0.009					0.022	85.0	32.7	
UTsa.B B1	33.000										0.021	84.2	0.4	
UTsa.B B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.3	
Wadang B1	33.000										0.047	86.3	0.9	
Wadang B2	0.415		0.002	0.002	0.009	0.005					0.013	85.0	19.5	
Wagar B1	33.000		0.001	0.000	0.002	0.001					0.131	87.4	2.4	
Wamjla B1	33.000		0.002	0.001	0.000	-					0.069	97.0	1.3	
Wangbi B1	33.000		0.006	0.004	0.001	0.001					0.028	92.4	0.5	
Wangling B1	33.000		0.002	0.001	0.000	-					0.049	98.5	0.9	
YlaptsaA B	6.600										0.139	83.5	13.0	
YlaptsaA B2	0.415		0.009	0.006	0.030	0.019					0.046	85.0	71.9	
YlaptsaB B1	6.600										0.091	83.1	8.5	
YlaptsaB B2	0.415		0.018	0.011	0.053	0.033					0.084	85.0	134.7	
Yongkp B1	33.000		0.001	0.001	0.000	-					0.045	98.0	0.8	
Ythg B1	33.000										0.285	89.7	5.2	
Ythg B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	26.7	
Zangbi B1	33.000		0.000	0.000	0.000	-					0.038	93.5	0.7	
Zhoblg B1	33.000										0.020	84.3	0.4	
Zhoblg B2	0.415		0.004	0.002	0.013	0.008					0.019	85.0	28.2	
Zphey B1	33.000										0.061	84.1	1.1	
Zphey B2	0.415		0.041	0.025	0.009	0.006					0.058	85.0	86.7	

* Indicates operating load of a bus exceeds the bus critical limit (100.0% of the Continuous Ampere rating).
# Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

Branch Loading Summary Report

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
BTL-T50Hs67	Cable	270.43							
A.ZHSS Tfr	Transformer				0.125	0.053	42.5	0.052	41.7
B.ZHSS Tfr	Transformer				0.125	0.068	54.7	0.067	53.4
Babshar Tfr	Transformer				0.025	0.020	80.5	0.019	77.9
BAFRA.O Tfr	Transformer				0.125	0.078	62.3	0.076	60.6
Bardang Tfr	Transformer				0.025	0.019	74.8	0.018	72.6
BdoSch Tfr	Transformer				0.025	0.020	79.3	0.019	76.8
BDYT.H Tfr	Transformer				0.125	0.098	78.7	0.095	76.1
* Berti Tfr	Transformer				0.063	0.114	180.9	0.106	168.0
BHU Tfr	Transformer				0.125	0.108	86.7	0.105	83.6
Bjoka Tfr	Transformer				0.016				
Bpong Tfr	Transformer				0.025	0.005	20.8	0.005	20.6
BTL Tfr	Transformer				0.030	0.020	68.0	0.020	66.1
* BuliA Tfr	Transformer				0.063	0.068	108.1	0.065	103.5
BuliB Tfr	Transformer				0.063	0.049	77.2	0.047	74.9
BuliC Tfr	Transformer				0.125	0.113	90.0	0.109	86.8
BuliCS Tfr	Transformer				0.250	0.035	14.2	0.035	14.1
Chelaibi Tfr	Transformer				0.025	0.019	76.4	0.019	74.1
Crong Tfr	Transformer				0.025	0.008	30.8	0.008	30.4
Dgbi Tfr	Transformer				0.063	0.006	9.5	0.006	9.5
* Dmang V1 Tfr	Transformer				0.025	0.038	150.8	0.035	141.9
* Dmang V2 Tfr	Transformer				0.025	0.027	109.6	0.026	104.9
DpaiT Tfr	Transformer				0.063	0.008	13.3	0.008	13.3
DpaiV Tfr	Transformer				0.063	0.008	13.4	0.008	13.3
* DPokto Tfr	Transformer				0.063	0.094	148.5	0.088	139.4
DVH Tfr	Transformer				0.125	0.107	85.3	0.103	82.3
Dzo Tfr	Transformer				0.500	0.104	20.8	0.103	20.7
Forest.O Tfr	Transformer				0.100	0.012	12.4	0.012	12.3
Glng PWD Tfr	Transformer				0.063	0.042	67.4	0.041	65.7
* Glng V Tfr	Transformer				0.063	0.071	113.0	0.068	108.1
* Glng Wdra Tfr	Transformer				0.063	0.065	102.6	0.062	98.5
GomC Tfr	Transformer				0.025	0.022	90.0	0.022	86.8
Gphu Zero Tfr	Transformer				0.063	0.019	29.8	0.019	29.5

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
ICT PWD	Transformer				1.500	0.782	52.1	0.764	50.9
ICT T50	Transformer				0.500	0.345	69.0	0.336	67.1
Jakhring Tfr	Transformer				0.025	0.015	60.0	0.015	58.6
Jangdla Tfr	Transformer				0.025	0.014	57.0	0.014	55.7
Jardgla Tfr	Transformer				0.025	0.016	62.1	0.015	60.6
Kaktong(BHU) Tfr	Transformer				0.025	0.016	65.1	0.016	63.4
Kaktong(Schl) Tfr	Transformer				0.025	0.020	79.4	0.019	76.9
Kamalung Tfr	Transformer				0.025	0.015	61.0	0.015	59.5
KD Smill Tfr	Transformer				0.075	0.056	75.0	0.055	72.7
Khomsr Tfr	Transformer				0.025	0.020	78.4	0.019	76.0
* Kkhar Tfr	Transformer				0.025	0.026	102.3	0.025	98.3
KphuI Tfr	Transformer				0.025	0.015	59.0	0.014	57.7
KphuVI Tfr	Transformer				0.025	0.003	10.4	0.003	10.4
* KphuVII Tfr	Transformer				0.025	0.029	116.5	0.028	111.2
L.Kamjong Tfr	Transformer				0.025	0.012	50.0	0.012	49.0
L.Lamthang Tfr	Transformer				0.025	0.012	47.9	0.012	47.0
L.Limapong Tfr	Transformer				0.025	0.012	47.9	0.012	47.0
L.Nshong Tfr	Transformer				0.025				
Lalng Tfr	Transformer				0.025	0.021	84.8	0.020	81.9
Langdbi Schl Tfr	Transformer				0.025	0.015	60.0	0.015	58.6
LGphu Tfr	Transformer				0.063	0.014	22.8	0.014	22.6
* LT School Tfr	Transformer				0.025	0.027	108.1	0.026	103.6
LTsaA Tfr	Transformer				0.025	0.021	85.5	0.021	82.6
LTsaB Tfr	Transformer				0.025	0.021	84.6	0.020	81.8
LWomlgA Tfr	Transformer				0.025	0.024	97.2	0.023	93.4
M.Nshong Tfr	Transformer				0.025	0.023	92.1	0.022	88.8
Mayungbi Tfr	Transformer				0.025	0.021	82.8	0.020	80.1
MWomlg Tfr	Transformer				0.025	0.024	96.3	0.023	92.6
NabjiI Tfr	Transformer				0.025	0.011	42.3	0.010	41.6
NabjiII Tfr	Transformer				0.016	0.014	90.2	0.014	87.1
NabjiIII Tfr	Transformer				0.025	0.011	43.2	0.011	42.5
NabjiIV Tfr	Transformer				0.025	0.014	56.2	0.014	55.0
NabjiV Tfr	Transformer				0.025	0.011	44.2	0.011	43.4
NabjiVI Tfr	Transformer				0.016	0.014	87.5	0.014	84.5
Nawabi Tfr	Transformer				0.025	0.021	85.7	0.021	82.8

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
Ngala Trng Tfr	Transformer				0.025	0.018	71.2	0.017	69.2
NI Tfr	Transformer				0.025	0.019	75.7	0.018	73.4
NII Tfr	Transformer				0.025	0.011	42.4	0.010	41.7
NIII Tfr	Transformer				0.025	0.009	35.8	0.009	35.3
NIV Tfr	Transformer				0.025	0.012	46.1	0.011	45.3
NRDCL Tfr	Transformer				0.630	0.018	2.9	0.018	2.9
NV Tfr	Transformer				0.025	0.006	23.6	0.006	23.4
NVII Tfr	Transformer				0.025	0.006	22.7	0.006	22.5
NVIII Tfr	Transformer				0.025	0.010	40.5	0.010	39.9
Nykhar Tfr	Transformer				0.063	0.014	21.7	0.014	21.5
Pemala Smill Tfr	Transformer				0.030	0.026	85.9	0.025	82.8
Phthang Tfr	Transformer				0.025	0.018	72.2	0.018	70.1
Plangtoe Tfr	Transformer				0.016	0.005	31.8	0.005	31.4
* Ptang I Tfr	Transformer				0.025	0.033	130.5	0.031	123.8
* Ptang II Tfr	Transformer				0.025	0.035	139.0	0.033	131.4
* PWD Mangdichu Tfr	Transformer				0.050	0.083	165.6	0.077	154.2
PWD Tfr	Transformer				0.125	0.074	59.6	0.073	58.1
RDTC Tfr	Transformer				0.500	0.043	8.5	0.043	8.5
RGH Tfr	Transformer				0.075	0.061	81.1	0.059	78.3
RMBF Tfr	Transformer				0.063	0.005	8.5	0.005	8.5
Samth Tfr	Transformer				0.025	0.019	74.7	0.018	72.5
Sansiri Tfr	Transformer				0.025	0.009	34.8	0.009	34.3
Shelgbi Tfr	Transformer				0.025	0.019	76.4	0.019	74.1
Shingkr.Scl Tfr	Transformer				0.025	0.021	85.5	0.021	82.6
Station/Colony Tfr	Transformer				0.100	0.028	28.3	0.028	28.0
Subrg Tfr	Transformer				0.063	0.032	51.0	0.032	50.0
Takabi Fishery Tfr	Transformer				0.025	0.012	48.5	0.012	47.6
Takabi Tfr	Transformer				0.063	0.025	40.3	0.025	39.7
Tali Tfr	Transformer				0.063	0.054	85.0	0.052	82.2
Tama Gonpai Tfr	Transformer				0.025	0.013	51.5	0.013	50.4
* Tama Tfr	Transformer				0.063	0.069	109.9	0.066	105.2
Thjong Tfr	Transformer				0.025	0.020	79.5	0.019	77.0
* Tingtibi HPP Tfr	Transformer				0.250	0.320	127.9	0.305	122.2
Tlajong Tfr	Transformer				0.063	0.050	79.7	0.049	77.3
TSchool Tfr	Transformer				0.025	0.019	74.5	0.018	72.3

CKT / Branch		Cable & Reactor			Transformer				
					Capability	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	(MVA)	MVA	%	MVA	%
TshibiA Tfr	Transformer				0.025	0.020	80.5	0.019	77.9
Ttibi BOD Tfr	Transformer				0.075	0.061	80.9	0.059	78.2
Ttibi DoR Tfr	Transformer				0.075	0.037	49.6	0.036	48.5
Ttibi Lichbi Tfr	Transformer				0.025	0.015	59.0	0.014	57.6
Ttibi Sub Tfr1	Transformer				1.500	0.308	20.5	0.306	20.4
Ttibi Sub Tfr2	Transformer				1.500	0.308	20.5	0.306	20.4
Ttibi Sub Tfr3	Transformer				3.000	2.053	68.4	2.005	66.8
Ttibi Sub Tfr4	Transformer				3.000	2.053	68.4	2.005	66.8
* Ttibi TownA Tfr	Transformer				0.050	0.079	157.5	0.074	147.2
* Ttibi TownB Tfr	Transformer				0.125	0.132	105.2	0.126	100.6
U.Limapong Tfr	Transformer				0.025	0.014	57.0	0.014	55.7
U.Nshong Tfr	Transformer				0.025	0.022	86.7	0.021	83.7
U.Scholing Tfr	Transformer				0.025	0.009	34.8	0.009	34.3
UGphu Tfr	Transformer				0.125	0.082	65.2	0.079	63.6
Umchagg Tfr	Transformer				0.025	0.021	83.7	0.020	80.9
Urti Tfr	Transformer				0.025	0.021	83.5	0.020	80.7
UT Tfr	Transformer				0.025	0.023	90.9	0.022	87.7
UTsa.B Tfr1	Transformer				0.025	0.021	83.7	0.020	80.9
Wadang Tfr	Transformer				0.025	0.013	53.8	0.013	52.7
YlaptsaA Tfr	Transformer				0.050	0.048	96.9	0.046	93.0
* YlaptsaB Tfr	Transformer				0.050	0.091	181.4	0.084	167.7
Ythg Tfr	Transformer				0.025	0.018	73.9	0.018	71.7
Zhoblg Tfr	Transformer				0.025	0.020	78.4	0.019	76.0
Zphey Tfr	Transformer				0.063	0.061	96.3	0.058	92.7

* Indicates a branch with operating load exceeding the branch capability.

Branch Losses Summary Report

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T10.11-A.ZHSS	-0.045	-0.028	0.045	0.028	0.0	0.0	93.1	93.1	0.01
A.ZHSS Tfr	0.045	0.028	-0.044	-0.027	0.6	0.9	93.1	91.4	1.66
T10.11-B.ZHSS	-0.058	-0.037	0.058	0.037	0.0	0.0	93.1	93.1	0.00
B.ZHSS Tfr	0.058	0.037	-0.057	-0.035	1.0	1.4	93.1	90.9	2.14
Babshar-Shelgbi	0.273	0.109	-0.273	-0.113	0.1	-4.0	96.3	96.3	0.04
T20.18-Babshar	-0.290	-0.120	0.290	0.118	0.1	-2.2	96.3	96.4	0.02
Babshar Tfr	0.017	0.011	-0.017	-0.010	0.4	0.6	96.3	93.3	3.05
BAFRA.O-T10.13	0.125	0.079	-0.125	-0.079	0.1	0.0	92.9	92.8	0.08
BDYT.H-BAFRA.O	-0.190	-0.121	0.190	0.121	0.1	0.1	92.9	92.9	0.06
BAFRA.O Tfr	0.066	0.042	-0.064	-0.040	1.2	1.9	92.9	90.4	2.45
Crong-Bardang	-0.016	-0.010	0.016	0.010	0.0	-0.5	96.1	96.1	0.00
Bardang Tfr	0.016	0.010	-0.015	-0.010	0.3	0.5	96.1	93.3	2.84
BdoSch-Ythg	0.256	0.125	-0.256	-0.126	0.0	-0.5	96.1	96.1	0.00
T40.27-BdoSch	-0.272	-0.136	0.272	0.133	0.0	-3.1	96.1	96.1	0.02
BdoSch Tfr	0.017	0.011	-0.016	-0.010	0.4	0.6	96.1	93.1	3.01
T10.12-B.DYT.H	-0.273	-0.174	0.273	0.174	0.1	0.1	92.9	93.0	0.05
BDYT.H Tfr	0.083	0.053	-0.081	-0.050	2.0	3.0	92.9	89.8	3.09
Takabi Fishery-Berti	-0.095	-0.063	0.095	0.063	0.1	-0.5	96.3	96.4	0.10
Berti Tfr	0.095	0.063	-0.090	-0.056	4.9	7.4	96.3	89.4	6.89
BHU-T10.11	0.379	0.242	-0.376	-0.240	2.3	2.1	93.7	93.1	0.66
T10.10-BHU	-0.470	-0.300	0.471	0.301	1.0	1.0	93.7	94.0	0.23
BHU Tfr	0.091	0.059	-0.089	-0.055	2.4	3.6	93.7	90.4	3.38
Bhudshe-Yongkp	0.044	0.007	-0.044	-0.009	0.0	-1.6	96.3	96.3	0.00
Wangling-Bhudshe	-0.046	-0.008	0.046	0.007	0.0	-1.5	96.3	96.3	0.00
Kamalung-Bjoka	-0.029	-0.018	0.029	0.017	0.0	-0.7	96.0	96.0	0.00
Bjoka Tfr	0.000	0.000	0.000	0.000			96.0	96.0	
T40.19-Blangbi	-0.307	-0.150	0.307	0.147	0.1	-3.1	96.1	96.2	0.02
T40.19-Lalng	0.305	0.149	-0.304	-0.152	0.1	-3.4	96.1	96.1	0.02
T30.1-Bpong	-0.004	-0.003	0.004	0.003	0.0	-0.1	96.8	96.8	0.00
Bpong Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	96.8	96.0	0.78
BTL-T50Hs67	0.000	0.000	0.000	0.000			93.3	93.3	
T50.4-BTL	-0.017	-0.011	0.017	0.011	0.0	-0.1	93.3	93.3	0.02
BTL Tfr	0.017	0.011	-0.017	-0.010	0.4	0.5	93.3	90.6	2.66
Buli(A-B)	0.538	0.220	-0.538	-0.223	0.1	-2.9	96.6	96.6	0.03

Branch ID	From-To Bus Flow MW	From-To Bus Flow Mvar	To-From Bus Flow MW	To-From Bus Flow Mvar	Losses kW	Losses kvar	% Bus Voltage From	% Bus Voltage To	Vd % Drop in Vmag
T40.15-BuliA	-0.595	-0.257	0.595	0.256	0.1	-1.0	96.6	96.6	0.01
BuliA Tfr	0.057	0.037	-0.055	-0.034	1.8	2.6	96.6	92.5	4.09
BuliB-T40.16	0.497	0.197	-0.495	-0.230	1.4	-33.2	96.6	96.3	0.32
BuliB Tfr	0.041	0.026	-0.040	-0.025	0.9	1.3	96.6	93.7	2.92
T40.15-BuliC	-0.095	-0.061	0.095	0.060	0.0	-1.1	96.6	96.6	0.00
BuliC Tfr	0.095	0.061	-0.092	-0.057	2.4	3.6	96.6	93.2	3.40
T40.14-BuliCS	-0.030	-0.019	0.030	0.018	0.0	-0.4	96.7	96.7	0.00
BuliCS Tfr	0.030	0.019	-0.030	-0.019	0.1	0.2	96.7	96.1	0.53
T40.9-Chamtg	-0.012	0.000	0.012	-0.004	0.0	-3.9	96.8	96.8	0.00
Chamtang-Gomphu Fdr	0.000	-0.007	0.000	0.000	0.0	-7.1	96.8	96.8	0.00
Mewagg-Chelaibi	-0.016	-0.010	0.016	0.009	0.0	-1.3	96.3	96.3	0.00
Chelaibi Tfr	0.016	0.010	-0.016	-0.010	0.3	0.5	96.3	93.4	2.89
T10.5-CPam	-0.007	-0.004	0.007	0.004	0.0	-0.5	96.9	96.9	0.00
T40.22-Crong	-0.022	-0.014	0.022	0.013	0.0	-0.7	96.1	96.1	0.00
Crong Tfr	0.007	0.004	-0.006	-0.004	0.1	0.1	96.1	95.0	1.17
DPokto-T10.10	0.563	0.361	-0.561	-0.359	2.2	2.1	94.4	94.0	0.43
ICT-D.Pokto	-0.641	-0.413	0.642	0.414	1.0	0.9	94.4	94.6	0.17
DPokto Tfr	0.078	0.051	-0.075	-0.046	3.5	5.2	94.4	88.6	5.76
D.Tsachu-T20.6	0.086	0.037	-0.086	-0.045	0.0	-7.7	96.7	96.6	0.02
T20.5-D.Tsachu	-0.098	-0.045	0.098	0.043	0.0	-1.5	96.7	96.7	0.01
T10.9-Dgbi	-0.005	-0.003	0.005	0.003	0.0	-0.4	96.9	96.9	0.00
Dgbi Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.9	96.5	0.36
Dmang(V1-V2)	0.023	0.015	-0.023	-0.015	0.0	-0.4	96.6	96.6	0.00
U.Kamjong-Dmang V1	-0.055	-0.035	0.055	0.027	0.0	-8.0	96.6	96.6	0.02
Dmang V1 Tfr	0.032	0.021	-0.030	-0.019	1.4	2.0	96.6	90.9	5.71
Dmang V2 Tfr	0.023	0.015	-0.022	-0.014	0.7	1.1	96.6	92.5	4.15
DpaiT-Tali	0.945	0.367	-0.944	-0.377	1.6	-10.0	97.2	97.0	0.20
T40.2-DpaiT	-0.952	-0.372	0.953	0.366	0.9	-5.8	97.2	97.3	0.11
DpaiT Tfr	0.007	0.004	-0.007	-0.004	0.0	0.0	97.2	96.7	0.50
T40.2-DpaiV	-0.007	-0.004	0.007	-0.002	0.0	-6.8	97.3	97.3	0.00
DpaiV Tfr	0.007	0.004	-0.007	-0.004	0.0	0.0	97.3	96.8	0.50
T10.10-DVH	-0.090	-0.058	0.090	0.058	0.0	0.0	94.0	94.0	0.02
DVH Tfr	0.090	0.058	-0.087	-0.054	2.3	3.4	94.0	90.6	3.32
T10.6-Dzo	-0.088	-0.055	0.088	0.054	0.0	-1.1	96.9	96.9	0.00
Dzo Tfr	0.088	0.055	-0.088	-0.054	0.5	0.8	96.9	96.1	0.78
Forest.O-RGH	0.051	0.033	-0.051	-0.033	0.0	0.0	92.8	92.8	0.00
T10.13-Forest.O	-0.062	-0.039	0.062	0.039	0.0	0.0	92.8	92.8	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Forest.O Tfr	0.011	0.007	-0.010	-0.007	0.0	0.1	92.8	92.3	0.49
Glng(PWD-Wdra)	0.114	0.061	-0.114	-0.066	0.0	-5.6	97.5	97.5	0.01
T20.1-Glng PWD	-0.150	-0.084	0.150	0.082	0.0	-1.7	97.5	97.5	0.00
Glng PWD Tfr	0.036	0.023	-0.035	-0.022	0.7	1.0	97.5	95.0	2.52
Glng V Tfr	-0.058	-0.036	0.060	0.039	1.9	2.8	93.2	97.5	4.24
Glng(Wdra-V)	-0.060	-0.039	0.060	0.031	0.0	-7.3	97.5	97.5	0.01
Glng Wdra Tfr	0.054	0.035	-0.053	-0.033	1.5	2.3	97.5	93.6	3.84
T10.1-GomC	-0.019	-0.012	0.019	0.012	0.0	-0.4	97.2	97.2	0.00
GomC Tfr	0.019	0.012	-0.018	-0.011	0.5	0.7	97.2	93.8	3.38
Goshing Trong-T20.20	0.237	0.097	-0.237	-0.100	0.1	-3.8	96.2	96.2	0.03
T20.20-Goshing Trong	-0.243	-0.100	0.243	0.099	0.0	-0.9	96.2	96.2	0.01
T20.5-Gphu Zero	-0.016	-0.010	0.016	0.010	0.0	-0.1	96.7	96.7	0.00
Gphu Zero Tfr	0.016	0.010	-0.016	-0.010	0.1	0.2	96.7	95.6	1.12
ICT PWD	-0.642	-0.414	0.646	0.440	4.5	26.8	94.6	96.9	2.29
ICT-Ttib TownB	0.148	0.130	-0.148	-0.129	0.4	0.1	94.0	93.8	0.19
ICT-YlaptsaA	0.117	0.077	-0.116	-0.077	0.4	0.1	94.0	93.8	0.27
ICT T50	-0.265	-0.206	0.270	0.215	5.7	8.5	94.0	96.7	2.71
Jakhring-Jardgla	0.038	0.022	-0.038	-0.023	0.0	-0.5	96.4	96.4	0.00
T20.9-Jakhring	-0.050	-0.030	0.050	0.030	0.0	-0.7	96.4	96.4	0.00
Jakhring Tfr	0.013	0.008	-0.012	-0.008	0.2	0.3	96.4	94.1	2.27
Jamphu-TshibiA	0.029	0.015	-0.029	-0.018	0.0	-3.1	96.3	96.3	0.00
T20.17-Jamphu	-0.035	-0.019	0.035	0.019	0.0	-0.6	96.3	96.3	0.00
T20.10-Jangdla	-0.012	-0.008	0.012	0.007	0.0	-0.1	96.4	96.4	0.00
Jangdla Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	96.4	94.2	2.16
Jardgla-T20.10	0.025	0.014	-0.025	-0.015	0.0	-0.6	96.4	96.4	0.00
Jardgla Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	96.4	94.1	2.35
Wadang-Jasar	-0.030	-0.018	0.030	0.017	0.0	-1.6	96.1	96.1	0.00
Jawlg-Samth	0.234	0.116	-0.233	-0.121	0.0	-4.7	96.1	96.1	0.02
Ythg-Jawlg	-0.240	-0.120	0.240	0.116	0.0	-4.2	96.1	96.1	0.02
Kaktong(BHU-Schl)	0.160	0.078	-0.160	-0.079	0.0	-1.5	96.0	96.0	0.01
T20.26-Kaktong	-0.173	-0.087	0.173	0.078	0.1	-8.7	96.0	96.1	0.05
Kaktong(BHU) Tfr	0.014	0.009	-0.013	-0.008	0.3	0.4	96.0	93.6	2.47
Kaktong(Schl)-Urti	0.143	0.069	-0.143	-0.072	0.0	-3.4	96.0	96.0	0.02
Kaktong(Schl) Tfr	0.017	0.011	-0.016	-0.010	0.4	0.6	96.0	93.0	3.02
Kalamti-PramJ	0.102	0.025	-0.102	-0.038	0.0	-12.9	96.5	96.5	0.04
T20.7-Kalamti	-0.115	-0.033	0.115	0.023	0.0	-9.4	96.5	96.5	0.03
T20.28-Kamalung	-0.042	-0.025	0.042	0.025	0.0	-0.7	96.0	96.0	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
	MW	Mvar	MW	Mvar	kW	kvar	From	To	
Kamalung Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	96.0	93.6	2.32
KD Smill-T50.4	0.039	0.025	-0.039	-0.025	0.0	0.0	93.4	93.3	0.06
T50.3-KD Smill	-0.086	-0.055	0.088	0.055	1.7	0.1	93.4	95.1	1.75
KD Smill Tfr	0.047	0.030	-0.046	-0.029	1.1	1.6	93.4	90.4	2.93
Khomsr-T40.25	0.032	0.018	-0.032	-0.019	0.0	-0.8	96.1	96.1	0.00
T40.23-Khomsr	-0.049	-0.029	0.049	0.028	0.0	-1.0	96.1	96.1	0.00
Khomsr Tfr	0.017	0.011	-0.016	-0.010	0.4	0.6	96.1	93.2	2.98
Kkhar Tfr	-0.021	-0.013	0.021	0.014	0.6	0.9	93.1	97.0	3.86
T40.5-Kkhar	-0.021	-0.014	0.021	0.011	0.0	-2.7	97.0	97.0	0.00
KphuI-T10.21	0.077	0.047	-0.077	-0.048	0.0	-0.8	96.8	96.8	0.00
T10.20-KphuI	-0.089	-0.055	0.089	0.050	0.0	-4.9	96.8	96.8	0.01
KphuI Tfr	0.012	0.008	-0.012	-0.008	0.2	0.3	96.8	94.6	2.22
Kphu(V-VI)	0.042	0.026	-0.042	-0.027	0.0	-0.2	96.8	96.8	0.00
T10.21-KphuV	-0.050	-0.031	0.050	0.031	0.0	-0.2	96.8	96.8	0.00
KphuVI-T10.22	0.040	0.025	-0.040	-0.026	0.0	-0.3	96.8	96.8	0.00
KphuVI Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	96.8	96.4	0.39
T10.22-KphuVII	-0.036	-0.023	0.036	0.023	0.0	-0.1	96.8	96.8	0.00
KphuVII Tfr	0.024	0.016	-0.024	-0.015	0.8	1.2	96.8	92.4	4.40
T20.6-L.Kamjong	-0.011	-0.007	0.011	0.006	0.0	-0.7	96.6	96.6	0.00
L.Kamjong Tfr	0.011	0.007	-0.010	-0.006	0.1	0.2	96.6	94.8	1.88
Lamthang (L-U)	0.247	0.099	-0.247	-0.101	0.0	-1.9	96.3	96.3	0.02
Shelgbi-L.Lamthang	-0.257	-0.105	0.257	0.103	0.1	-2.8	96.3	96.3	0.02
L.Lamthang Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	96.3	94.5	1.81
L.Limapong-T20.22	0.224	0.092	-0.224	-0.093	0.0	-0.2	96.2	96.2	0.00
T20.21-L.Limapong	-0.234	-0.099	0.234	0.099	0.0	-0.2	96.2	96.2	0.00
L.Limapong Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	96.2	94.4	1.81
Nshong (L-M)	0.053	0.029	-0.053	-0.029	0.0	-0.4	96.2	96.2	0.00
T40.17-L.Nshong	-0.053	-0.029	0.053	0.024	0.0	-5.0	96.2	96.2	0.01
L.Nshong Tfr	0.000	0.000	0.000	0.000			96.2	96.2	
Scholing (L-U)	0.208	0.084	-0.208	-0.085	0.0	-1.3	96.2	96.2	0.01
T20.22-L.Scholing	-0.212	-0.086	0.212	0.085	0.0	-0.9	96.2	96.2	0.01
Lalng-T40.27	0.287	0.141	-0.287	-0.142	0.0	-0.9	96.1	96.1	0.01
Lalng Tfr	0.018	0.011	-0.017	-0.011	0.4	0.6	96.1	92.9	3.22
T20.10-Langdbi Schl	-0.013	-0.008	0.013	0.007	0.0	-0.6	96.4	96.4	0.00
Langdbi Schl Tfr	0.013	0.008	-0.012	-0.008	0.2	0.3	96.4	94.1	2.27
Langman-Zangbi	0.036	0.008	-0.036	-0.014	0.0	-5.3	96.3	96.3	0.01
T20.19-Langman	-0.037	-0.009	0.037	0.006	0.0	-3.3	96.3	96.3	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Gphu(L-U)	0.081	0.048	-0.081	-0.052	0.0	-3.3	96.7	96.7	0.01
T20.4-LGphu	-0.094	-0.056	0.094	0.054	0.0	-1.8	96.7	96.7	0.01
LGphu Tfr	0.012	0.008	-0.012	-0.008	0.1	0.1	96.7	95.9	0.86
Llgang-T40.12	0.058	0.029	-0.058	-0.032	0.0	-2.8	96.6	96.6	0.00
T40.11-Llgang	-0.062	-0.032	0.062	0.029	0.0	-3.3	96.6	96.6	0.00
LT School Tfr	-0.022	-0.014	0.023	0.015	0.7	1.0	92.5	96.6	4.09
T40.13-LT.School	-0.023	-0.015	0.023	0.015	0.0	-0.2	96.6	96.6	0.00
LTsa(A-B)	0.018	0.011	-0.018	-0.011	0.0	-0.9	96.0	96.0	0.00
T40.29-LTsaA	-0.036	-0.022	0.036	0.021	0.0	-1.2	96.0	96.0	0.00
LTsaA Tfr	0.018	0.012	-0.018	-0.011	0.4	0.7	96.0	92.7	3.25
LTsaB Tfr	0.018	0.011	-0.017	-0.011	0.4	0.6	96.0	92.8	3.22
LWomlgA-Shingkr.Scl	0.081	0.045	-0.081	-0.047	0.0	-2.2	96.0	96.0	0.00
Womlg(LB-LA)	-0.102	-0.058	0.102	0.057	0.0	-0.9	96.0	96.0	0.00
LWomlgA Tfr	0.020	0.013	-0.020	-0.012	0.6	0.9	96.0	92.3	3.70
Womlg(M-LB)	-0.108	-0.061	0.108	0.061	0.0	-0.4	96.0	96.0	0.00
M.Nshong-T40.18	0.033	0.017	-0.033	-0.017	0.0	-0.3	96.2	96.2	0.00
M.Nshong Tfr	0.019	0.012	-0.019	-0.012	0.5	0.8	96.2	92.7	3.50
T40.33-Mayungbi	-0.017	-0.011	0.017	0.008	0.0	-2.7	96.0	96.0	0.00
Mayungbi Tfr	0.017	0.011	-0.017	-0.011	0.4	0.6	96.0	92.8	3.15
Olangbi-Mewagg	-0.027	-0.016	0.027	0.013	0.0	-2.6	96.3	96.3	0.00
T40.30-MWomlg	-0.128	-0.074	0.128	0.074	0.0	0.0	96.0	96.0	0.00
MWomlg Tfr	0.020	0.013	-0.020	-0.012	0.6	0.8	96.0	92.3	3.66
NI Tfr	-0.016	-0.010	0.016	0.010	0.3	0.5	94.0	96.8	2.85
Nabji(I-II)	0.054	0.029	-0.054	-0.033	0.0	-4.0	96.8	96.8	0.00
T10.20-NabjiI	-0.063	-0.035	0.063	0.032	0.0	-2.4	96.8	96.8	0.00
NabjiI Tfr	0.009	0.006	-0.009	-0.005	0.1	0.2	96.8	95.2	1.59
NabjiII-T10.23	0.042	0.025	-0.042	-0.025	0.0	-0.1	96.8	96.8	0.00
NabjiII Tfr	0.012	0.008	-0.012	-0.007	0.3	0.5	96.8	93.4	3.41
Nabji(III-IV)	0.012	0.007	-0.012	-0.008	0.0	-0.1	96.8	96.8	0.00
T10.23-NabjiIII	-0.021	-0.013	0.021	0.013	0.0	-0.6	96.8	96.8	0.00
NabjiIII Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	96.8	95.2	1.63
NabjiIV Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	96.8	94.7	2.12
Nabji(V-VI)	0.012	0.007	-0.012	-0.008	0.0	-0.6	96.8	96.8	0.00
T10.23-NabjiV	-0.021	-0.013	0.021	0.013	0.0	-0.2	96.8	96.8	0.00
NabjiV Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	96.8	95.1	1.66
NabjiVI Tfr	0.012	0.008	-0.011	-0.007	0.3	0.4	96.8	93.5	3.30
T40.25-Nawabi	-0.018	-0.012	0.018	0.011	0.0	-0.4	96.1	96.1	0.00

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Nawabi Tfr	0.018	0.012	-0.018	-0.011	0.4	0.7	96.1	92.9	3.26
Ngala Trng-T20.28	0.109	0.053	-0.109	-0.066	0.1	-13.0	96.0	96.0	0.05
T20.27-Ngala Trng	-0.124	-0.063	0.124	0.062	0.0	-0.9	96.0	96.0	0.00
Ngala Trng Tfr	0.015	0.010	-0.015	-0.009	0.3	0.5	96.0	93.3	2.71
NI-NII	0.009	0.005	-0.009	-0.006	0.0	-0.3	96.8	96.8	0.00
T10.15-NI	-0.025	-0.016	0.025	0.015	0.0	-0.2	96.8	96.8	0.00
NII Tfr	0.009	0.006	-0.009	-0.005	0.1	0.2	96.8	95.3	1.59
T10.15-NIII	-0.008	-0.005	0.008	0.004	0.0	-0.3	96.8	96.8	0.00
NIII Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	96.8	95.5	1.35
T10.16-NIV	-0.010	-0.006	0.010	0.006	0.0	-0.2	96.8	96.8	0.00
NIV Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	96.8	95.1	1.74
T40.1-NRDCL	-0.015	-0.010	0.015	0.009	0.0	-0.6	97.5	97.5	0.00
NRDCL Tfr	0.015	0.010	-0.015	-0.010	0.0	0.0	97.5	97.4	0.11
NV(V-VI)	0.170	0.072	-0.170	-0.072	0.0	-0.4	96.8	96.8	0.00
T10.16-NV	-0.175	-0.075	0.176	0.074	0.0	-0.2	96.8	96.8	0.00
NV Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.8	96.0	0.89
NVI-T10.17	0.168	0.071	-0.168	-0.071	0.0	-0.1	96.8	96.8	0.00
T10.17-NVII	-0.005	-0.003	0.005	0.003	0.0	-0.1	96.8	96.8	0.00
NVII Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.8	96.0	0.85
T10.18-NVIII	-0.009	-0.005	0.009	0.005	0.0	-0.1	96.8	96.8	0.00
NVIII Tfr	0.009	0.005	-0.008	-0.005	0.1	0.1	96.8	95.3	1.52
Nykhar-T40.11	0.068	0.032	-0.068	-0.033	0.0	-0.9	96.6	96.6	0.00
T40.10-Nykhar	-0.080	-0.039	0.080	0.016	0.0	-22.7	96.6	96.7	0.03
Nykhar Tfr	0.012	0.007	-0.012	-0.007	0.1	0.1	96.6	95.8	0.82
Zangbi-Olangbi	-0.036	-0.018	0.036	0.013	0.0	-5.0	96.3	96.3	0.01
Panabi-T20.16	0.061	0.015	-0.061	-0.019	0.0	-4.1	96.4	96.4	0.00
Wamjrla-Panabi	-0.065	-0.017	0.065	0.015	0.0	-2.1	96.4	96.4	0.00
T50.4-Pemala Smill	-0.022	-0.014	0.022	0.014	0.0	0.0	93.3	93.3	0.01
Pemala Smill Tfr	0.022	0.014	-0.021	-0.013	0.6	0.8	93.3	89.9	3.36
T40.18-Phthang	-0.015	-0.010	0.015	0.006	0.0	-4.0	96.2	96.2	0.00
Phthang Tfr	0.015	0.010	-0.015	-0.009	0.3	0.5	96.2	93.5	2.74
Pkobi-T20.8	0.069	0.018	-0.069	-0.019	0.0	-1.0	96.5	96.5	0.00
PramJ-Pkobi	-0.085	-0.028	0.085	0.028	0.0	-0.6	96.5	96.5	0.00
T20.13-Plangtoe	-0.004	-0.003	0.004	0.001	0.0	-1.8	96.4	96.4	0.00
Plangtoe Tfr	0.004	0.003	-0.004	-0.003	0.0	0.1	96.4	95.2	1.20
Ptang I Tfr	-0.026	-0.016	0.027	0.018	1.0	1.5	91.4	96.4	4.95
Ptang I-T20.14	0.442	0.155	-0.441	-0.156	0.0	-1.3	96.4	96.4	0.01

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T20.13-Ptang	-0.469	-0.173	0.469	0.169	0.1	-4.1	96.4	96.4	0.04
T20.14-Ptang II	-0.029	-0.019	0.029	0.019	0.0	-0.3	96.4	96.4	0.00
Ptang II Tfr	0.029	0.019	-0.028	-0.017	1.2	1.7	96.4	91.1	5.28
T10.13-PWD	-0.063	-0.040	0.063	0.040	0.0	0.0	92.8	92.8	0.02
PWD Tfr	0.063	0.040	-0.062	-0.038	1.1	1.7	92.8	90.4	2.34
PWD Mangdichu-T50.2	-0.149	-0.064	0.149	0.064	0.2	0.1	93.9	94.1	0.16
Ttibi BOD-PWD Mangdichu	0.080	0.018	-0.080	-0.018	0.1	0.0	93.9	93.8	0.08
PWD Mangdichu Tfr	0.069	0.046	-0.066	-0.041	3.4	5.2	93.9	87.5	6.46
T10.8-RDTC B	-0.036	-0.023	0.036	0.022	0.0	-0.3	96.9	96.9	0.00
RDTC Tfr	0.036	0.023	-0.036	-0.022	0.1	0.1	96.9	96.5	0.32
RGH Tfr	0.051	0.033	-0.050	-0.031	1.3	1.9	92.8	89.6	3.19
T10.9-RMBF	-0.005	-0.003	0.005	-0.005	0.0	-8.0	96.9	96.9	0.00
RMBF Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.9	96.5	0.32
Rmya-T40.8	0.041	0.004	-0.041	-0.006	0.0	-2.6	96.8	96.8	0.00
T40.7-Rmya	-0.043	-0.005	0.043	-0.001	0.0	-6.1	96.8	96.8	0.00
Samth-T40.28	0.218	0.111	-0.218	-0.121	0.1	-10.1	96.1	96.0	0.05
Samth Tfr	0.016	0.010	-0.015	-0.010	0.3	0.5	96.1	93.2	2.84
Sanglung-T20.26	0.178	0.075	-0.178	-0.081	0.1	-6.0	96.1	96.1	0.04
Ttibi Lichbi-Sanglung	-0.180	-0.076	0.180	0.071	0.1	-5.2	96.1	96.2	0.03
Sansiri-T20.1	0.338	0.123	-0.338	-0.125	0.0	-1.8	96.4	96.4	0.01
T20.15-Sansiri	-0.345	-0.128	0.345	0.127	0.0	-0.2	96.4	96.4	0.00
Sansiri Tfr	0.007	0.005	-0.007	-0.005	0.1	0.1	96.4	95.0	1.32
Wangbi-Selingtoe	-0.019	-0.012	0.019	0.006	0.0	-5.3	96.3	96.3	0.00
Shelgbi Tfr	0.016	0.010	-0.016	-0.010	0.3	0.5	96.3	93.4	2.89
Shingkr.Scl-T40.31	0.063	0.036	-0.063	-0.036	0.0	-0.4	96.0	96.0	0.00
Shingkr.Scl Tfr	0.018	0.012	-0.018	-0.011	0.4	0.7	96.0	92.7	3.25
Station/Colony Tfr	-0.024	-0.015	0.024	0.015	0.2	0.3	95.8	96.9	1.07
T20.3-Subrg	-0.027	-0.017	0.027	0.011	0.0	-6.0	96.9	96.9	0.01
Subrg Tfr	0.027	0.017	-0.027	-0.017	0.4	0.6	96.9	95.0	1.92
Surpng-T20.19	0.039	0.007	-0.039	-0.007	0.0	-0.1	96.3	96.3	0.00
Yongkp-Surpng	-0.042	-0.009	0.042	0.008	0.0	-1.0	96.3	96.3	0.00
L1-T10.1	-1.053	-0.606	1.057	0.589	3.9	-16.5	97.2	97.7	0.43
T10(1-2)	1.034	0.594	-1.031	-0.606	2.8	-12.1	97.2	96.9	0.31
T10(2-3)	0.251	0.101	-0.251	-0.104	0.0	-3.2	96.9	96.9	0.01
T10(2-6)	0.781	0.505	-0.781	-0.507	0.2	-1.4	96.9	96.9	0.03
T10(3-4)	0.233	0.093	-0.233	-0.098	0.0	-4.5	96.9	96.9	0.02
T10(4-5)	0.015	0.008	-0.015	-0.009	0.0	-0.4	96.9	96.9	0.00

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T10(4-14)	0.218	0.089	-0.218	-0.100	0.1	-10.4	96.9	96.8	0.04
T10(6-7)	0.692	0.453	-0.692	-0.454	0.1	-1.1	96.9	96.9	0.02
T10(7-8)	0.046	0.013	-0.046	-0.014	0.0	-0.4	96.9	96.9	0.00
T10(T8-T9)	0.010	-0.009	-0.010	0.002	0.0	-6.2	96.9	96.9	0.00
T10(11-12)	0.274	0.175	-0.273	-0.174	0.3	0.3	93.1	93.0	0.11
T10(14-15)	0.032	0.019	-0.032	-0.020	0.0	-0.4	96.8	96.8	0.00
T10(14-16)	0.185	0.080	-0.185	-0.080	0.0	-0.2	96.8	96.8	0.00
T10(17-18)	0.164	0.068	-0.164	-0.068	0.0	-0.2	96.8	96.8	0.00
T10(18-19)	0.155	0.063	-0.155	-0.082	0.1	-19.3	96.8	96.8	0.05
T10(19-20)	0.152	0.080	-0.152	-0.082	0.0	-1.4	96.8	96.8	0.00
L1-T20.1	-1.099	-0.394	1.100	0.386	1.5	-7.2	97.5	97.7	0.16
T20.1-Tlajong	0.949	0.312	-0.948	-0.317	0.9	-5.7	97.5	97.4	0.11
T20(2-3)	0.854	0.263	-0.851	-0.287	2.9	-24.5	97.3	96.9	0.40
T20.2-Zphey	0.051	0.032	-0.051	-0.033	0.0	-0.6	97.3	97.3	0.00
Tlajong-T20.2	-0.905	-0.295	0.905	0.290	0.7	-4.9	97.3	97.4	0.09
T20(3-4)	0.824	0.276	-0.823	-0.286	1.1	-9.9	96.9	96.7	0.16
T20(4-5)	0.729	0.232	-0.729	-0.237	0.4	-5.1	96.7	96.7	0.07
T20(5-7)	0.615	0.184	-0.614	-0.197	0.8	-13.1	96.7	96.5	0.15
T20.6-U.Kamjong	0.075	0.039	-0.075	-0.040	0.0	-1.1	96.6	96.6	0.00
T20(7-11)	0.500	0.174	-0.500	-0.174	0.0	-0.3	96.5	96.5	0.00
T20(8-9)	0.062	0.015	-0.062	-0.037	0.0	-21.9	96.5	96.4	0.05
T20(11-12)	0.487	0.166	-0.487	-0.170	0.1	-3.7	96.5	96.5	0.03
T20.12-Umpala	0.476	0.163	-0.476	-0.167	0.1	-3.4	96.5	96.5	0.03
Umpala-T20.13	-0.473	-0.169	0.473	0.165	0.2	-4.3	96.4	96.5	0.04
T20(14-15)	0.412	0.138	-0.412	-0.140	0.1	-2.1	96.4	96.4	0.02
T20.15-Wamjla	0.067	0.012	-0.067	-0.017	0.0	-4.6	96.4	96.4	0.00
T20(16-17)	0.061	0.019	-0.061	-0.027	0.0	-7.8	96.4	96.3	0.01
T20.17-Wangbi	0.026	0.009	-0.026	-0.011	0.0	-2.1	96.3	96.3	0.00
T20.18-Wangling	0.048	0.007	-0.048	-0.008	0.0	-1.1	96.4	96.3	0.00
U.Lamthang-T20.20	-0.245	-0.100	0.245	0.100	0.0	-0.6	96.2	96.3	0.00
T20.22-U.Limapong	0.012	0.007	-0.012	-0.008	0.0	-0.4	96.2	96.2	0.00
T20(23-24)	0.198	0.079	-0.198	-0.081	0.0	-1.8	96.2	96.2	0.01
U.Scholing-T20.23	-0.200	-0.080	0.200	0.080	0.0	0.0	96.2	96.2	0.00
T20(24-25)	0.195	0.079	-0.195	-0.079	0.0	-0.3	96.2	96.2	0.00
T20.25-Ttibi Lichbi	0.193	0.078	-0.193	-0.079	0.0	-1.1	96.2	96.2	0.01
Urti-Tab20.28	-0.125	-0.063	0.125	0.061	0.0	-1.8	96.0	96.0	0.01
L1-T30.1	-0.201	-0.128	0.201	0.128	0.2	-0.1	96.8	96.9	0.10

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T30(1-2)	0.196	0.125	-0.196	-0.125	0.1	0.0	96.8	96.7	0.04
T30.2-Takabi	0.127	0.082	-0.127	-0.082	0.2	-0.3	96.7	96.6	0.15
T30.2-Tama	0.069	0.043	-0.069	-0.044	0.1	-0.7	96.7	96.6	0.09
L1-T40.1	-0.978	-0.360	0.979	0.354	1.1	-6.6	97.5	97.7	0.13
T40(1-2)	0.963	0.351	-0.961	-0.364	2.0	-12.3	97.5	97.3	0.24
T40(3-4)	0.052	0.019	-0.052	-0.027	0.0	-8.2	97.0	97.0	0.01
T40(3-6)	0.847	0.329	-0.846	-0.337	1.0	-7.8	97.0	96.8	0.13
Tali-T40.3	-0.899	-0.349	0.899	0.348	0.0	0.0	97.0	97.0	0.00
T40(4-5)	0.046	0.024	-0.046	-0.026	0.0	-2.4	97.0	97.0	0.00
T40(6-7)	0.045	0.000	-0.045	0.000	0.0	-0.6	96.8	96.8	0.00
T40(6-10)	0.801	0.337	-0.800	-0.347	1.1	-10.1	96.8	96.7	0.17
T40(8-9)	0.028	-0.001	-0.028	0.000	0.0	-1.2	96.8	96.8	0.00
T40.9-Zhoblg	0.017	0.004	-0.017	-0.011	0.0	-6.8	96.8	96.8	0.00
T40(10-14)	0.720	0.331	-0.720	-0.332	0.0	-0.3	96.7	96.7	0.00
T40(12-13)	0.042	0.025	-0.042	-0.026	0.0	-1.0	96.6	96.6	0.00
T40.12-TSchool	0.016	0.007	-0.016	-0.010	0.0	-2.9	96.6	96.6	0.00
T40.13-UT	0.019	0.011	-0.019	-0.012	0.0	-0.9	96.6	96.6	0.00
T40(14-15)	0.690	0.313	-0.690	-0.316	0.2	-2.8	96.7	96.6	0.04
T40(16-17)	0.494	0.229	-0.494	-0.233	0.2	-4.1	96.3	96.2	0.04
T40.17-Thjong	0.441	0.210	-0.441	-0.210	0.0	-0.2	96.2	96.2	0.00
T40.18-U.Nshong	0.018	0.012	-0.018	-0.012	0.0	-0.2	96.2	96.2	0.00
T40(19-210)	0.424	0.203	-0.424	-0.206	0.1	-3.6	96.2	96.2	0.03
Thjong-T40.19	-0.424	-0.203	0.424	0.199	0.1	-3.6	96.2	96.2	0.03
T40(20-21)	0.117	0.059	-0.117	-0.064	0.0	-4.8	96.2	96.1	0.01
T40.21-Wagar	0.115	0.062	-0.115	-0.064	0.0	-1.4	96.1	96.1	0.00
T40(22-23)	0.090	0.050	-0.090	-0.052	0.0	-1.6	96.1	96.1	0.00
Wagar-T40.22	-0.112	-0.063	0.112	0.062	0.0	-1.2	96.1	96.1	0.00
T40.22-Wadang	0.041	0.024	-0.041	-0.024	0.0	-0.1	96.1	96.1	0.00
T40(25-26)	0.014	0.008	-0.014	-0.009	0.0	-0.7	96.1	96.1	0.00
T40(28-29)	0.062	0.034	-0.062	-0.036	0.0	-2.9	96.0	96.0	0.00
T40(28-30)	0.156	0.087	-0.156	-0.091	0.0	-3.5	96.0	96.0	0.01
T40.29-UTsa.B	0.018	0.010	-0.018	-0.011	0.0	-1.1	96.0	96.0	0.00
T40(31-33)	0.035	0.019	-0.035	-0.019	0.0	-0.2	96.0	96.0	0.00
T40.33-Umchagg	0.018	0.010	-0.018	-0.011	0.0	-0.8	96.0	96.0	0.00
L1-T50.1	-0.270	-0.215	0.271	0.215	0.4	0.1	96.7	96.9	0.13
T50(2-3)	-0.180	-0.084	0.182	0.085	1.9	0.8	94.1	95.1	1.02
T50.2-Ttibi DoR	0.031	0.020	-0.031	-0.020	0.0	0.0	94.1	94.1	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T50.3-Hydel B	-0.270	-0.140	0.271	0.140	1.1	0.5	95.1	95.5	0.39
Takabi-Takabi Fishery	0.105	0.069	-0.105	-0.069	0.2	-0.4	96.6	96.4	0.16
Takabi Tfr	0.021	0.014	-0.021	-0.013	0.2	0.4	96.6	95.1	1.52
Takabi Fishery Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	96.4	94.6	1.84
Tali Tfr	0.045	0.029	-0.044	-0.027	1.1	1.6	97.0	93.8	3.20
Tama-Tama Gonpai	0.011	0.007	-0.011	-0.007	0.0	-0.3	96.6	96.6	0.01
Tama Tfr	0.058	0.038	-0.056	-0.035	1.8	2.7	96.6	92.5	4.16
Tama Gonpai Tfr	0.011	0.007	-0.011	-0.007	0.2	0.2	96.6	94.7	1.94
Thjong Tfr	0.017	0.011	-0.016	-0.010	0.4	0.6	96.2	93.2	3.02
Ttibi Sub Tfr1	0.249	0.181	-0.248	-0.179	1.5	2.2	97.7	96.9	0.79
Ttibi Sub Tfr2	0.249	0.181	-0.248	-0.179	1.5	2.2	97.7	96.9	0.79
Ttibi Sub Tfr3	-1.817	-0.846	1.849	0.893	31.2	46.7	97.7	100.0	2.35
Ttibi Sub Tfr4	-1.817	-0.846	1.849	0.893	31.2	46.7	97.7	100.0	2.35
Tingtibi HPP Tfr	0.280	0.154	-0.271	-0.140	9.1	13.6	100.0	95.5	4.51
Tlajong Tfr	0.042	0.027	-0.041	-0.026	0.9	1.4	97.4	94.4	2.99
TSchool Tfr	0.016	0.010	-0.015	-0.010	0.3	0.5	96.6	93.8	2.81
TshibiA Tfr	0.017	0.011	-0.017	-0.010	0.4	0.6	96.3	93.3	3.05
Ttibi TownA-BOD	0.028	-0.015	-0.028	0.015	0.0	0.0	93.8	93.8	0.01
Ttibi BOD Tfr	0.051	0.033	-0.050	-0.031	1.2	1.9	93.8	90.7	3.15
Ttibi DoR Tfr	0.031	0.020	-0.031	-0.019	0.5	0.7	94.1	92.2	1.92
Ttibi Lichbi Tfr	0.012	0.008	-0.012	-0.008	0.2	0.3	96.2	93.9	2.24
Ttibi TownB Tfr	-0.107	-0.066	0.110	0.071	3.5	5.2	89.7	93.8	4.10
Ttibi Town(B-A)	-0.037	-0.058	0.037	0.058	0.0	0.0	93.8	93.8	0.00
Ttibi TownA Tfr	0.066	0.043	-0.063	-0.039	3.1	4.7	93.8	87.7	6.15
U.Limapong Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	96.2	94.0	2.16
U.Nshong Tfr	0.018	0.012	-0.018	-0.011	0.5	0.7	96.2	92.9	3.29
U.Scholing Tfr	0.007	0.005	-0.007	-0.005	0.1	0.1	96.2	94.9	1.32
UGphu Tfr	0.069	0.044	-0.068	-0.042	1.3	1.9	96.7	94.3	2.46
Umchagg Tfr	0.018	0.011	-0.017	-0.011	0.4	0.6	96.0	92.8	3.18
Urti Tfr	0.018	0.011	-0.017	-0.011	0.4	0.6	96.0	92.8	3.17
UT Tfr	0.019	0.012	-0.019	-0.012	0.5	0.7	96.6	93.2	3.44
UTsa.B Tfr1	0.018	0.011	-0.017	-0.011	0.4	0.6	96.0	92.8	3.18
Wadang Tfr	0.011	0.007	-0.011	-0.007	0.2	0.3	96.1	94.1	2.04
Ylaptsa(A-B)	0.075	0.050	-0.075	-0.050	0.1	0.0	93.8	93.7	0.07
YlaptsaA Tfr	0.041	0.026	-0.040	-0.024	1.2	1.8	93.8	90.0	3.78
YlaptsaB Tfr	0.075	0.050	-0.071	-0.044	4.2	6.2	93.7	86.6	7.10
Ythg Tfr	0.016	0.010	-0.015	-0.009	0.3	0.5	96.1	93.3	2.81

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Zhoblg Tfr	0.017	0.011	-0.016	-0.010	0.4	0.5	96.8	93.9	2.96
Zphey Tfr	0.051	0.033	-0.050	-0.031	1.4	2.1	97.3	93.7	3.61
					206.8	-397.7			

Alert Summary Report

	% Alert Settings	
	Critical	**Marginal**
Loading		
Bus	100.0	95.0
Cable	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	110.0	105.0
UnderVoltage	90.0	95.0
Generator Excitation		
OverExcited (Q Max.)	100.0	95.0
UnderExcited (Q Min.)	100.0	

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
BDYT.H B2	Bus	Under Voltage	0.415	kV	0.373	89.8	3-Phase
Berti B2	Bus	Under Voltage	0.415	kV	0.37	89.4	3-Phase
Berti Tfr	Transformer	Overload	0.063	MVA	0.11	180.9	3-Phase
BuliA Tfr	Transformer	Overload	0.063	MVA	0.07	108.1	3-Phase
Dmang V1 Tfr	Transformer	Overload	0.025	MVA	0.04	150.8	3-Phase
Dmang V2 Tfr	Transformer	Overload	0.025	MVA	0.03	109.6	3-Phase
DPokto B2	Bus	Under Voltage	0.415	kV	0.37	88.6	3-Phase
DPokto Tfr	Transformer	Overload	0.063	MVA	0.09	148.5	3-Phase
Glng V Tfr	Transformer	Overload	0.063	MVA	0.07	113.0	3-Phase
Glng Wdra Tfr	Transformer	Overload	0.063	MVA	0.06	102.6	3-Phase
Kkhar Tfr	Transformer	Overload	0.025	MVA	0.03	102.3	3-Phase
KphuVII Tfr	Transformer	Overload	0.025	MVA	0.03	116.5	3-Phase
LT School Tfr	Transformer	Overload	0.025	MVA	0.03	108.1	3-Phase
Pemala Smill B2	Bus	Under Voltage	0.415	kV	0.37	89.9	3-Phase
Ptang I Tfr	Transformer	Overload	0.025	MVA	0.03	130.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Ptang II Tfr	Transformer	Overload	0.025	MVA	0.035	139.0	3-Phase
PWD Mangdichu B2	Bus	Under Voltage	0.415	kV	0.36	87.5	3-Phase
PWD Mangdichu Tfr	Transformer	Overload	0.050	MVA	0.08	165.6	3-Phase
RGH B2	Bus	Under Voltage	0.415	kV	0.37	89.6	3-Phase
Tama Tfr	Transformer	Overload	0.063	MVA	0.07	109.9	3-Phase
Tingtibi HPP	Generator	Overload	0.200	MW	0.28	140.2	3-Phase
Tingtibi HPP Tfr	Transformer	Overload	0.250	MVA	0.32	127.9	3-Phase
Ttibi Town B2	Bus	Under Voltage	0.415	kV	0.37	89.7	3-Phase
Ttibi TownA B2	Bus	Under Voltage	0.415	kV	0.36	87.7	3-Phase
Ttibi TownA Tfr	Transformer	Overload	0.050	MVA	0.08	157.5	3-Phase
Ttibi TownB Tfr	Transformer	Overload	0.125	MVA	0.13	105.2	3-Phase
YlaptsaA B2	Bus	Under Voltage	0.415	kV	0.37	90.0	3-Phase
YlaptsaB B2	Bus	Under Voltage	0.415	kV	0.36	86.6	3-Phase
YlaptsaB Tfr	Transformer	Overload	0.050	MVA	0.09	181.4	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
A.ZHSS B1	Bus	Under Voltage	6.600	kV	6.143	93.1	3-Phase
A.ZHSS B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
B.ZHSS B1	Bus	Under Voltage	6.600	kV	6.14	93.1	3-Phase
B.ZHSS B2	Bus	Under Voltage	0.415	kV	0.38	90.9	3-Phase
Babshar B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
BAFRA.O B1	Bus	Under Voltage	6.600	kV	6.13	92.9	3-Phase
BAFRA.O B2	Bus	Under Voltage	0.415	kV	0.38	90.4	3-Phase
Bardang B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
BdoSch B2	Bus	Under Voltage	0.415	kV	0.39	93.1	3-Phase
BDYT.H B1	Bus	Under Voltage	6.600	kV	6.13	92.9	3-Phase
BHU B1	Bus	Under Voltage	6.600	kV	6.19	93.7	3-Phase
BHU B2	Bus	Under Voltage	0.415	kV	0.38	90.4	3-Phase
BTL B	Bus	Under Voltage	6.600	kV	6.16	93.3	3-Phase
BTL B2	Bus	Under Voltage	0.415	kV	0.38	90.6	3-Phase
BuliA B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
BuliB B2	Bus	Under Voltage	0.415	kV	0.39	93.7	3-Phase
BuliC B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Chelaibi B2	Bus	Under Voltage	0.415	kV	0.39	93.4	3-Phase
Crong B2	Bus	Under Voltage	0.415	kV	0.39	95.0	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
D.Pokto B1	Bus	Under Voltage	6.600	kV	6.231	94.4	3-Phase
Dmang V1 B2	Bus	Under Voltage	0.415	kV	0.38	90.9	3-Phase
Dmang V2 B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
DVH B1	Bus	Under Voltage	6.600	kV	6.20	94.0	3-Phase
DVH B2	Bus	Under Voltage	0.415	kV	0.38	90.6	3-Phase
Forest.O B1	Bus	Under Voltage	6.600	kV	6.12	92.8	3-Phase
Forest.O B2	Bus	Under Voltage	0.415	kV	0.38	92.3	3-Phase
Glng PWD B2	Bus	Under Voltage	0.415	kV	0.39	95.0	3-Phase
Glng Tfr B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Glng Wdra B2	Bus	Under Voltage	0.415	kV	0.39	93.6	3-Phase
GomC B2	Bus	Under Voltage	0.415	kV	0.39	93.8	3-Phase
ICT B	Bus	Under Voltage	6.600	kV	6.24	94.6	3-Phase
ICT B1	Bus	Under Voltage	6.600	kV	6.21	94.0	3-Phase
Jakhring B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
Jangdla B2	Bus	Under Voltage	0.415	kV	0.39	94.2	3-Phase
Jardgla B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
Kaktong(BHU) B2	Bus	Under Voltage	0.415	kV	0.39	93.6	3-Phase
Kaktong(Schl) B2	Bus	Under Voltage	0.415	kV	0.39	93.0	3-Phase
Kamalung B2	Bus	Under Voltage	0.415	kV	0.39	93.6	3-Phase
KD Smill B	Bus	Under Voltage	6.600	kV	6.16	93.4	3-Phase
KD Smill B2	Bus	Under Voltage	0.415	kV	0.38	90.4	3-Phase
Khomsr B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Kihar B2	Bus	Under Voltage	0.415	kV	0.39	93.1	3-Phase
KphuI B2	Bus	Under Voltage	0.415	kV	0.39	94.6	3-Phase
KphuVII B2	Bus	Under Voltage	0.415	kV	0.38	92.4	3-Phase
L.Kamjong B2	Bus	Under Voltage	0.415	kV	0.39	94.8	3-Phase
L.Lamthang B2	Bus	Under Voltage	0.415	kV	0.39	94.5	3-Phase
L.Limapong B2	Bus	Under Voltage	0.415	kV	0.39	94.4	3-Phase
Lalng B2	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
Langdbi Schl B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
LT School B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
LTsaA B2	Bus	Under Voltage	0.415	kV	0.38	92.7	3-Phase
LTsaB B2	Bus	Under Voltage	0.415	kV	0.39	92.8	3-Phase
LWomlgA B2	Bus	Under Voltage	0.415	kV	0.38	92.3	3-Phase
LWomlgA Tfr	Transformer	Overload	0.025	MVA	0.02	97.2	3-Phase
M.Nshong B2	Bus	Under Voltage	0.415	kV	0.38	92.7	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Mayungbi B2	Bus	Under Voltage	0.415	kV	0.385	92.8	3-Phase
MWomlg B2	Bus	Under Voltage	0.415	kV	0.38	92.3	3-Phase
MWomlg Tfr	Transformer	Overload	0.025	MVA	0.02	96.3	3-Phase
N1 B2	Bus	Under Voltage	0.415	kV	0.39	94.0	3-Phase
NabjiII B2	Bus	Under Voltage	0.415	kV	0.39	93.4	3-Phase
NabjiIV B2	Bus	Under Voltage	0.415	kV	0.39	94.7	3-Phase
NabjiVI B2	Bus	Under Voltage	0.415	kV	0.39	93.5	3-Phase
Nawabi B2	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
Ngala Trng B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
Pemala Smill B1	Bus	Under Voltage	6.600	kV	6.16	93.3	3-Phase
Ptang B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Ptang II B2	Bus	Under Voltage	0.415	kV	0.38	91.1	3-Phase
Pthang B2	Bus	Under Voltage	0.415	kV	0.39	93.5	3-Phase
PWD B1	Bus	Under Voltage	6.600	kV	6.12	92.8	3-Phase
PWD B2	Bus	Under Voltage	0.415	kV	0.38	90.4	3-Phase
PWD Mangdichu B	Bus	Under Voltage	6.600	kV	6.20	93.9	3-Phase
RGH B1	Bus	Under Voltage	6.600	kV	6.12	92.8	3-Phase
Samth B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Shelgbi B2	Bus	Under Voltage	0.415	kV	0.39	93.4	3-Phase
Shingkr.Scl B2	Bus	Under Voltage	0.415	kV	0.38	92.7	3-Phase
Subrg B2	Bus	Under Voltage	0.415	kV	0.39	95.0	3-Phase
T10.10	Bus	Under Voltage	6.600	kV	6.20	94.0	3-Phase
T10.11	Bus	Under Voltage	6.600	kV	6.14	93.1	3-Phase
T10.12	Bus	Under Voltage	6.600	kV	6.14	93.0	3-Phase
T10.13	Bus	Under Voltage	6.600	kV	6.12	92.8	3-Phase
T50.2	Bus	Under Voltage	6.600	kV	6.21	94.1	3-Phase
T50.4	Bus	Under Voltage	6.600	kV	6.16	93.3	3-Phase
T50H267 B	Bus	Under Voltage	6.600	kV	6.16	93.3	3-Phase
Takabi Fishery B2	Bus	Under Voltage	0.415	kV	0.39	94.6	3-Phase
Tali B2	Bus	Under Voltage	0.415	kV	0.39	93.8	3-Phase
Tama B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
Tama Gonpai B2	Bus	Under Voltage	0.415	kV	0.39	94.7	3-Phase
Thjong B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Tlajong B2	Bus	Under Voltage	0.415	kV	0.39	94.4	3-Phase
TSchool B2	Bus	Under Voltage	0.415	kV	0.39	93.8	3-Phase
TshibiA B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Ttibi BOD B1	Bus	Under Voltage	6.600	kV	6.193	93.8	3-Phase
Ttibi BOD B2	Bus	Under Voltage	0.415	kV	0.38	90.7	3-Phase
Ttibi DoR B1	Bus	Under Voltage	6.600	kV	6.21	94.1	3-Phase
Ttibi DoR B2	Bus	Under Voltage	0.415	kV	0.38	92.2	3-Phase
Ttibi LichbiB2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
Ttibi TownA B	Bus	Under Voltage	6.600	kV	6.19	93.8	3-Phase
Ttibi TownB B1	Bus	Under Voltage	6.600	kV	6.19	93.8	3-Phase
U.Limapong B2	Bus	Under Voltage	0.415	kV	0.39	94.0	3-Phase
U.Nshong B2	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
U.Scholing B2	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
UGphu B2	Bus	Under Voltage	0.415	kV	0.39	94.3	3-Phase
Umchagg B2	Bus	Under Voltage	0.415	kV	0.39	92.8	3-Phase
Urti B2	Bus	Under Voltage	0.415	kV	0.39	92.8	3-Phase
UT B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
UTsa.B B2	Bus	Under Voltage	0.415	kV	0.39	92.8	3-Phase
Wadang B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
YlaptsaA B	Bus	Under Voltage	6.600	kV	6.19	93.8	3-Phase
YlaptsaA Tfr	Transformer	Overload	0.050	MVA	0.05	96.9	3-Phase
YlaptsaB B1	Bus	Under Voltage	6.600	kV	6.18	93.7	3-Phase
Ythg B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
Zhoblg B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
Zphey B2	Bus	Under Voltage	0.415	kV	0.39	93.7	3-Phase
Zphey Tfr	Transformer	Overload	0.063	MVA	0.06	96.3	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	3.977	1.939	4.425	89.89 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	3.977	1.939	4.425	89.89 Lagging
Total Motor Load:	1.490	0.923	1.753	85.00 Lagging
Total Static Load:	2.281	1.413	2.683	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.207	-0.398		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure-5: Feeder Wise Reliability Indices

Feeder Name: 33kV Zhemgang Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	3		1			2				2		1	9
2	Line Jumpering			1		1				3				5
3	Collaps of Pole-Breakdown	1												1
4	Snap of Conductor						1	1						2
5	Puncture of insulator/Leakage			2										2
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain			2		1	2	1		14	1	3		24
8	Tree/branch fall on line					2		1						3
9	RoW Clearing	1											1	2
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB	2		1	1	1	1	1	1	1	1			10
13	Preventive Maintenance of substation/Switchyard								1					1
14	Breakdown Maintenance of Line/LBS/GO/ARCB			1					1					2
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault		2	1		1		1		14	2	5		26
19	Trace of fault on line						2							2
20	Because of Bird/Animals	1												1
21	Close and Open of GO/LBS						4			14		5		23
	SAIFI	**-**	**0.179**	**0.950**	**-**	**0.706**	**0.354**	**0.882**	**1.167**	**0.882**	**0.468**	**0.855**	**1.032**	**7.475**
	SAIDI	**-**	**0.095**	**13.692**	**-**	**2.917**	**4.176**	**2.774**	**3.006**	**2.774**	**0.441**	**1.824**	**1.774**	**33.473**

Feeder Name: 33kV Zhemgang Feeder												FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor	1								1				2
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain	8	13	4				3		6			9	43
8	Tree/branch fall on line	2						2					3	7
9	RoW Clearing												1	1
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB							1						1
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown							1						1
17	Adhoc Shutdown (Tapping, Emergency request)	2								1				3
18	Momentary/Traisent fault	6	12	4				1		5			11	39
19	Trace of fault on line													0
20	Because of Bird/Animals							1						1
21	Close and Open of GO/LBS	8	5	4				2		1			2	22
	SAIFI	**2.299**	**2.405**	**0.692**	**-**	**0.517**	**1.382**	**1.149**	**1.150**	**1.607**	**1.834**	**0.573**	**3.442**	**17.051**
	SAIDI	**2.593**	**2.037**	**0.258**	**-**	**0.100**	**2.350**	**2.345**	**11.024**	**1.887**	**2.519**	**7.014**	**8.333**	**40.459**

Feeder Name: 6.6kV Yebilaptsha Feeder												FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	1					1				1			3
2	Line Jumpering	2												2
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage				1									1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line					1								1
9	RoW Clearing					1		1					1	3
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB													0
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB				1									1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault		2							1				3
19	Trace of fault on line					1								1
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**-**	**-**	**0.096**	**0.096**	**0.096**	**-**	**0.096**	**0.096**	**0.096**	**-**	**-**	**-**	**0.575**
	SAIDI	**-**	**-**	**0.024**	**0.208**	**0.240**	**-**	**0.012**	**0.216**	**0.012**	**-**	**-**	**-**	**0.712**

Feeder Name: 6.6kV Yebilaptsha Feeder												FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor							1						1
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain							5						5
8	Tree/branch fall on line							3						3
9	RoW Clearing													0
10	Land Slide							1						1
11	Forest fire													
12	Preventive Maintenance of Line/LBS/GO/ARCB													
13	Preventive Maintenance of substation/Switchyard													
14	Breakdown Maintenance of Line/LBS/GO/ARCB													
15	Breakdown Maintenance of Substation/Switchyard													
16	SMD Planned shutdown													
17	Adhoc Shutdown (Tapping, Emergency request)													
18	Momentary/Traisent fault							1						
19	Trace of fault on line													
20	Because of Bird/Animals													
21	Close and Open of GO/LBS							2						
	SAIFI	**-**	**-**	**-**	**-**	**0.278**	**0.092**	**0.430**	**-**	**-**	**-**	**-**	**-**	**0.800**
	SAIDI	**-**	**-**	**-**	**-**	**0.054**	**0.021**	**0.514**	**-**	**-**	**-**	**-**	**-**	**0.589**

Feeder Name: 11kV Tama Feeder												FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace		1				1							2
2	Line Jumpering		1											1
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage							1						1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line					1								1
9	RoW Clearing											1		1
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB													0
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB							1						1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault			1										1
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**-**	**0.021**	**0.021**	**-**	**0.022**	**-**	**0.150**	**-**	**0.150**	**-**	**-**	**-**	**0.364**
	SAIDI	**-**	**0.021**	**0.220**	**-**	**0.013**	**-**	**0.648**	**-**	**0.648**	**-**	**-**	**-**	**1.550**

Feeder Name: 11kV Tama Feeder													FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	1					1							2
2	Line Jumpering						1							1
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor							1						1
5	Puncture of insulator/Leakage								1					1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line						1		1					2
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire													
12	Preventive Maintenance of Line/LBS/GO/ARCB								1					
13	Preventive Maintenance of substation/Switchyard													
14	Breakdown Maintenance of Line/LBS/GO/ARCB													
15	Breakdown Maintenance of Substation/Switchyard													
16	SMD Planned shutdown													
17	Adhoc Shutdown (Tapping, Emergency request)													
18	Momentary/Traisent fault													
19	Trace of fault on line													
20	Because of Bird/Animals													
21	Close and Open of GO/LBS													
	SAIFI	**-**	**-**	**-**	**-**	**0.088**	**-**	**-**	**0.030**	**-**	**-**	**-**	**-**	**0.118**
	SAIDI	**-**	**-**	**-**	**-**	**0.019**	**-**	**-**	**0.008**	**-**	**-**	**-**	**-**	**0.027**

Feeder Name: 33kV Gomphu Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	5				3				3			6	17
2	Line Jumpering						2							2
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor						1			1				2
5	Puncture of insulator/Leakage									1				1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain		3	4	4	6	16	2		8	4			47
8	Tree/branch fall on line				2		2						1	5
9	RoW Clearing							1		1				2
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB			2	1		1			2				6
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB						2			4				6
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault		2	4	4	4	5	2		4	4	3	3	35
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS			2			2			4		3		11
	SAIFI	**0.874**	**0.890**	**0.890**	**1.780**	**2.673**	**5.027**	**0.894**	**1.195**	**0.894**	**-**	**0.902**	**0.900**	**16.918**
	SAIDI	**0.847**	**3.633**	**7.005**	**4.185**	**14.954**	**14.082**	**1.490**	**14.253**	**1.490**	**-**	**0.568**	**2.233**	**64.739**

Feeder Name: 33kV Gomphu Feeder												FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	1	1	1										3
2	Line Jumpering													0
3	Collaps of Pole-Breakdown						1	4						5
4	Snap of Conductor						2	4						6
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain		7	4			7	9		14			1	42
8	Tree/branch fall on line		1	1			3			1			3	9
9	RoW Clearing										2		1	3
10	Land Slide							3						3
11	Forest fire													0
1	Preventive Maintenance of Line/LBS/GO/ARCB		2				2	1						5
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)						1	1						2
18	Momentary/Traisent fault	2	10	3			3	3		21			4	46
19	Trace of fault on line													0
20	Because of Bird/Animals	1												1
21	Close and Open of GO/LBS		3					4		4				11
	SAIFI	**0.952**	**3.809**	**1.581**	**1.902**	**4.019**	**2.680**	**2.117**	**1.331**	**7.809**	**5.919**	**1.665**	**1.314**	**35.099**
	SAIDI	**0.397**	**10.010**	**4.089**	**4.274**	**8.702**	**5.351**	**14.685**	**0.473**	**7.255**	**18.694**	**0.540**	**3.011**	**77.481**

Feeder Name: 33kV Dakpai Feeder												FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	4	3	4	1	2			3	2	1	1	2	23
2	Line Jumpering		1			2					1			4
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor					2								2
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance						1							1
7	Ligtining /Strom/Rain		2	2		2	2	2		2				12
8	Tree/branch fall on line						1	1						2
9	RoW Clearing											1		1
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB					1		1				1		3
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB					1								1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault		2	4			1	2						9
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS						1	2		1	1			5
	SAIFI	**0.28**	**0.28**	**1.10**	**-**	**0.28**	**0.83**	**2.21**	**0.55**	**2.21**	**0.28**	**-**	**-**	**8.00**
	SAIDI	**0.53**	**0.03**	**1.38**	**-**	**1.78**	**3.56**	**3.42**	**1.61**	**3.42**	**0.12**	**-**	**-**	**15.85**

Feeder Name: 33kV Dakpai Feeder													FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace		2				1		1					4
2	Line Jumpering													0
3	Collaps of Pole-Breakdown						1	2		1				4
4	Snap of Conductor		1				1	1		4				7
5	Puncture of insulator/Leakage		1	1			1	1		1				5
6	Puncture of LA/LA Maintenance							1						1
7	Ligtining /Strom/Rain						3	5		6				14
8	Tree/branch fall on line	1					1	2		4			1	9
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB	2	1									1		4
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB							2		4				6
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)		1							1			1	3
18	Momentary/Traisent fault						1	1		5			4	11
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS						2	2		4			1	9
	SAIFI	**0.833**	**0.555**	**-**	**-**	**1.819**	**1.300**	**1.459**	**1.309**	**2.355**	**1.046**	**1.044**	**1.756**	**13.478**
	SAIDI	**0.747**	**0.869**	**-**	**-**	**6.471**	**5.404**	**8.225**	**2.570**	**3.792**	**0.68**	**0.540**	**1.610**	**30.909**

Annexure-6: Material Cost of Upgrading single phase (11 kV and 33 kV) Lines to three-phase

Sl. No	Name of ESDs	Total Cost in Nu. For upgradation of Line to 3Φ from 1Φ		Total cost in Nu.
		11 kV Line in Km	33 kV Line in Km	
		Cost in Nu.	Cost in Nu.	
1	Bumthang	604,083.80	626,364.17	1,230,447.97
2	Chukhha	1,372,746.06	6,450,371.80	7,823,117.86
3	Dagana	–	2,495,645.61	2,495,645.61
4	Haa	–	341,755.04	341,755.04
5	Lhuntse	1,648,680.77	6,292,698.01	7,941,378.78
6	Mongar	–	–	–
7	Paro	1,576,599.08	1,663,407.47	3,240,006.55
8	Pemagatshel	–	2,467,625.51	2,467,625.51
9	Punakha	612,259.13	8,183,731.48	8,795,990.60
10	S/Jongkhar	–	7,593,301.40	7,593,301.40
11	Samtse	2,031,083.74	536,799.03	2,567,882.76
12	Sarpang	756,490.07	1,112,902.61	1,869,392.68
13	Trashi Gang	251,649.96	626,304.45	877,954.41
14	Trashiyangtse		2,207,281.49	2,207,281.49
15	Thimphu	5,228,316.74	-	5,228,316.74
16	Trongsa	–	651,860.25	651,860.25
17	Tsirang	–	1,693,286.88	1,693,286.88
18	Wangdue	98,146.90	3,133,078.14	3,231,225.04
19	Zhemgang	–	5,303,863.16	5,303,863.16
	TOTAL	**14,180,056.24**	**51,380,276.50**	**65,560,332.75**

The cost of extending one phase in case of ACSR conductor and AAAC covered conductor were considered and incase of HV ABC, the cost of constructing three core cable has been considered in estimation. Above estimation indicates the total material cost involved in upgrading the existing single phase line to three phase under each ESD.

The total cost including material cost (Nu. 65 million), transportation cost (Nu. 3.47 million) and labor cost (Nu. 28 million) will amount to Nu. 97 million.

11 kV and 33 kV Single Phase Line Length in km under each ESD

Sl. No	Name of ESDs	11kV 1Φ Line (km)	33kV 1Φ Line (km)	Total 1Φ Line (km)
1	Bumthang	6.96276	5.6246	12.58736
2	Chukhha	21.569	78.274	99.843
3	Dagana	0	30.527	30.527
4	Haa	0	4.391	4.391
5	Lhuntse	18.7075	80.851	99.5585
6	Mongar	0	0	0
7	Paro	24.772	14.937	39.709
8	Pemagatshel	0	31.705	31.705
9	Punakha	9.62	58.4	68.02
10	S/Jongkhar	0	93.672	93.672
11	Samtse	31.913	6.897	38.81
12	Sarpang	11.8862	14.299	26.1852
13	Trashigang	3.954	8.047	12.001
14	Trashiyangtse	0	28.36	28.36
15	Thimphu	5.93	0	5.93
16	Trongsa	0	5.383	5.383
17	Tsirang	0	21.756	21.756
18	Wangdue	1.01	29.7	30.71
19	Zhemgang	0	66.785	66.785
TOTAL		**136.32446**	**579.6086**	**715.93306**

Annexure-7: Distribution Transformer Loading

Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**		2025		2030	
					2019-2020		**1247.06**	**%**	**1376.47**	**%**
							2.14		2.47	
							3.14		3.47	
1	33kV Zhemgang feeder	Dzong ss	33/.415kV	500	29.88	6%	93.92	19%	103.67	21%
2		PWD ss	33/11/6.6kV	1500	Step down transformer					
3		Dungbi ss	33/.415kV	63	1.68	2.67%	5.28	8%	5.83	9%
4		RMBF ss	33/.415kV	63	1.622	2.57%	5.10	8%	5.63	9%
5		RDTC ss	33/.415kV	500	12.57	2.51%	39.51	8%	43.61	9%
6		Gompong ss	33/.415kV	25	13.2	52.80%	20.00	80%	24.00	96%
7		Tingbi pam	33/.240kV	25	10.5	42.00%	15.00	60%	22.00	88%
8		Crushpai pam	33/.240kV	25	2.34	9.36%	7.36	29%	8.12	32%
9		Kalamchen pam	33/.240kV	25	2.66	10.64%	8.36	33%	9.23	37%
					74.452					
190	33/6.6kV Ring feeder	Dangkhar Pokto	6.6/.415kV	50	28.75	57.50%	90.37	181%	99.75	199%
191		DVH	6.6/.415kV	125	37.28	29.82%	117.18	94%	129.34	103%
192		BHU	6.6/.415kV	125	33.07	26.46%	103.95	83%	114.74	92%
193		Below ZHCS	6.6/.415kV	125	20.95	16.76%	65.85	53%	72.69	58%
194		Above ZHCS	6.6/.415kV	125	16.15	12.92%	50.76	41%	56.03	45%
195		Royal Guest House	6.6/.415kV	75	18.94	25.25%	59.53	79%	65.71	88%
196		Below DYT	6.6/.415kV	125	30.37	24.30%	95.46	76%	105.37	84%
197		BAFRA	6.6/.415kV	125	23.98	19.18%	75.38	60%	83.20	67%
198		Old PWD Zhemgang	6.6/.415kV	125	34.48	27.58%	59.48	48%	84.48	68%
199		Forest Office	6.6/.415kV	100	3.92	3.92%	12.32	12%	13.60	14%
					247.89					
11	33kV Korphu Feeder	Nimshong I	33/0.415	25	5.47	21.88%	17.19	69%	18.98	76%
		Nimshong II	33/0.415	25	3.063	12.25%	9.63	39%	10.63	43%
		Nimshong III	33/0.415	25	2.6	10.40%	8.17	33%	9.02	36%
		Nimshong IV	33/0.415	25	3.325	13.30%	10.45	42%	11.54	46%
		Nimshong V	33/0.415	25	1.71	6.84%	5.38	22%	5.93	24%
		Nimshong VI	33/0.240	16	0.7	4.38%	2.20	14%	2.43	15%
		Nimshong VII	33/0.415	25	1.597	6.39%	5.02	20%	5.54	22%
		Nimshong VIII	33/0.415	25	2.938	11.75%	9.24	37%	10.19	41%
		Korphu-I	33/0.415	25	4.29	17.16%	13.48	54%	14.88	60%
		Korphu-II	33/0.415	16	2.189	13.68%	6.88	43%	7.59	47%
		Korphu-III	33/0.240	16	2.96	18.50%	9.30	58%	10.27	64%
		Korphu-IV	33/0.240	10	3.705	37.05%	11.65	116%	12.85	129%
		Korphu-V	33/0.240	16	2.69	16.81%	8.46	53%	9.33	58%
		Korphu-VI	33/0.415	25	0.726	2.90%	2.28	9%	2.52	10%
		Korphu-VII	33/0.415	25	8.56	34.24%	26.91	108%	29.70	119%
		Korphu-VIII	33/0.240	16	3.9059	24.41%	12.28	77%	13.55	85%
		Nabji -I	33/0.415	25	3.044	12.18%	9.57	38%	10.56	42%
		Nabji-II	33/0.240	16	4.192	26.20%	13.18	82%	14.54	91%
		Nabji-III	33/0.415	25	3.1	12.40%	9.74	39%	10.76	43%
		Nabji-IV	33/0.240	25	4.09	16.36%	12.86	51%	14.19	57%
		Nabji-V	33/0.415	25	3.174	12.70%	9.98	40%	11.01	44%
		Nabji-VI	33/0.415	16	4.1	25.63%	12.89	81%	14.23	89%
		Dingling	33/0.240	10	1.39	13.90%	4.37	44%	4.82	48%
		Pam Kharangdung	33/0.240	10	0.87	8.70%	2.73	27%	3.02	30%
					74.3889					
					396.7309					

Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**		2025		2030	
					2019-2020		1247.06	%	1376.47	%
							1403.53		1675.29	
							3.71		4.62	
							4.71		5.62	
10	Gomphu feeder	Tshanglajong	33/.415kV	63	8.38	13.30%	39.48	63%	47.12	75%
11		Zhurphey	33/.415kV	63	19.11	30.33%	40.00	63%	60.00	95%
12		Goling	33/.415kV	63	7.026	11.15%	33.10	53%	39.51	63%
13		Goling Wangdra	33/.415kV	63	13.899	22.06%	38.90	62%	63.90	101%
14		Goling Village	33/.415kV	63	19.648	31.19%	44.65	71%	69.65	111%
15		Subrang	33/.415kV	63	5.38	8.54%	25.35	40%	30.25	48%
16		Gamphu Zero	33/.415kV	63	3.144	4.99%	14.81	24%	17.68	28%
17		Lower Gomphu	33/.415kV	63	2.38	3.78%	11.21	18%	13.38	21%
18		Upper Gomphu	33/.415kV	125	13.52	10.82%	63.69	51%	76.03	61%
19		Kamjong	33/.240kV	25	2.11	8.44%	9.94	40%	11.87	47%
20		Kamjong II	33/.240kV	25	4.16	16.64%	19.60	78%	23.39	94%
21		Phawa	33/.240kV	16	5.48	34.25%	10.00	63%	15.00	94%
22		Payebang	33/.240kV	16	3.21	20.06%	9.00	56%	15.00	94%
23		Mamung	33/.240kV	25	2.17	8.68%	10.22	41%	12.20	49%
24		Umpala	33/.240kV	16	0.45	2.81%	2.12	13%	2.53	16%
25		Palangtoe	33/.415kV	16	0.859	5.37%	4.05	25%	4.83	30%
26		Pangtang A	33/.415kV	25	5.36	21.44%	25.25	101%	30.14	121%
27		Pantang B	33/.415kV	25	5.69	22.76%	26.81	107%	32.00	128%
28		Sangsiri	33/.415kV	25	1.46	5.84%	6.88	28%	8.21	33%
29		Wamjarla	33/.240kV	10	0.44	4.40%	2.07	21%	2.47	25%
30		Panabi	33/.240kV	16	0.73	4.56%	3.44	21%	4.10	26%
31		Kulamtoe	33/.240kV	16	1.11	6.94%	5.23	33%	6.24	39%
32		Jamphu	33/.240kV	10	2.82	28.20%	6.00	60%	8.00	80%
33		Tashibi A	33/.415kV	25	5.07	20.28%	12.57	50%	20.07	80%
34		Tashibi B	33/.240kV	16	3.98	24.88%	8.98	56%	13.98	87%
35		Wangbi	33/.240kV	10	3.64	36.40%	6.14	61%	8.64	86%
36		Selingtoe	33/.240kV	16	4.19	26.19%	9.19	57%	14.19	89%
37		Duenmang village I	33/.415kV	25	16.78	67.12%	26.78	107%	36.78	147%
38		Duenmang villahe II	33/.415kV	25	11.97	47.88%	19.47	78%	26.97	108%
39		Kalamti	33/.240kV	16	2.61	16.31%	12.30	77%	14.68	92%
40		Pramjong Degala	33/.240kV	25	3.27	13.08%	15.41	62%	18.39	74%
41		Pakobi Degala	33/.240kV	25	3.29	13.16%	15.50	62%	18.50	74%
42		Relingbi	33/.240kV	25	1.25	5.00%	5.89	24%	7.03	28%
43		Langdurbi Goenpai	33/.240kV	16	4.21	26.31%	9.21	58%	14.21	89%
44		Jalakhering Langdurbi	33/.415kV	25	4.9	19.60%	9.90	40%	14.90	60%
45		Jardongla Langdurbi	33/.415kV	25	5.52	22.08%	10.52	42%	15.52	62%
46		Langdurbi school	33/.415kV	25	5.06	20.24%	10.06	40%	15.06	60%
47		Langdurbi Jangdala	33/.415kV	25	4.29	17.16%	9.29	37%	14.29	57%
48		Wangling	33/.240kV	10	0.47	4.70%	2.21	22%	2.64	26%
49		Bhudashe	33/.240kV	16	0.38	2.38%	1.79	11%	2.14	13%
50		Yongkorpong	33/.240kV	16	0.34	2.13%	1.60	10%	1.91	12%
51		Surpang	33/.240kV	16	0.68	4.25%	3.20	20%	3.82	24%
52		Bongman village	33/.240kV	16	0.4	2.50%	1.88	12%	2.25	14%
53		Langman	33/.240kV	10	0.19	1.90%	0.90	9%	1.07	11%
54		Zangbi	33/.240kV	10	0.054	0.54%	0.25	3%	0.30	3%
55		Olangbi	33/.240kV	10	2.37	23.70%	4.87	49%	9.87	99%
56		Mewagang	33/.240kV	16	3.26	20.38%	8.26	52%	13.26	83%
57		Chailabi	33/.240kV	25	3.19	12.76%	15.03	60%	17.94	72%
58		Babshar	33/.415kV	25	3.33	13.32%	15.69	63%	18.73	75%
59		Shelingbi	33/.415kV	25	3.16	12.64%	14.89	60%	17.77	71%
60		Lower Lamthang	33/.415kV	25	2	8.00%	9.42	38%	11.25	45%
61		Upper Lamthang	33/.240kV	16	0.34	2.13%	1.60	10%	1.91	12%
62		Lungtham village	33/.240kV	10	0.44	4.40%	2.07	21%	2.47	25%
63		Goshing Trong	33/.240kV	16	1.06	6.63%	4.99	31%	5.96	37%

Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**		2025		2030	
					2019-2020		1247.06	%	1376.47	%
64		Umling	33/.240kV	16	0.23	1.44%	1.08	7%	1.29	8%
65		Shermaling	33/.240kV	10	0.39	3.90%	1.84	18%	2.19	22%
66		Lower Linmapong	33/.415kV	25	2.02	8.08%	9.52	38%	11.36	45%
67		Upper Linmapong	33/.415kV	25	2.4	9.60%	11.31	45%	13.50	54%
68		Lower Samcholing	33/.240kV	16	0.87	5.44%	4.10	26%	4.89	31%
69		Upper Samcholing	33/.240kV	25	1.48	5.92%	6.97	28%	8.32	33%
70		Drangling	33/.240kV	16	0.47	2.94%	2.21	14%	2.64	17%
71		Tikchung Lichibi	33/.240kV	16	0.503	3.14%	2.37	15%	2.83	18%
72		Middle Lichibi	33/.240kV	16	0.46	2.88%	2.17	14%	2.59	16%
73		Tingbi Lichibi	33/.415kV	25	2.47	9.88%	11.64	47%	13.89	56%
74		Sanglung	33/.240kV	10	0.507	5.07%	2.39	24%	2.85	29%
75		Amdha	33/.240kV	10	0.69	6.90%	3.25	33%	3.88	39%
76		Pongchiling	33/.240kV	25	0.214	0.86%	1.01	4%	1.20	5%
77		Kakthong BHU	33/.415kV	25	2.74	10.96%	12.91	52%	15.41	62%
78		Kakthong School	33/.415kV	25	3.3	13.20%	15.55	62%	18.56	74%
79		Urti	33/.415kV	25	3.49	13.96%	16.44	66%	19.63	79%
80		Choekar	33/.240kV	10	0.3	3.00%	1.41	14%	1.69	17%
81		Ngala Trong	33/.240kV	25	2.96	11.84%	13.94	56%	16.64	67%
82		Kamalung Bjoka	33/.415kV	25	5.13	20.52%	10.13	41%	15.13	61%
+C142:C1		Bjoka Gewog	33/.240kV	16	1.78	11.13%	8.39	52%	10.01	63%
S		Bjoka Trong	33/.240kV	25	0.81	3.24%	3.82	15%	4.55	18%
85		Gangdar BHU Bjoka	33/.240kV	10	5.41	54.10%	25.49	255%	30.42	304%
86		Kamati	33/.240kV	25	4.08	16.32%	19.22	77%	22.94	92%
87		Dalabi	33/.240kV	10	4.47	44.70%	6.97	70%	9.47	95%
88		Barpong	33/.240kV	25	5.37	21.48%	10.37	41%	15.37	61%
89		Namrigang	33/.240kV	25	6.17	24.68%	11.17	45%	16.17	65%
90		Dunmang Tshachhu	33/.240kV	10	8.98	89.80%	11.48	115%	13.98	140%
					297.924					
							218.82		304.71	
							2.90		4.43	
							3.90		5.43	
91	Tama feeder	Takabi Fishery	11/.415kV	25	2.26	9.04%	8.81	35%	12.27	49%
92		Tama village	11/.415kV	63	23.98	38.06%	50.00	79%	75.00	119%
93		Takabi	11/.415kV	63	4.71	7.48%	18.36	29%	25.57	41%
94		Berti	11/.415kV	63	21.87	34.71%	85.26	135%	118.72	188%
95		Tama Gonpai	11/.415kV	25	2.37	9.48%	9.24	37%	12.87	51%
96		Barpong	11/.415kV	25	0.94	3.76%	3.66	15%	5.10	20%
					56.13					
							1450.00		1701.18	
							3.12		3.83	
							4.12		4.83	
97		Dakpai village	33/.415kV	63	1.86	2.95%	7.66	12%	8.98	14%
98		Dakpai turning	33/.415kV	63	1.85	2.94%	7.62	12%	8.93	14%
99		Tali	33/.415kV	63	17.57	27.89%	37.57	60%	57.57	91%
100		Buli A	33/.415kV	63	23.7	37.62%	48.70	77%	73.70	117%
101		Buli B	33/.415kV	63	10.8	17.14%	44.46	71%	52.16	83%
102		Buli C	33/.415kV	125	25.04	20.03%	103.07	82%	120.92	97%
103		Buli CS	33/.415kV	250	7.53	3.01%	31.00	12%	36.36	15%
104		NRDCL	33/.415kV	630	3.3	0.52%	13.58	2%	15.94	3%
105		Thajong	33/.415kV	25	6.54	26.16%	14.04	56%	21.54	86%
106		Lower Nimshong	33/.415kV	25	6.57	26.28%	16.57	66%	26.57	106%
107		Middle Nimshong	33/.415kV	25	5.08	20.32%	15.08	60%	25.08	100%
108		Upper Nimshong	33/.415kV	25	4.88	19.52%	20.09	80%	23.57	94%
109		Phumethang	33/.415kV	25	4.04	16.16%	16.63	67%	19.51	78%
110		Nyakhar	33/.415kV	63	2.96	4.70%	12.18	19%	14.29	23%
111		Nyakhar Dratshang	33/.240kV	10	2.6	26.00%	5.10	51%	7.60	76%
112		Leleygang	33/.240kV	10	1.25	12.50%	5.15	51%	6.04	60%

Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**		2025		2030	
					2019-2020		1247.06	%	1376.47	%
113		Tshaidang school	33/.415kV	25	10.04	40.16%	15.04	60%	20.04	80%
114		Upper Tshaidang	33/.415kV	25	14.57	58.28%	19.57	78%	24.57	98%
115		Lower Tshaidang	33/.415kV	25	14.27	57.08%	21.77	87%	29.27	117%
116		Namjur	33/.240kV	16	1.52	9.50%	6.26	39%	7.34	46%
117		Kikhar	33/.415kV	25	12.54	50.16%	20.04	80%	27.54	110%
118		Anim Dratshang	33/.240kV	10	10.05	100.50%	41.37	414%	48.53	485%
119		Buli Goenpa	33/.240kV	16	5.63	35.19%	10.63	66%	15.63	98%
120		Zhobling	33/.415kV	25	5.89	23.56%	13.39	54%	20.89	84%
121		Chamtang	33/.240kV	16	2.96	18.50%	12.18	76%	14.29	89%
122		Zangling	33/.240kV	16	14.3	89.38%	14.30	89%	14.30	89%
123		Rashaling	33/.240kV	10	0.2	2.00%	0.82	8%	0.97	10%
124		Phumchung	33/.240kV	10	0.503	5.03%	2.07	21%	2.43	24%
125		Wagar	33/.240kV	25	0.69	2.76%	2.84	11%	3.33	13%
126		Crong	33/.415kV	25	1.72	6.88%	7.08	28%	8.31	33%
127		Bardang	33/.415kV	25	5.16	20.64%	12.66	51%	20.16	81%
128		Khomshar School	33/.415kV	25	6.21	24.84%	13.71	55%	21.21	85%
129	Dakpai feeder	Nawabi	33/.415kV	25	8.19	32.76%	15.69	63%	23.19	93%
130		Rawathang	33/.240kV	16	4.69	29.31%	9.69	61%	14.69	92%
131		Perbi Gonpa	33/.240kV	25	0.611	2.44%	2.52	10%	2.95	12%
132		Wadang	33/.415kV	25	3.01	12.04%	12.39	50%	14.54	58%
133		Jasar	33/.240kV	16	1.43	8.94%	5.89	37%	6.91	43%
134		Dunglabi	33/.240kV	16	2.12	13.25%	8.73	55%	10.24	64%
135		Zilangbi	33/.240kV	10	2.39	23.90%	4.89	49%	9.89	99%
136		Phulabi	33/.240kV	25	2.05	8.20%	8.44	34%	9.90	40%
137		Balangbi	33/.240kV	10	0.58	5.80%	2.39	24%	2.80	28%
138		Laling	33/.415kV	25	7.92	31.68%	15.42	62%	22.92	92%
139		Kuther	33/.240kV	25	3.74	14.96%	15.39	62%	18.06	72%
140		Bardo school	33/.415kV	25	6.59	26.36%	14.09	56%	21.59	86%
141		Yangthang	33/.415kV	25	5.1	20.40%	12.60	50%	20.10	80%
142		Jawaling	33/.240kV	10	1.44	14.40%	5.93	59%	6.95	70%
143		Sameth	33/.415kV	25	5.21	20.84%	12.71	51%	20.21	81%
144		Upper Thrisa A	33/.240kV	25	2.23	8.92%	9.18	37%	10.77	43%
145		Upper Thrisa B	33/.415kV	25	5.14	20.56%	12.64	51%	22.64	91%
146		Lower Thrisa A	33/.415kV	25	5.77	23.08%	13.27	53%	23.27	93%
147		Lower Thrisa B	33/.415kV	25	5.52	22.08%	13.02	52%	23.02	92%
148		Upper Wamling B	33/.240kV	16	1.65	10.31%	6.79	42%	7.97	50%
149		Upper Wamling A	33/.240kV	25	5.48	21.92%	22.56	90%	26.46	106%
150		Middle Wamling	33/.415kV	25	5.41	21.64%	22.27	89%	26.13	105%
151		Lower Wamling A	33/.415kV	25	5.51	22.04%	22.68	91%	26.61	106%
152		Lower Wamling B	33/.240kV	25	1.67	6.68%	6.87	27%	8.06	32%
153		Shingkhar School	33/.415kV	25	5.66	22.64%	13.16	53%	23.16	93%
154		Umchagang	33/.415kV	25	5.3	21.20%	12.80	51%	22.80	91%
155		Mayungbi	33/.415kV	25	4.99	19.96%	14.99	60%	22.49	90%
156		Chabi	33/.240kV	16	1.9	11.88%	7.82	49%	9.18	57%
157		Changkhar	33/.240kV	16	1.7	10.63%	7.00	44%	8.21	51%
158		Lower Radhi	33/.240kV	25	1.91	7.64%	7.86	31%	9.22	37%
159		Upper Radhi	33/.240kV	25	1.81	7.24%	7.45	30%	8.74	35%
160		BT Churmulung	33/.415kV	25	0.34	1.36%	1.40	6%	1.64	7%
161		Remuya	33/.240kV	10	3.01	30.10%	3.01	30%	3.01	30%
162		T.Cell	33/.240kV	25	0.37	1.48%	1.52	6%	1.79	7%
					352.264					
							602.94		**720.00**	
							1.40		**1.87**	
							2.40		**2.87**	
163		Tingtibi Power House	0.415/6.6kV	250	Step-Up					
164		PWD Mangdichu	6.6/.415kV	50	33.09	66.18%	79.51	159%	94.95	189.9%
165		Tingtibi Town BoD	6.6/.415kV	75	23.81	31.75%	57.21	76%	68.32	91.1%

Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**		2025		2030	
					2019-2020		1247.06	%	1376.47	%
166	Yebilaptsha feeder	Tingtibi School	11/6.6kV	500	ICT transformer					
167		Yebilaptsha A	6.6/.415kV	50	19.12	38.24%	45.94	92%	54.86	109.7%
168		Yebilaptsha B	6.6/.415kV	50	36.54	73.08%	87.80	176%	104.85	209.7%
169		Pemala sawmill	6.6/.415kV	30	10.23	34.10%	24.58	82%	29.35	97.8%
170		Telecom Zhemgang	6.6/.415kV	30	8.06	26.87%	19.37	65%	23.13	77.1%
171		KD sawmill	6.6/.415kV	75	22.25	29.67%	53.47	71%	63.85	85.1%
172		Tingtibi town A	6.6/.415kV	50	31.47	62.94%	75.62	151%	90.30	180.6%
173		Tingtibi main town B	6.6/.415kV	125	51.92	41.54%	124.76	100%	148.98	119.2%
174		Tingtibi DoR	6.6/.415kV	75	14.43	19.24%	34.67	46%	41.41	55.2%
					250.92					

Annexure-8: Material Cost of three-phase (3Φ) Transformers

Sl. No	Name of ESDs	Cost for replacement of single phase transformers and distribution boards with three phase		Total cost in Nu.
		11 kV transformers	33 kV transformers	
		Cost in Nu.	Cost in Nu.	
1	Bumthang	421,565.09	132,535.04	554,100.14
2	Chukhha	956,241.73	9,144,917.99	10,101,159.72
3	Dagana	–	6,361,682.08	6,361,682.08
4	Haa	–	3,048,306.00	3,048,306.00
5	Lhuntse	731,506.19	8,747,312.86	9,478,819.05
6	Mongar	182,876.55	4,108,586.34	4,291,462.89
7	Paro	836,897.46	1,060,280.35	1,897,177.81
8	Pemagatshel	91,438.27	6,759,287.21	6,850,725.48
9	Punakha	274,314.82	4,771,261.56	5,045,576.38
10	S/Jongkhar	–	15,506,600.07	15,506,600.07
11	Samtse	6,674,993.95	4,241,121.39	10,916,115.34
12	Sarpang	2,053,501.01	3,445,911.13	5,499,412.14
13	Trashi Gang	906,662.46	4,903,796.60	5,810,459.06
14	Trashiyangtse	–	4,638,726.52	4,638,726.52
15	Thimphu	723,785.91	–	723,785.91
16	Trongsa	91,438.27	3,445,911.13	3,537,349.40
17	Tsirang	–	5,168,866.69	5,168,866.69
18	Wangdue	182,876.55	1,457,885.48	1,640,762.02
19	Zhemgang	105,391.27	11,928,153.90	12,033,545.17
	TOTAL	**14,233,489.55**	**98,871,142.33**	**113,104,631.87**

Here the existing single phase transformers and distribution boards were replaced by three phase system, therefore the estimation includes the cost of three phase transformers and distribution boards.In line with Distribution Design and Construction Standard (DDCS) 2015, the transformer capacities according to voltage level are standardized as shown below:

33 kV System		11 kV System	
3 Φ	**1Φ**	**3 Φ**	**1Φ**
25 kVA	25 kVA, 16 kVA	25 kVA, 16 kVA	25 kVA,16 kVA, 10 kVA

Therefore, during the estimation, on 33 kV system, the cost of 25 kVA transformers was taken for 10 kVA and 16 kVA transformers and for 11 kV system, the cost of 16 kVA transformers was taken for 10 kVA ratings. The total cost for replacing the 1-phase transformers under whole ESD including transportation cost (Nu. 2.6 million) and labor cost (Nu. 70 million) is Nu. 186 million. Therefore, the total cost under this option will amount to Nu. 283 million.

11 kV & 33 kV Single Phase Transformers used under each ESD

Sl. No	Name of ESDs	TRANSFORMERS (Nos.)					
		11/0.240 kV			33/0.240 kV		
		10 kVA	16kVA	25kVA	10 kVA	16kVA	25kVA
1	Bumthang	–	–	4	–	1	–
2	Chukhha	2	5	3	19	31	19
3	Dagana	–	–	–	4	43	1
4	Haa	–	–	–	8	13	2
5	Lhuntse	3	5	–	3	19	44
6	Mongar		2	–	12	17	2
7	Paro	5	3	1	6	2	–
8	Pemagatshel	–	1	–	4	8	39
9	Punakha	1	2	–	2	5	29
10	S/Jongkhar	–	–	–	18	24	75
11	Samtse	15	58	–	–	32	–
12	Sarpang	10	9	3	9	8	9
13	Trashi Gang	3	–	6	–	–	37
14	Trashiyangtse	–	–	–	16	19	–
15	Thimphu*	–	1	6	–	–	–
16	Trongsa	1	–	–	9	17	–
17	Tsirang	–	–	–	7	32	–
18	Wangdue	1	1	–	–	2	9
19	Zhemgang	–	–	1	27	36	27
	TOTAL	**41**	**87**	**24**	**144**	**309**	**293**