BHUTAN POWER CORPORATION LIMITED
(An ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 Certified Company)
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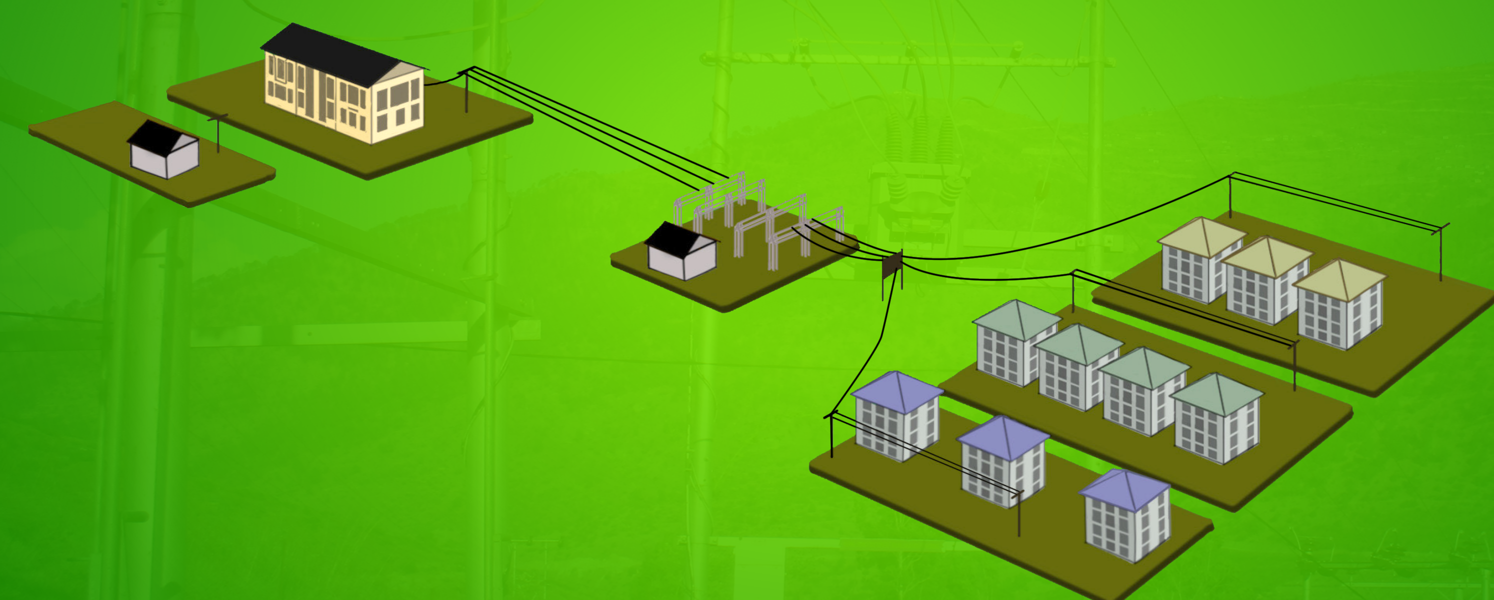
DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

TRASHIYANGTSE DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

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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

Preparation, Review & Approval of the Document

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Reviewed& Vetted by:	Management, Bhutan Power Corporation Limited, Thimphu. (18^{th} September, 2020 – Meeting No. 584)	**CEO, BPC**
Approved by:	Board Tender & Technical Committee (BTTC), Bhutan Power Corporation Limited, Thimphu. (8^{th} October, 2020 – 23^{rd}BTTC Meeting)	**Chairman, BTCC**

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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
KHEL: Kholongchu Hydro Electric Project

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 star 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 place 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 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 is 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 sakes 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 performances. 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 complexities 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 are not limited to a reliable power supply to the customers, reduction of distribution losses, and 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; 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 5.5and as shown in **Figure 1** are considered to suit BPC's requirement for developing the DSMP.

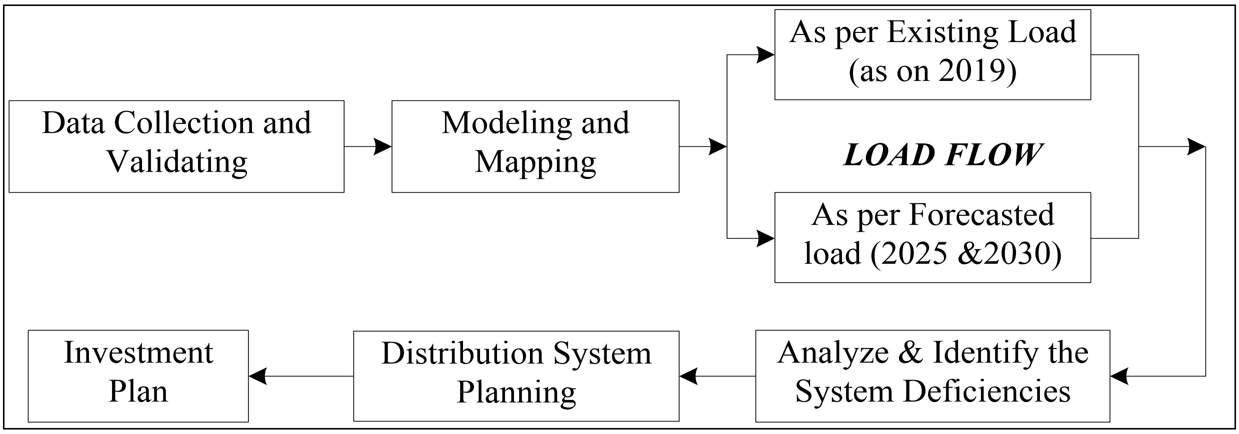


Figure 1: Block diagram for distribution system planning for thematic studies

5.1 Data Collection and Validation

In order to carry out the detailed studies with greater accuracy, complete and reliable data of the existing distribution infrastructure is required. Therefore, intensive field investigation was carried out during the months of April and May (2019-2020) 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 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 (Detailed parameters attached as **Annexure-2)** to develop the base model. 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 to TSA which is based on the historical data and accordingly the behavior of the distribution system was analyzed, and the system deficiencies were identified. The details on load forecast methodology is attached as **Annexure-3.**

5.4 Distribution System Planning

Necessary deterministic and probable distribution system planning methods are proposed to address the system gaps focusing on 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 2020 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 eight (8) Gewogs (Bumdeling, Jamkhar, Khamdang, Ramjar, Toetsho, Tomzhangtshen, Trashiyantse and Yalang) of Trashiyangtse Dzongkhag is from 132/33 kV 2x5MVA, Kanglung substation which is distributed (LILO) through Doksum ARCB switchyard and 33/11kV, 2x2.5MVA Chenary substation. The overall power distribution network of the Dzongkhag is illustrated in the schematic diagram shown in **Figure 2.**

Until the commissioning of 2x10 MVA, 132/33kV, Korlung substation, the power supply to most of the customers of the Dzongkhag are catered from five (5) 33kV feeders which is sourced from Kanglung and Chenary substations. However, with the commissioning of 2x10MVA, 132/33 kV Korlung substation, the Dzongkhag has alternative power supply through 33kV MV line. The Korlung substation has six (6) number of 33kV outgoing feeders (i.e. 33kV Dam site, 33kV Doksum Switchyard & rest are spare feeders).

The power supply to Golamzor, Youb, Tongla, Chema, Tachema, Rejung and Baling villages under Jamkhar Gewog is catered from 11kV Gongthung feeder of 2x2.5 MVA, 33/11 kV Chenary substation.

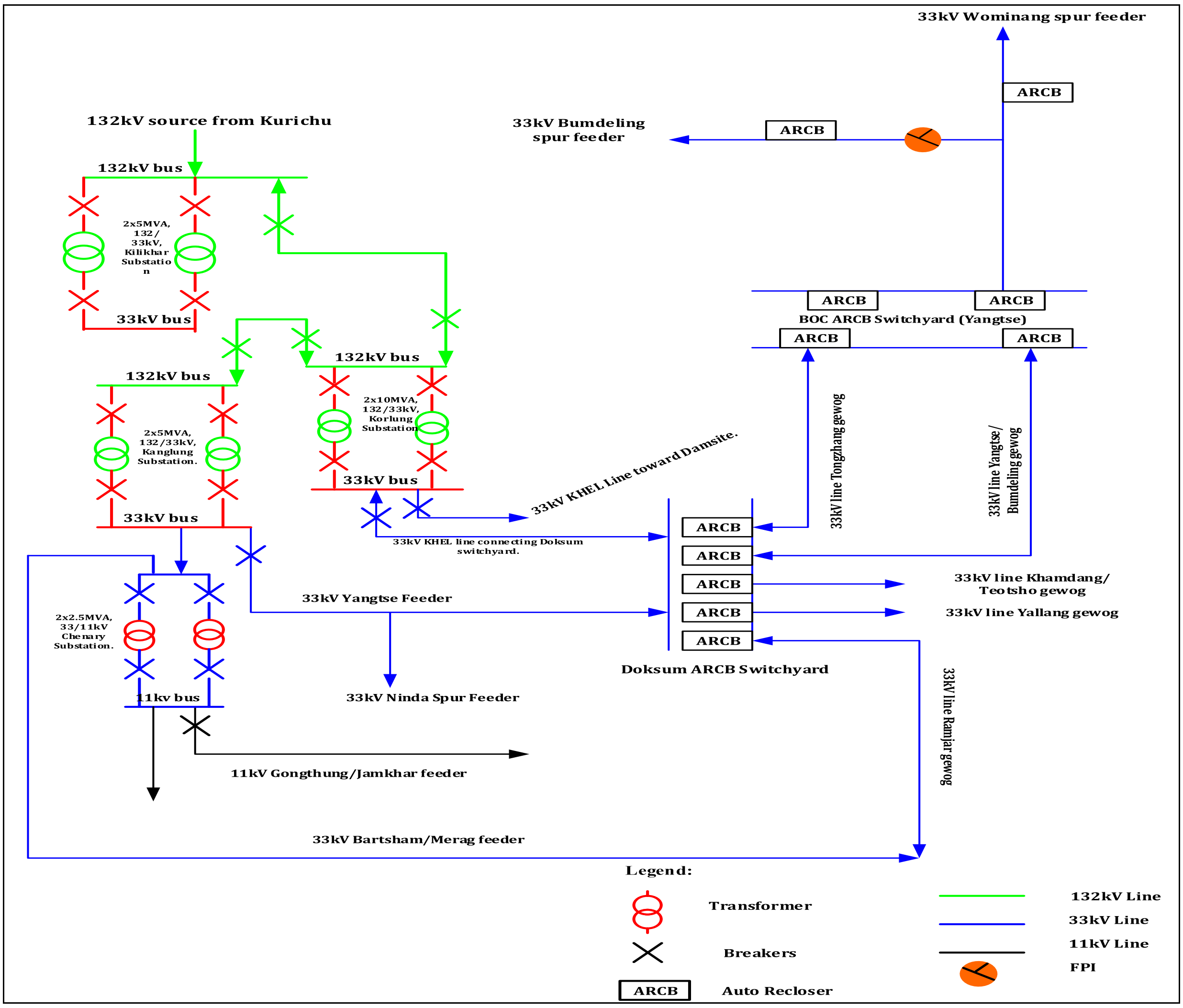


Figure 2: Electricity distribution schematic diagram

6.2 Electricity Distribution Lines

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

Table 1: MV and LV line infrastructure details

Sl. No.	33 kV (km)		11 kV (km)		Total MV line (km)	LV lines (km)		Total LV length (km)
	OH	UG	OH	UG		OH	UG	
1	232.54	0.21	6.94	-	**239.69**	491.28	-	**491.28**

The total MV line length is 239.69 km and the total LV line length is 491.283km. The ratio of LV to MV line length is 2.05:1 which reflects a high proportion of power distribution through LV network. While the ratio of LV to MV line length would vary according to the site conditions, as a general thumb rule, network ratio of 1.2:1 (LV to MV) should be maintained for optimum initial capex and the running and maintenance costs. The MV distribution network is mainly through 33kV and 11kV overhead lines.

6.3 Distribution Transformers

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

Table 2: Total numbers of transformers, installed capacity and customers

Source	Capacity (MVA)	Feeder	Feeder Length (km)	DTs (Nos.)	Connected (kVA)	Customers (Nos.)
132/33kV Kanglung Substation	2x5	33kV Yangtse	232.75	180	12213	5326
132/33kV, Korlung SS	2x10					
33/11kV Chenary Substation*	2x2.5	11kV Jamkhar	6.940	7	495	332
Total			**239.688**	**187**	**12,708.00**	**5,658.00**

**Only the details of Trashiyangtse Dzongkhag*

As of July 2020, there were 187 distribution transformers with a total capacity of 12,708kVA. As can be inferred from **Table 2,** the installed capacity of the transformer per customer is 2.25kVA.

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 were assessed and accordingly the augmentation and reinforcement works are proposed which shall be the 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 peak load (2019-2020) and forecasted load. The source capability assessment had to be carried out to ascertain the adequacy of the installed capacity against the existing and the forecasted load. The source capability assessment had been carried out bifurcating HV and MV substations as detailed below.

7.1.1 HV Substation (132/33kV)

Kanglung and Korlung substations are the primary power sources for the Dzongkhag. To assess the adequacy of the substation, the peak power consumed has been compiled based on the historical data. The daily and monthly peak demand has been consolidated to annual peak demand as shown in **Table 3.**

Table 3: Peak load of Kanglung and Korlung substations

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW*	2019	2025	2030
1	Kanglung Substation	132/33	2x5	8.5	2.20	4.21	4.84
2	Korlung Substation	132/33	2x10	17			

** Pf of 0.85 is considered for study purpose*
The detailed assessment and the recommendations to address the issues related to the Kanglung and the Chenary substations are outlined in the DSMP of ESD Trashigang

The Korlung substation is constructed primarily to meet the constructional power supply for 600 MW of KHEL and for power evacuation once commissioned. It is currently the alternate source for the Dzongkhag. The 33kV Yangtse feeder which emanates from Kanglung substation is the primary source and caters most of the loads of the Dzongkhag. Due to the longer circuit length and line passing through the rugged terrain, it is susceptible to interruptions which would ultimately affect most of the customers of the Dzongkhag. Although, power can be also arranged from 33kV Bartsham/Merak feeder, the feeder is also connected with many customers in between and thus subject to power interruptions. Therefore, in order to reduce the power interruptions, it is prudent to switch the primary source to Korlung substation and the existing 33kV Yangtse feeder can be an alternate source.

The Dzongkhag has recorded a peak load of 2.199 MW and is forecasted to reach 4.840 MW (including the load of 1.44MW for new town) by 2030 against its installed capacity of 17.00 MW (@0.85 pf). Considering the combined loads of the Dzongkhag and construction power supply of KHEL (8MW approximately), the substation would be adequate to meet the power requirement of the Dzongkhag.

7.1.2 MV Substation (33/11 kV)

The power requirement for the customers of Jamkhar Gewog is catered by 11 kV Gongthung feeder which emanates from 2x2.5 MVA, 33/11 kV Chenary substation under Trashigang Dzongkhag. The detailed assessment on the Chenary's substation capability is outlined in the DSMP of Trashigang Dzongkhag and the assessment was carried out considering the combined loads of the Dzongkhags. The power requirement for customers of the Dzongkhag which is fed from Chenary substation is tabulated in **Table 4** and the same can be fed from Korlung substation by constructing ICT in Jamkhardrang as is detailed in **Section 7.2.1.**

Table 4: Peak load of Chenary substation

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)*	Forecasted Load (MW)	
			MVA	MW	2019	2025	2030
1	Chenary Substation	33/11	2x2.5	4.25	0.114	0.135	0.151

**The load of Trashiyangtse only*

7.2 Assessment of MV Feeders

Feeder wise planning is necessary to ensure that the power delivery capacity, power quality and reliability requirements of the customers are met. In 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 identification of feeders that require reinforcement and reconfiguration works.

The behavior of the MV feeders are 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 next 30 years. Therefore, it is equally important to consider the asset life of the system in addition to the assessment of the system in different time horizons.

7.2.1 Assessment of MV Feeder Capacity with Load

The feeder wise peak power consumption was 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 historical peak demand recorded at the source is presented in **Table 5** and the corresponding feeder-wise annual load curve is presented in **Figure 3.**

Table 5: Historical feeder wise peak power demand

Sl. No.	Feeder Name	Peak Load (MW)					
		2014	2015	2016	2017	2018	2019
1	33kV Yangtse feeder	1.52	1.59	1.92	1.96	2.14	2.20
2	11kV Jamkhar feeder	0.12	0.13	0.14	0.15	0.16	0.17

Note: 11 kV Jamgkhar feeder also caters the load of Gongthung and Yangneer Gewogs under Trashigang Dzongkhag

As can be inferred from **Figure 3**, the peak load of 33kV Yangtse feeder has increased steadily and has seen significant increase from 2016 onwards which could be due to implementation of

Doksum new town (Khitshang) and KHEL project. However, the peak power requirement of 11kV Jamkhar feeder has remained almost constant throughout the years indicating that the feeder is catering the power to the rural customers.

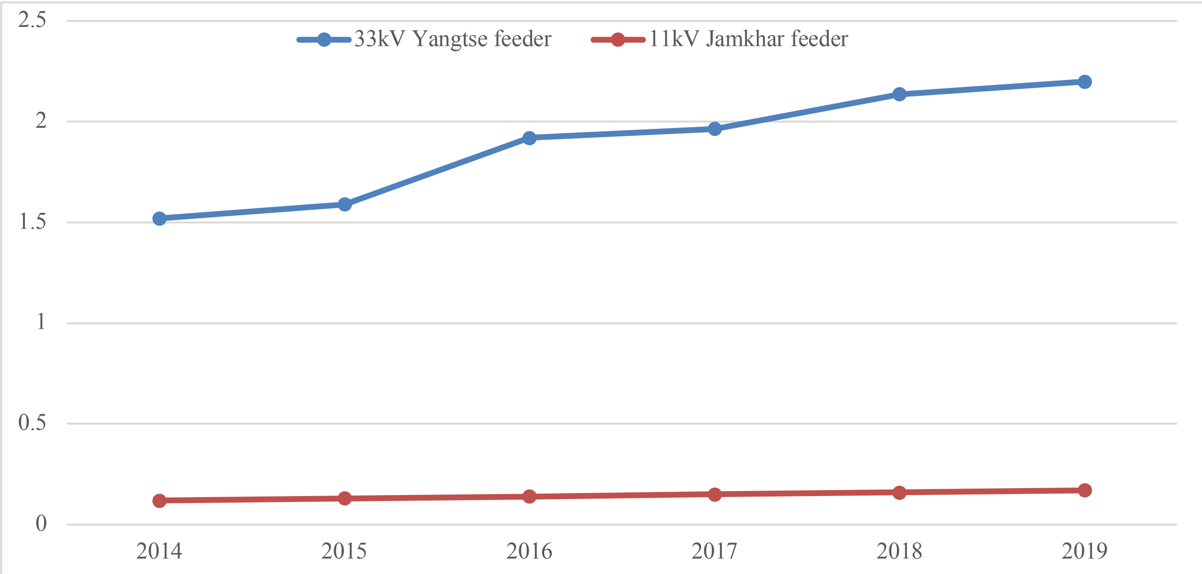


Figure 3: Peak Load (MW) of Yangtse and Jamkhar outgoing feeders

The assessment of the feeder is carried out based on the following aspects:

a) System study: Existing load

b) System study based on forecasted load: 2025 & 2030 scenario

c) System study based on when the source is from Kanglung substation

a) System Study (Existing Load)

Based on the peak load (2019-2020) and the thermal capacity of the line, the load flow and accordingly the assessment of the feeder was carried out. The simulation result shows no abnormality and the ampacity capability will be within the range with the existing as well as with the forecasted load. The thermal capacity of the different conductor sizes is as shown in **Table 6.**

Table 6: 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

Ampacity capability (thermal loading) of the lines has 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.

b) System Study with Forecasted Load (2025 and 2030)

The peak power demand from 2014-2019 has been considered to forecast the peak power demand for the next 10 years (2020-2030) as shown in **Table 7** and **Figure 4** adopting the commonly practiced methodology of LRM and TSA with the help of ETAP. The detailed simulation result is attached as **Annexure-4.**

Table 7: Feeder wise load forecast (2020-2030)

Name of Feeder	Forecasted Load (MW)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Yangtse Feeder	2.48	2.63	2.77	2.92	3.06	3.21	3.35	3.50	3.64	3.79	3.93
11kV Jamkhar Feeder	0.34	0.35	0.36	0.37	0.38	0.39	0.46	0.47	0.48	0.49	0.50

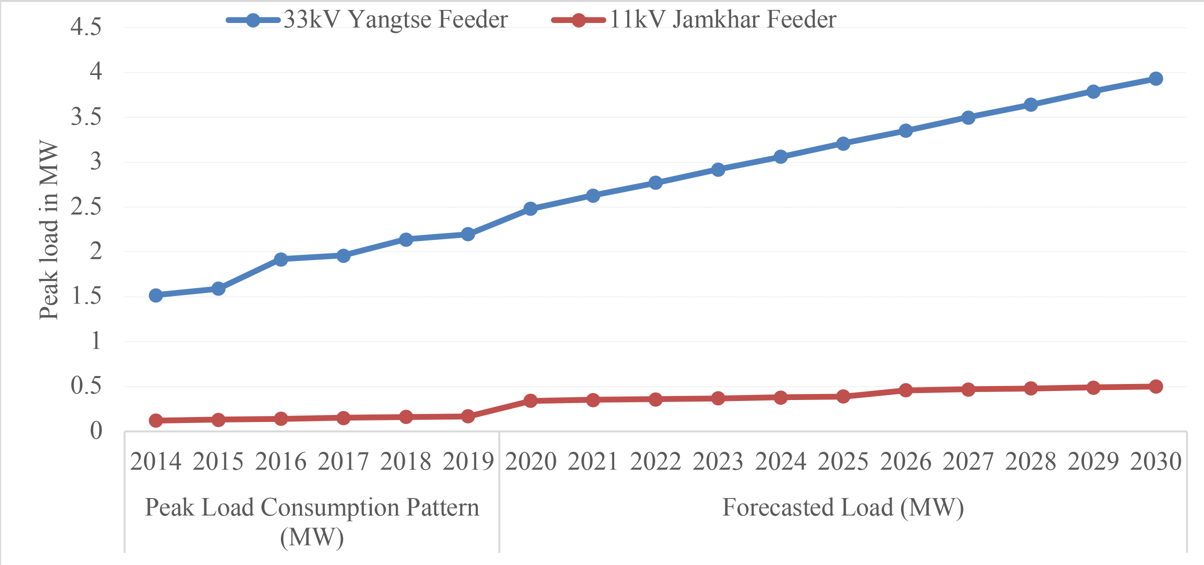


Figure 4: Plot of feeder wise peak power demand forecast

The simulation results for the feeders with marginal and critical voltage profile is tabulated in **Table 8** which is based on 2025 & 2030 forecasted load. From the simulation result, no abnormality was observed in 33 kV feeders. However, 11 kV Jamkhar feeder would experience voltage drop beyond the acceptable range.

Table 8: Voltage profile of the feeders

Feeder Name	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage		
	Load	Bus	End	Load	Bus	End
Korlung SS	**2.96**	**100**	**99.45**	**3.60**	**100**	**99.28**
33kV Yangtse Main	**2.94**	**98.94**	**98.87**	**3.57**	**98.64**	**98.55**
33kV I Khamdang	0.56	98.94	98.76	0.684	98.64	98.42
33kV II Ramjar	0.24	98.94	98.91	0.292	98.64	98.61
33kV III Yalang	0.42	98.94	98.73	0.517	98.64	98.38
33kV IV Tongzhang	0.46	98.94	98.72	0.554	98.64	98.36
33kV V Yangtse sub	0.95	98.94	98.32	1.152	98.64	97.85
33kV BOD ARCB SW	0.69	98.32	98.24	0.839	97.85	97.74

As evident from the above **Table 10,** the 11 kV Jamkhar would experience critical voltage drop beyond 2025 although it doesn't exceed the thermal limit. The 11 kV Jamkhar feeder which emanates from Chenary substation also meets the power requirement of the customers of Gongthung and Yangneer Gewogs of Trashigang Dzongkhag in addition to those customers under Trashiyangtse Dzongkhag. There are 20 DTs with a total installed capacity of 1,110 kVA for 1,042 customers out of which 13DTs with installed capacity of 615kVA and 710 customers are under the jurisdiction of ESD Trashigang.

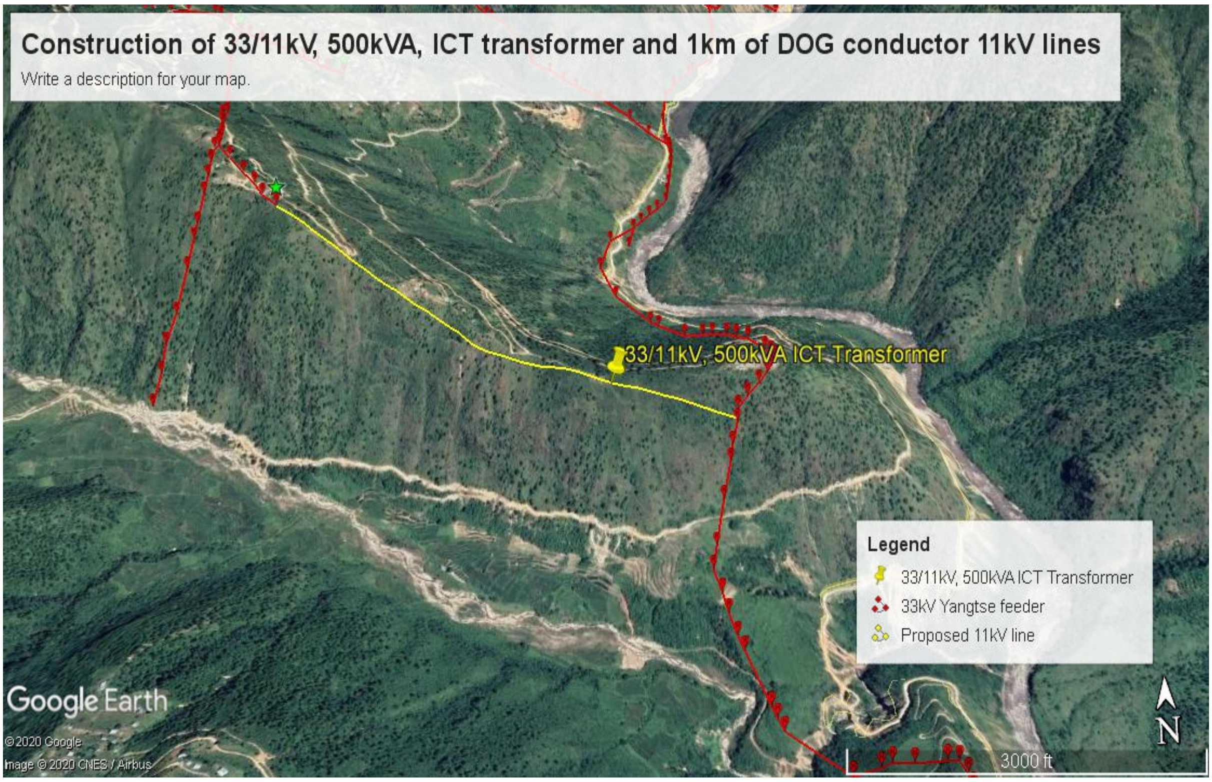


Figure 5: Proposed Location for the construction of ICT

While the voltage profile can be improved by changing the tap position of the power transformer and DTs, it would be prudent to install 33/11 kV ICT as a long term alternative solution as ICT would be handy to alternate the power transfer either through 11kV and 33kV nominal voltage. Should the customers experience power interruptions (when sourced from Chenary substation) the feeder can still cater power through ICT sourcing from Korlung substation. Therefore, it is proposed to construct the ICT at Jamkhardrang and extend the 11kV line till Golamzor village as shown in **Figure 5.**

Table 9: Voltage profile of the feeders with ICT

Feeder Name	2025 Load (MW) and Voltage (%)			2030		
	Load (MW)	Bus V (%)	End V (%)	Load (MW)	Bus V (%)	End V (%)
Korlung SS	**3.083**	**100**	**99.42**	**3.740**	**100**	**99.25**
33kV Yangtse Main	**2.938**	**98.92**	**98.86**	**3.571**	**98.62**	**98.54**
33kV I Khamdang	0.563	98.92	98.74	0.684	98.62	98.39
33kV II Ramjar	0.239	98.92	98.89	0.292	98.62	98.58
33kV III Yalang	0.424	98.92	98.71	0.517	98.62	98.36
33kV IV Tongzhang	0.455	98.92	98.70	0.554	98.62	98.33
33kV V Yangtse sub	0.950	98.92	98.30	1.151	98.62	97.82
33kV BOD ARCB SW	0.693	98.30	98.22	0.839	97.82	97.72
ICT (33/11kV) Jamkhar	0.129	99.40	98.11	0.144	99.22	97.77
11kV Jamkhar	0.129	98.11	97.87	0.143	97.77	97.50

As evident from **Table 9,** not only the voltage profile of the 11kV Jamkhar feeder would improve from 87.28 % to 97.50 %, the reliability and loss are also expected to reduce due to shorter line length when the power is arranged from Korlung substation through 33/11kV ICT.

c) System Study when the Source is from Kanglung

The system study was also carried out to find out the behavior of feeders when the source is from Kanglung. The load flow shows that with existing and forecasted load, the 11kV Jamkhar feeder would experience critical voltage at the end of the feeder. Therefore, it is recommended to source from Korlung substation as mentioned in b) and to source it from Kanglung when need arises. The simulation result is as shown in **Table 10.**

Table 10: Voltage profile of the feeders with ICT

Name of Feeder	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage (%)		
	Load	Bus	End	Load	Bus	End
132/33 Kanglung SS	8.443	100	95.3	10820	100	93.7
33/11kV Chenary SS	3.975	93.64	91.36	5.174	91.47	88.9
11kV Gongthung-Jamkhar	0.401	91.36	89.98	0.471	88.9	87.28

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 transformers and lines. 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.

To carry out the assessment, the energy sales, purchase and loss is as tabulated in **Table 11** and as shown in **Figure 6.**

Table 11: Energy sales, purchase and loss trend

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
1	**Energy Requirement (MU)**						
i)	Diesel Generation	0.00	0.00	0.00	0.00	0.00	
ii)	Import from Trashigang (Chenary & Jamkhar)	5.61	6.56	6.96	7.04	7.32	
iii)	Export to Trashigang (Chenary & Jamkhar)	0.00	0.00	-0.11	-0.13	-0.13	
	Total	**5.61**	**6.56**	**6.85**	**6.90**	**7.19**	
	% growth over previous year	-	16.92%	4.34%	0.83%	4.10%	**6.55%**

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
2	**Energy Sales in kWh (Category Wise)**						
i)	LV Total	4.88	5.18	5.91	6.16	6.27	
ii)	Medium Voltage				0.02	0.05	
	Total Energy Sales (MU)	**4.88**	**5.18**	**5.91**	**6.18**	**6.32**	
	% growth over previous year	-	6.05%	14.13%	4.50%	2.34%	**6.75%**
	Energy Loss (MU)	0.73	1.38	0.93	0.72	0.86	0.93
	Total Loss (%)	12.94%	21.04%	14.79%	12.19%	11.79%	14.55%

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.

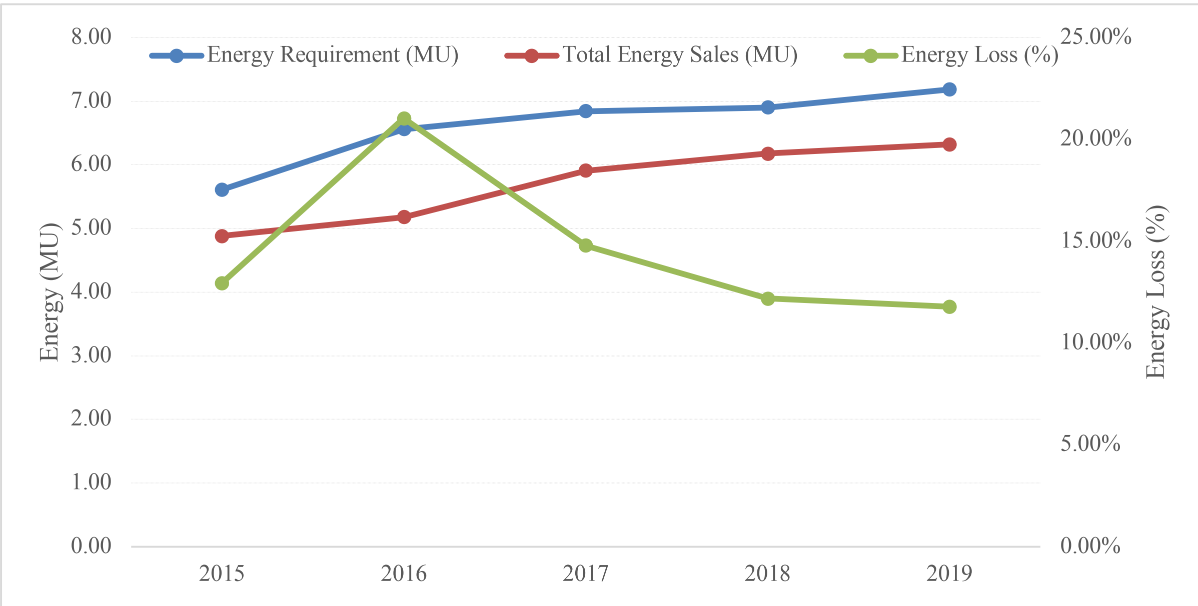


Figure 6: Energy sales, purchase and loss trend

As evident, the energy requirement has increased steadily over the year @ 6.55 % and so is the energy consumed @ 6.75 % on the average from the year 2015-2019.

Generally, the system loss (MV & LV) is 8.9% and any loss more than this for the distribution network would require in-depth study. An independent study carried out by 19 ESDs for 38 feeders in 2017 (two feeders each in ESD with more loss) showed that average of 6.84% is due to technical loss. The study also showed that loss pattern was never consistent because of variant characteristics of distribution network and loading pattern. The average loss index of the Dzongkhag (2015-2019) is 14.55% (0.93 million units on average) indicating that loss is exceptionally high and therefore, the Division needs to focus on reducing the commercial loss. However, it is inspiring to note that the loss has improved over the years and has reduced from 21.04% to 11.79% from 2016 to 2019. The feeder wise energy loss for 2019 is as tabulated in **Table 12** and **Figure 7.**

Table 12: Feeder wise energy loss (2019)

Sl. No.	Name of Feeder	2019		
		Energy Purchase (MU)	Energy Sales (MU)	Energy Loss (%)
1	33kV Yangtse Feeder	7.125	6.26	12.13%
2	11kV Jamkhar Feeder	0.296	0.27	8.43%
	Total	**7.41**	**6.53**	**10.28%**

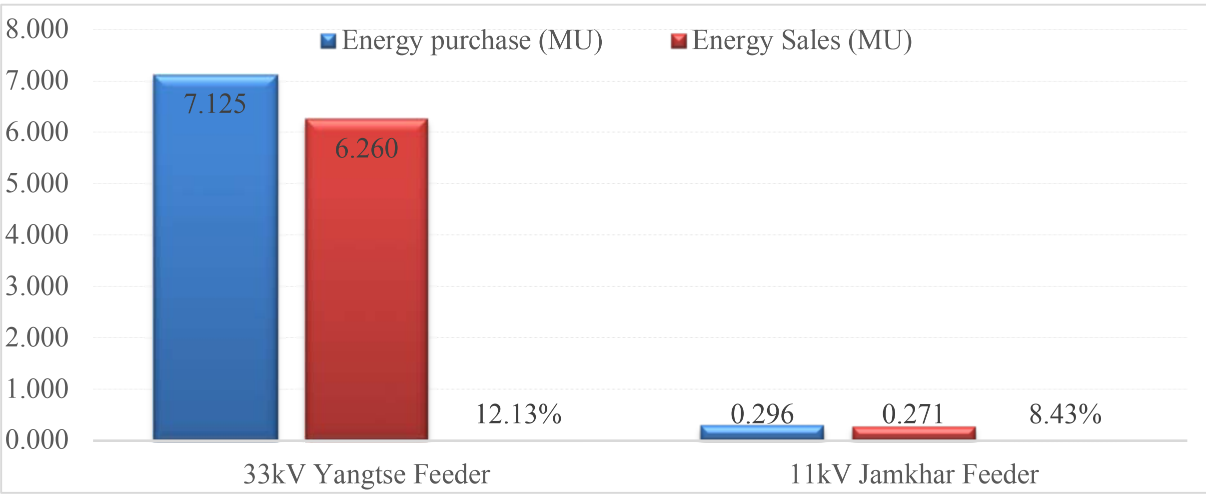


Figure 7: Feeder wise energy loss

As evident from **Figure 7,** of the two feeders 33 Yangtse feeder has contributed more loss with 12.13% in 2019 which is beyond the acceptable range. The feeder has a total circuit line length of around 233 km catering to the 5326 customers.

As the system study is till DT, the technical loss obtained through the ETAP software tool is for MV lines including the DT and doesn't account the loss due to LV network and transmission system. The simulation result shows only 2.40 % loss out of 14.55% as technical loss due to MV lines, DT and rest (12.15%) is due to LV and commercial loss. The feeder wise MV and DT technical loss is as shown in **Table 13.**

Table 13: Feeder wise power loss (Technical)

Sl. No.	Feeder Name	Power Demand (MW)	Apparent Loss (MW)	Loss (%)
1	33kV Yangtse Feeder	3.108	0.051	1.64%
2	11kV Jamkhar Feeder	0.132	0.001	0.76%
	Total	**3.240**	**0.052**	**2.40%**

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. In order to assess the reliability of the distribution system, the historical data was referred. The yearly (2017-2019) feeder reliability indices summary is compiled as tabulated in **Table 14** and details used to derive such 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 for actual representation to compute the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2017-2019 are 3.91 & 3.46 respectively which indicates that the power supply to the Dzongkhag is exceptionally reliable. The reliability of the 11kV Jamkhar feeder is included in the DSMP of Trashigang Dzongkhag.

Table 14: Feeder wise reliability indices (2017-2019)

Sl. No	Name of Feeder	2017		2018		2019		Average	
		SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
1	33kV Yangtse Feeder	4.36	3.75	3.76	1.90	3.63	4.72	3.91	3.46

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.

Although, the power supply in the Dzongkhag is commendable there is high risk of Dzongkhag being without power supply as there is only a 33kV incomer. Any interruption to this feeder would mean that entire Dzongkhag would experience the outage simultaneously. Therefore, evaluating the risk associated with single incomer, it is recommended that following contingencies to be implemented to address the issue:

a) To arrange the power supply from Korlung substation (as primary source);

b) Arrange to connect 33 kV Ramjar feeder to 132/33 kV Korlung substation by constructing about 3km of MV line; and

c) Arrange to connect 33 kV Tongzhang feeder to 132/33 kV Korlung substation by constructing about 2km of MV line.

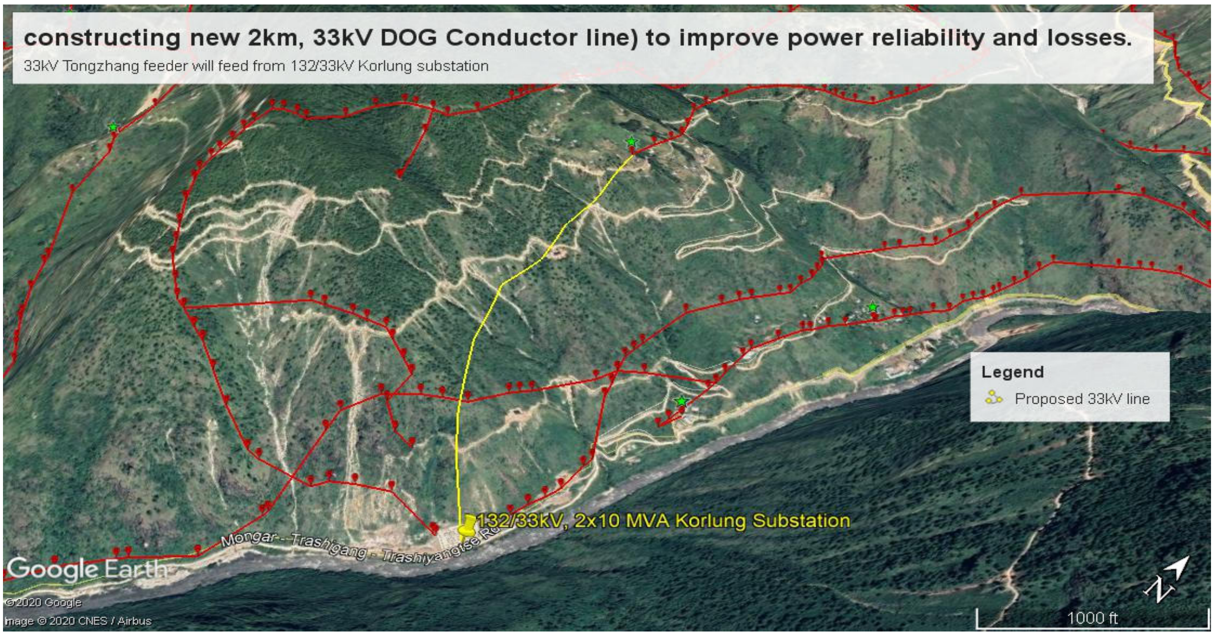


Figure 8: 33kV line extension from Korlung to Tongzhang

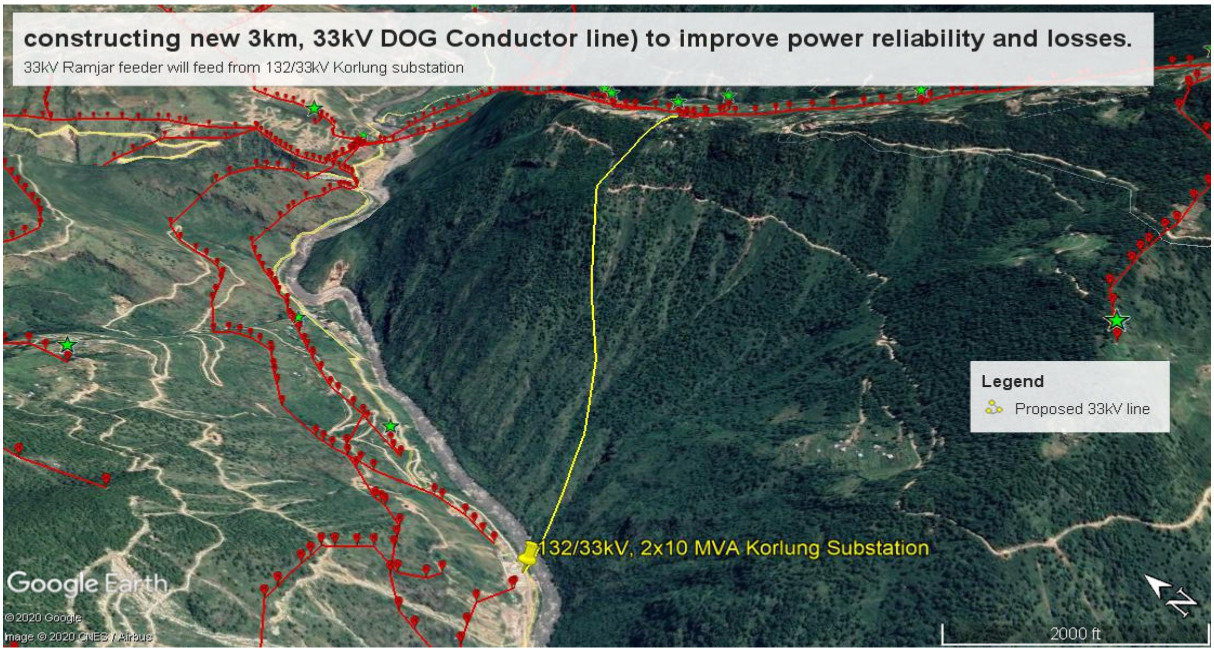


Figure 9: 33kV line extension from Korlung to Ramjar

Implementation of these corrective measures will not only improve the power supply reliability; the proposal would also lead towards optimum usage of Korlung substation and reduce losses to some extent.

Reliability of the lines and substations can also be enhanced through training of line staff. They need to be equipped with the knowledge, skills, and the 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. Although it is not possible to quantify the reliability indices that can be achieved with preventive and corrective measures in place, the proposed contingency plans would significantly improve the power quality.

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 these loads is gaining an 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 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. 96.67 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 required to be converted to three-phase in the Dzongkhag is 28.36km and the estimate for such conversion would require Nu. 3.46 Million.

As the single phase to three phase network conversions is a demand-driven planning, conversions 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 Distribution Transformers

7.3.1 Distribution Transformer Loading

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

As per the peak loading pattern, some of the existing transformer capacities would not be adequate to cater the forecasted load growth for next ten (10) years. Accordingly, the capacities of the transformers need to be up-graded and such proposal is tabulated in **Table 15**. The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Table 15: List of overloaded distribution transformers

Sl. No.	Transformer Name/Location	Capacity (KVA)	Existing Loading 2019		Loading (%)		Remarks
			KVA	% Loading	2025	2030	
1	Gomkora	100.00	46.70	47%	108%	132%	Upgrade to 250kVA between 2055 to 2030

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 although some of the transformers would get overloaded as per the forecasted load. Nevertheless, considering the actual site-specific growth rate and judgment of the field offices, it is recommended that arrangements be made for the up-gradation of only one transformer.

7.3.2 Asset life of Distribution Transformers

The DTs are one of the most critical equipment of the distribution network. Therefore, assessment of existing loading pattern together with the remaining asset life is crucial to ascertain its capabilities to cater the projected load growth. The life cycle of transformer and its mapping provides the clear information for its optimal utilization and development of an asset replacement framework.

Although, as listed in **Table 16**, 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 16: List of outlived distribution transformers

Asset Code	DT Location Name	Transformer Ratio	kVA	MFD	2019	2025	2030
1501787	Rejung	11/ 0.415 kV	150.00	1989	30.00	36.00	41.00
1501786	Baaling	11/ 0.415 kV	63.00	1990	29.00	35.00	40.00
1502960	Pangthang	33/ 0.400kV	63.00	1996	23.00	29.00	34.00
1502961	Shangthang	33/ 0.400kV	63.00	1996	23.00	29.00	34.00
1502962	Ramjar Binangreb	33/ 0.400kV	63.00	1996	23.00	29.00	34.00
1502963	Wongkhar	33/ 0.400kV	63.00	1996	23.00	29.00	34.00
1502964	Gonpa (Ramjar Gonpa)	33/ 0.400kV	63.00	1996	23.00	29.00	34.00
1501767	Buyang	33/0.400 kV	63.00	1996	23.00	29.00	34.00
1501803	Yangtse Town 'B' (Yangtse Lower Market)	33/0.400 kV	100.00	1996	23.00	29.00	34.00
1502948	RBP	33/0.400 kV	63.00	1996	23.00	29.00	34.00
1502945	Lower Khamdang	33/0.400kV	63.00	1996	23.00	29.00	34.00
1502946	Upper Khamdang	33/0.415kV	63.00	1996	23.00	29.00	34.00
1502952	Nombari	33/0.400kV	63.00	1996	23.00	29.00	34.00
1501785	Darchen	33/0.400 kV	25.00	1996	23.00	29.00	34.00
	NHDC (National Housing Colony), Pvt.	33/0.415 kV	100.00	1996	23.00	29.00	34.00
	URC	33/0.400kV	63.00	1996	23.00	29.00	34.00

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 need basis. Total of Nu. 283.00 million is estimated for replacing all single-phase transformers including the distribution board. The detailed work out is produced as **Annexure-8.**

There are 35 single phase transformers in the Dzongkhag and the estimate for up-grading all the single to three-phase transformers would require Nu. 7.47 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 Dzongkhag's Thromde stretches from Dzong till Chortenkora. Industrial and commercial activities are most likely to be limited to small scale activities. Therefore, power requirement in the Dzongkhag would be steady in next foreseeable years.

Nevertheless, with the commencement of the KHEL and with Doksum new town (Khitshang) mushrooming with commercial and residential buildings, the power requirement would be significant.

The Khitshang town has 190 plots, the total power demand of around 1.44 MW is anticipated when it is fully developed assuming a coincidental peak of 2 kW per unit. The detailed power demand estimation is presented in **Table 17.**

Table 17: Power estimation for Khitshang town

Sl. No.	Proposed Facilities	No. of Plots	No. of Floor	No. of Units	Power Required (MW)
1	Total Commercial Building	40	2	160	0.32
2	Total Residential Building	150	3	560	1.12
	Total Plots	**190**			**1.44**

The power requirement of the LAP can be met from the Khamdang feeder through 250kVA and 500kVA installed in the area and is adequate to cater the existing load. However, based on the projected load growth of the town (1.44MW), additional transformer would be required to meet the power requirement.

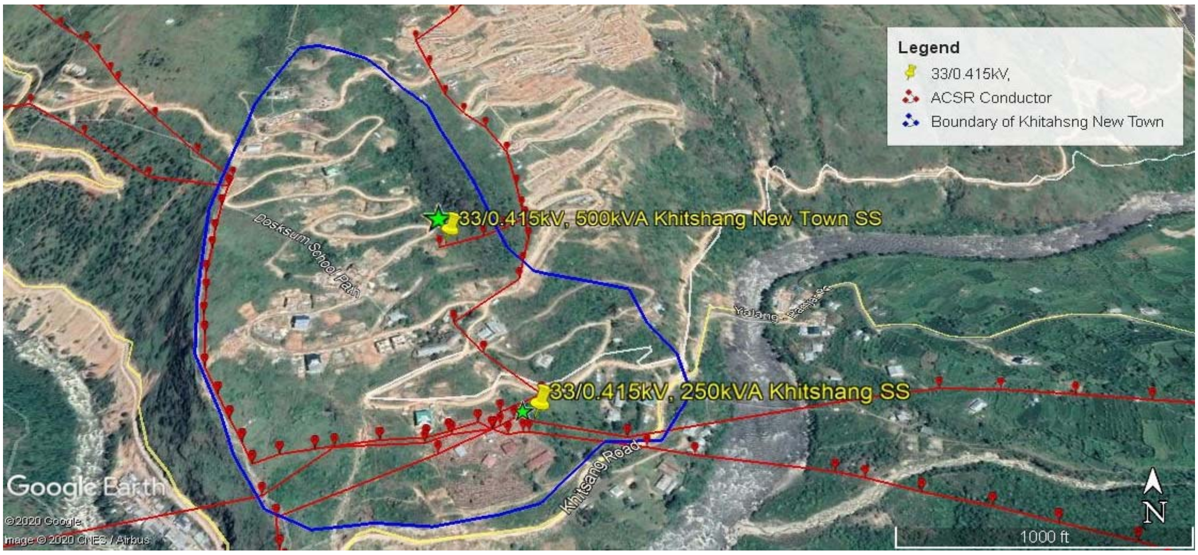


Figure 10: Existing distribution infrastructure within the boundary of Khitshang town

8. Distribution System Planning

The distribution network of the Dzongkhag has a radial topology with 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. In order to have 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 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 are detailed from **Section 8.1** through **Section 8.4.**

8.1 Power Supply Source

8.1.1 HV substation

The Korlung and Kanglung substations which are the primary power sources for the Dzongkhag would be adequate to meet the existing and forecasted power requirement.

8.1.2 MV Substation

There is no MV substation under the jurisdiction of the Dzongkhag.

8.2 MV Lines

The detailed MV line assessment made in **Section 7.2** shows that the MV distribution lines of the Dzongkhag would be adequate to cater the existing as well as the forecasted load. However, in order to improve the reliability of the power supply, it is recommended to implement the following proposals:

a) Arrange to connect 33 kV Ramjar feeder to Korlung substation by constructing about 3 km of MV; and

b) Arrange to connect 33 kV Tongzhang feeder to Korlung substation by constructing about 2 km of MV line is essential to have source contingency in place for the Dzongkhag; and

c) To construct 1.5 km, 11 kV line from Jamkhardrang to Golamzor and install 500 kVA, 33/11 kV ICT at Jamkhardrang to improve the voltage profile of 11 kV Jamkhar feeder.

8.3 Distribution Transformers

As detailed in **Section 7.3.1,** it is proposed to up-grade the 33/0.415kV, 100kVA Gomkora DT to 250 kVA and install additional 33/0.415, 500 kVA DT at Khitshang town.

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, optimizes the resource usage and more importantly the revenue generation will be enhanced. Similarly, in order to capture the real time data and information, it is inevitable to have automated and smart distribution system. The feeders which are more susceptible to faults are identified with proposed restorative measures through the studies. With the exception of tripping of breakers in the sending end substations, existing distribution network is neither automated nor smart to detect the faults and respond in real-time manner. The automation and smart grid components are detailed in 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 Dzongkhag has only the 33kV incomer. Although, the reliability indices of the feeder are exceptionally good compared to other Dzongkhags, to further improve the reliability of the feeder, it proposed to revive the ARCBs and install sectionalizers and FPIs in the strategic locations and source it from Korlung substation.

In order to improve reliability and power quality of the 33kV feeder, it is proposed to have technology in place to respond to fault and clear it accordingly rather than through ex-post facto approach. Therefore, it is proposed to enhance the existing switching and control system by having 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. **Figure 11 & Table 18** shows the list of proposed switching devices for easing operation and maintenance and for improving the reliability of the power supply for the Dzongkhag.

However, the quantum and location of the devices to be installed shall be based on the Smart Grid Master Plan 2019.

Table 18: List of switching equipment

Sl. No.	**Name of Feeder**	**ARCBs**		**LBS**		**FPI**	
		Existing (nos.)	**Proposed (Nos.)**	**Existing (Set)**	**Proposed (Set)**	**Existing (nos.)**	**Proposed (Nos.)**
1	33kV Yangtse Feeder	11	0	1	4	9	0
2	11kV Jamkhar Feeder	0	0	0	1	0	3
	Total	**11**	**0**	**1**	**5**	**9**	**3**

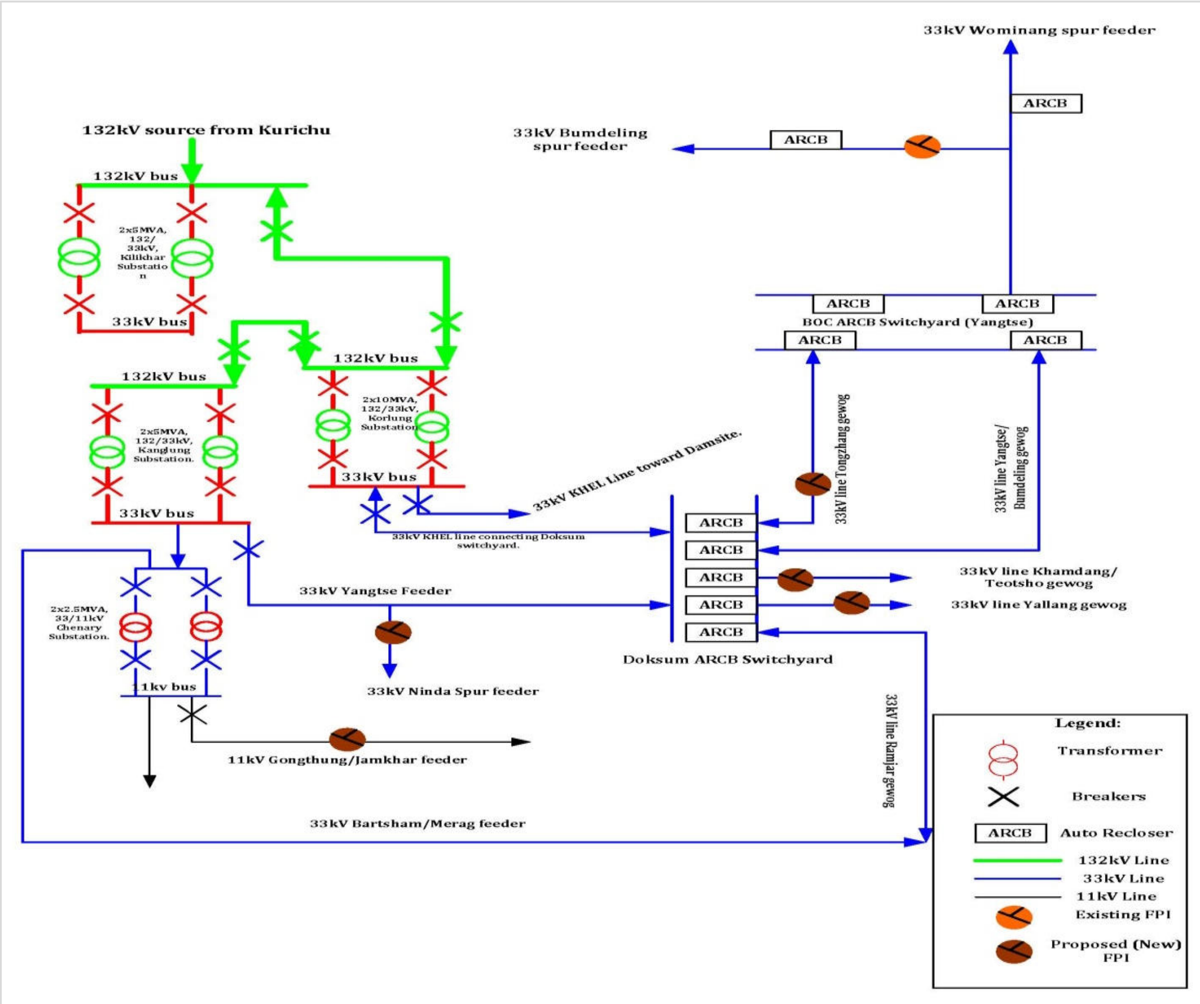


Figure 11: Proposed switching equipment for distribution network

8.4.2 Distribution System Smart Grid

The distribution grid modernization is outlined in Smart Grid Master Plan2019 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 which would require system augmentation and reinforcement as per the existing and projected load.

9. Investment Plan

In accordance to the above mentioned contingency plans targeted to improve the power quality, reduce losses and improve reliability indices of the Dzongkhag, 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 (2020-2024) 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 12.**

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 switchgears 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).

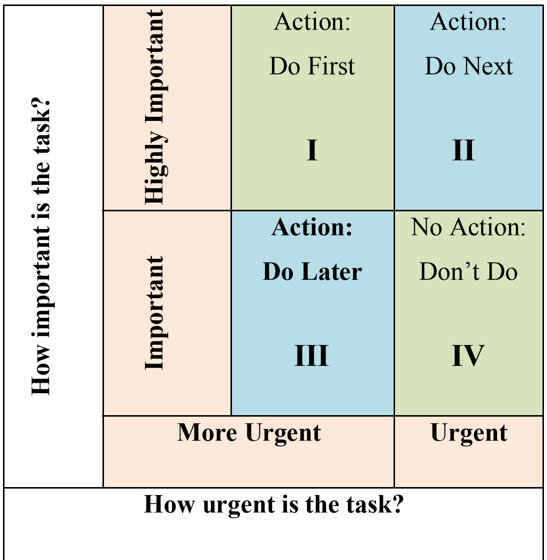


Figure 12: Priority Matrix

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 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 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 19** 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 the actual investment cost for the following years.

In the span of next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Trashiyangtse Dzongkhag is Nu. 21.36 million (Nu. 2.14 million per year).

Table 19: Investment Plan till 2030

Sl. No.	Project Activities	Investment Plan (Million Nu.)											Total
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
1	**MV Lines**												
1.1	Construction of 3km of 33kV line on DOG from Korlung SS to connect the Ramjar feeder.	-	-	-	2.82	-	-	-	-	-	-	-	**2.82**
1.2	Construction of 2km of 33kVline on DOG from Korlung SS to connect to Tongzhang feeder.	-	-	-	-	1.91	-	-	-	-	-	-	**1.91**
1.3	Construction of 33/11kV, 500kVA, ICT at Jamkhardrang and interconnecting 1.5km of MV line on DOG from Jamkhardrang to Golamzor.	-	-	4.82	-	-	-	-	-	-	-	-	**4.82**
1.4	Single to three-phase line conversion	-	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	**3.50**
2	**Distribution Transformer**												**-**
2.1	Up-rate 33/0.415kV, 100kVA transformer of Gomkora to 125kVA.	-	-	-	-	-	0.41	-	-	-	-	-	**0.41**
2.2	Replacement of single by three-phase transformers		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	**7.50**
3	**Switching and Control**												**-**
3.1	Installation of 33kV LBS	-	-	0.40	-	-	-	-	-	-	-	-	**0.40**
Total		**-**	**1.10**	**6.32**	**3.92**	**3.01**	**1.51**	**1.10**	**1.10**	**1.10**	**1.10**	**1.10**	**21.36**

10. Conclusion

Based on the inputs from Divisional 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 are 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 actually 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 to 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 are 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.

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

11. Recommendation

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	The Korlung and Kanglung substations would be adequate to cater the load requirement.
2	MV Substations	There are no MV substations under the jurisdiction of the Dzongkhag.
B. MV Lines		
1	MV lines	As reflected in **Section 8.2,** it is recommended to implement the interconnecting and extension lines from Korlung SS to improve the reliability of the power supply for the Dzongkhag.
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% so as to ensure that transformer is operated at maximum efficiency. As 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 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.

Sl. No.	Parameters	Recommendations
		2) Installation of 11kV& 33kV RMUs at various identified locations.
E. others		
1	Investment Plan	As reflected in **Section 9** of this report, overall investment plan as proposed is recommended.
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 situation demands.
3	System Studies beyond DT	It is observed that 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 time constraint and non-availability of required LV data, it is recommended to carry out the studies on 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 customer mapping process carried out annually.
5	Right of Way	RoW should be maintained as per the DDCS 2016. However, increased frequency of RoW clearing in the problematic sections of the line and in fast growth sub-tropical forest is recommended.
7	Asset life of DTs	The asset life of DTs needs to be gathered to enable development of asset replacement framework. However, it is recommended to regularly monitor the health of the transformers which have already outlived their lives.
8	Overloading of	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

Sl. No.	Parameters	Recommendations
	DTs	that the DTs that have already exhausted its statutory life (25 years and above) be regularly monitored.
9	New extension through 33kV network	The power carrying capacity of 33kV system is almost 3-fold compared to that of 11kV system. Therefore, any new extension of lines may be done through 33kV system (based on fund availability and practical convenience).
10	Reliability	In order to improve the reliability of the feeder/network, it is recommended that fault should be located within short period of time there by reducing the restoration time and the number of customers affected. In this regard, the following initiatives are recommended: 1) To install ISDs (communicable FPIs, Sectionalizers& ARCBs); 2) To explore with construction of feeders with customized 11kV & 33kV towers; and 3) To increase the frequency of Row clearing in a year.

12. Annexure

Annexure-1: MV Line Details and Single Line Diagram

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

Annexure-3: The details on load forecast methodology

Annexure-4: Detailed Simulation Results

Annexure 5: Feeder Wise Reliability Indices

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

Annexure 7: Distribution Transformer loading

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. Trashiyangtse City Development Strategy (2008).
11. Industrial Parks (Department of Industry).
12. 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, ratio of 80% (static load) to 20% (industrial feeders) were assumed;
3. The voltage level of ±10% is given as critical value which is indicated by red color while simulating and voltage level of ±5% is given as marginal value which is indicated by pink color while simulating.
4. The typical inbuilt value of X/R ratio of 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 & off-line Key b) Balanced Load Flow c) Limitations of No. of buses (1000)	a) Can opt for on line key with fewer more modules specially to carry out the technical evaluation of un-balanced load flow system. This would be more applicable and accrue good result for LV networks.
2	Data	a) No recorded data (reliability & energy) on the out-going feeders of MV SS	a) Feeder Meters could be install for outgoing feeders of MV substations to record actual data (reliability & energy)
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to timing and number of DTs.	b) In order 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 to have proper TLM and replacement framework.
3	Manpower	a) Resource gap in terms of trained (ETAP) and adequate engineers (numbers)	a) Due to lesser number of trained engineers in the relevant fields (software), engineers from other areas were involved.

12. Annexures

Annexure-1: MV Line Details and Single Line Diagram

MV line details of Trashiyangtse Dzongkhag

Annexure-II: Verified data of Trashiyangtse Distribution Network

Sl.No.	Source	Feeder details		Voltage (kV)	Section	CONDUCTOR	Conductor type & Line Length					Length (km)		
		Name	ID				50 UG	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
	33 kV Yangtse Feeder													
1	Kanglung (132/33 kV), 5 MVA	33kV Yangtse Feeder	O20	33	O20H001 to O20H108	WOLF	-	6.54	-	-	-	-	6.54	3
			O160		O160H001 to O160H079	WOLF	-	6.17	-	-	-		6.17	3
					O160H080 to TAE30H044	WOLF	-	3.92	-	-	-		3.92	3
					O160H094 to O160H096	DG	-	-	0.28	-	-		0.28	3
			TAE30		TAE30H045 to TAE30H065	WOLF	-	2.51	-	-	-		2.51	3
					TAE30H066 to TAE30H069	DG	-	-	0.34	-	-		0.34	3
					TAE30H070 to TAE30H114	WOLF	-	2.92	-	-	-		2.92	3
					TAE30H118 to TAE30H132	DOG	-	-	1.28	-	-		1.28	3
					TAE30H132 to TAE30H182	RAB	-	-	-	6.83	-		6.83	3
			TAE10		TAE10H001 to TAE10H132	DOG	-	-	9.39	-	-		9.39	3
					TAE10H052 to TAE10H053	WOLF	-	0.10	-	-	-		0.10	3
			TAE11		TAE11H001 to TAE11H096	DOG	-	-	7.73	-	-		7.73	3
					TAE11H021 to TAE11H034	RAB	-	-	-	1.10	-		1.10	3
					TAE11H097 to TAE11H241	RAB	-	-	-	17.41	-		17.41	3
					TAE11H242 to TAE11H225	DOG	-	-	1.55	-	-		1.55	3
			TAE12		TAE12H001 to TAE12H110	DOG	-	-	8.69	-	-		8.69	3
					TAE12H474 to TAE12H483	RAB	-	-	-	0.47	-		0.47	3
					TAE12H111 to TAE12H205	DOG	-	-	6.57	-	-		6.57	3
					TAE12H206 to TAE12H458	RAB	-	-	-	11.29	-		11.29	3
			TAE13		TAE13H001 to TAE13H191	WOLF	-	13.33	-	-	-		13.33	3
					TAE13H196 to TAE13H227	RAB	-	-	-	2.54	-		2.54	3
					TAE13H238 to TAE13H411	WOLF	-	8.74	-	-	-		8.74	3
					TAE13H244 to TAE13H691	DOG	-	-	0.03	-	-		0.03	3
					TAE13H1207 to TAE13H1197	DOG	-	-	1.21	-	-		1.21	3
					TAE13H356 to TAE13H409	RAB	-	-	-	4.32	-		4.32	3
					TAE13H1208 to TAE13H1197	DOG	-	-	1.21	-	-		1.21	3
					TAE13H356 to TAE13H409	RAB	-	-	-	4.32	-		4.32	3
					TAE13H412 to TAE13H424	WOLF	-	1.03	-	-	-		1.03	3
					TAE13H419 to TAE13H420	DOG	-	-	0.01	-	-		0.01	3
					TAE13H425 to TAE13H463	DOG	-	-	2.02	-	-		2.02	3
					TAE13H464 to TAE13H498	WOLF	-	1.91	-	-	-		1.91	3
					TAE13H471 to TAE13H478	DOG	-	-	0.36	-	-		0.36	3
					TAE13H499 to TAE13H504	DOG	-	-	0.29	-	-		0.29	3
					TAE13H505 to TAE13H533	RAB	-	-	-	1.78	-		1.78	3
					TAE13H541 to TAE13H545	RAB	-	-	-	0.20	-		0.20	3
					TAE13H546 to TAE13H659	DOG	-	-	8.12	-	-		8.12	3
					TAE13H661 to TAE13H665	DOG	-	-	0.15	-	-		0.15	3
					TAE13H667 to TAE13H690	RAB	-	-	-	2.00	-		2.00	3
					TAE13H668 to TAE13H770	DOG	-	-	7.27	-	-		7.27	3
					TAE13H782 to TAE13H849	AAAC	-	-	-	-	12.93		12.93	3
					TAE13H850 to TAE13H854	AAAC	-	-	-	-	0.56		0.56	1
					TAE13H854 to TAE13H855	AAAC	-	-	-	-	0.12		0.12	3
					TAE13H856 to TAE13H911	DOG	-	-	6.50	-	-		6.50	3
					TAE13H912 to TAE13H921	RAB	-	-	-	1.60	-		1.60	3
					TAE13H922 to TAE13H943	RAB	-	-	-	4.05	-		4.05	3
					TAE13H944 to TAE13H946	RAB	-	-	-	0.30	-		0.30	1
					TAE13H947 to TAE13H965	RAB	-	-	-	2.45	-		2.45	3
					TAE13H966 to TAE13H975	RAB	-	-	-	1.05	-		1.05	1
					TAE13H976 to TAE13H981	RAB	-	-	-	0.58	-		0.58	3
					TAE13H985 to TAE13H1049	RAB	-	-	-	4.52	-		4.52	3
					TAE13H1050 to TAE13H1058	RAB	-	-	-	0.62	-		0.62	1
					TAE13H1059 to TAE13H1067	RAB	-	-	-	0.56	-		0.56	3
					TAE13H1068 to TAE13H1080	RAB	-	-	-	1.06	-		1.06	1
					TAE13H1081 to TAE13H1085	RAB	-	-	-	0.25	-		0.25	3
					TAE13H1087 to TAE13H1107	DOG	-	-	2.02	-	-		2.02	3
					TAE13H1108 to TAE13H1118	RAB	-	-	-	0.80	-		0.80	1
					TAE13H1128 to TAE13H1145	RAB	-	-	-	1.18	-		1.18	3
					P1 to P5	UG	0.21	-	-	-	-		0.21	3
					TAE13H1147 to TAE13H1164	RAB	-	-	-	2.37	-		2.37	3
					TAE13H1165 to TAE13H1196	RAB	-	-	-	4.05	-		4.05	1

			TAE14		TAE14H001 to TAE14H032	DOG	-	-	2.79	-	-		2.79	3
					TAE14H033 to TAE14H153	RAB	-	-	-	13.67	-		13.67	3
					TAE14H154 to TAE14H210	DOG	-	-	4.27	-	-		4.27	3
					TAE14H211 to TAE14H304	DOG	-	-	8.29	-	-		8.29	3
Total							0.21	47.18	80.37	91.38	13.61	**-**	**232.75**	

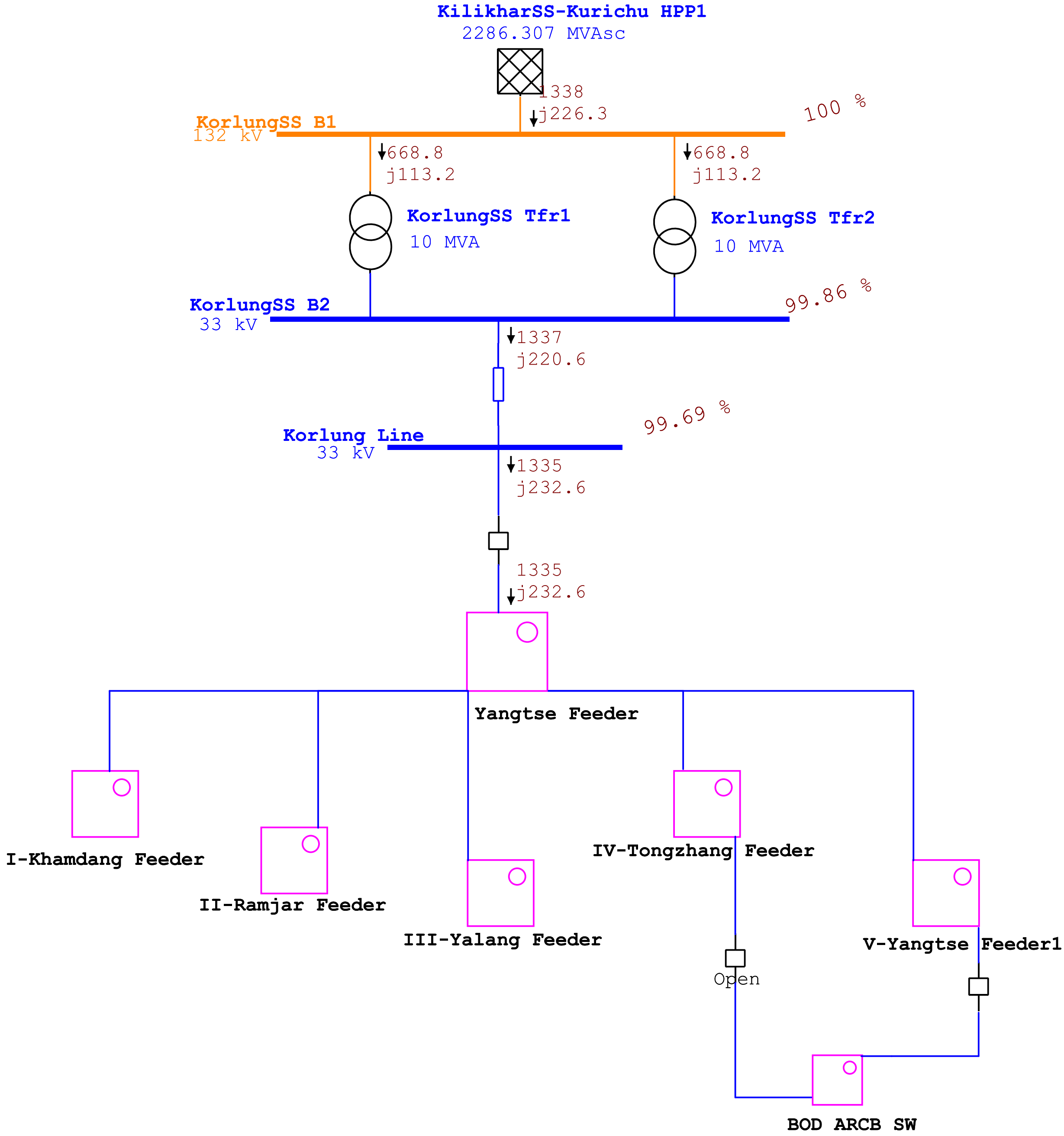
1	**11 kV Jamkhar Feeder**													
	Chenary (33/11 kV),2.5 MVA	11kV Jamkhar Feeder	P20	11	P20H001 to P20H046	DG	-	-	3.04	-	-	-	3.04	3
					P20H047 to P20H087	RAB	-	-	-	3.89	-	-	3.89	3
	TOTAL						**-**	**-**	3.04	3.89	**-**	**-**	**6.94**	
MV Line Total													**239.68**	

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

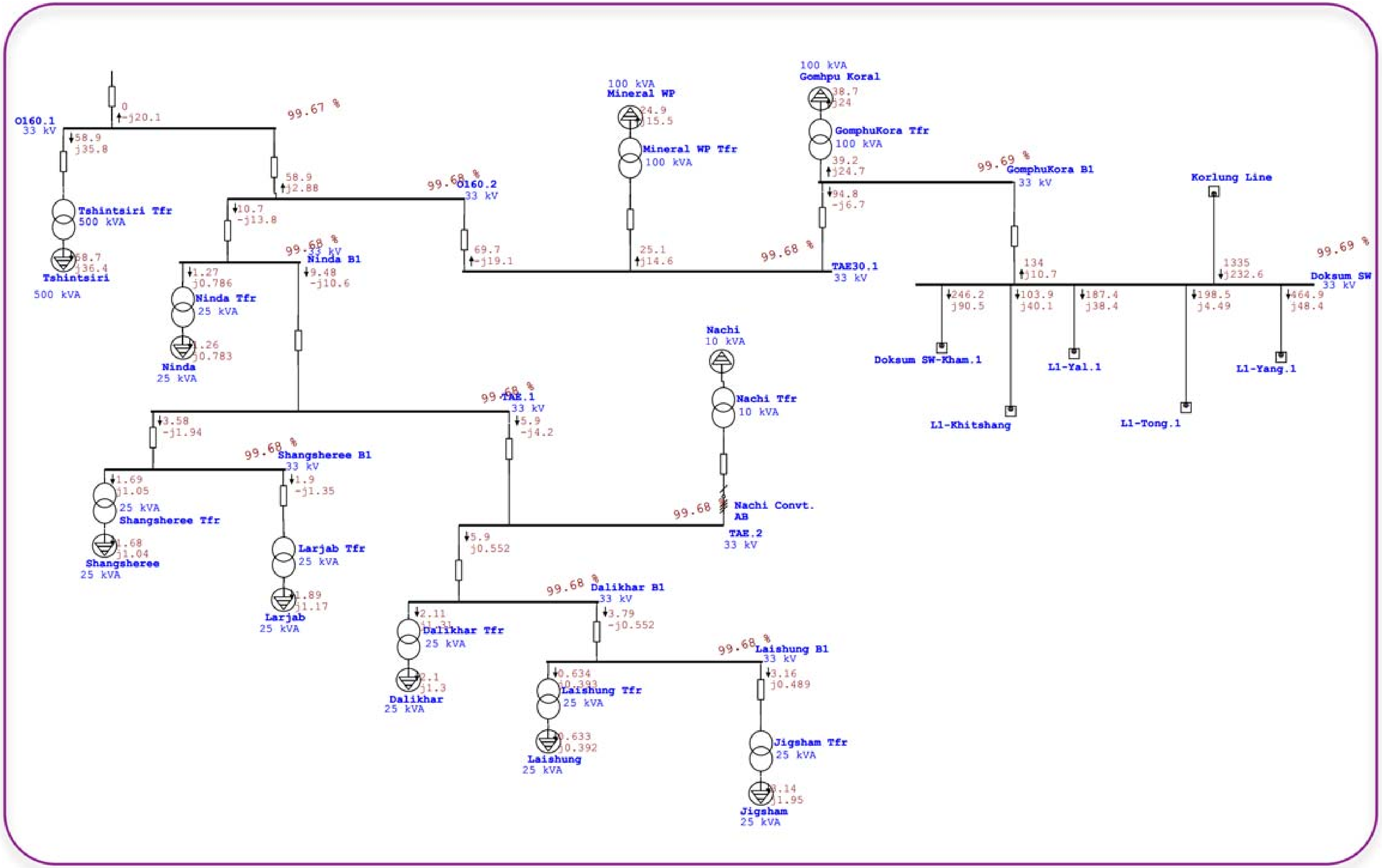
Sl. No.	Parameter	Requirement
1	Applicable standard	IS 2026, IEC 60076
2	Type	Oil filled[1] / two winding
3	Winding material	Copper
4	Core Material	CRGO silicon steel/Amorphous Metal
5	Cooling	Oil natural air natural (ONAN)
6	Terminations	
	· Primary	Outdoor Bushing or cable box[2]
	· Secondary	Outdoor 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

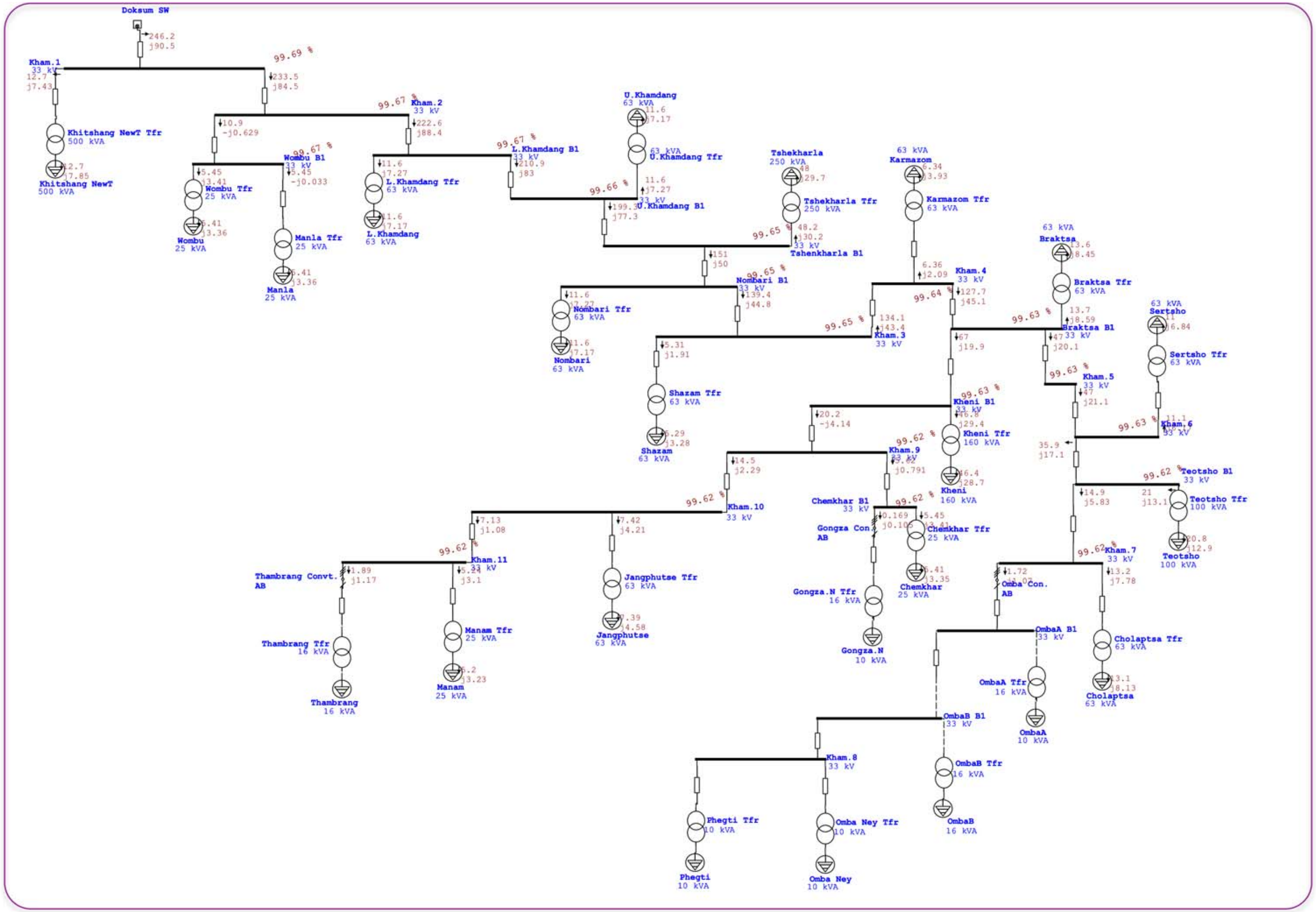
Annexure-3: Load Forecast adopting LRM & TSA

One-Line Diagram - OLV1 (Load Flow Analysis)

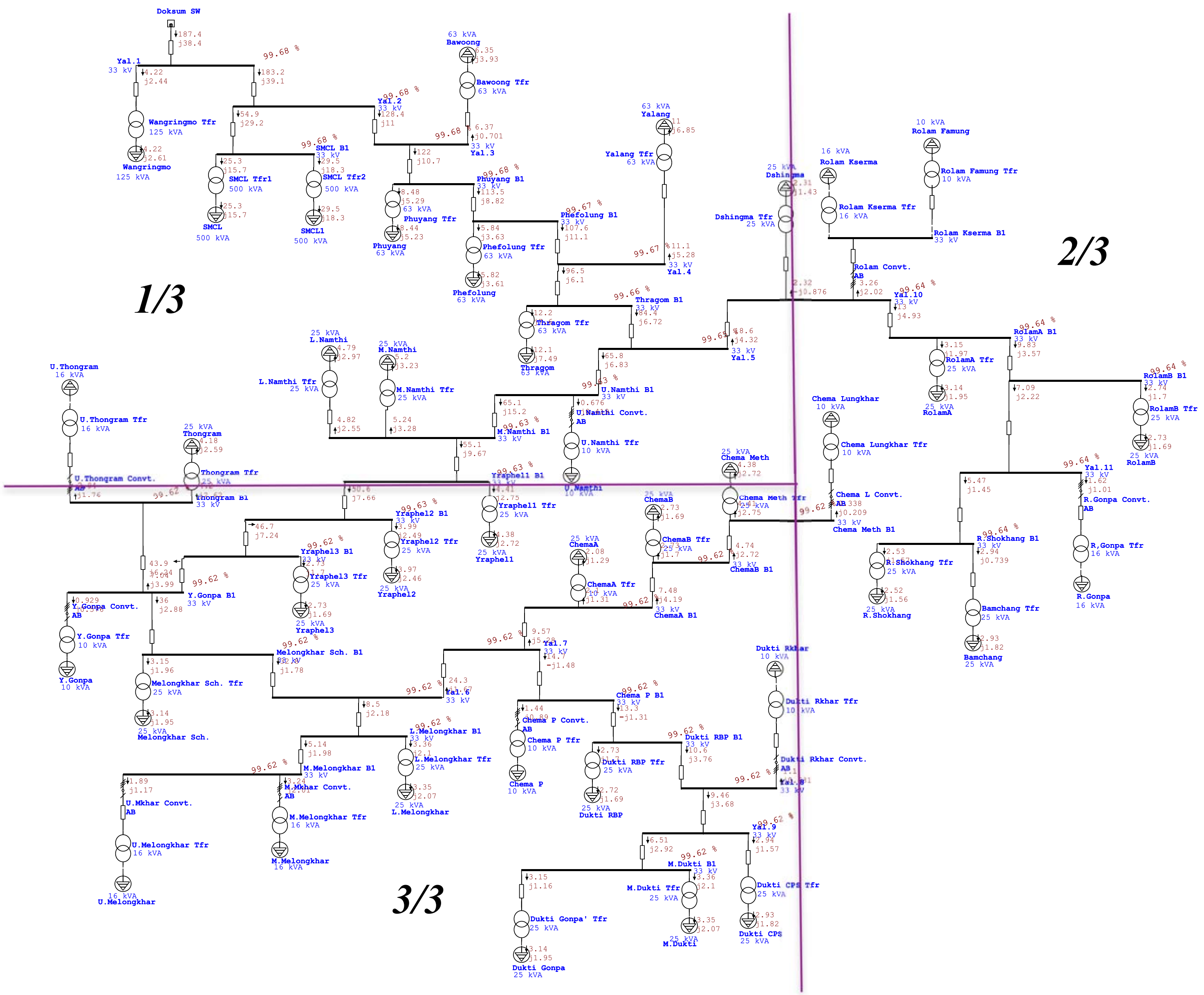


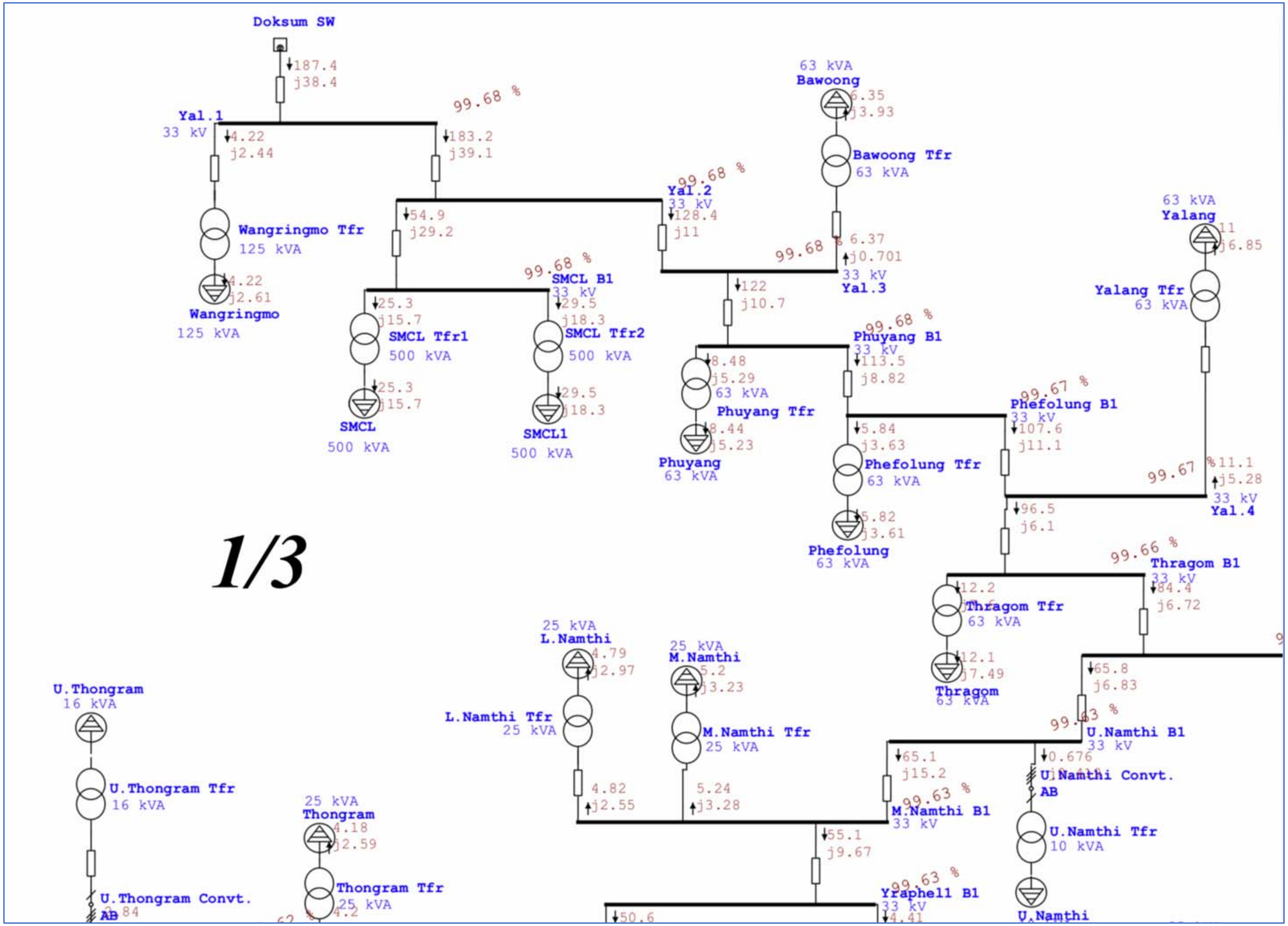
One-Line Diagram - OLV1=>Yangtse Feeder (Load Flow Analysis)



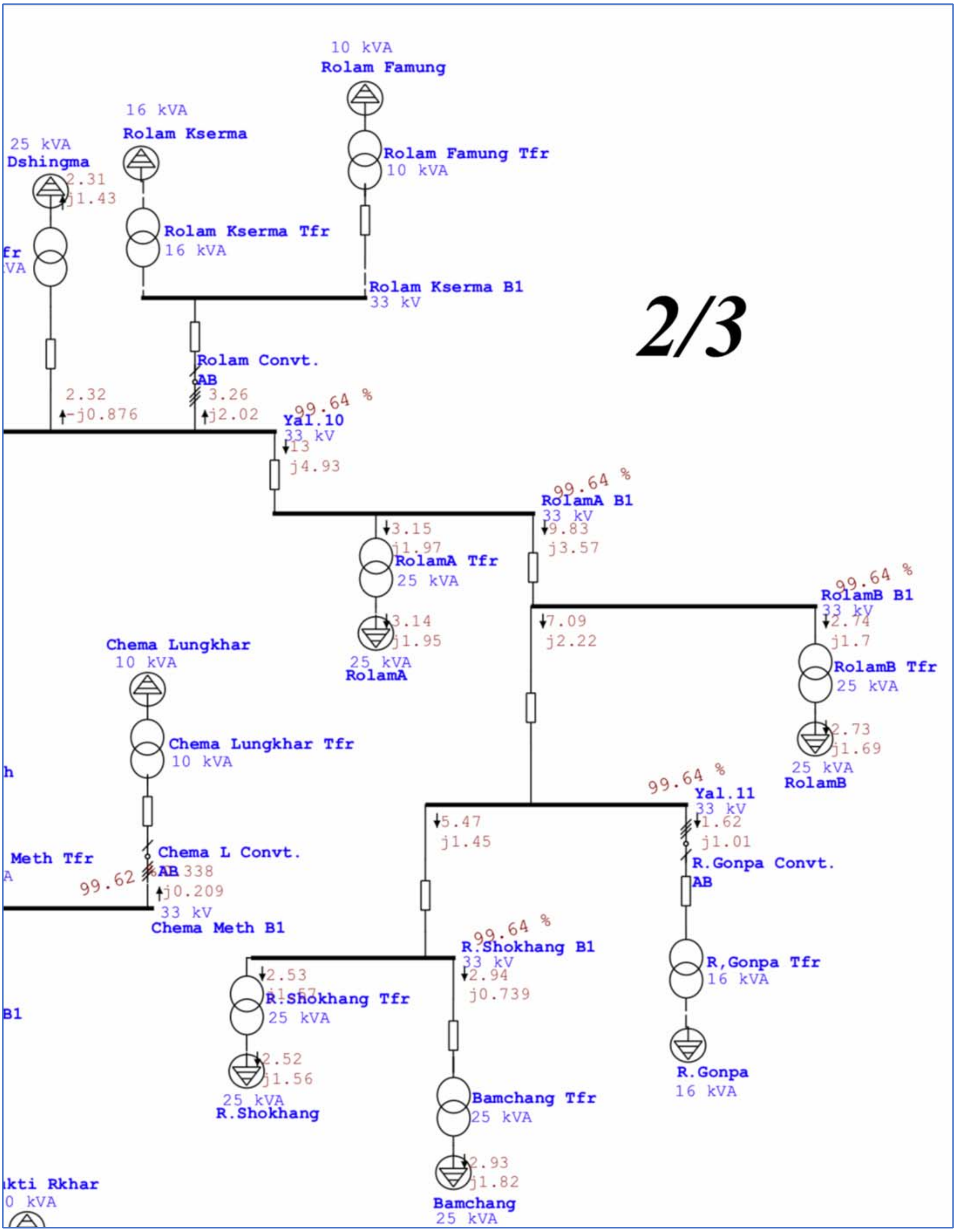

Doksum SW
Kham.1
33 kV
Khitshang NewT Tfr
500 kVA
Khitshang NewT
500 kVA
Kham.2
33 kV
Wombu B1
33 kV
Wombu Tfr
25 kVA
Wombu
25 kVA
Manla Tfr
25 kVA
Manla
25 kVA
L.Khamdang B1
33 kV
L.Khamdang Tfr
63 kVA
L.Khamdang
63 kVA
U.Khamdang
63 kVA
U.Khamdang Tfr
U.Khamdang B1
Tshekharla
250 kVA
Tshekharla Tfr
250 kVA
Tshenkharla B1
Nombari B1
33 kV
Nombari Tfr
63 kVA
Nombari
63 kVA
Karmazom
63 kVA
Karmazom Tfr
63 kVA
Kham.3
33 kV
Kham.4
33 kV
Shazam Tfr
63 kVA
Shazam
63 kVA
Braktsa
63 kVA
Braktsa Tfr
63 kVA
Braktsa B1
33 kV
Kham.5
33 kV
Sertsho
63 kVA
Sertsho Tfr
63 kVA
Kham.6
33 kV
Kheni B1
33 kV
Kheni Tfr
160 kVA
Kheni
160 kVA
Teotsho B1
33 kV
Teotsho Tfr
100 kVA
Teotsho
100 kVA
Kham.9
33 kV
Chemkhar B1
33 kV
Chemkhar Tfr
25 kVA
Chemkhar
25 kVA
Gongza Con.
AB
Gongza.N Tfr
16 kVA
Gongza.N
10 kVA
Kham.10
33 kV
Kham.11
33 kV
Jangphutse Tfr
63 kVA
Jangphutse
63 kVA
Thambrang Convt.
AB
Thambrang Tfr
16 kVA
Thambrang
16 kVA
Manam Tfr
25 kVA
Manam
25 kVA
Kham.7
33 kV
Omba Con.
AB
Cholaptsa Tfr
63 kVA
Cholaptsa
63 kVA
OmbaA B1
33 kV
OmbaA Tfr
16 kVA
OmbaA
10 kVA
OmbaB B1
33 kV
OmbaB Tfr
16 kVA
OmbaB
16 kVA
Kham.8
33 kV
Phegti Tfr
10 kVA
Phegti
10 kVA
Omba Ney Tfr
10 kVA
Omba Ney
10 kVA

One-Line Diagram - OLV1=>III-Yalang Feeder (Load Flow Analysis)

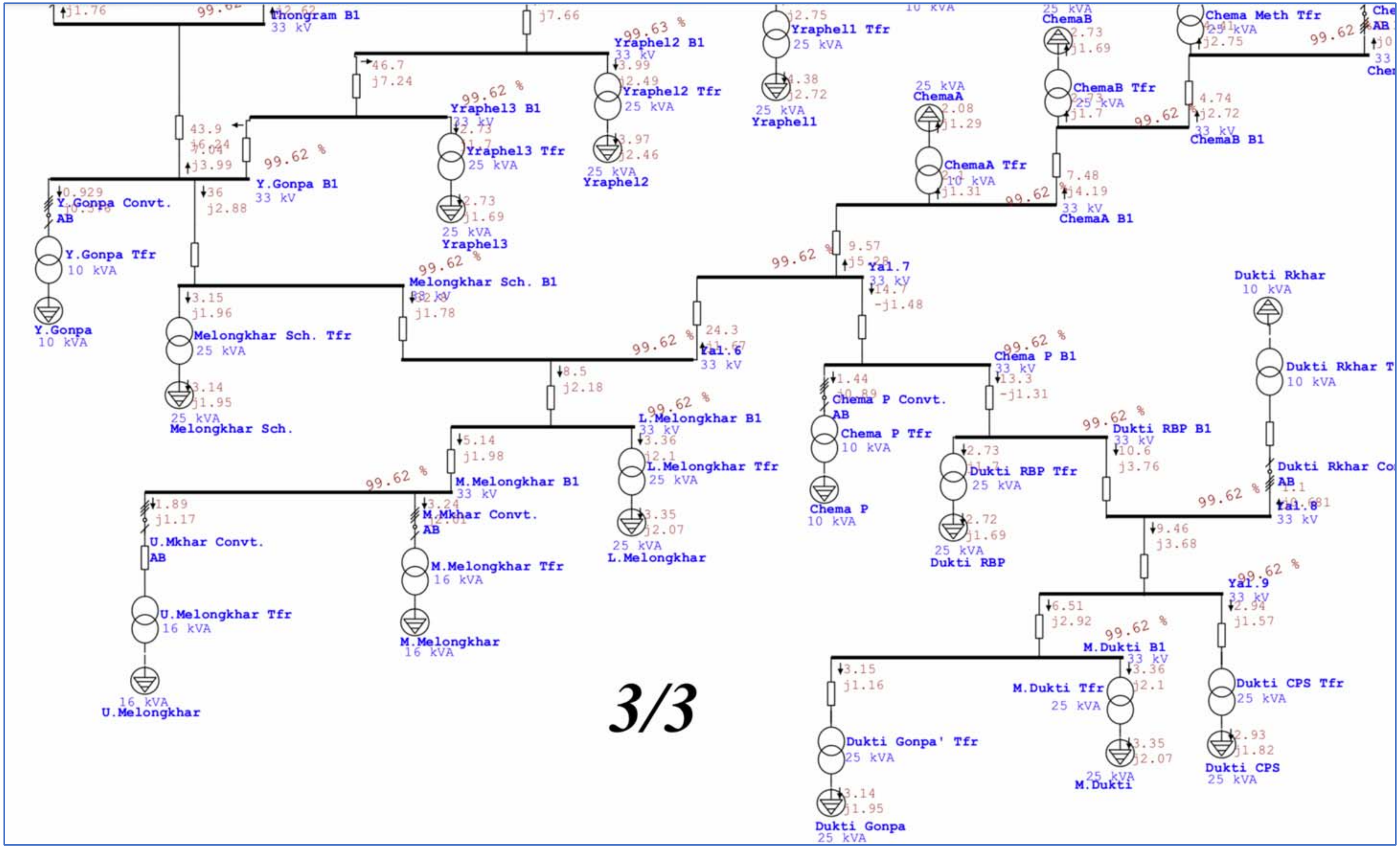



Doksum SW
187.4
j38.4
Yal.1
33 kV
4.22
j2.44
99.68 %
183.2
j39.1
Wangringmo Tfr
125 kVA
Wangringmo
125 kVA
54.9
j29.2
SMCL Tfr1
500 kVA
SMCL
500 kVA
SMCL B1
33 kV
29.5
j18.3
SMCL Tfr2
500 kVA
SMCL1
500 kVA
Yal.2
33 kV
128.4
j11
Yal.3
33 kV
6.37
j0.701
122
j10.7
Bawoong
63 kVA
6.35
j3.93
Bawoong Tfr
63 kVA
Phuyang B1
33 kV
113.5
j8.82
8.48
j5.29
Phuyang Tfr
63 kVA
Phuyang
63 kVA
8.44
j5.23
Phefolung B1
33 kV
107.6
j11.1
99.67 %
5.84
j3.63
Phefolung Tfr
63 kVA
Phefolung
63 kVA
5.82
j3.61
Yalang
63 kVA
11
j6.85
Yalang Tfr
63 kVA
Yal.4
33 kV
11.1
j5.28
96.5
j6.1
Thragom B1
33 kV
99.66 %
84.4
j6.72
12.2
Thragom Tfr
63 kVA
Thragom
63 kVA
12.1
j7.49
65.8
j6.83
U.Namthi B1
33 kV
99.63 %
0.676
U.Namthi Convt.
AB
U.Namthi Tfr
10 kVA
U.Namthi
M.Namthi B1
33 kV
65.1
j15.2
L.Namthi
25 kVA
4.79
j2.97
L.Namthi Tfr
25 kVA
4.82
j2.55
M.Namthi
25 kVA
5.2
j3.23
M.Namthi Tfr
25 kVA
5.24
j3.28
55.1
j9.67
Yraphel1 B1
33 kV
4.41
50.6
U.Thongram
16 kVA
U.Thongram Tfr
16 kVA
U.Thongram Convt.
AB
Thongram
25 kVA
4.18
j2.59
Thongram Tfr
25 kVA
4.2

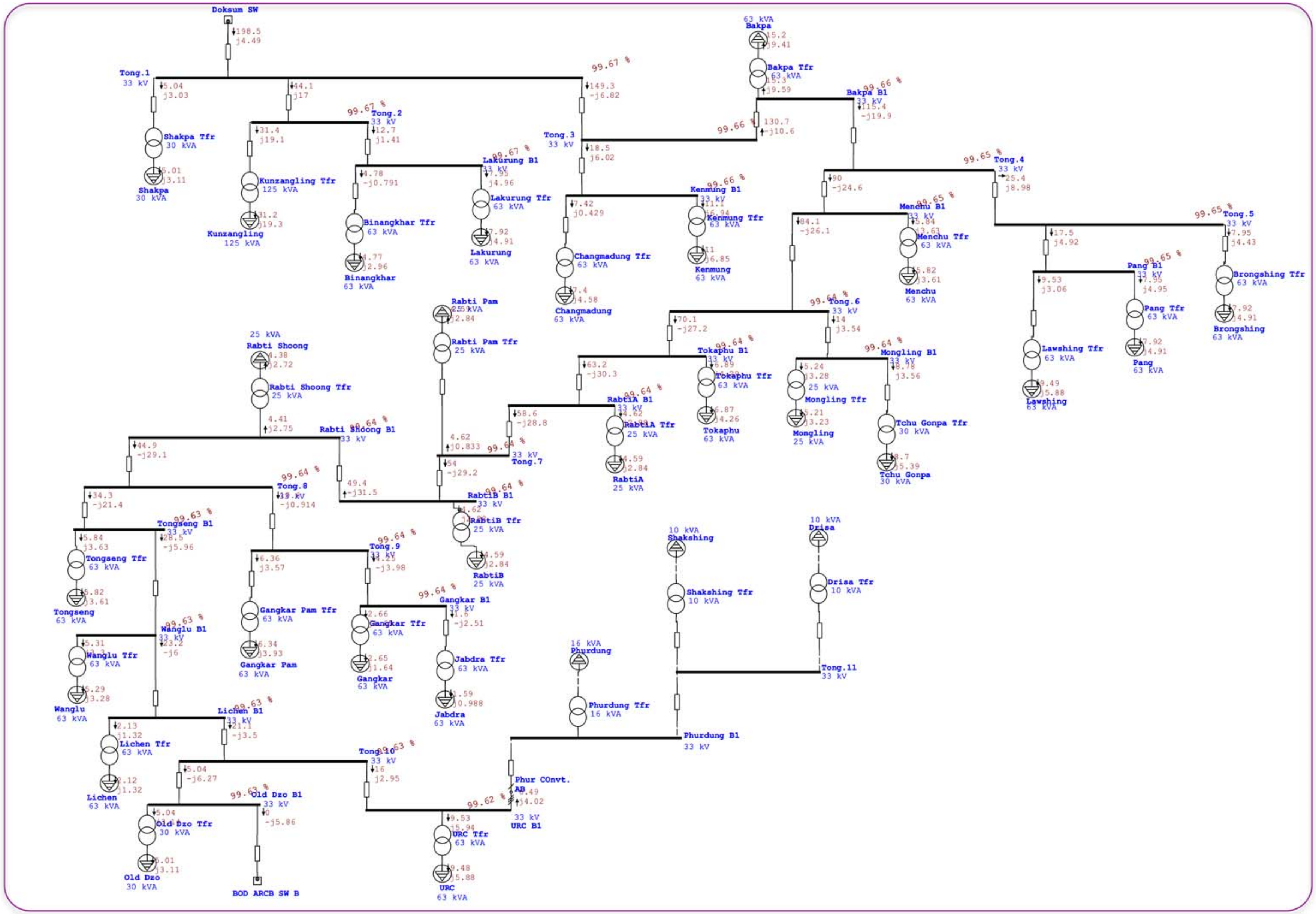
1/3

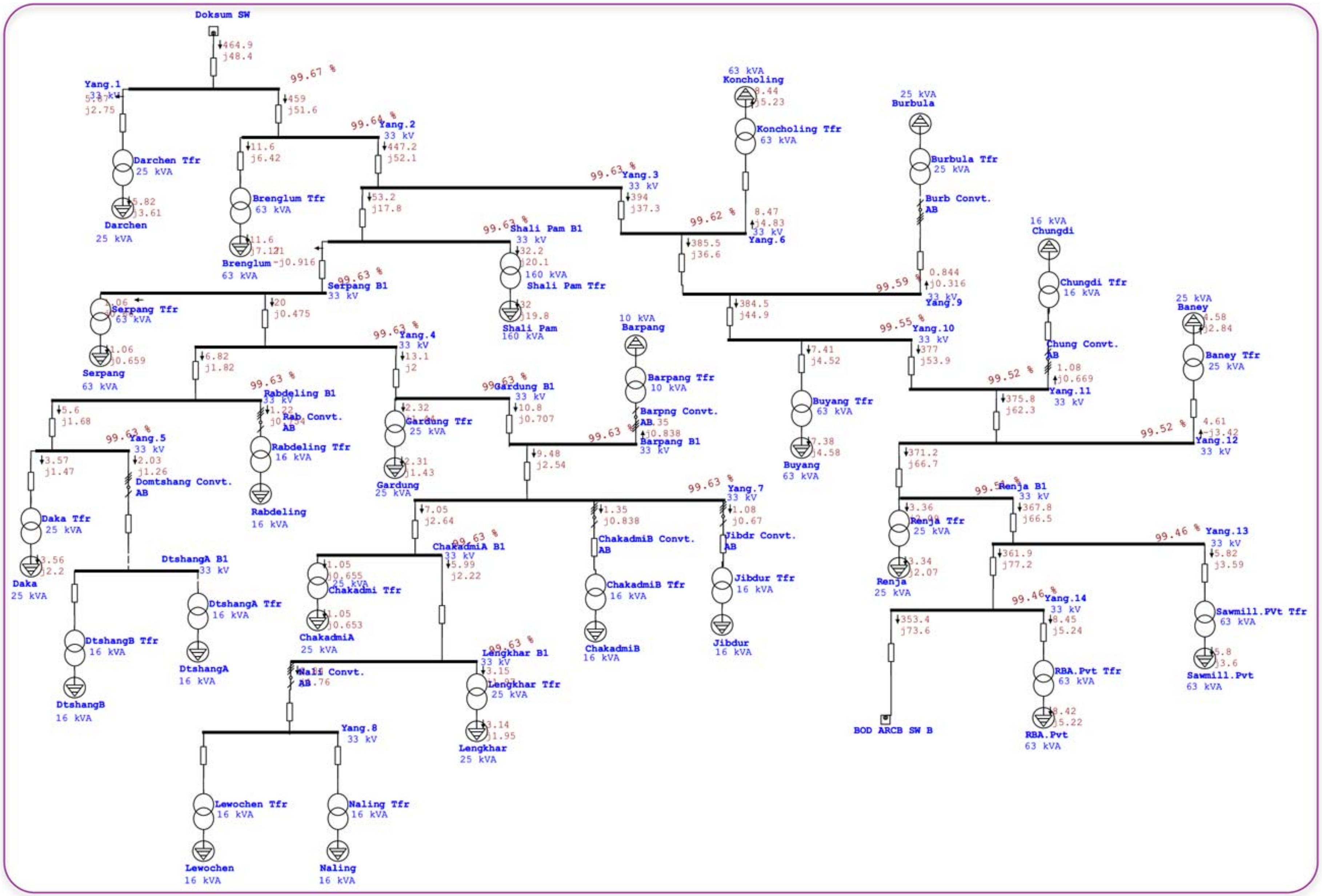


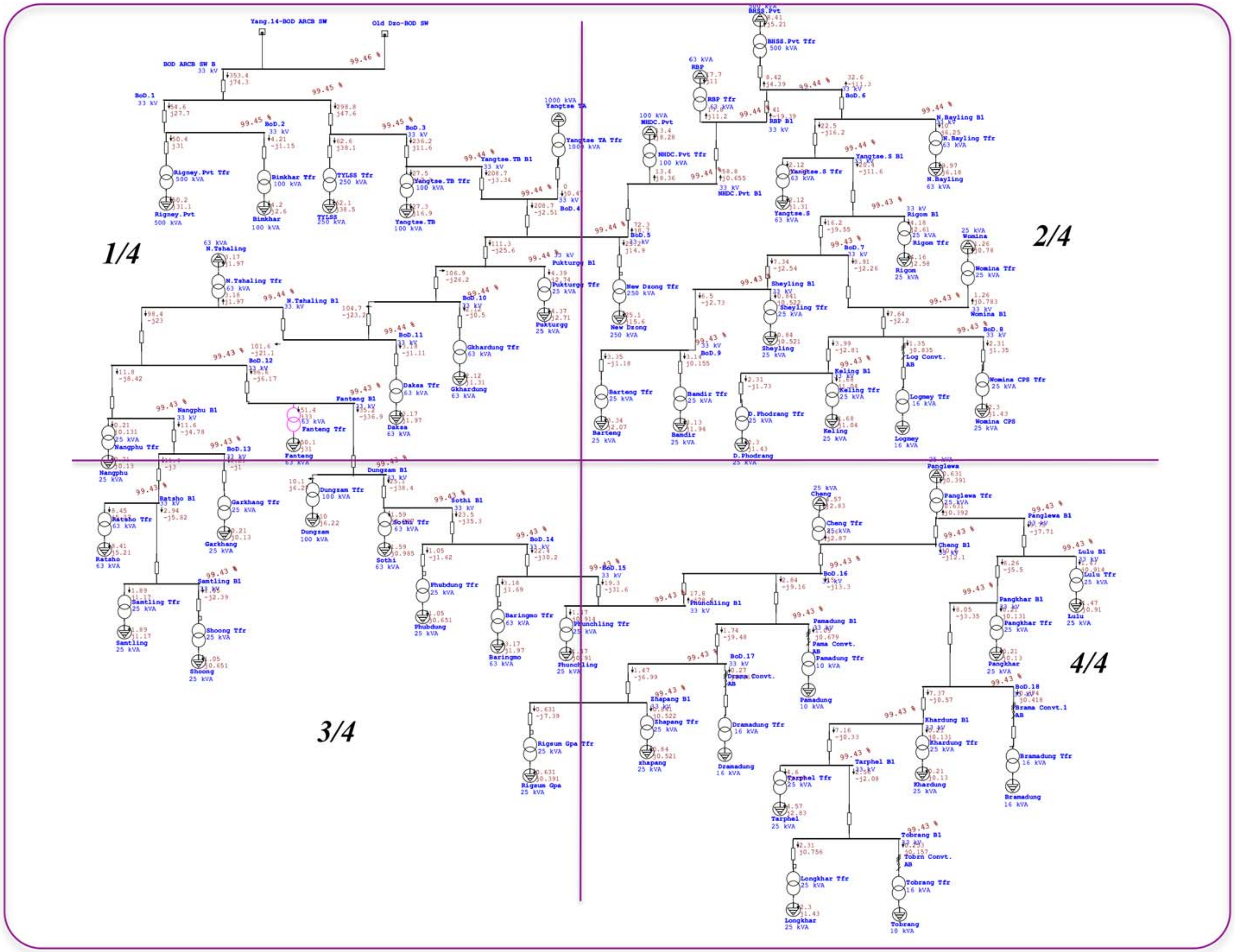
10 kVA
Rolam Famung
16 kVA
Rolam Kserma
25 kVA
Dshingma
2.31
j1.43
Rolam Famung Tfr
10 kVA
Rolam Kserma Tfr
16 kVA
Rolam Kserma B1
33 kV
2/3
Rolam Convt.
AB
2.32
-j0.876
3.26
j2.02
99.64 %
Yal.10
33 kV
13
j4.93
99.64 %
RolamA B1
33 kV
3.15
j1.97
9.83
j3.57
RolamA Tfr
25 kVA
3.14
j1.95
25 kVA
RolamA
99.64 %
RolamB B1
33 kV
2.74
j1.7
7.09
j2.22
RolamB Tfr
25 kVA
2.73
j1.69
25 kVA
RolamB
Chema Lungkhar
10 kVA
Chema Lungkhar Tfr
10 kVA
99.64 %
Yal.11
33 kV
1.62
j1.01
5.47
j1.45
R.Gonpa Convt.
AB
Meth Tfr
Chema L Convt.
AB
.338
j0.209
99.62 %
33 kV
Chema Meth B1
99.64 %
R.Shokhang B1
33 kV
2.53
2.94
j0.739
R.Shokhang Tfr
25 kVA
R,Gonpa Tfr
16 kVA
2.52
j1.56
25 kVA
R.Shokhang
R.Gonpa
16 kVA
Bamchang Tfr
25 kVA
2.93
j1.82
Bamchang
25 kVA
B1
Rkhar

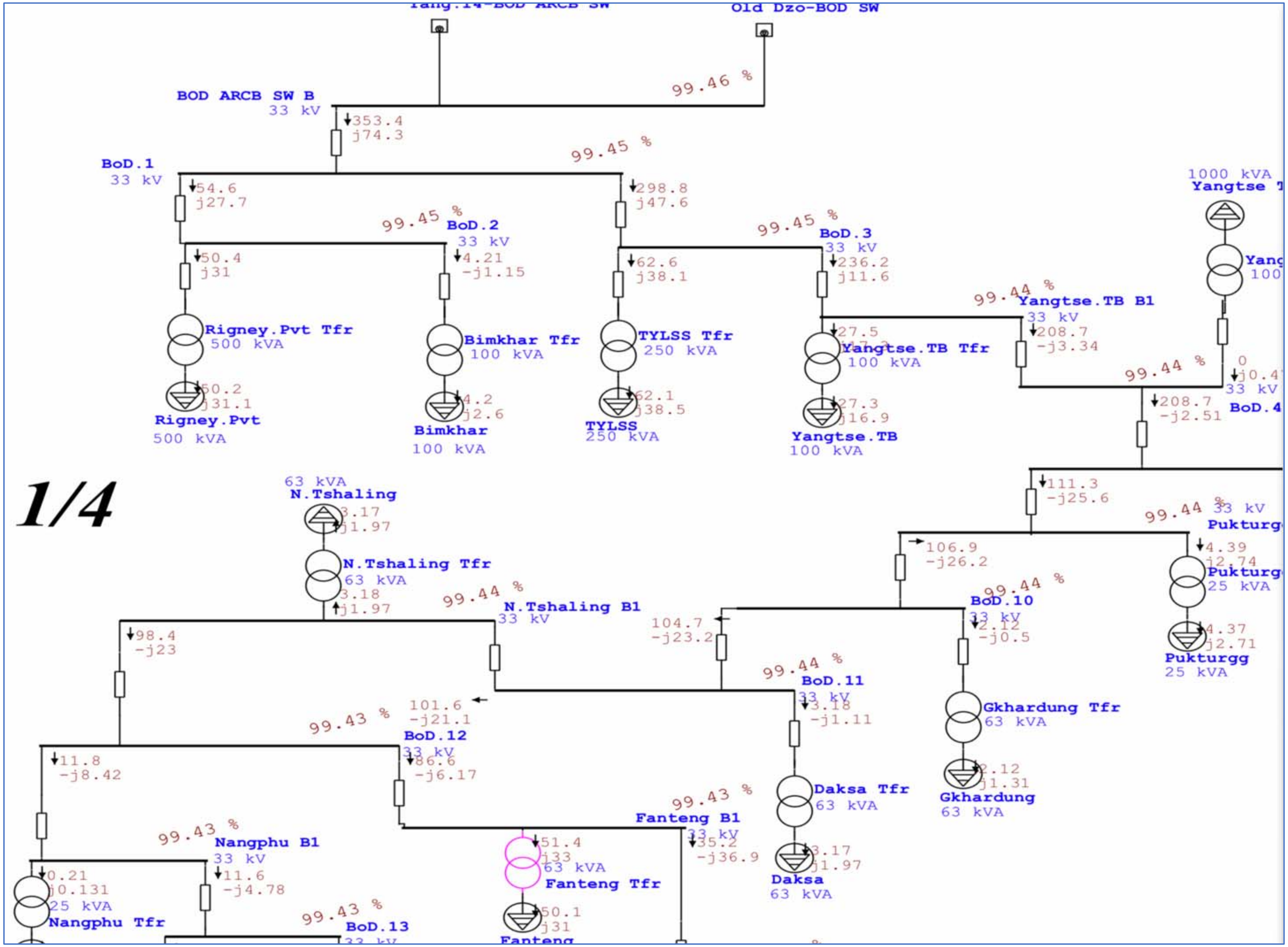

Thongram B1
33 kV
Y.Gonpa B1
33 kV
Y.Gonpa Convt.
AB
Y.Gonpa Tfr
10 kVA
Y.Gonpa
10 kVA
Yraphel2 B1
33 kV
Yraphel2 Tfr
25 kVA
Yraphel2
25 kVA
Yraphel3 B1
33 kV
Yraphel3 Tfr
25 kVA
Yraphel3
25 kVA
Yraphel1 Tfr
25 kVA
Yraphel1
25 kVA
Melongkhar Sch. B1
Melongkhar Sch. Tfr
25 kVA
Melongkhar Sch.
25 kVA
Yal.6
33 kV
Yal.7
33 kV
Yal.8
33 kV
Yal.9
33 kV
ChemaA B1
33 kV
ChemaA Tfr
10 kVA
ChemaA
25 kVA
ChemaB B1
33 kV
ChemaB Tfr
25 kVA
ChemaB
25 kVA
Chema Meth Tfr
25 kVA
Chema P B1
33 kV
Chema P Convt.
AB
Chema P Tfr
10 kVA
Chema P
10 kVA
Dukti RBP B1
33 kV
Dukti RBP Tfr
25 kVA
Dukti RBP
25 kVA
Dukti Rkhar
10 kVA
AB
L.Melongkhar B1
33 kV
L.Melongkhar Tfr
25 kVA
L.Melongkhar
25 kVA
M.Melongkhar B1
33 kV
M.Mkhar Convt.
AB
M.Melongkhar Tfr
16 kVA
M.Melongkhar
16 kVA
U.Mkhar Convt.
AB
U.Melongkhar Tfr
16 kVA
U.Melongkhar
16 kVA
M.Dukti B1
33 kV
M.Dukti Tfr
25 kVA
M.Dukti
25 kVA
Dukti CPS Tfr
25 kVA
Dukti CPS
25 kVA
Dukti Gonpa' Tfr
25 kVA
Dukti Gonpa
25 kVA
99.62 %
99.63 %

3/3


Doksum SW
Tong.1
33 kV
Shakpa Tfr
30 kVA
Shakpa
30 kVA
Tong.2
33 kV
Kunzangling Tfr
125 kVA
Kunzangling
125 kVA
Binangkhar Tfr
63 kVA
Binangkhar
63 kVA
Lakurung B1
Lakurung Tfr
63 kVA
Lakurung
63 kVA
Tong.3
33 kV
Changmadung Tfr
63 kVA
Changmadung
63 kVA
Kenmung B1
Kenmung Tfr
63 kVA
Kenmung
63 kVA
Bakpa
63 kVA
Bakpa Tfr
63 kVA
Bakpa B1
Tong.4
33 kV
Menchu B1
Menchu Tfr
63 kVA
Menchu
63 kVA
Tong.5
33 kV
Brongshing Tfr
63 kVA
Brongshing
63 kVA
Pang B1
Pang Tfr
63 kVA
Pang
63 kVA
Lawshing Tfr
63 kVA
Lawshing
63 kVA
Tong.6
33 kV
Tokaphu B1
Tokaphu Tfr
63 kVA
Tokaphu
63 kVA
Mongling B1
Mongling Tfr
25 kVA
Mongling
25 kVA
Tchu Gonpa Tfr
30 kVA
Tchu Gonpa
30 kVA
RabtiA B1
RabtiA Tfr
25 kVA
RabtiA
25 kVA
Tong.7
33 kV
Rabti Pam
25 kVA
Rabti Pam Tfr
25 kVA
Rabti Shoong
25 kVA
Rabti Shoong Tfr
25 kVA
Rabti Shoong B1
33 kV
RabtiB B1
33 kV
RabtiB Tfr
25 kVA
RabtiB
25 kVA
Tong.8
Tongseng B1
Tongseng Tfr
63 kVA
Tongseng
63 kVA
Tong.9
Gangkar Pam Tfr
63 kVA
Gangkar Pam
63 kVA
Gangkar B1
Gangkar Tfr
63 kVA
Gangkar
63 kVA
Jabdra Tfr
63 kVA
Jabdra
63 kVA
Wanglu B1
Wanglu Tfr
63 kVA
Wanglu
63 kVA
Lichen B1
Lichen Tfr
63 kVA
Lichen
63 kVA
Tong.10
33 kV
Old Dzo B1
33 kV
Old Dzo Tfr
30 kVA
Old Dzo
30 kVA
BOD ARCB SW B
URC Tfr
63 kVA
URC
63 kVA
Phur COnvt.
AB
33 kV
URC B1
Phurdung
16 kVA
Phurdung Tfr
16 kVA
Phurdung B1
33 kV
Shakshing
10 kVA
Shakshing Tfr
10 kVA
Drisa
10 kVA
Drisa Tfr
10 kVA
Tong.11
33 kV

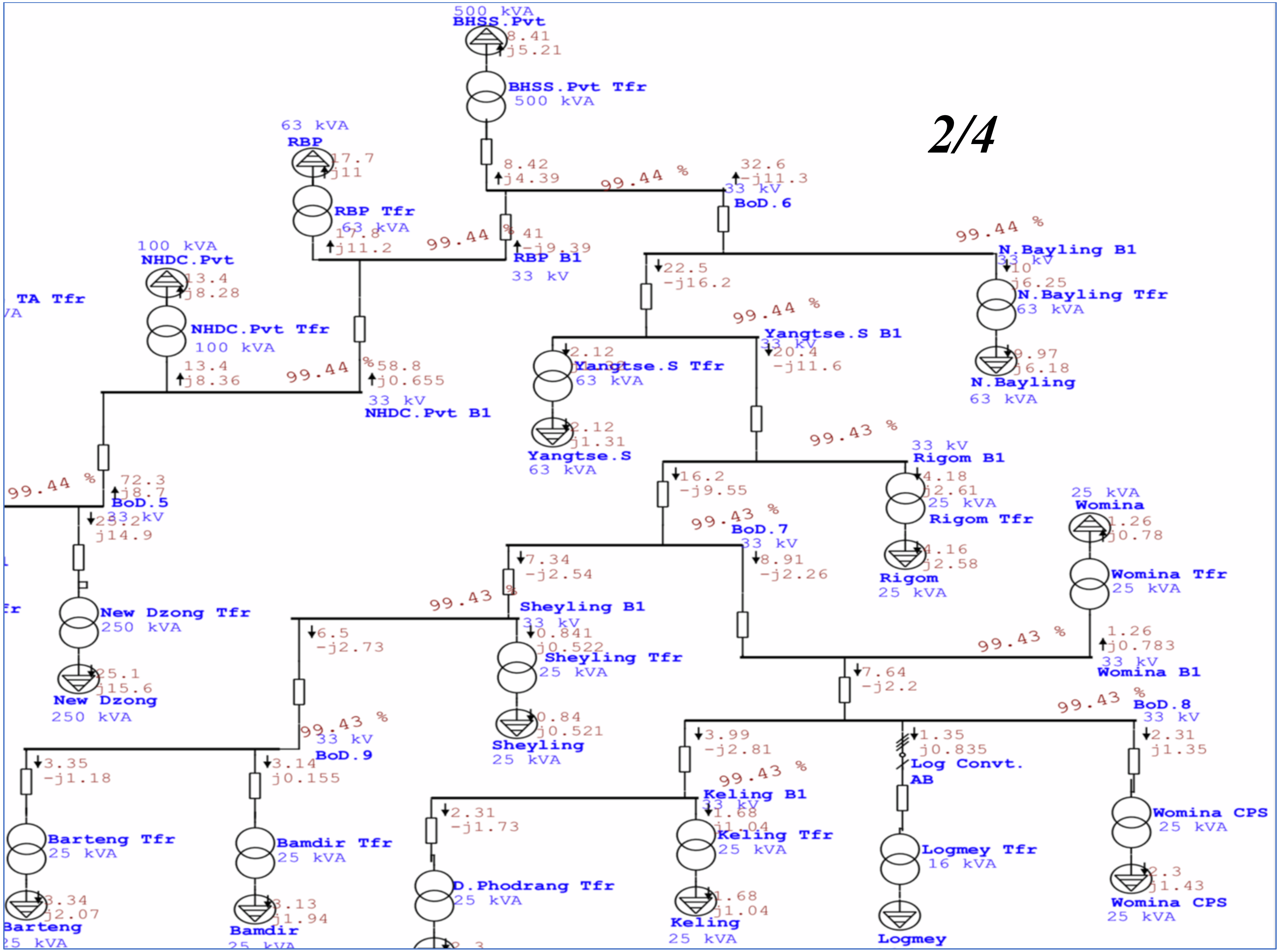

Doksum SW
464.9
j48.4
99.67 %
Yang.1
33 kV
j2.75
459
j51.6
Darchen Tfr
25 kVA
5.82
j3.61
Darchen
25 kVA
99.64 % Yang.2
33 kV
11.6
j6.42
447.2
j52.1
Brenglum Tfr
63 kVA
Brenglum
63 kVA
53.2
j17.8
99.63 % Yang.3
33 kV
394
j37.3
99.62 %
8.47
j4.83
33 kV
Yang.6
63 kVA
Koncholing
8.44
j5.23
Koncholing Tfr
63 kVA
25 kVA
Burbula
Burbula Tfr
25 kVA
Burb Convt.
AB
99.63 % Shali Pam B1
33 kV
32.2
j20.1
160 kVA
Shali Pam Tfr
32
j19.8
Shali Pam
160 kVA
385.5
j36.6
99.63 %
Serpang B1
33 kV
20
j0.475
Serpang Tfr
63 kVA
1.06
j0.659
Serpang
63 kVA
0.844
j0.316
99.59 %
33 kV
Yang.9
384.5
j44.9
16 kVA
Chungdi
Chungdi Tfr
16 kVA
99.63 % Yang.4
33 kV
13.1
j2
6.82
j1.82
99.63 %
Rabdeling B1
33 kV
Rab Convt.
AB
Rabdeling Tfr
16 kVA
Rabdeling
16 kVA
5.6
j1.68
99.63 % Yang.5
33 kV
2.03
j1.26
Domtshang Convt.
AB
3.57
j1.47
Daka Tfr
25 kVA
3.56
j2.2
Daka
25 kVA
DtshangA B1
33 kV
DtshangA Tfr
16 kVA
DtshangA
16 kVA
DtshangB Tfr
16 kVA
DtshangB
16 kVA
99.63 % Gardung B1
33 kV
10.8
j0.707
2.32
Gardung Tfr
25 kVA
2.31
j1.43
Gardung
25 kVA
10 kVA
Barpang
Barpang Tfr
10 kVA
Barpng Convt.
AB
j0.838
99.63 %
Barpang B1
33 kV
9.48
j2.54
99.55 % Yang.10
33 kV
377
j53.9
7.41
j4.52
Buyang Tfr
63 kVA
7.38
j4.58
Buyang
63 kVA
Chung Convt.
AB
1.08
j0.669
99.52 %
Yang.11
33 kV
375.8
j62.3
25 kVA
Baney
4.58
j2.84
Baney Tfr
25 kVA
4.61
-j3.42
99.52 %
Yang.12
33 kV
371.2
j66.7
99.63 %
Yang.7
33 kV
1.08
j0.67
Jibdr Convt.
AB
Jibdur Tfr
16 kVA
Jibdur
16 kVA
1.35
j0.838
ChakadmiB Convt.
AB
ChakadmiB Tfr
16 kVA
ChakadmiB
16 kVA
7.05
j2.64
99.63 %
ChakadmiA B1
33 kV
5.99
j2.22
1.05
j0.655
25 kVA
Chakadmi Tfr
1.05
j0.653
ChakadmiA
25 kVA
99.63 %
Lengkhar B1
33 kV
3.15
Lengkhar Tfr
25 kVA
3.14
j1.95
Lengkhar
25 kVA
Nali Convt.
AB
Yang.8
33 kV
Lewochen Tfr
16 kVA
Lewochen
16 kVA
Naling Tfr
16 kVA
Naling
16 kVA
Renja B1
33 kV
3.36
Renja Tfr
25 kVA
3.34
j2.07
Renja
25 kVA
367.8
j66.5
361.9
j77.2
99.46 % Yang.13
33 kV
5.82
j3.59
Sawmill.PVt Tfr
63 kVA
5.8
j3.6
Sawmill.Pvt
63 kVA
99.46 % Yang.14
33 kV
8.45
j5.24
RBA.Pvt Tfr
63 kVA
8.42
j5.22
RBA.Pvt
63 kVA
353.4
j73.6
BOD ARCB SW B

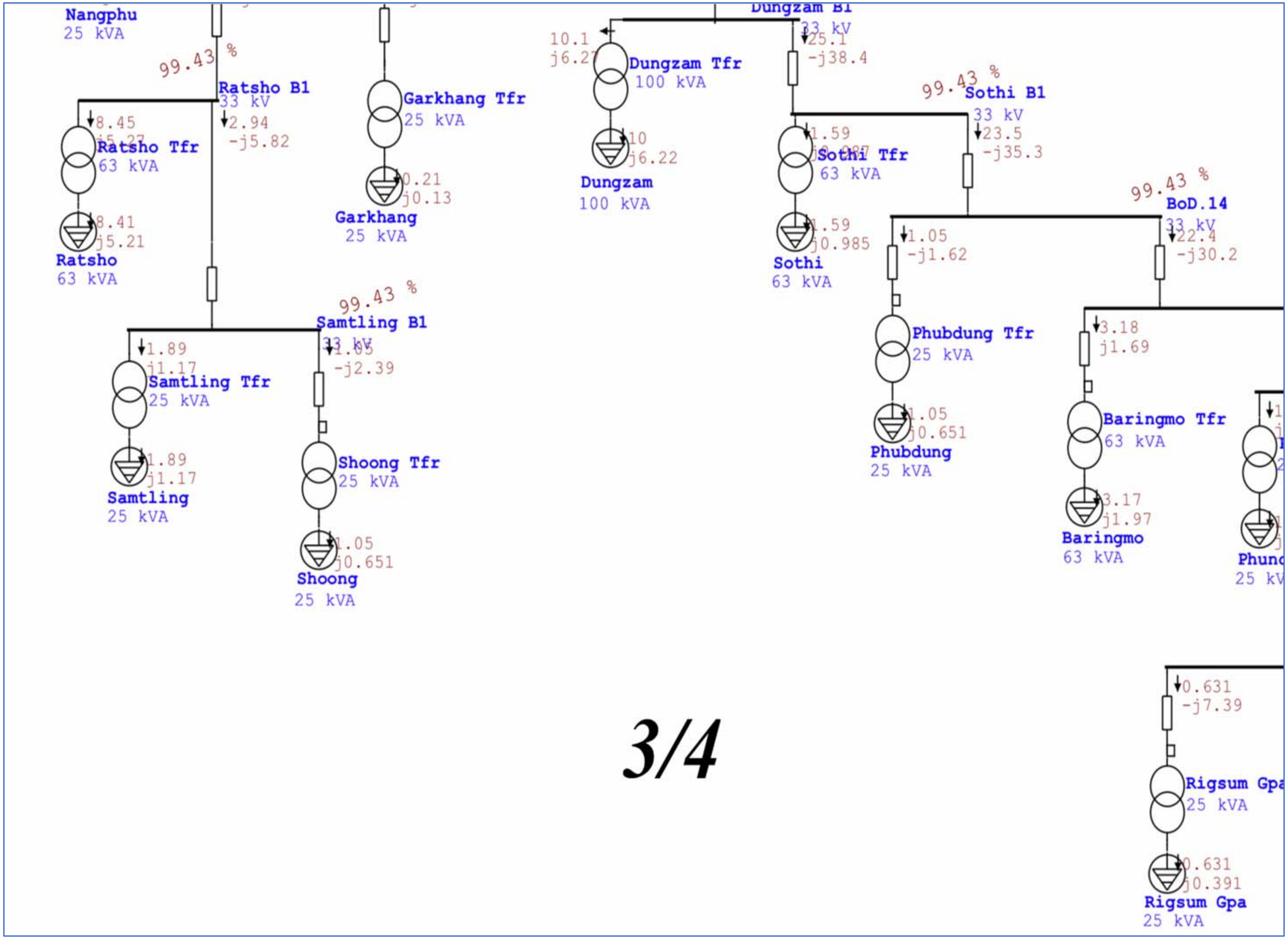

1/4
2/4
3/4
4/4



Old Dzo-BOD SW
BOD ARCB SW B
33 kV
99.46 %
353.4
j74.3
BoD.1
33 kV
99.45 %
54.6
j27.7
298.8
j47.6
BoD.2
33 kV
99.45 %
50.4
j31
4.21
-j1.15
Rigney.Pvt Tfr
500 kVA
50.2
j31.1
Rigney.Pvt
500 kVA
Bimkhar Tfr
100 kVA
4.2
j2.6
Bimkhar
100 kVA
BoD.3
33 kV
99.45 %
62.6
j38.1
236.2
j11.6
TYLSS Tfr
250 kVA
62.1
j38.5
TYLSS
250 kVA
Yangtse.TB B1
33 kV
99.44 %
27.5
208.7
-j3.34
Yangtse.TB Tfr
100 kVA
27.3
j16.9
Yangtse.TB
100 kVA
1000 kVA
99.44 %
0
33 kV
208.7
-j2.51
111.3
-j25.6
99.44 %
33 kV
106.9
-j26.2
4.39
25 kVA
4.37
j2.71
Pukturgg
25 kVA
BoD.10
33 kV
99.44 %
2.12
-j0.5
Gkhardung Tfr
63 kVA
2.12
j1.31
Gkhardung
63 kVA
63 kVA
N.Tshaling
3.17
j1.97
N.Tshaling Tfr
63 kVA
3.18
j1.97
N.Tshaling B1
33 kV
99.44 %
98.4
-j23
104.7
-j23.2
BoD.11
33 kV
99.44 %
-j1.11
Daksa Tfr
63 kVA
3.17
j1.97
Daksa
63 kVA
BoD.12
33 kV
99.43 %
101.6
-j21.1
11.8
-j8.42
86.6
-j6.17
Fanteng B1
33 kV
99.43 %
-j36.9
51.4
j33
63 kVA
Fanteng Tfr
50.1
j31
Nangphu B1
33 kV
99.43 %
0.21
j0.131
25 kVA
Nangphu Tfr
11.6
-j4.78
BoD.13
99.43 %

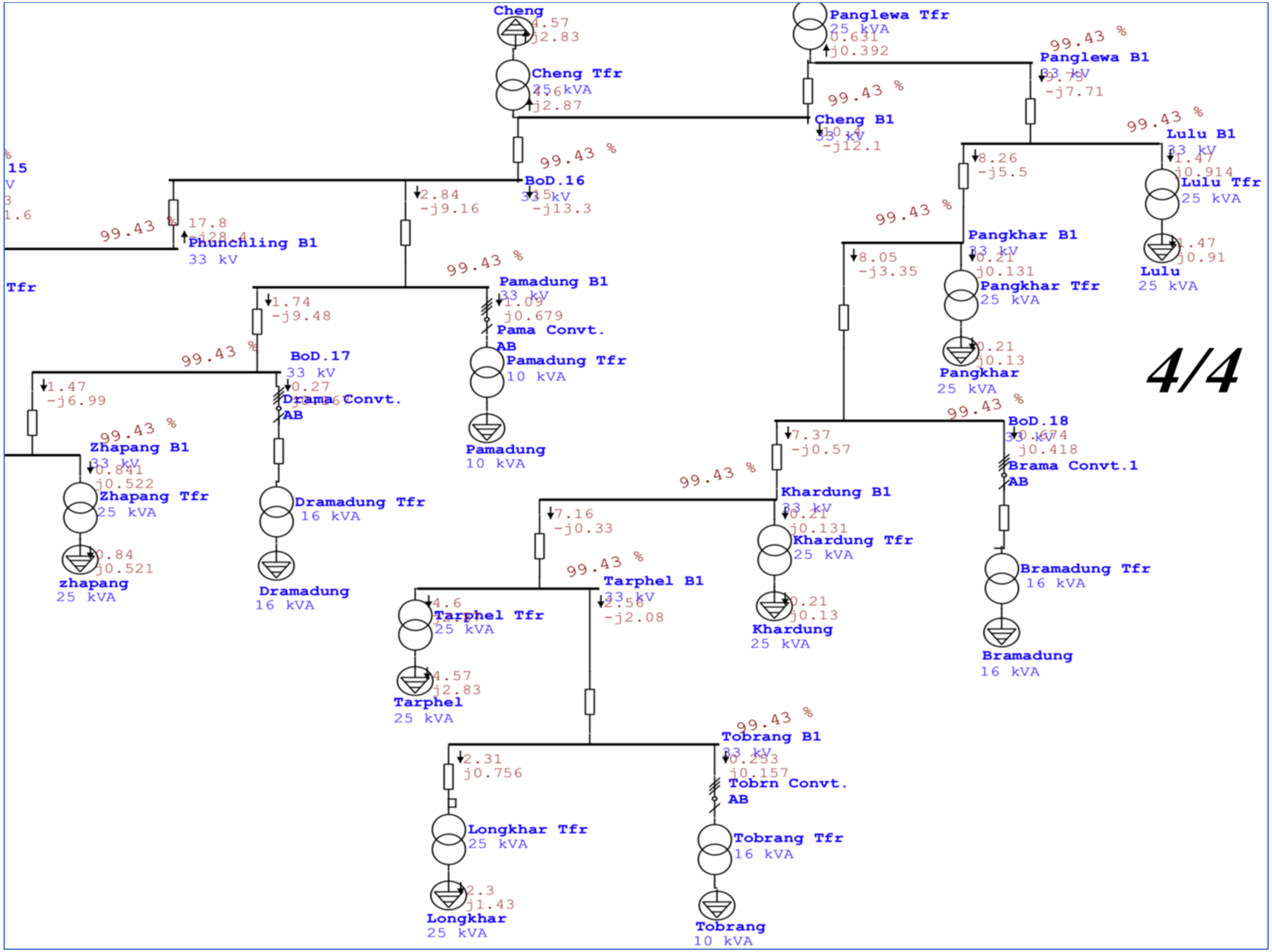
1/4


2/4
BHSS.Pvt
500 kVA
BHSS.Pvt Tfr
500 kVA
RBP
63 kVA
RBP Tfr
63 kVA
RBP B1
33 kV
BoD.6
33 kV
NHDC.Pvt
100 kVA
NHDC.Pvt Tfr
100 kVA
NHDC.Pvt B1
33 kV
BoD.5
N.Bayling B1
N.Bayling Tfr
63 kVA
N.Bayling
63 kVA
Yangtse.S B1
Yangtse.S Tfr
63 kVA
Yangtse.S
63 kVA
Rigom B1
33 kV
Rigom Tfr
25 kVA
Rigom
25 kVA
BoD.7
33 kV
Womina
25 kVA
Womina Tfr
25 kVA
Womina B1
33 kV
New Dzong Tfr
250 kVA
New Dzong
250 kVA
Sheyling B1
33 kV
Sheyling Tfr
25 kVA
Sheyling
25 kVA
BoD.8
33 kV
BoD.9
33 kV
Keling B1
Keling Tfr
25 kVA
Keling
25 kVA
Log Convt.
AB
Logmey Tfr
16 kVA
Logmey
Womina CPS
25 kVA
Barteng Tfr
25 kVA
Barteng
Bamdir Tfr
25 kVA
Bamdir
D.Phodrang Tfr
25 kVA

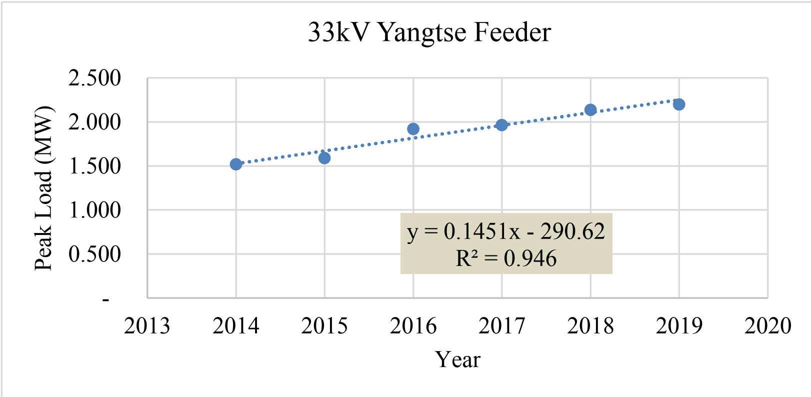


Nangphu
25 kVA
99.43 %
Ratsho B1
33 kV
2.94
-j5.82
8.45
Ratsho Tfr
63 kVA
8.41
j5.21
Ratsho
63 kVA
Garkhang Tfr
25 kVA
0.21
j0.13
Garkhang
25 kVA
99.43 %
Samtling B1
33 kV
-j2.39
1.89
j1.17
Samtling Tfr
25 kVA
1.89
j1.17
Samtling
25 kVA
Shoong Tfr
25 kVA
1.05
j0.651
Shoong
25 kVA
33 kV
25.1
-j38.4
10.1
Dungzam Tfr
100 kVA
10
j6.22
Dungzam
100 kVA
99.43 %
Sothi B1
33 kV
23.5
-j35.3
1.59
Sothi Tfr
63 kVA
1.59
j0.985
Sothi
63 kVA
99.43 %
BoD.14
33 kV
22.4
-j30.2
1.05
-j1.62
Phubdung Tfr
25 kVA
1.05
j0.651
Phubdung
25 kVA
3.18
j1.69
Baringmo Tfr
63 kVA
3.17
j1.97
Baringmo
63 kVA
0.631
-j7.39
25 kVA
0.631
j0.391
Rigsum Gpa
25 kVA

3/4


4/4
Cheng
Cheng Tfr
Cheng B1
Panglewa Tfr
Panglewa B1
Lulu B1
Lulu Tfr
Lulu
BoD.16
Phunchling B1
Pamadung B1
Pama Convt.
AB
Pamadung Tfr
Pamadung
Pangkhar B1
Pangkhar Tfr
Pangkhar
BoD.17
Drama Convt.
Dramadung Tfr
Dramadung
Zhapang B1
Zhapang Tfr
zhapang
BoD.18
Brama Convt.1
Bramadung Tfr
Bramadung
Khardung B1
Khardung Tfr
Khardung
Tarphel B1
Tarphel Tfr
Tarphel
Tobrang B1
Tobrn Convt.
Tobrang Tfr
Tobrang
Longkhar Tfr
Longkhar

Sl.No.	Power Source	Feeder Name	Peak Load (MW)																
			2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	132/33kV Kanglung Substation	33kV Yangtse Feeder	1.520	1.590	1.920	1.964	2.136	2.199	2.482	2.627	2.772	2.917	3.062	3.207	3.353	3.498	3.643	3.788	3.933



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.**

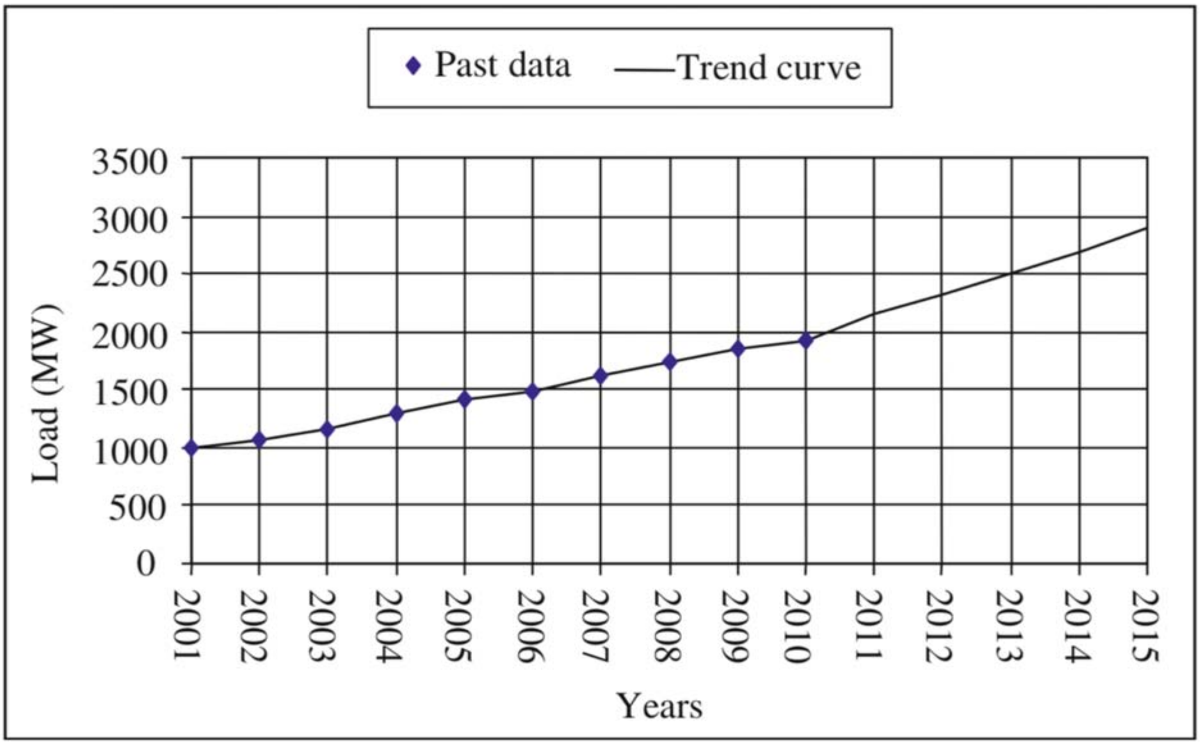


Figure 1: Typical trend curve[1]

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.

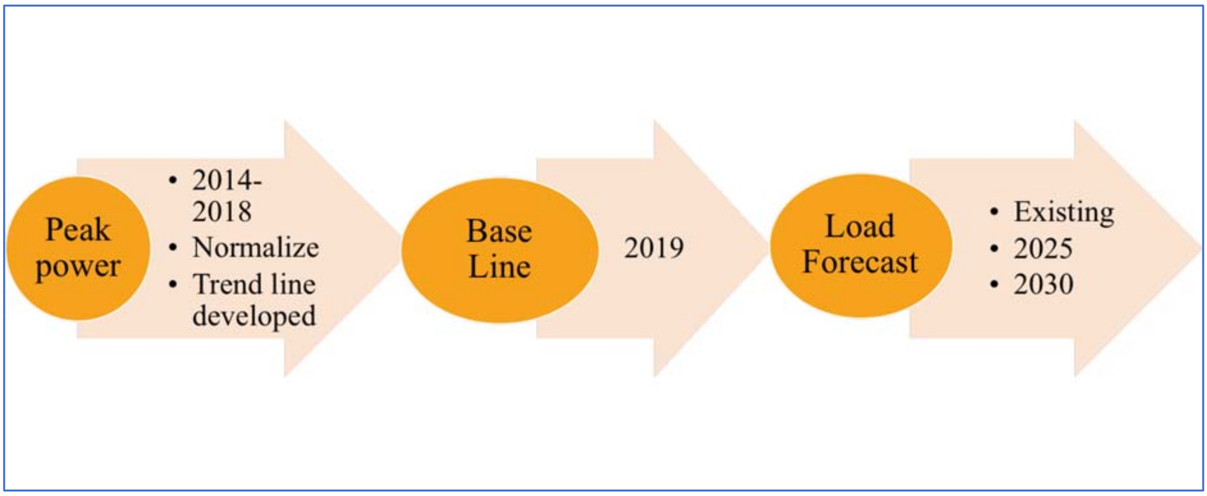


Figure 2: Flow diagram for load forecast

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**

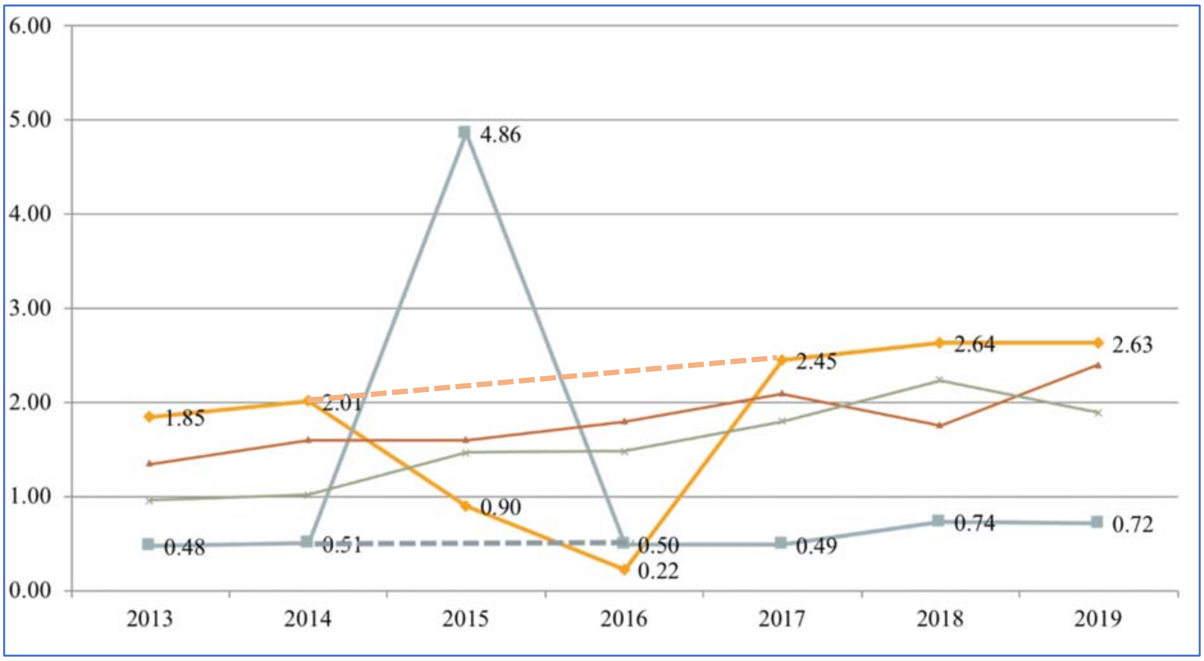


Figure 3: Actual data of Punakha Dzongkhag

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

$Where:$

$x \text{ is the normalized data}$

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

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.**

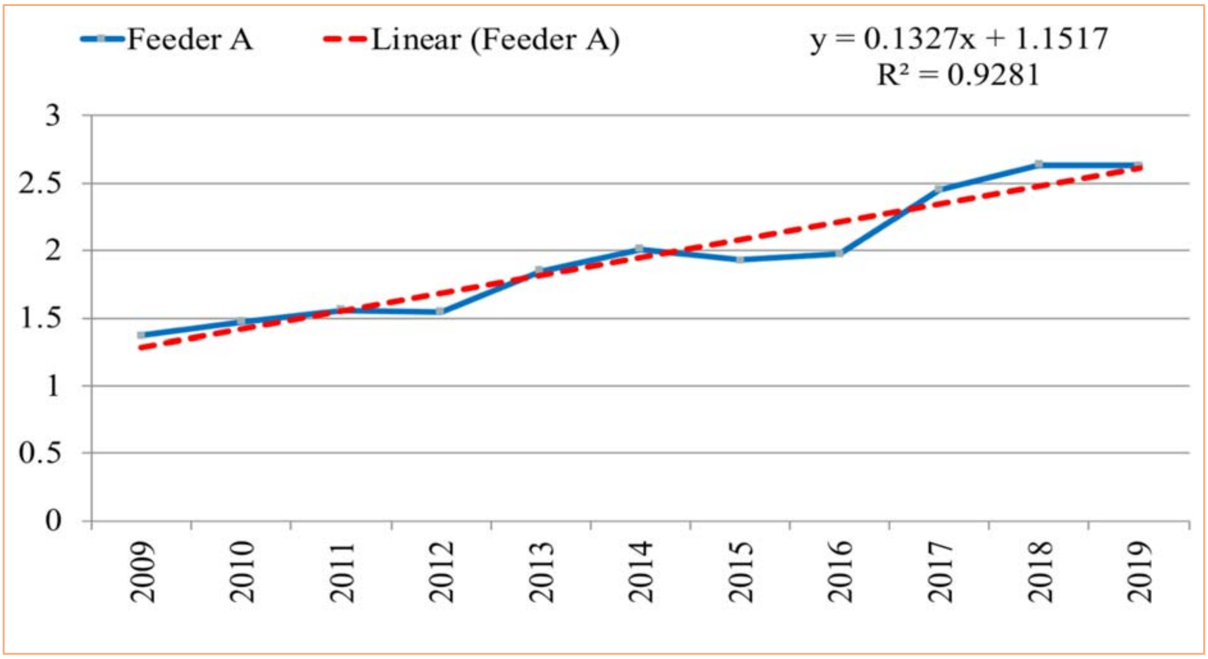


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$y = ax + b$

$Where:$

$y\ is\ the\ dependent\ variable\ or\ forecasted\ load$

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

$It\ also\ gives\ x\ is\ the\ independent\ variable\ or\ time\ in\ year$

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

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.

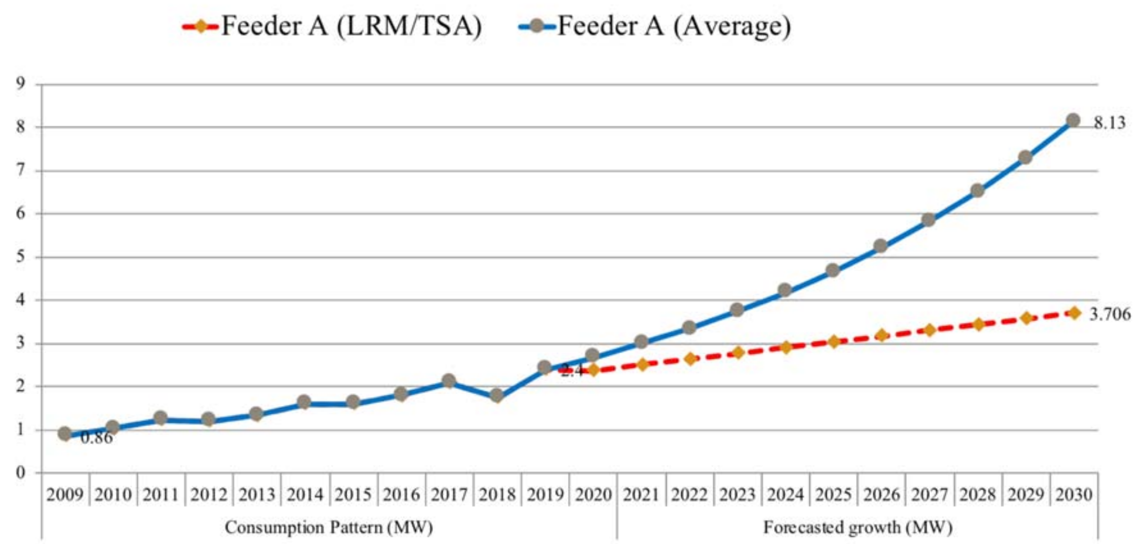


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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 given 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.

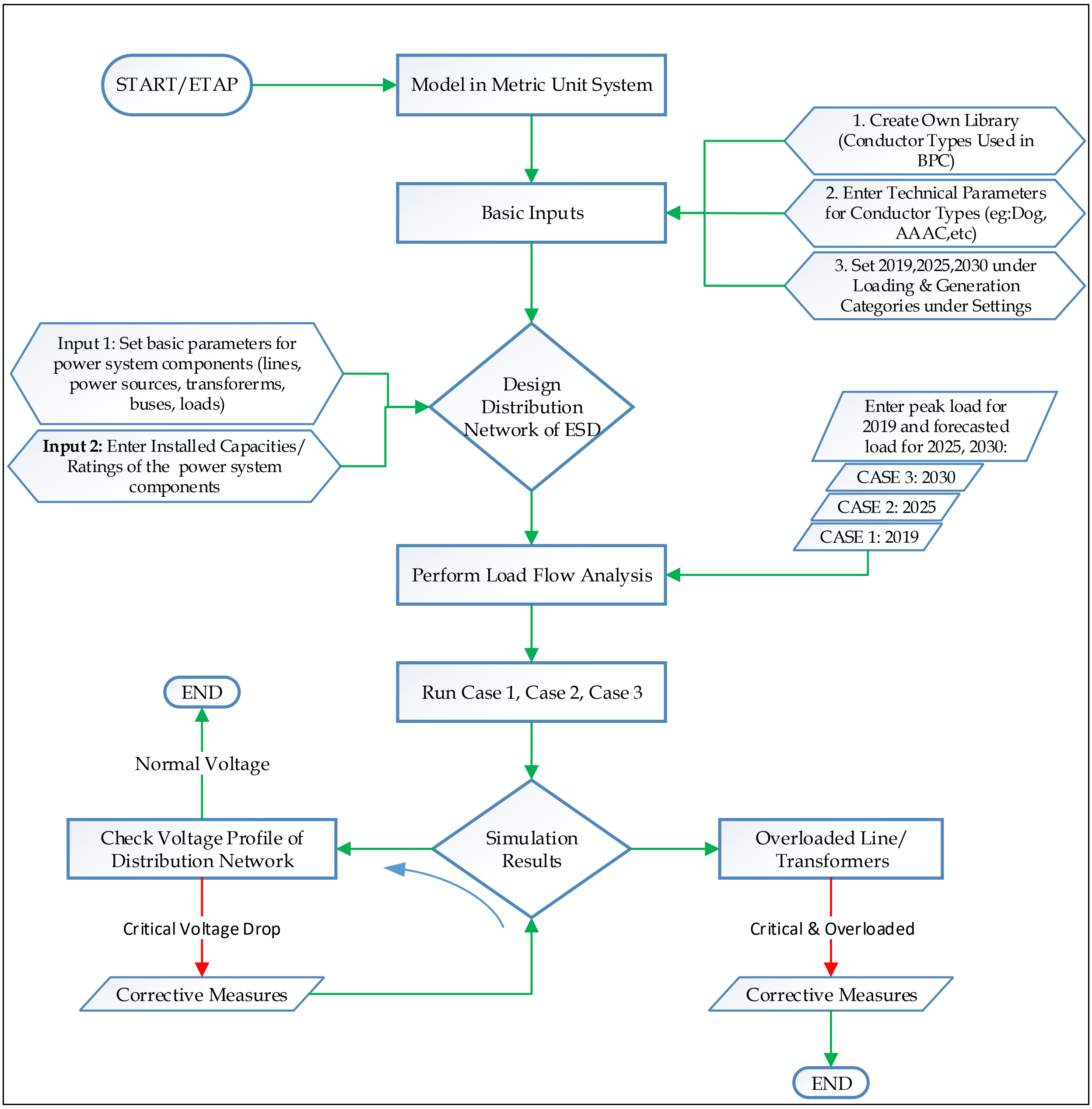


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

[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

Annexure 4: The 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
Bakpa B1	33.000										0.389	93.3	6.9	
Bakpa B2	0.415		0.009	0.006	0.033	0.020					0.049	85.0	71.7	
Bamchang B1	33.000										0.010	84.6	0.2	
Bamchang B2	0.415		0.002	0.001	0.006	0.004					0.010	85.0	13.7	
Bamdir B1	33.000										0.010	84.6	0.2	
Bamdir B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	14.3	
Baney B1	33.000										0.015	84.5	0.3	
Baney B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	21.0	
Baringmo B1	33.000										0.011	84.8	0.2	
Baringmo B2	0.415		0.002	0.001	0.007	0.005					0.011	85.0	15.5	
Barpang B1	33.000		0.001	0.000	0.003	0.002					0.034	88.9	0.6	
Barteng B1	33.000										0.011	84.6	0.2	
Barteng B2	0.415		0.002	0.001	0.007	0.004					0.011	85.0	15.6	
Bawoong B1	33.000										0.022	84.7	0.4	
Bawoong B2	0.415		0.004	0.002	0.015	0.009					0.022	85.0	31.0	
BHSS.Pvt B1	33.000										0.024	85.0	0.4	
BHSS.Pvt B2	0.415		0.004	0.003	0.016	0.010					0.024	85.0	34.3	
Bimkhar B1	33.000										0.014	84.9	0.3	
Bimkhar B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	20.5	
Binangkhar B1	33.000										0.016	84.8	0.3	
Binangkhar B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	22.5	
Binangreb B1	33.000										0.044	84.4	0.8	
Binangreb B2	0.415		0.008	0.005	0.028	0.018					0.043	85.0	61.6	
BOD ARCB SW B	33.000										0.924	90.8	16.5	
BoD.1	33.000										0.925	90.7	16.5	
BoD.2	33.000										0.175	85.7	3.1	
BoD.3	33.000										0.752	91.5	13.5	
BoD.4	33.000										0.464	94.8	8.3	
BoD.5	33.000										0.464	94.8	8.3	
BoD.6	33.000										0.118	94.5	2.1	
BoD.7	33.000										0.047	95.6	0.8	
BoD.8	33.000		0.001	0.000	0.003	0.002					0.023	93.5	0.4	
BoD.9	33.000										0.019	94.3	0.3	
BoD.10	33.000										0.161	99.7	2.9	
BoD.11	33.000										0.156	99.7	2.8	
BoD.12	33.000										0.138	99.6	2.5	
BoD.13	33.000										0.034	95.5	0.6	
BoD.14	33.000										0.066	99.9	1.2	
BoD.15	33.000										0.064	99.2	1.1	

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
BoD.16	33.000										0.050	99.4	0.9	
BoD.17	33.000		0.000	0.000	0.001	-					0.007	67.6	0.1	
BoD.18	33.000		0.000	0.000	0.002	0.001					0.024	92.7	0.4	
Braktsa B1	33.000										0.400	87.6	7.1	
Braktsa B2	0.415		0.008	0.005	0.029	0.018					0.044	85.0	64.1	
Brenglum B1	33.000										0.038	84.4	0.7	
Brenglum B2	0.415		0.007	0.004	0.025	0.015					0.037	85.0	54.0	
Brongshing B1	33.000										0.026	84.6	0.5	
Brongshing B2	0.415		0.005	0.003	0.017	0.011					0.026	85.0	37.0	
Burbula B1	33.000		0.000	0.000	0.002	0.001					0.002	85.0	-	
Buyang B1	33.000										0.024	84.7	0.4	
Buyang B2	0.415		0.004	0.003	0.016	0.010					0.023	85.0	33.5	
ChakadmiA B1	33.000										0.023	87.6	0.4	
ChakadmiA B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
Changmadung B1	33.000										0.025	84.6	0.4	
Changmadung B2	0.415		0.004	0.003	0.017	0.010					0.025	85.0	35.3	
Chema Meth B1	33.000		0.000	0.000	0.001	-					0.015	84.5	0.3	
Chema Meth B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.1	
Chema P B1	33.000		0.001	0.001	0.003	0.002					0.044	92.9	0.8	
ChemaA B1	33.000										0.030	85.2	0.5	
ChemaA B2	0.415		0.001	0.001	0.004	0.003					0.007	85.0	9.5	
ChemaB B1	33.000										0.024	85.0	0.4	
ChemaB B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.3	
Chemkhar B1	33.000		0.000	0.000	0.000	-					0.018	84.4	0.3	
Chemkhar B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.8	
Cheng B1	33.000										0.043	98.0	0.8	
Cheng B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.7	
Cholaptsa B1	33.000										0.042	84.4	0.8	
Cholaptsa B2	0.415		0.007	0.005	0.028	0.017					0.041	85.0	59.9	
D.Phodrang B1	33.000										0.008	84.7	0.1	
D.Phodrang B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	10.9	
Daka B1	33.000										0.012	84.6	0.2	
Daka B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.0	
Daksa B1	33.000										0.011	84.8	0.2	
Daksa B2	0.415		0.002	0.001	0.007	0.005					0.011	85.0	15.5	
Dalikhar B1	33.000										0.019	90.9	0.3	
Dalikhar B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
Darchen B1	33.000										0.019	84.3	0.3	
Darchen B2	0.415		0.003	0.002	0.012	0.008					0.019	85.0	27.1	
Doksum SW	33.000										3.956	90.3	70.2	
Dshingma B1	33.000										0.007	84.7	0.1	
Dshingma B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.3	

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
Dukti CPS B1	33.000										0.010	84.6	0.2	
Dukti CPS B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	14.0	
Dukti Gonpa B1	33.000										0.010	84.6	0.2	
Dukti Gonpa B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	14.3	
Dukti RBP B1	33.000										0.042	87.5	0.8	
Dukti RBP B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.0	
Dungzam B1	33.000										0.100	98.4	1.8	
Dungzam B2	0.415		0.006	0.004	0.022	0.014					0.033	85.0	47.7	
Fanteng B1	33.000										0.104	99.7	1.9	
Fanteng B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.6	
Gangar B2	0.415		0.001	0.001	0.006	0.004					0.009	85.0	12.1	
Gangkar B1	33.000										0.013	93.5	0.2	
Gangkar Pam B1	33.000										0.021	84.7	0.4	
Gangkar Pam B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	30.2	
Gardung B1	33.000										0.041	90.7	0.7	
Gardung B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.6	
Garkhang B1	33.000										0.001	85.0	-	
Garkhang B2	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
Gkhardung B1	33.000										0.006	84.9	0.1	
Gkhardung B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.6	
GomphuKora B1	33.000										0.422	88.8	7.5	
GomphuKora B2	0.415		0.023	0.014	0.080	0.049					0.120	85.0	178.4	
Jabdra B1	33.000										0.006	84.9	0.1	
Jabdra B2	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.8	
Jangphutse B1	33.000										0.024	84.6	0.4	
Jangphutse B2	0.415		0.004	0.003	0.016	0.010					0.024	85.0	34.4	
Jigsham B1	33.000										0.010	84.6	0.2	
Jigsham B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	14.7	
Karmazom B1	33.000										0.021	84.7	0.4	
Karmazom B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	30.2	
Keling B1	33.000										0.012	94.2	0.2	
Keling B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.2	
Kenmung B1	33.000										0.060	87.5	1.1	
Kenmung B2	0.415		0.007	0.004	0.024	0.015					0.036	85.0	52.3	
Kham.1	33.000										0.780	87.7	13.8	
Kham.2	33.000										0.737	87.7	13.1	
Kham.3	33.000										0.434	88.4	7.7	
Kham.4	33.000										0.419	88.0	7.4	
Kham.5	33.000										0.149	86.8	2.7	
Kham.6	33.000										0.150	86.2	2.7	
Kham.7	33.000		0.001	0.001	0.004	0.002					0.048	84.9	0.9	
Kham.9	33.000										0.061	90.7	1.1	

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
Kham.10	33.000										0.046	88.0	0.8	
Kham.11	33.000		0.001	0.001	0.004	0.003					0.023	84.9	0.4	
Khardung B1	33.000										0.022	92.8	0.4	
Khardung B2	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
Kheni B1	33.000										0.208	87.6	3.7	
Kheni B2	0.415		0.027	0.017	0.097	0.060					0.146	85.0	213.8	
Khitshang B1	33.000										0.333	87.6	5.9	
Khitshang B2	0.415		0.027	0.017	0.100	0.062					0.149	85.0	214.4	
Khitshang NewT B2	0.415		0.008	0.005	0.030	0.018					0.044	85.0	62.0	
Khitshang NewT B3	33.000										0.044	84.9	0.8	
Koncholing B1	33.000										0.028	84.6	0.5	
Koncholing B2	0.415		0.005	0.003	0.018	0.011					0.027	85.0	39.5	
Korlung Line	33.000										3.956	90.3	70.2	
KorlungSS B1	132.000										4.004	89.8	17.5	
KorlungSS B2	33.000										3.975	90.3	70.1	
Kunzangling B2	0.415		0.018	0.011	0.067	0.042					0.101	85.0	147.2	
Kuzangling B1	33.000										0.104	84.2	1.9	
L.Khamdang B1	33.000										0.706	87.3	12.5	
L.Khamdang B2	0.415		0.007	0.004	0.025	0.016					0.037	85.0	54.0	
L.Melongkhar B1	33.000										0.028	86.7	0.5	
L.Melongkhar B2	0.415		0.002	0.001	0.007	0.005					0.011	85.0	15.7	
L.Namthi B1	33.000										0.016	84.4	0.3	
L.Namthi B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	22.4	
Laishung B1	33.000										0.012	89.6	0.2	
Laishung B2	0.415		0.000	0.000	0.002	0.001					0.002	85.0	3.4	
Lakurung B1	33.000										0.041	88.5	0.7	
Lakurung B2	0.415		0.005	0.003	0.018	0.011					0.026	85.0	37.9	
Larjab B1	33.000										0.007	84.8	0.1	
Larjab B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	9.3	
Lawshing B1	33.000										0.030	84.6	0.5	
Lawshing B2	0.415		0.005	0.003	0.020	0.012					0.030	85.0	43.0	
Lengkhar B1	33.000		0.002	0.001	0.006	0.004					0.020	84.8	0.4	
Lengkhar B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.0	
Lichen B1	33.000										0.069	93.5	1.2	
Lichen B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.5	
Longkhar B1	33.000										0.007	84.7	0.1	
Longkhar B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.6	
Lulu B1	33.000										0.028	97.0	0.5	
Lulu B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.8	
M.Dukti B1	33.000										0.021	86.3	0.4	
M.Dukti B2	0.415		0.002	0.001	0.007	0.004					0.011	85.0	15.4	
M.Melongkhar B1	33.000		0.003	0.002	0.012	0.007					0.017	85.0	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
M.Namthi B1	33.000										0.201	89.7	3.6	
M.Namthi B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.4	
Manam B1	33.000										0.017	84.4	0.3	
Manla B1	33.000										0.018	84.4	0.3	
Manla B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.8	
Manm B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.1	
Melongkhar Sch. B1	33.000										0.109	91.3	1.9	
Melongkhar Sch. B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.0	
Menchu B1	33.000										0.263	95.1	4.7	
Menchu B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	28.5	
Mineral WP B1	33.000										0.083	84.2	1.5	
Mineral WP B2	0.415		0.015	0.009	0.053	0.033					0.080	85.0	116.5	
Mongling B1	33.000										0.045	86.1	0.8	
Mongling B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.1	
N.Bayling B1	33.000										0.095	95.6	1.7	
N.Bayling B2	0.415		0.006	0.004	0.022	0.013					0.032	85.0	47.0	
N.Tshaling B1	33.000										0.147	99.8	2.6	
N.Tshaling B2	0.415		0.002	0.001	0.007	0.005					0.011	85.0	15.5	
Nangphu B1	33.000										0.034	96.3	0.6	
Nangphu B2	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
New Dzong B1	33.000										0.084	84.7	1.5	
New Dzong B2	0.415		0.015	0.009	0.055	0.034					0.083	85.0	119.2	
NHDC.Pvt B1	33.000										0.218	91.0	3.9	
NHDC.Pvt B2	0.415		0.008	0.005	0.030	0.018					0.044	85.0	63.9	
Ninda B1	33.000										0.031	99.5	0.5	
Ninda B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.5	
Nombari B1	33.000										0.472	88.1	8.4	
Nombari B2	0.415		0.007	0.004	0.025	0.015					0.037	85.0	53.1	
O160.1	33.000										0.198	84.8	3.5	
O160.2	33.000										0.219	90.7	3.9	
Old Dzo B1	33.000										0.017	84.5	0.3	
Old Dzo B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	23.7	
Pamadung B1	33.000		0.001	0.000	0.002	0.002					0.011	73.9	0.2	
Pang B1	33.000										0.055	86.8	1.0	
Pang B2	0.415		0.005	0.003	0.017	0.011					0.026	85.0	37.0	
Pangkhar B1	33.000										0.024	96.3	0.4	
Pangkhar B2	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
Panglewa B1	33.000										0.030	98.5	0.5	
Panglewa B2	0.415		0.000	0.000	0.002	0.001					0.002	85.0	3.4	
Pangthang B1	33.000										0.027	84.6	0.5	
Pangthang B2	0.415		0.005	0.003	0.018	0.011					0.026	85.0	37.9	
Phefolung B1	33.000										0.347	91.0	6.2	

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
Phefolung B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	28.5	
Phubdung B1	33.000										0.003	84.9	0.1	
Phubdung B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
Phunchling B1	33.000										0.054	99.2	1.0	
Phunchling B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.8	
Phuyang B1	33.000										0.373	91.1	6.6	
Phuyang B2	0.415		0.005	0.003	0.019	0.012					0.028	85.0	40.4	
Pukturgg B1	33.000										0.172	99.5	3.1	
Pukturgg B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.0	
R.Shokhang B1	33.000										0.017	87.4	0.3	
R.Shokhang B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.3	
Rabdeling B1	33.000		0.001	0.000	0.003	0.002					0.022	88.2	0.4	
Rabti Pam B1	33.000										0.015	84.4	0.3	
Rabti Pam B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.4	
Rabti Shoong B1	33.000										0.140	97.6	2.5	
Rabti Shoong B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.1	
RabtiA B1	33.000										0.181	96.6	3.2	
RabtiA B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.4	
RabtiB B1	33.000										0.153	97.6	2.7	
RabtiB B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.4	
Ram Gonpa B1	33.000										0.035	88.2	0.6	
Ram Gonpa B2	0.415		0.005	0.003	0.020	0.012					0.030	85.0	43.0	
Ram.1	33.000										0.185	88.3	3.3	
Ram.2	33.000										0.159	88.5	2.8	
Ram.3	33.000										0.134	88.6	2.4	
Ram.4	33.000										0.067	90.1	1.2	
Ram.5	33.000												-	
Ratsho B1	33.000										0.035	90.6	0.6	
Ratsho B2	0.415		0.005	0.003	0.018	0.011					0.027	85.0	39.4	
RBA.Pvt B1	33.000										0.028	84.6	0.5	
RBA.Pvt B2	0.415		0.005	0.003	0.018	0.011					0.027	85.0	39.4	
RBP B1	33.000										0.174	92.2	3.1	
RBP B2	0.415		0.010	0.007	0.037	0.023					0.056	85.0	83.0	
Renja B1	33.000										0.975	91.0	17.4	
Renja B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.0	
Rigney.Pvt B1	33.000										0.163	84.7	2.9	
Rigney.Pvt B2	0.415		0.029	0.018	0.108	0.067					0.161	85.0	231.7	
Rigom B1	33.000										0.059	96.0	1.1	
Rigom B2	0.415		0.002	0.002	0.009	0.006					0.013	85.0	19.3	
Rigsum Gpa B1	33.000										0.002	84.9	-	
Rigsum Gpa B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.7	
RMSS B1	33.000										0.026	84.8	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
RMSS B2	0.415		0.004	0.003	0.017	0.011					0.025	85.0	36.1	
RolamA B1	33.000										0.041	87.3	0.7	
RolamA B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.0	
RolamB B1	33.000										0.031	87.7	0.5	
RolamB B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.7	
Romang B1	33.000										0.006	84.9	0.1	
Romang B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	7.8	
Samtling B1	33.000										0.009	92.6	0.2	
Samtling B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
Sawmill.Pvt B1	33.000										0.018	84.7	0.3	
Sawmill.Pvt B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	25.8	
Serpang B1	33.000										0.064	92.0	1.1	
Serpang B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.3	
Sertsho B1	33.000										0.037	84.5	0.7	
Sertsho B2	0.415		0.007	0.004	0.024	0.015					0.036	85.0	52.3	
Shakpa B1	33.000										0.016	84.5	0.3	
Shakpa B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	22.9	
Shali Pam B1	33.000										0.170	88.0	3.0	
Shali Pam B2	0.415		0.019	0.012	0.070	0.043					0.105	85.0	152.1	
Shangsheree B1	33.000										0.011	93.2	0.2	
Shangsheree B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.2	
Shangthang B1	33.000										0.026	84.6	0.5	
Shangthang B2	0.415		0.004	0.003	0.017	0.011					0.025	85.0	36.2	
Shazam B1	33.000										0.018	84.7	0.3	
Shazam B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	25.0	
Sheyling B1	33.000										0.021	95.6	0.4	
Sheyling B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.1	
Shoong B1	33.000										0.003	84.9	0.1	
Shoong B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
SMCL B1	33.000										0.170	84.8	3.0	
SMCL B2	0.415		0.014	0.009	0.055	0.034					0.082	85.0	116.8	
SMCL1 B2	0.415		0.015	0.009	0.059	0.036					0.087	85.0	123.7	
Sothi B1	33.000										0.071	99.5	1.3	
Sothi B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.9	
TAE.1	33.000										0.028	98.1	0.5	
TAE.2	33.000										0.018	91.3	0.3	
TAE30.1	33.000										0.297	90.4	5.3	
Tarphel B1	33.000										0.021	91.2	0.4	
Tarphel B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	21.0	
Tchu Gonpa B1	33.000										0.029	84.1	0.5	
Tchu Gonpa B2	0.415		0.005	0.003	0.018	0.011					0.028	85.0	40.5	
Teotsho B1	33.000										0.115	85.7	2.0	

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
Teotsho B2	0.415		0.012	0.007	0.044	0.028					0.066	85.0	96.4	
Thongram B1	33.000		0.002	0.001	0.006	0.004					0.023	84.7	0.4	
Thongram B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	19.1	
Thragom B1	33.000										0.295	90.8	5.2	
Thragom B2	0.415		0.007	0.004	0.027	0.016					0.040	85.0	57.4	
Tobrang B1	33.000		0.000	0.000	0.001	-					0.008	88.3	0.1	
Tokaphu B1	33.000										0.202	96.3	3.6	
Tokaphu B2	0.415		0.004	0.002	0.015	0.009					0.022	85.0	31.9	
Tong.1	33.000										0.604	91.6	10.7	
Tong.2	33.000										0.143	86.5	2.5	
Tong.3	33.000										0.448	92.8	7.9	
Tong.4	33.000										0.341	94.0	6.0	
Tong.5	33.000										0.080	88.0	1.4	
Tong.6	33.000										0.244	95.5	4.3	
Tong.7	33.000										0.167	97.2	3.0	
Tong.8	33.000										0.128	97.4	2.3	
Tong.9	33.000										0.032	92.9	0.6	
Tong.10	33.000										0.063	94.1	1.1	
Tongseng B1	33.000										0.101	93.4	1.8	
Tongseng B2	0.415		0.003	0.002	0.013	0.008					0.019	85.0	26.7	
Tshekharla B2	0.415		0.028	0.018	0.105	0.065					0.157	85.0	227.7	
Tshenkharla B1	33.000										0.632	87.3	11.2	
Tshintsiri B1	33.000										0.199	84.6	3.5	
Tshintsiri B2	0.415		0.035	0.022	0.131	0.081					0.196	85.0	280.3	
TYLSS B1	33.000										0.206	84.2	3.7	
TYLSS B2	0.415		0.037	0.023	0.133	0.082					0.200	85.0	293.2	
U.Khamdang B1	33.000										0.669	87.4	11.9	
U.Khamdang B2	0.415		0.007	0.004	0.025	0.016					0.037	85.0	54.0	
U.Namthi B1	33.000		0.000	0.000	0.002	0.001					0.203	89.7	3.6	
URC B1	33.000		0.004	0.002	0.014	0.009					0.053	84.7	0.9	
URC B2	0.415		0.006	0.003	0.021	0.013					0.031	85.0	44.6	
Wanglu B1	33.000										0.084	93.6	1.5	
Wanglu B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	23.3	
Wangringmo B1	33.000										0.016	84.9	0.3	
Wangringmo B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	22.4	
Wombu B1	33.000										0.034	88.6	0.6	
Wombu B2	0.415		0.003	0.002	0.012	0.007					0.017	85.0	25.1	
Womina B1	33.000										0.026	94.3	0.5	
Womina B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.2	
Womina CPS B1	33.000										0.007	84.7	0.1	
Womina CPS B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.2	
Wongkhar B1	33.000										0.035	84.5	0.6	

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
Wongkhar B2	0.415		0.006	0.004	0.023	0.014					0.035	85.0	49.8	
Y.Gonpa B1	33.000		0.001	0.000	0.002	0.001					0.134	90.6	2.4	
Yal.1	33.000										0.574	89.9	10.2	
Yal.2	33.000										0.559	90.0	9.9	
Yal.3	33.000										0.392	91.4	7.0	
Yal.4	33.000										0.327	91.3	5.8	
Yal.5	33.000										0.257	91.0	4.6	
Yal.6	33.000										0.100	91.2	1.8	
Yal.7	33.000										0.074	90.7	1.3	
Yal.8	33.000		0.001	0.000	0.002	0.002					0.033	87.4	0.6	
Yal.9	33.000										0.030	86.6	0.5	
Yal.10	33.000		0.002	0.001	0.007	0.005					0.058	88.6	1.0	
Yal.11	33.000		0.001	0.001	0.003	0.002					0.022	88.4	0.4	
Yalang B1	33.000										0.036	84.5	0.6	
Yalang B2	0.415		0.006	0.004	0.024	0.015					0.035	85.0	50.6	
Yang.1	33.000										1.256	91.7	22.3	
Yang.2	33.000										1.239	91.5	22.0	
Yang.3	33.000										1.202	91.6	21.4	
Yang.4	33.000										0.062	90.3	1.1	
Yang.5	33.000		0.001	0.001	0.005	0.003					0.019	86.4	0.3	
Yang.6	33.000										1.034	92.0	18.4	
Yang.7	33.000		0.001	0.001	0.005	0.003					0.031	87.3	0.5	
Yang.9	33.000										1.009	91.9	18.0	
Yang.10	33.000										1.011	91.4	18.0	
Yang.11	33.000		0.001	0.000	0.002	0.001					0.990	91.3	17.7	
Yang.12	33.000										0.987	91.2	17.6	
Yang.13	33.000										0.969	90.6	17.3	
Yang.14	33.000										0.952	90.6	17.0	
Yangtse TA B1	33.000												-	
Yangtse TA B2	0.415													
Yangtse.S B1	33.000										0.065	97.0	1.2	
Yangtse.S B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.4	
Yangtse.TB B1	33.000										0.551	93.5	9.8	
Yangtse.TB B2	0.415		0.016	0.010	0.057	0.035					0.086	85.0	126.5	
Yraphel1 B1	33.000										0.169	90.3	3.0	
Yraphel1 B2	0.415		0.003	0.002	0.009	0.006					0.014	85.0	20.1	
Yraphel2 B1	33.000										0.155	90.3	2.8	
Yraphel2 B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.7	
Yraphel3 B1	33.000										0.143	90.6	2.5	
Yraphel3 B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.3	
Zhapang B1	33.000										0.008	51.3	0.1	

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
Zhapang B2	0.415		0.000	0.000	0.002	0.001					0.003	85.0	3.8	

* 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	%
Bakpa Tfr	Transformer				0.063	0.051	80.6	0.049	78.1
Bamchang Tfr	Transformer				0.025	0.010	38.7	0.010	38.1
Bamdir Tfr	Transformer				0.025	0.010	40.1	0.010	39.5
Baney Tfr	Transformer				0.025	0.015	59.3	0.014	57.9
Baringmo Tfr	Transformer				0.063	0.011	17.3	0.011	17.2
Barteng Tfr	Transformer				0.025	0.011	43.9	0.011	43.2
Bawoong Tfr	Transformer				0.063	0.022	34.9	0.022	34.5
BHSS.Pvt Tfr	Transformer				0.500	0.024	4.8	0.024	4.8
Bimkhar Tfr	Transformer				0.100	0.014	14.4	0.014	14.4
Binangkhar Tfr	Transformer				0.063	0.016	25.3	0.016	25.0
Binangreb Tfr	Transformer				0.063	0.044	69.3	0.043	67.5
Braktsa Tfr	Transformer				0.063	0.045	72.0	0.044	70.0
Brenglum Tfr	Transformer				0.063	0.038	60.6	0.037	59.3
Brongshing Tfr	Transformer				0.063	0.026	41.6	0.026	40.9
Buyang Tfr	Transformer				0.063	0.024	37.5	0.023	37.0
Chakadmi Tfr	Transformer				0.025	0.003	13.6	0.003	13.5
Changmadung Tfr	Transformer				0.063	0.025	39.7	0.025	39.1
Chema Meth Tfr	Transformer				0.025	0.014	56.8	0.014	55.6
ChemaA Tfr	Transformer				0.010	0.007	67.2	0.007	65.5
ChemaB Tfr	Transformer				0.025	0.009	34.8	0.009	34.4
Chemkhar Tfr	Transformer				0.025	0.018	70.1	0.017	68.2
Cheng Tfr	Transformer				0.025	0.015	60.9	0.015	59.5
Cholaptsa Tfr	Transformer				0.063	0.042	67.2	0.041	65.5
D.Phodrang Tfr	Transformer				0.025	0.008	30.6	0.008	30.3
Daka Tfr	Transformer				0.025	0.012	48.2	0.012	47.3
Daksa Tfr	Transformer				0.063	0.011	17.3	0.011	17.2
Dalikhar Tfr	Transformer				0.025	0.007	28.2	0.007	27.9
Darchen Tfr	Transformer				0.025	0.019	76.9	0.019	74.6
Dshingma Tfr	Transformer				0.025	0.007	29.1	0.007	28.8
Dukti CPS Tfr	Transformer				0.025	0.010	39.6	0.010	39.0
Dukti Gonpa' Tfr	Transformer				0.025	0.010	40.6	0.010	39.9
Dukti RBP Tfr	Transformer				0.025	0.009	36.7	0.009	36.2
Dungzam Tfr	Transformer				0.100	0.034	33.5	0.033	33.1

CKT / Branch		Cable & Reactor			Transformer				
		Ampacity (Amp)	Loading Amp		Capability (MVA)	Loading (input)		Loading (output)	
ID	Type			%		MVA	%	MVA	%
Fanteng Tfr	Transformer				0.063	0.006	9.6	0.006	9.6
Gangkar Pam Tfr	Transformer				0.063	0.021	33.9	0.021	33.4
Gangkar Tfr	Transformer				0.063	0.009	13.6	0.009	13.5
Gardung Tfr	Transformer				0.025	0.008	30.0	0.007	29.7
Garkhang Tfr	Transformer				0.025	0.001	3.9	0.001	3.8
Gkhardung Tfr	Transformer				0.063	0.006	9.6	0.006	9.6
* GomphuKora Tfr	Transformer				0.100	0.126	126.5	0.120	120.5
Jabdra Tfr	Transformer				0.063	0.006	8.8	0.005	8.7
Jangphutse Tfr	Transformer				0.063	0.024	38.7	0.024	38.1
Jigsham Tfr	Transformer				0.025	0.010	41.6	0.010	41.0
Karmazom Tfr	Transformer				0.063	0.021	33.9	0.021	33.5
Keling Tfr	Transformer				0.025	0.006	23.0	0.006	22.8
Kenmung Tfr	Transformer				0.063	0.037	58.8	0.036	57.5
Khardung Tfr	Transformer				0.025	0.001	3.9	0.001	3.8
Kheni Tfr	Transformer				0.160	0.151	94.5	0.146	91.2
Khitshang NewT Tfr	Transformer				0.500	0.044	8.8	0.044	8.8
Khitshang Tfr	Transformer				0.250	0.152	60.8	0.149	59.4
Koncholing Tfr	Transformer				0.063	0.028	44.4	0.027	43.6
KorlungSS Tfr1	Transformer				10.000	2.002	20.0	1.988	19.9
KorlungSS Tfr2	Transformer				10.000	2.002	20.0	1.988	19.9
Kunzangling Tfr	Transformer				0.125	0.104	83.4	0.101	80.8
L.Khamdang Tfr	Transformer				0.063	0.038	60.7	0.037	59.4
L.Melongkhar Tfr	Transformer				0.025	0.011	44.4	0.011	43.6
L.Namthi Tfr	Transformer				0.025	0.016	63.4	0.015	61.9
Laishung Tfr	Transformer				0.025	0.002	9.8	0.002	9.7
Lakurung Tfr	Transformer				0.063	0.027	42.6	0.026	41.9
Larjab Tfr	Transformer				0.025	0.007	26.2	0.006	26.0
Lawshing Tfr	Transformer				0.063	0.030	48.3	0.030	47.4
Lengkhar Tfr	Transformer				0.025	0.011	42.5	0.010	41.8
Lichen Tfr	Transformer				0.063	0.007	10.7	0.007	10.6
Longkhar Tfr	Transformer				0.025	0.007	29.7	0.007	29.4
Lulu Tfr	Transformer				0.025	0.005	19.2	0.005	19.1
M.Dukti Tfr	Transformer				0.025	0.011	43.4	0.011	42.7
M.Namthi Tfr	Transformer				0.025	0.017	69.1	0.017	67.3
Manam Tfr	Transformer				0.025	0.017	68.2	0.017	66.4

CKT / Branch		Cable & Reactor			Transformer				
		Ampacity	Loading		Capability	Loading (input)		Loading (output)	
ID	Type	(Amp)	Amp	%	(MVA)	MVA	%	MVA	%
Manla Tfr	Transformer				0.025	0.018	70.3	0.017	68.4
Melongkhar Sch. Tfr	Transformer				0.025	0.011	42.5	0.010	41.8
Menchu Tfr	Transformer				0.063	0.020	32.0	0.020	31.6
Mineral WP Tfr	Transformer				0.100	0.083	82.6	0.080	80.0
Mongling Tfr	Transformer				0.025	0.017	68.2	0.017	66.5
N.Bayling Tfr	Transformer				0.063	0.033	52.4	0.032	51.4
N.Tshaling Tfr	Transformer				0.063	0.011	17.3	0.011	17.2
Nangphu Tfr	Transformer				0.025	0.001	3.9	0.001	3.8
New Dzong Tfr	Transformer				0.250	0.084	33.5	0.083	33.1
NHDC.Pvt Tfr	Transformer				0.100	0.045	44.9	0.044	44.1
Ninda Tfr	Transformer				0.025	0.004	15.6	0.004	15.5
Nombari Tfr	Transformer				0.063	0.038	59.7	0.037	58.4
Old Dzo Tfr	Transformer				0.030	0.017	55.8	0.016	54.6
Pang Tfr	Transformer				0.063	0.026	41.6	0.026	40.9
Pangkhar Tfr	Transformer				0.025	0.001	3.9	0.001	3.8
Panglewa Tfr	Transformer				0.025	0.002	9.6	0.002	9.6
Pangthang Tfr	Transformer				0.063	0.027	42.6	0.026	41.9
Phefolung Tfr	Transformer				0.063	0.020	32.0	0.020	31.6
Phubdung Tfr	Transformer				0.025	0.003	13.5	0.003	13.4
Phunchling Tfr	Transformer				0.025	0.005	19.2	0.005	19.1
Phuyang Tfr	Transformer				0.063	0.029	45.5	0.028	44.7
Pukturgg Tfr	Transformer				0.025	0.012	47.7	0.012	46.9
R.Shokhang Tfr	Transformer				0.025	0.008	32.0	0.008	31.6
Rabti Pam Tfr	Transformer				0.025	0.015	60.6	0.015	59.2
Rabti Shoong Tfr	Transformer				0.025	0.014	56.8	0.014	55.6
RabtiA Tfr	Transformer				0.025	0.015	60.6	0.015	59.2
RabtiB Tfr	Transformer				0.025	0.015	60.6	0.015	59.2
Ram Gonpa Tfr	Transformer				0.063	0.030	48.4	0.030	47.5
Ratsho Tfr	Transformer				0.063	0.028	43.9	0.027	43.2
RBA.Pvt Tfr	Transformer				0.063	0.028	44.0	0.027	43.3
RBP Tfr	Transformer				0.063	0.058	92.6	0.056	89.4
Renja Tfr	Transformer				0.025	0.011	42.2	0.010	41.5
Rigney.Pvt Tfr	Transformer				0.500	0.163	32.6	0.161	32.2
Rigom Tfr	Transformer				0.025	0.014	54.3	0.013	53.2
Rigsum Gpa Tfr	Transformer				0.025	0.002	7.7	0.002	7.7

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
RMSS Tfr	Transformer				0.125	0.026	20.4	0.025	20.3
RolamA Tfr	Transformer				0.025	0.011	42.5	0.010	41.8
RolamB Tfr	Transformer				0.025	0.009	35.8	0.009	35.3
Romang Tfr	Transformer				0.063	0.006	8.8	0.006	8.8
Samtling Tfr	Transformer				0.025	0.006	24.9	0.006	24.7
Sawmill.PVt Tfr	Transformer				0.063	0.018	28.8	0.018	28.5
Serpang Tfr	Transformer				0.063	0.003	4.9	0.003	4.9
Sertsho Tfr	Transformer				0.063	0.037	58.7	0.036	57.4
Shakpa Tfr	Transformer				0.030	0.016	54.1	0.016	53.0
Shali Pam Tfr	Transformer				0.160	0.108	67.2	0.105	65.5
Shangsheree Tfr	Transformer				0.025	0.006	23.3	0.006	23.1
Shangthang Tfr	Transformer				0.063	0.026	40.7	0.025	40.1
Shazam Tfr	Transformer				0.063	0.018	28.1	0.018	27.8
Sheyling Tfr	Transformer				0.025	0.003	11.5	0.003	11.5
Shoong Tfr	Transformer				0.025	0.003	13.5	0.003	13.4
SMCL Tfr1	Transformer				0.500	0.083	16.6	0.082	16.5
SMCL Tfr2	Transformer				0.500	0.088	17.5	0.087	17.4
Sothi Tfr	Transformer				0.063	0.005	7.7	0.005	7.7
Tarphel Tfr	Transformer				0.025	0.015	59.0	0.014	57.7
Tchu Gonpa Tfr	Transformer				0.030	0.029	95.5	0.028	92.1
Teotsho Tfr	Transformer				0.100	0.068	68.2	0.066	66.4
Thongram Tfr	Transformer				0.025	0.013	53.9	0.013	52.8
Thragom Tfr	Transformer				0.063	0.041	64.5	0.040	62.9
Tokaphu Tfr	Transformer				0.063	0.023	35.8	0.022	35.3
Tongseng Tfr	Transformer				0.063	0.019	30.0	0.019	29.7
Tshekharla Tfr	Transformer				0.250	0.161	64.5	0.157	62.9
Tshintsiri Tfr	Transformer				0.500	0.199	39.7	0.196	39.1
TYLSS Tfr	Transformer				0.250	0.206	82.5	0.200	79.9
U.Khamdang Tfr	Transformer				0.063	0.038	60.7	0.037	59.3
URC Tfr	Transformer				0.063	0.032	50.1	0.031	49.1
Wanglu Tfr	Transformer				0.063	0.016	26.2	0.016	25.9
Wangringmo Tfr	Transformer				0.125	0.016	12.7	0.016	12.6
Wombu Tfr	Transformer				0.025	0.018	71.2	0.017	69.3
Womina CPS Tfr	Transformer				0.025	0.007	28.7	0.007	28.4
Womina Tfr	Transformer				0.025	0.004	17.3	0.004	17.2

CKT / Branch		Cable & Reactor			Transformer				
					Capability (MVA)	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%		MVA	%	MVA	%
Wongkhar Tfr	Transformer				0.063	0.035	56.0	0.035	54.8
Yalang Tfr	Transformer				0.063	0.036	56.9	0.035	55.7
Yangtse TA Tfr	Transformer				1.000				
Yangtse.S Tfr	Transformer				0.063	0.007	11.5	0.007	11.5
Yangtse.TB Tfr	Transformer				0.100	0.089	88.9	0.086	85.9
Yraphel1 Tfr	Transformer				0.025	0.014	56.8	0.014	55.6
Yraphel2 Tfr	Transformer				0.025	0.013	53.0	0.013	51.9
Yraphel3 Tfr	Transformer				0.025	0.009	34.8	0.009	34.4
Zhapang Tfr	Transformer				0.025	0.003	10.6	0.003	10.5

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

Branch Losses Summary Report

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
Bakpa-Tong.4	0.320	0.112	-0.320	-0.116	0.1	-4.1	98.5	98.5	0.04
Tong.3-Bakpa	-0.363	-0.140	0.363	0.139	0.0	-0.3	98.5	98.5	0.00
Bakpa Tfr	0.043	0.027	-0.042	-0.026	0.9	1.4	98.5	95.5	2.99
R Shokhang-Bamchang	-0.008	-0.005	0.008	0.004	0.0	-1.1	98.5	98.5	0.00
Bamchang Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	98.5	97.0	1.43
BoD.9-Bamdir	-0.008	-0.005	0.008	0.004	0.0	-1.7	97.8	97.8	0.00
Bamdir Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	97.8	96.3	1.50
Yang.12-Baney	-0.013	-0.008	0.013	0.002	0.0	-6.1	98.0	98.0	0.00
Baney Tfr	0.013	0.008	-0.012	-0.008	0.2	0.3	98.0	95.8	2.21
BoD.15-Baringmo	-0.009	-0.006	0.009	0.005	0.0	-0.3	97.8	97.8	0.00
Baringmo Tfr	0.009	0.006	-0.009	-0.006	0.0	0.1	97.8	97.1	0.64
Barpang-Yang.7	0.027	0.013	-0.027	-0.015	0.0	-1.6	98.4	98.4	0.00
Gardung-Barpang	-0.031	-0.016	0.031	0.013	0.0	-2.6	98.4	98.4	0.00
BoD.9-Barteng	-0.009	-0.006	0.009	0.003	0.0	-3.2	97.8	97.8	0.00
Barteng Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	97.8	96.1	1.64
Yal.3-Bawoong	-0.019	-0.012	0.019	0.009	0.0	-3.2	98.6	98.6	0.00
Bawoong Tfr	0.019	0.012	-0.018	-0.011	0.2	0.3	98.6	97.3	1.29
BoD.6-BHSS.Pvt	-0.020	-0.013	0.020	0.012	0.0	-0.8	97.8	97.8	0.00
BHSS.Pvt Tfr	0.020	0.013	-0.020	-0.013	0.0	0.0	97.8	97.6	0.18
BoD.2-Bimkhar	-0.012	-0.008	0.012	0.004	0.0	-3.6	97.8	97.8	0.00
Bimkhar Tfr	0.012	0.008	-0.012	-0.008	0.0	0.1	97.8	97.3	0.54
Lakurung-Binangkhar	-0.013	-0.008	0.013	0.005	0.0	-3.7	98.5	98.5	0.00
Binangkhar Tfr	0.013	0.008	-0.013	-0.008	0.1	0.1	98.5	97.6	0.93
Ram.3-Binangreb	-0.037	-0.023	0.037	0.022	0.0	-1.0	98.6	98.6	0.00
Binangreb Tfr	0.037	0.023	-0.036	-0.022	0.7	1.0	98.6	96.0	2.57
L1-BoD.1	0.839	0.388	-0.839	-0.389	0.1	-0.9	97.8	97.8	0.01
Yang.14-BOD ARCB SW	-0.839	-0.388	0.839	0.388	0.0	-0.6	97.8	97.8	0.01
BoD(1-2)	0.150	0.088	-0.150	-0.090	0.0	-2.2	97.8	97.8	0.01
BoD(1-3)	0.689	0.301	-0.689	-0.303	0.1	-1.8	97.8	97.8	0.02
BoD.2-Rigney.Pvt	0.138	0.086	-0.138	-0.087	0.0	-0.3	97.8	97.8	0.00
BoD.3-TYLSS	0.174	0.110	-0.174	-0.111	0.0	-1.1	97.8	97.8	0.00
BoD.3-Yangte.TB	0.515	0.193	-0.515	-0.195	0.1	-2.2	97.8	97.8	0.01
BoD(4-5)	0.440	0.148	-0.440	-0.148	0.0	-0.5	97.8	97.8	0.00
BoD.4-Yangtse TA	0.000	0.000	0.000	0.000	0.0	-0.5	97.8	97.8	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
Yangtse.T-BoD.4	-0.440	-0.147	0.440	0.147	0.0	-0.3	97.8	97.8	0.00
BoD.5-New Dzong	0.071	0.044	-0.071	-0.045	0.0	-0.7	97.8	97.8	0.00
BoD.5-NHDC.Pvt	0.198	0.090	-0.198	-0.090	0.0	-0.3	97.8	97.8	0.00
BoD.5-Pukturgg	0.171	0.014	-0.171	-0.016	0.0	-2.1	97.8	97.8	0.00
BoD.6-N.Bayling	0.091	0.026	-0.091	-0.028	0.0	-1.3	97.8	97.8	0.00
RBP-BoD.6	-0.111	-0.038	0.111	0.036	0.0	-2.4	97.8	97.8	0.01
BoD.7-Sheyling	0.020	0.006	-0.020	-0.006	0.0	-0.3	97.8	97.8	0.00
BoD.7-Womina	0.025	0.008	-0.025	-0.009	0.0	-0.8	97.8	97.8	0.00
Rigom-BoD.7	-0.045	-0.014	0.045	0.009	0.0	-4.6	97.8	97.8	0.01
BoD.8-Keling	0.011	0.002	-0.011	-0.004	0.0	-2.0	97.7	97.7	0.00
BoD.8-Womina CPS	0.006	0.004	-0.006	-0.004	0.0	-0.1	97.7	97.7	0.00
Womina-BoD.8	-0.021	-0.008	0.021	0.006	0.0	-1.5	97.7	97.8	0.00
Sheyling-BoD.9	-0.018	-0.006	0.018	0.005	0.0	-1.6	97.8	97.8	0.00
BoD(10-11)	0.156	0.011	-0.156	-0.012	0.0	-0.9	97.8	97.8	0.00
BoD.10-Gkhardung	0.005	0.001	-0.005	-0.003	0.0	-1.8	97.8	97.8	0.00
Pukturgg-BoD.10	-0.161	-0.013	0.161	0.010	0.0	-2.4	97.8	97.8	0.01
BoD.11-Daksa	0.009	0.003	-0.009	-0.006	0.0	-3.0	97.8	97.8	0.00
BoD.11-N.Tshaling	0.146	0.009	-0.146	-0.009	0.0	-0.1	97.8	97.8	0.00
BoD.12-Fanteng	0.104	0.006	-0.104	-0.008	0.0	-2.2	97.8	97.8	0.00
BoD.12-Nangphu	0.033	0.006	-0.033	-0.009	0.0	-3.6	97.8	97.8	0.00
N.Tshaling-BoD.12	-0.137	-0.012	0.137	0.004	0.0	-8.1	97.8	97.8	0.01
BoD.13-Garkhang	0.001	-0.001	-0.001	-0.001	0.0	-1.1	97.8	97.8	0.00
BoD.13-Ratsho	0.032	0.010	-0.032	-0.012	0.0	-2.4	97.8	97.8	0.00
Nangphu-BoD.13	-0.032	-0.010	0.032	0.009	0.0	-0.7	97.8	97.8	0.00
BoD(14-15)	0.063	-0.003	-0.063	0.003	0.0	-0.3	97.8	97.8	0.00
BoD.14-Phubdung	0.003	0.000	-0.003	-0.002	0.0	-2.2	97.8	97.8	0.00
Sothi-BoD.14	-0.066	0.003	0.066	-0.007	0.0	-3.4	97.8	97.8	0.00
BoD.15-Phunchling	0.054	-0.008	-0.054	0.004	0.0	-4.0	97.8	97.7	0.00
BoD.15-Phunchling1	0.042	0.005	-0.042	-0.009	0.0	-4.0	97.7	97.7	0.00
BoD.16-Pamadung	0.008	-0.006	-0.008	0.005	0.0	-0.3	97.7	97.7	0.00
Phunchling-BoD.16	-0.050	0.001	0.050	-0.007	0.0	-5.7	97.7	97.7	0.00
BoD.17-Zhapang	0.004	-0.005	-0.004	0.005	0.0	-0.1	97.7	97.7	0.00
Pamadung-BoD.17	-0.005	0.005	0.005	-0.007	0.0	-2.6	97.7	97.7	0.00
BoD.18-Khardung	0.020	0.008	-0.020	-0.008	0.0	-0.4	97.7	97.7	0.00
Pangkhar-BoD.18	-0.022	-0.009	0.022	0.006	0.0	-3.1	97.7	97.7	0.00
Braktsa-Kham.5	0.130	0.073	-0.130	-0.074	0.0	-1.0	98.4	98.4	0.00
Braktsa-Kheni	0.183	0.095	-0.183	-0.100	0.0	-5.2	98.4	98.4	0.02

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
Kham.4-Braktsa	-0.351	-0.193	0.351	0.189	0.1	-3.4	98.4	98.5	0.02
Braktsa Tfr	0.038	0.024	-0.038	-0.023	0.7	1.1	98.4	95.8	2.67
Yang.2-Brenglum	-0.032	-0.020	0.032	0.020	0.0	-0.8	98.5	98.5	0.00
Brenglum Tfr	0.032	0.020	-0.032	-0.020	0.5	0.8	98.5	96.2	2.25
Tong.5-Brongshing	-0.022	-0.014	0.022	0.013	0.0	-0.5	98.5	98.5	0.00
Brongshing Tfr	0.022	0.014	-0.022	-0.014	0.2	0.4	98.5	96.9	1.54
Yang.9-Burbula	-0.002	-0.001	0.002	0.001	0.0	-0.2	98.3	98.3	0.00
Yang.10-Buyang	-0.020	-0.013	0.020	0.012	0.0	-0.1	98.1	98.1	0.00
Buyang Tfr	0.020	0.013	-0.020	-0.012	0.2	0.3	98.1	96.7	1.39
ChakadmiA-Lengkhar	0.017	0.009	-0.017	-0.011	0.0	-1.5	98.4	98.4	0.00
Yang.7-ChakadmiA	-0.020	-0.011	0.020	0.011	0.0	-0.2	98.4	98.4	0.00
Chakadmi Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.4	97.9	0.50
Kenmung-Changmadung	-0.021	-0.013	0.021	0.009	0.0	-4.1	98.5	98.5	0.00
Changmadung Tfr	0.021	0.013	-0.021	-0.013	0.2	0.3	98.5	97.1	1.47
Chema(B-Meth)	-0.013	-0.008	0.013	0.008	0.0	-0.2	98.4	98.4	0.00
Chema Meth Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	98.4	96.3	2.10
Chema P-Dukti RBP	0.037	0.014	-0.037	-0.020	0.0	-6.6	98.4	98.4	0.01
Yal.7-Chema P	-0.041	-0.016	0.041	0.015	0.0	-1.0	98.4	98.4	0.00
Chema(A-B)	0.020	0.012	-0.020	-0.013	0.0	-0.2	98.4	98.4	0.00
Yal.7-ChemaA	-0.026	-0.016	0.026	0.016	0.0	-0.2	98.4	98.4	0.00
ChemaA Tfr	0.006	0.004	-0.006	-0.003	0.1	0.2	98.4	95.9	2.49
ChemaB Tfr	0.007	0.005	-0.007	-0.005	0.1	0.1	98.4	97.1	1.29
Kham.9-Chemkhar	-0.015	-0.010	0.015	0.007	0.0	-2.7	98.4	98.4	0.00
Chemkhar Tfr	0.015	0.009	-0.014	-0.009	0.3	0.4	98.4	95.8	2.60
Cheng-Panglewa	0.029	0.000	-0.029	-0.005	0.0	-4.6	97.7	97.7	0.00
Cheng Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	97.7	95.5	2.27
Kham.7-Cholaptsa	-0.036	-0.023	0.036	0.022	0.0	-0.5	98.4	98.4	0.00
Cholaptsa Tfr	0.036	0.023	-0.035	-0.022	0.7	1.0	98.4	95.9	2.49
Keling-D.Phodrang	-0.006	-0.004	0.006	0.001	0.0	-3.1	97.7	97.7	0.00
D.Phodrang Tfr	0.006	0.004	-0.006	-0.004	0.1	0.1	97.7	96.6	1.14
Yang.5-Daka	-0.010	-0.006	0.010	0.006	0.0	-0.7	98.4	98.4	0.00
Daka Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	98.4	96.6	1.79
Daksa Tfr	0.009	0.006	-0.009	-0.006	0.0	0.1	97.8	97.1	0.64
Dalikhar-Laishung	0.011	0.004	-0.011	-0.005	0.0	-1.4	98.6	98.6	0.00
TAE.2-Dalikhar	-0.017	-0.008	0.017	0.008	0.0	-0.2	98.6	98.6	0.00
Dalikhar Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	98.6	97.5	1.04
Yang.1-Darchen	-0.016	-0.010	0.016	0.009	0.0	-0.9	98.6	98.6	0.00

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
Darchen Tfr	0.016	0.010	-0.016	-0.010	0.3	0.5	98.6	95.7	2.85
Doksum SW-Kham.1	0.684	0.373	-0.684	-0.374	0.1	-1.3	98.6	98.6	0.02
GomphuKora-Doksum SW	0.374	0.187	-0.374	-0.194	0.1	-7.0	98.6	98.6	0.03
L1-Khitshang	0.292	0.160	-0.292	-0.160	0.0	-0.1	98.6	98.6	0.00
L1-Tong.1	0.554	0.234	-0.553	-0.242	0.4	-8.2	98.6	98.6	0.08
L1-Yal.1	0.517	0.248	-0.517	-0.251	0.1	-3.0	98.6	98.6	0.03
L1-Yang.1	1.152	0.497	-1.151	-0.502	0.7	-4.9	98.6	98.6	0.08
Yal.10-Dshingma	-0.006	-0.004	0.006	0.002	0.0	-2.3	98.5	98.5	0.00
Dshingma Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	98.5	97.4	1.08
Yal.9-Dukti CPS	-0.008	-0.005	0.008	0.005	0.0	-0.3	98.4	98.4	0.00
Dukti CPS Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	98.4	96.9	1.47
Dukti(M-Gonpa)	-0.009	-0.005	0.009	0.005	0.0	-0.8	98.4	98.4	0.00
Dukti Gonpa' Tfr	0.009	0.005	-0.008	-0.005	0.1	0.1	98.4	96.9	1.50
Dukti RBP-Yal.8	0.029	0.016	-0.029	-0.016	0.0	-0.6	98.4	98.4	0.00
Dukti RBP Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	98.4	97.0	1.36
Dungzam-Sothi	0.070	-0.008	-0.070	0.004	0.0	-3.9	97.8	97.8	0.00
Fanteng-Dungzam	-0.099	-0.010	0.099	0.005	0.0	-4.7	97.8	97.8	0.01
Dungzam Tfr	0.028	0.018	-0.028	-0.017	0.3	0.4	97.8	96.5	1.25
Fanteng Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	97.8	97.4	0.36
Gangkar Tfr	-0.007	-0.004	0.007	0.005	0.0	0.0	97.9	98.4	0.50
Gangkar-Jabdra	0.005	-0.001	-0.005	-0.003	0.0	-3.4	98.4	98.4	0.00
Tong.9-Gangkar	-0.012	-0.004	0.012	0.001	0.0	-3.0	98.4	98.4	0.00
Tong.9-Gangkar Pam	-0.018	-0.011	0.018	0.011	0.0	-0.4	98.4	98.4	0.00
Gangkar Pam Tfr	0.018	0.011	-0.018	-0.011	0.2	0.2	98.4	97.2	1.25
Yang.4-Gardung	-0.037	-0.017	0.037	0.017	0.0	-0.1	98.4	98.4	0.00
Gardung Tfr	0.006	0.004	-0.006	-0.004	0.1	0.1	98.4	97.3	1.11
Garkhang Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	97.8	97.6	0.14
Gkhardung Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	97.8	97.4	0.36
TAE30.1-GomphuKora	0.268	0.125	-0.268	-0.127	0.0	-2.2	98.6	98.6	0.01
GomphuKora Tfr	0.106	0.069	-0.102	-0.063	3.6	5.5	98.6	93.9	4.69
Jabdra Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	98.4	98.1	0.32
Kham.10-Jangphutse	-0.021	-0.013	0.021	0.013	0.0	-0.4	98.4	98.4	0.00
Jangphutse Tfr	0.021	0.013	-0.020	-0.013	0.2	0.3	98.4	97.0	1.43
Laishung-Jigsham	-0.009	-0.006	0.009	0.004	0.0	-1.4	98.6	98.6	0.00
Jigsham Tfr	0.009	0.006	-0.009	-0.005	0.1	0.1	98.6	97.0	1.54
Kham.4-Karmazom	-0.018	-0.011	0.018	0.010	0.0	-1.8	98.5	98.5	0.00
Karmazom Tfr	0.018	0.011	-0.018	-0.011	0.2	0.2	98.5	97.2	1.25

	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
Keling Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	97.7	96.9	0.86
Tong.3-Kenmung	-0.052	-0.029	0.052	0.028	0.0	-1.3	98.5	98.5	0.00
Kenmung Tfr	0.031	0.020	-0.031	-0.019	0.5	0.7	98.5	96.4	2.18
Kham(1-2)	0.647	0.351	-0.647	-0.354	0.2	-3.0	98.6	98.6	0.04
Kham.1-Khitshang New	0.037	0.023	-0.037	-0.023	0.0	-0.4	98.6	98.6	0.00
Kham.2-L.Khamdang	0.617	0.343	-0.617	-0.344	0.1	-1.8	98.6	98.6	0.02
Kham.2-Wombu	0.030	0.012	-0.030	-0.016	0.0	-3.9	98.6	98.6	0.00
Kham(3-4)	0.369	0.195	-0.369	-0.199	0.1	-3.6	98.5	98.5	0.03
Kham.3-Shazam	0.015	0.008	-0.015	-0.009	0.0	-1.4	98.5	98.5	0.00
Nombari-Kham.3	-0.384	-0.203	0.384	0.203	0.0	-0.5	98.5	98.5	0.00
Kham(5-6)	0.130	0.074	-0.130	-0.076	0.0	-2.1	98.4	98.4	0.01
Kham.6-Sertsho	0.031	0.019	-0.031	-0.020	0.0	-0.8	98.4	98.4	0.00
Kham.6-Teotsho	0.098	0.057	-0.098	-0.059	0.0	-1.8	98.4	98.4	0.01
Teotsho-Kham.7	-0.041	-0.025	0.041	0.022	0.0	-2.9	98.4	98.4	0.00
Kham(9-10)	0.040	0.019	-0.040	-0.022	0.0	-2.9	98.4	98.4	0.00
Khani-Kham.9	-0.055	-0.026	0.055	0.019	0.0	-7.0	98.4	98.4	0.01
Kham(10-11)	0.020	0.009	-0.020	-0.012	0.0	-3.1	98.4	98.4	0.00
Kham.11-Manam	0.014	0.009	-0.014	-0.009	0.0	-0.2	98.4	98.4	0.00
Khardung-Tarphel	0.019	0.008	-0.019	-0.009	0.0	-1.1	97.7	97.7	0.00
Khardung Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	97.7	97.6	0.14
Kheni Tfr	0.127	0.082	-0.124	-0.077	3.3	4.9	98.4	94.9	3.51
Khitshang-Ram.1	0.163	0.079	-0.163	-0.087	0.0	-8.0	98.6	98.6	0.02
Khitshang Tfr	0.128	0.081	-0.126	-0.078	2.1	3.2	98.6	96.4	2.25
Khitshang NewT Tfr	-0.037	-0.023	0.037	0.023	0.1	0.1	98.3	98.6	0.32
Yang.6-Koncholing	-0.024	-0.015	0.024	0.014	0.0	-0.4	98.4	98.4	0.00
Koncholing Tfr	0.024	0.015	-0.023	-0.014	0.3	0.4	98.4	96.7	1.64
Korlung-Doksum line	-3.573	-1.699	3.588	1.710	16.0	11.1	98.6	99.3	0.64
KorlungSS Tfr1	1.798	0.880	-1.794	-0.855	4.1	24.7	100.0	99.3	0.72
KorlungSS Tfr2	1.798	0.880	-1.794	-0.855	4.1	24.7	100.0	99.3	0.72
Kunzangling Tfr	-0.086	-0.053	0.088	0.056	2.0	3.0	95.5	98.5	3.09
Tong.2-Kunzangling	-0.088	-0.056	0.088	0.056	0.0	-0.5	98.5	98.5	0.00
Kham.2-U.Khamdang	0.584	0.324	-0.584	-0.325	0.1	-1.5	98.6	98.5	0.02
L.Khamdang Tfr	0.032	0.020	-0.032	-0.020	0.5	0.8	98.6	96.3	2.25
Melongkhar(L-M)	0.015	0.008	-0.015	-0.009	0.0	-1.2	98.4	98.4	0.00
Yal.6-L.Melongkhar	-0.024	-0.014	0.024	0.012	0.0	-1.8	98.4	98.4	0.00
L.Melongkhar Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.4	96.7	1.64
Namthi(M-L)	-0.013	-0.009	0.013	0.008	0.0	-0.5	98.4	98.4	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
L.Namthi Tfr	0.013	0.009	-0.013	-0.008	0.2	0.3	98.4	96.1	2.35
Laishung Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	98.6	98.2	0.36
Tong.2-Lakurung	-0.036	-0.019	0.036	0.016	0.0	-2.7	98.5	98.5	0.00
Lakurung Tfr	0.023	0.014	-0.022	-0.014	0.3	0.4	98.5	97.0	1.58
Shangsheree-Larjab	-0.006	-0.003	0.006	0.001	0.0	-2.5	98.6	98.6	0.00
Larjab Tfr	0.006	0.003	-0.006	-0.003	0.0	0.1	98.6	97.6	0.97
Pang-Lawshing	-0.026	-0.016	0.026	0.013	0.0	-2.8	98.5	98.5	0.00
Lawshing Tfr	0.026	0.016	-0.025	-0.016	0.3	0.5	98.5	96.7	1.79
Lengkhar Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.4	96.8	1.57
Lichen-Tong.10	0.059	0.021	-0.059	-0.021	0.0	-0.2	98.4	98.4	0.00
Wanglu-Lichen	-0.065	-0.024	0.065	0.021	0.0	-3.7	98.4	98.4	0.01
Lichen Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	98.4	98.0	0.40
Tobrang-Longkhar	-0.006	-0.004	0.006	0.003	0.0	-0.7	97.7	97.7	0.00
Longkhar Tfr	0.006	0.004	-0.006	-0.004	0.1	0.1	97.7	96.6	1.11
Lulu-Pangkhar	0.023	0.004	-0.023	-0.006	0.0	-2.2	97.7	97.7	0.00
Panglewa-Lulu	-0.027	-0.007	0.027	0.004	0.0	-3.0	97.7	97.7	0.00
Lulu Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	97.7	97.0	0.72
Yal.9-M.Dukti	-0.018	-0.010	0.018	0.010	0.0	-0.3	98.4	98.4	0.00
M.Dukti Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.4	96.8	1.61
M.Namthi-Yraphel1	0.152	0.072	-0.152	-0.072	0.0	-0.7	98.4	98.4	0.00
Namthi(U-M)	-0.180	-0.089	0.180	0.089	0.0	-0.3	98.4	98.4	0.00
M.Namthi Tfr	0.015	0.009	-0.014	-0.009	0.3	0.4	98.4	95.9	2.56
Manam Tfr	0.014	0.009	-0.014	-0.009	0.3	0.4	98.4	95.9	2.53
Wombu-Manla	-0.015	-0.009	0.015	0.006	0.0	-3.4	98.6	98.6	0.00
Manla Tfr	0.015	0.009	-0.015	-0.009	0.3	0.4	98.6	96.0	2.60
Melongkhar Sch.-Yal.6	0.091	0.039	-0.091	-0.041	0.0	-2.0	98.4	98.4	0.01
Y.Gonpa-Melongkhar Sch.	-0.100	-0.045	0.100	0.044	0.0	-0.8	98.4	98.4	0.00
Melongkhar Sch. Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.4	96.8	1.57
Menchu-Tong.6	0.233	0.070	-0.233	-0.073	0.0	-2.4	98.5	98.5	0.02
Tong.4-Menchu	-0.250	-0.081	0.250	0.079	0.0	-2.1	98.5	98.5	0.02
Menchu Tfr	0.017	0.011	-0.017	-0.010	0.1	0.2	98.5	97.3	1.18
TAE30.1-Mineral WP	-0.070	-0.044	0.070	0.043	0.0	-1.1	98.6	98.6	0.00
Mineral WP Tfr	0.070	0.044	-0.068	-0.042	1.6	2.3	98.6	95.5	3.06
Mongling-Tchu Gonpa	0.024	0.014	-0.024	-0.015	0.0	-1.9	98.4	98.4	0.00
Tong.6-Mongling	-0.038	-0.023	0.038	0.020	0.0	-3.2	98.4	98.5	0.00
Mongling Tfr	0.014	0.009	-0.014	-0.009	0.3	0.4	98.4	95.9	2.53
N.Bayling-Yangtse.S	0.063	0.010	-0.063	-0.016	0.0	-5.7	97.8	97.8	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
N.Bayling Tfr	0.028	0.018	-0.028	-0.017	0.4	0.6	97.8	95.8	1.96
N.Tshaling Tfr	0.009	0.006	-0.009	-0.006	0.0	0.1	97.8	97.1	0.64
Nangphu Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	97.8	97.6	0.14
New Dzong Tfr	0.071	0.045	-0.070	-0.044	0.7	1.0	97.8	96.5	1.25
NHDC-RBP	0.160	0.066	-0.160	-0.068	0.0	-1.1	97.8	97.8	0.01
NHDC.Pvt Tfr	0.038	0.024	-0.038	-0.023	0.5	0.7	97.8	96.1	1.67
0160.2-Ninda	-0.031	-0.003	0.031	-0.001	0.0	-3.9	98.6	98.6	0.00
Ninda-TAE.1	0.027	0.001	-0.027	-0.005	0.0	-4.3	98.6	98.6	0.00
Ninda Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.6	98.0	0.58
Tshekharla-Nombari	-0.416	-0.223	0.416	0.221	0.1	-2.0	98.5	98.5	0.02
Nombari Tfr	0.032	0.020	-0.031	-0.019	0.5	0.8	98.5	96.3	2.21
O160(1-2)	-0.168	-0.105	0.168	0.092	0.0	-12.5	98.6	98.6	0.03
O160.1-Tshintsiri	0.168	0.105	-0.168	-0.106	0.0	-0.9	98.6	98.6	0.00
O160.2-TAE30.1	-0.199	-0.092	0.199	0.084	0.0	-8.0	98.6	98.6	0.02
Tong.10-Old Dzo	-0.014	-0.003	0.014	0.000	0.0	-3.5	98.4	98.4	0.00
Old Dzo-BOD SW	0.000	-0.006	0.000	0.000	0.0	-5.7	98.4	98.4	0.00
Old Dzo Tfr	0.014	0.009	-0.014	-0.009	0.2	0.3	98.4	96.3	2.07
Tong.5-Pang	-0.048	-0.027	0.048	0.024	0.0	-3.0	98.5	98.5	0.00
Pang Tfr	0.022	0.014	-0.022	-0.014	0.2	0.4	98.5	96.9	1.54
Pangkhar Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	97.7	97.6	0.14
Panglewa Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.7	97.4	0.36
Ram.1-Pangthang	-0.023	-0.014	0.023	0.014	0.0	-0.2	98.6	98.6	0.00
Pangthang Tfr	0.023	0.014	-0.022	-0.014	0.3	0.4	98.6	97.0	1.58
Phefolung-Yal.4	0.298	0.133	-0.298	-0.134	0.0	-0.3	98.5	98.5	0.00
Phuyang-Phefolung	-0.316	-0.144	0.316	0.138	0.1	-5.7	98.5	98.6	0.03
Phefolung Tfr	0.017	0.011	-0.017	-0.010	0.1	0.2	98.5	97.4	1.18
Phubdung Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	97.8	97.3	0.50
Phunchling Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	97.7	97.0	0.72
Yal.3-Phuyang	-0.340	-0.154	0.340	0.150	0.1	-3.3	98.6	98.6	0.02
Phuyang Tfr	0.024	0.015	-0.024	-0.015	0.3	0.4	98.6	96.9	1.68
Pukturgg Tfr	0.010	0.006	-0.010	-0.006	0.1	0.2	97.8	96.0	1.78
Yal.11-R.Shokhang	-0.015	-0.008	0.015	0.007	0.0	-0.8	98.5	98.5	0.00
R.Shokhang Tfr	0.007	0.004	-0.007	-0.004	0.1	0.1	98.5	97.3	1.18
Rabdeling-Yang.5	0.016	0.008	-0.016	-0.009	0.0	-1.0	98.4	98.4	0.00
Yang.4-Rabdeling	-0.019	-0.010	0.019	0.010	0.0	-0.6	98.4	98.4	0.00
Tong.7-Rabti Pam	-0.013	-0.008	0.013	0.006	0.0	-2.0	98.4	98.4	0.00
Rabti Pam Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	98.4	96.2	2.25

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	
Rabti Shoong-Tong.8	0.125	0.023	-0.125	-0.029	0.0	-6.6	98.4	98.4	0.01
Rabti(B-Shoong)	-0.137	-0.030	0.137	0.025	0.0	-5.1	98.4	98.4	0.01
Rabti Shoong Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	98.4	96.3	2.10
RabtiA-Tong.7	0.162	0.038	-0.162	-0.039	0.0	-0.5	98.4	98.4	0.00
Tokaphu-RabtiA	-0.175	-0.047	0.175	0.042	0.0	-4.3	98.4	98.4	0.01
RabtiA Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	98.4	96.2	2.25
Tong.7-RabtiB	-0.150	-0.033	0.150	0.033	0.0	-0.5	98.4	98.4	0.00
RabtiB Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	98.4	96.2	2.25
Ram Gonpa-Ram.5	0.000	-0.001	0.000	0.000	0.0	-0.8	98.6	98.6	0.00
Ram Gonpa-Romang	0.005	-0.002	-0.005	-0.003	0.0	-4.7	98.6	98.6	0.00
Ram.4-Ram Gonpa	-0.030	-0.014	0.030	0.010	0.0	-3.2	98.6	98.6	0.00
Ram Gonpa Tfr	0.026	0.016	-0.025	-0.016	0.3	0.5	98.6	96.8	1.79
Ram(1-2)	0.141	0.073	-0.141	-0.074	0.0	-1.1	98.6	98.6	0.00
Ram(2-3)	0.119	0.061	-0.119	-0.062	0.0	-1.1	98.6	98.6	0.00
Ram.2-RMSS	0.022	0.013	-0.022	-0.014	0.0	-0.7	98.6	98.6	0.00
Ram(3-4)	0.060	0.026	-0.060	-0.029	0.0	-2.6	98.6	98.6	0.00
Ram.3-Shangthang	0.022	0.013	-0.022	-0.014	0.0	-0.3	98.6	98.6	0.00
Ram.4-Wongkhar	0.030	0.019	-0.030	-0.019	0.0	-0.4	98.6	98.6	0.00
Ratsho-Samtling	0.008	-0.002	-0.008	-0.002	0.0	-4.5	97.8	97.8	0.00
Ratsho Tfr	0.023	0.015	-0.023	-0.014	0.3	0.4	97.8	96.1	1.64
Yang.14-RBA.Pvt	-0.023	-0.015	0.023	0.015	0.0	0.0	97.8	97.8	0.00
RBA.Pvt Tfr	0.023	0.015	-0.023	-0.014	0.3	0.4	97.8	96.2	1.64
RBP Tfr	0.049	0.032	-0.048	-0.030	1.3	1.9	97.8	94.3	3.46
Renja-Yang.13	0.879	0.398	-0.878	-0.411	1.0	-12.6	98.0	97.9	0.15
Yang.12-Renja	-0.888	-0.404	0.888	0.402	0.1	-1.6	98.0	98.0	0.02
Renja Tfr	0.009	0.006	-0.009	-0.005	0.1	0.2	98.0	96.4	1.57
Rigney.Pvt Tfr	0.138	0.087	-0.137	-0.085	1.2	1.8	97.8	96.6	1.21
Yangtse.S-Rigom	-0.057	-0.016	0.057	0.012	0.0	-4.5	97.8	97.8	0.01
Rigom Tfr	0.011	0.007	-0.011	-0.007	0.2	0.3	97.8	95.7	2.03
Zhapang-Rigsum Gpa	-0.002	-0.001	0.002	-0.007	0.0	-7.5	97.7	97.7	0.00
Rigsum Gpa Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.7	97.5	0.29
RMSS Tfr	0.022	0.014	-0.022	-0.013	0.1	0.2	98.6	97.9	0.76
Rolam(A-B)	0.027	0.014	-0.027	-0.015	0.0	-0.3	98.5	98.5	0.00
Yal.10-RolamA	-0.036	-0.020	0.036	0.019	0.0	-0.6	98.5	98.5	0.00
RolamA Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.5	96.9	1.57
RolamB-Yal.11	0.019	0.010	-0.019	-0.010	0.0	-0.2	98.5	98.5	0.00
RolamB Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	98.5	97.1	1.33

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
Romang Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	98.6	98.3	0.32
Samtling-Shoong	0.003	-0.001	-0.003	-0.002	0.0	-2.9	97.8	97.8	0.00
Samtling Tfr	0.005	0.003	-0.005	-0.003	0.0	0.1	97.8	96.8	0.93
Yang.13-Sawmill.Pvt	-0.015	-0.010	0.015	0.010	0.0	0.0	97.9	97.9	0.00
Sawmill.PVt Tfr	0.015	0.010	-0.015	-0.009	0.1	0.2	97.9	96.8	1.07
Serpang-Yang.4	0.056	0.024	-0.056	-0.027	0.0	-3.3	98.4	98.4	0.01
Shali Pam-Serpang	-0.059	-0.025	0.059	0.023	0.0	-2.0	98.4	98.4	0.00
Serpang Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.4	98.2	0.18
Sertsho Tfr	0.031	0.020	-0.031	-0.019	0.5	0.7	98.4	96.3	2.18
Tong.1-Shakpa	-0.014	-0.009	0.014	0.009	0.0	-0.1	98.6	98.6	0.00
Shakpa Tfr	0.014	0.009	-0.014	-0.008	0.2	0.3	98.6	96.6	2.00
Yang.3-Shali Pam	-0.150	-0.081	0.150	0.079	0.0	-1.4	98.4	98.4	0.01
Shali Pam Tfr	0.091	0.058	-0.089	-0.055	1.7	2.5	98.4	95.9	2.49
TAE.1-Shangsheree	-0.011	-0.004	0.011	0.002	0.0	-1.6	98.6	98.6	0.00
Shangsheree Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	98.6	97.7	0.86
Shangthang Tfr	0.022	0.014	-0.021	-0.013	0.2	0.4	98.6	97.1	1.50
Shazam Tfr	0.015	0.009	-0.015	-0.009	0.1	0.2	98.5	97.5	1.04
Sheyling Tfr	0.002	0.002	-0.002	-0.002	0.0	0.0	97.8	97.3	0.43
Shoong Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	97.8	97.3	0.50
Yal.2-SMCL	-0.145	-0.090	0.145	0.085	0.0	-4.7	98.6	98.6	0.01
SMCL Tfr1	0.070	0.044	-0.070	-0.043	0.3	0.5	98.6	98.0	0.61
SMCL Tfr2	0.074	0.046	-0.074	-0.046	0.4	0.5	98.6	97.9	0.65
Sothi Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	97.8	97.5	0.29
TAE(1-2)	0.017	0.003	-0.017	-0.008	0.0	-4.6	98.6	98.6	0.00
Tarphel-Tobrang	0.007	0.001	-0.007	-0.004	0.0	-2.9	97.7	97.7	0.00
Tarphel Tfr	0.012	0.008	-0.012	-0.008	0.2	0.3	97.7	95.5	2.20
Tchu Gonpa Tfr	0.024	0.015	-0.023	-0.015	0.6	0.9	98.4	94.9	3.54
Teotsho Tfr	0.058	0.037	-0.056	-0.035	1.1	1.6	98.4	95.9	2.53
Y.Gonpa-Thongram	-0.019	-0.012	0.019	0.012	0.0	-0.4	98.4	98.4	0.00
Thongram Tfr	0.011	0.007	-0.011	-0.007	0.2	0.2	98.4	96.4	2.00
Thragom-Yal.5	0.234	0.102	-0.234	-0.107	0.1	-4.3	98.5	98.5	0.03
Yal.4-Thragom	-0.268	-0.124	0.268	0.116	0.1	-8.0	98.5	98.5	0.04
Thragom Tfr	0.034	0.022	-0.034	-0.021	0.6	0.9	98.5	96.1	2.39
Tong.6-Tokaphu	-0.194	-0.054	0.194	0.053	0.0	-1.1	98.4	98.5	0.01
Tokaphu Tfr	0.019	0.012	-0.019	-0.012	0.2	0.3	98.4	97.1	1.33
Tong(1-2)	0.124	0.069	-0.124	-0.072	0.0	-3.5	98.6	98.5	0.01
Tong(1-3)	0.416	0.165	-0.415	-0.167	0.1	-2.1	98.6	98.5	0.03

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
Tong(4-5)	0.070	0.037	-0.070	-0.038	0.0	-0.4	98.5	98.5	0.00
Tong(8-9)	0.030	0.011	-0.030	-0.012	0.0	-0.5	98.4	98.4	0.00
Tong.8-Tongseng	0.095	0.018	-0.095	-0.036	0.0	-18.6	98.4	98.4	0.03
Tong.10-URC	0.045	0.021	-0.045	-0.028	0.0	-6.8	98.4	98.4	0.01
Tongseng-Wanglu	0.079	0.026	-0.079	-0.029	0.0	-3.2	98.4	98.4	0.01
Tongseng Tfr	0.016	0.010	-0.016	-0.010	0.1	0.2	98.4	97.3	1.11
Tshekharla Tfr	-0.134	-0.083	0.136	0.086	2.4	3.6	96.1	98.5	2.39
U.Khamdang-Tshekharla	-0.552	-0.308	0.552	0.305	0.1	-2.6	98.5	98.5	0.03
Tshintsiri Tfr	0.168	0.106	-0.166	-0.103	1.8	2.7	98.6	97.1	1.47
TYLSS Tfr	0.174	0.111	-0.170	-0.105	3.9	5.9	97.8	94.7	3.08
U.Khamdang Tfr	0.032	0.020	-0.032	-0.020	0.5	0.8	98.5	96.3	2.25
Yal.5-U.Namthi	-0.182	-0.090	0.182	0.081	0.1	-8.5	98.4	98.5	0.05
URC Tfr	0.027	0.017	-0.026	-0.016	0.4	0.5	98.4	96.5	1.86
Wanglu Tfr	0.014	0.009	-0.014	-0.009	0.1	0.1	98.4	97.4	0.97
Yal.1-Wangringmo	-0.013	-0.008	0.013	0.008	0.0	-0.2	98.6	98.6	0.00
Wangringmo Tfr	0.013	0.008	-0.013	-0.008	0.0	0.1	98.6	98.1	0.47
Wombu Tfr	0.015	0.010	-0.015	-0.009	0.3	0.4	98.6	95.9	2.64
Womina Tfr	0.004	0.002	-0.004	-0.002	0.0	0.0	97.8	97.1	0.64
Womina CPS Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	97.7	96.7	1.07
Wongkhar Tfr	0.030	0.019	-0.029	-0.018	0.5	0.7	98.6	96.5	2.07
Yraphel3-Y.Gonpa	-0.122	-0.057	0.122	0.056	0.0	-1.2	98.4	98.4	0.00
Yal(1-2)	0.503	0.243	-0.503	-0.244	0.0	-1.0	98.6	98.6	0.01
Yal(2-3)	0.359	0.158	-0.359	-0.159	0.0	-0.4	98.6	98.6	0.00
Yal.4-Yalang	0.030	0.018	-0.030	-0.019	0.0	-1.6	98.5	98.5	0.00
Yal(5-10)	0.051	0.025	-0.051	-0.027	0.0	-1.7	98.5	98.5	0.00
Yal(6-7)	0.067	0.029	-0.067	-0.031	0.0	-2.1	98.4	98.4	0.00
Yal(8-9)	0.026	0.014	-0.026	-0.015	0.0	-0.8	98.4	98.4	0.00
Yalang Tfr	0.030	0.019	-0.030	-0.018	0.5	0.7	98.5	96.4	2.11
Yang(1-2)	1.135	0.493	-1.134	-0.499	0.7	-5.7	98.6	98.5	0.09
Yang(2-3)	1.102	0.479	-1.102	-0.481	0.3	-2.5	98.5	98.4	0.04
Yang(3-6)	0.952	0.402	-0.952	-0.406	0.3	-3.6	98.4	98.4	0.05
Yang(6-9)	0.928	0.391	-0.927	-0.399	0.6	-7.5	98.4	98.3	0.09
Yang(9-10)	0.925	0.398	-0.924	-0.409	1.0	-11.8	98.3	98.1	0.15
Yang(10-11)	0.904	0.397	-0.904	-0.405	0.6	-7.9	98.1	98.0	0.10
Yang(11-12)	0.901	0.403	-0.900	-0.404	0.1	-0.9	98.0	98.0	0.01
Yang(13-14)	0.863	0.401	-0.862	-0.402	0.1	-1.4	97.9	97.8	0.02
Yangtse TA Tfr	0.000	0.000	0.000	0.000			97.8	97.8	

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
Yangtse.S Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	97.8	97.3	0.43
Yangtse.TB Tfr	0.075	0.048	-0.073	-0.045	1.8	2.8	97.8	94.5	3.32
Yraphel(1-2)	0.140	0.065	-0.140	-0.067	0.0	-2.0	98.4	98.4	0.01
Yraphel1 Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	98.4	96.3	2.10
Yraphel(2-3)	0.129	0.060	-0.129	-0.060	0.0	-0.7	98.4	98.4	0.00
Yraphel2 Tfr	0.011	0.007	-0.011	-0.007	0.2	0.2	98.4	96.4	1.96
Yraphel3 Tfr	0.007	0.005	-0.007	-0.005	0.1	0.1	98.4	97.1	1.29
Zhapang Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.7	97.4	0.39
					84.8	-416.6			

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
GomphuKora Tfr	Transformer	Overload	0.100	MVA	0.126	126.5	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
GomphuKora B2	Bus	Under Voltage	0.415	kV	0.390	93.9	3-Phase
Kheni B2	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
RBP B2	Bus	Under Voltage	0.415	kV	0.39	94.3	3-Phase
Tchu Gonpa B2	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
Tchu Gonpa Tfr	Transformer	Overload	0.030	MVA	0.03	95.5	3-Phase
TYLSS B2	Bus	Under Voltage	0.415	kV	0.39	94.7	3-Phase
Yangtse.TB B2	Bus	Under Voltage	0.415	kV	0.39	94.5	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	3.597	1.760	4.004	89.82 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	3.597	1.760	4.004	89.82 Lagging
Total Motor Load:	0.745	0.462	0.877	85.00 Lagging
Total Static Load:	2.767	1.715	3.255	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.085	-0.417		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure 5: Feeder Wise Reliability Indices

Sl.No.	Year	Reliability Indices	33kV YangtseFeeder	11kV Jamkhar Feeder
1	2017	SAIFI	4.360	-
		SAIDI	3.750	-
2	2018	SAIFI	3.755	-
		SAIDI	1.896	-
3	2019	SAIFI	3.629	-
		SAIDI	4.720	-
		SAIFI	**11.74**	**-**

Sl.No	Name of Feeder	2017		2018		2019		Total	
		SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
1	33kV YangtseFeeder	4.360	3.750	3.755	1.896	3.629	4.720	**11.74**	**10.37**
2	11kV Jamkhar Feeder	-	-	-	-	-	-	-	-
Average SAIFI & SAIDI								**5.87**	**5.18**

Annexure 6: Material Cost for 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

Transformers Details										
Sl.No.	Name of Feeder	DT Location Name	Transformer Ratio	Transformer Details	Peak Load (kVA)**	% Loading	2025		2030	
				kVA	2019-2020		KVA	%loading	KVA	%loading
11kV Jamkhar Feeder							**159.0588235**		**177.8823529**	
							1.05		**1.29**	
							2.05		**2.29**	
1	11kV Jamkhar Feeder	Gulamzor	11/ 0.415 kV	63.00	8.66	14%	17.75	28%	19.85	32%
2		Rejung	11/ 0.415 kV	150.00	25.33	17%	51.89	35%	58.03	39%
3		Yub	11/ 0.415 kV	30.00	10.31	34%	21.12	70%	23.62	**79%**
4		Baaling	11/ 0.415 kV	63.00	13.19	21%	27.02	43%	30.22	48%
5		Tongla	11/ 0.415 kV	63.00	9.20	15%	18.84	30%	21.07	33%
6		Chema	11/ 0.415 kV	63.00	3.84	6%	7.87	12%	8.81	14%
7		Tachema	11/ 0.415 kV	63.00	7.10	11%	14.55	23%	16.27	26%
				495.00	77.63					
33kV Yangtse Feeder							**3773.529412**		**4627.058824**	
							1.33		**1.86**	
							2.33		**2.86**	
1		Pangthang	33/ 0.400kV	63.00	9.66	15%	22.51	36%	27.60	44%
2		Shangthang	33/ 0.400kV	63.00	9.25	15%	21.54	34%	26.42	42%
3		Ramjar Binangreb	33/ 0.400kV	63.00	15.96	25%	37.19	59%	45.60	72%
4		Wongkhar	33/ 0.400kV	63.00	12.77	20%	29.76	47%	36.50	58%
5		Gonpa (Ramjar Gonpa)	33/ 0.400kV	63.00	11.02	17%	25.67	41%	31.47	50%
6		Romang	33/ 0.415 kV	63.00	1.97	3%	4.58	7%	5.62	9%
7		Bawoong	33/0.415/0.240kV	63.00	7.86	12%	18.32	29%	22.46	36%
8		Ninda	33/0.415kV	25.00	1.39	6%	3.23	13%	3.97	16%
9		Shangsharee	33/0.415kV	25.00	2.12	8%	4.94	20%	6.06	24%
10		Larjab	33/0.415kV	25.00	2.33	9%	5.43	22%	6.66	27%
11		Nachi	33/0.240kV	10.00	0.24	2%	0.55	6%	0.68	7%
12		Pachu/Dalikhar school	33/0.415kV	25.00	2.57	10%	6.00	24%	7.36	29%
13		Laishung	33/0.415kV	25.00	0.85	3%	1.99	8%	2.44	10%
14		Jigtsham	33/0.415kV	25.00	3.78	15%	8.82	35%	10.81	43%
15		Brongkashing	33/ 0.415 kV	63.00	9.45	15%	22.02	35%	27.00	43%
16		Pang	33/ 0.415 kV	63.00	9.46	15%	22.05	35%	27.04	43%
17		Kenmung	33/ 0.415 kV	63.00	13.46	21%	31.36	50%	38.45	61%
18		Changmadung	33/ 0.415 kV	63.00	9.11	14%	21.22	34%	26.02	41%
19		Lawshing	33/ 0.415 kV	63.00	11.11	18%	25.89	41%	31.75	50%
20		Menchu	33/ 0.415 kV	63.00	7.19	11%	16.75	27%	20.54	33%
21		Tokaphu	33/ 0.415 kV	63.00	8.21	13%	19.14	30%	23.47	37%
22		Mongling	33/ 0.415 kV	25.00	6.24	25%	14.55	58%	17.84	71%
23		Thrichu Gonpa	33/ 0.415 kV	30.00	10.48	35%	24.43	**81%**	29.96	**100%**
24		Rabty A	33/0.415 kV	25.00	5.55	22%	12.93	52%	15.86	63%
25		Rabtey B	33/0.415 kV	25.00	5.53	22%	12.89	52%	15.81	63%
26		Rabtey Shung	33/0.415 kV	25.00	5.14	21%	11.99	48%	14.70	59%
27		Rabtey Pam	33/0.415 kV	25.00	5.47	22%	12.74	51%	15.63	63%
28		Shali Pam	33/0.415 kV	160.00	39.04	24%	90.97	57%	111.54	70%
29		Serpang	33/0.415 kV	63.00	1.05	2%	2.44	4%	2.99	5%
30		Gardung	33/0.415 kV	25.00	2.71	11%	6.31	25%	7.74	31%
31		Barpang	33/0.240 kV	10.00	1.62	16%	3.77	38%	4.62	46%
32		Chakadimi A	33/0.415 kV	25.00	1.27	5%	2.96	12%	3.62	14%

33	Jibdure	33/0.240 kV	16.00	1.21	8%	2.82	18%	3.46	22%
34	Chakadimi B	33/0.240 kV	16.00	1.63	10%	3.81	24%	4.67	29%
35	Lengkhar	33/0.415 kV	25.00	3.86	15%	8.99	36%	11.03	44%
36	Lewochen	33/0.240 kV	16.00	1.59	10%	3.71	23%	4.55	28%
37	Naling	33/0.240 kV	16.00	1.82	11%	4.25	27%	5.21	33%
38	Rabdeling	33/0.240 kV	10.00	1.37	14%	3.20	32%	3.93	39%
39	Domtshang A	33/0.240 kV	16.00	1.82	11%	4.25	27%	5.21	33%
40	Domtshang B	33/0.240kV	16.00	0.70	4%	1.63	10%	1.99	12%
41	Daka	33/0.415 kV	25.00	4.36	17%	10.15	41%	12.45	50%
42	Koncholing	33/0.415 kV	63.00	10.19	16%	23.74	38%	29.10	46%
43	Burbula	33/0.240 kV	25.00	0.91	4%	2.12	8%	2.60	10%
44	Buyang	33/0.400 kV	63.00	8.62	14%	20.10	32%	24.64	39%
45	Gangkhar Pam	33/0.415/0.240 kV	63.00	7.69	12%	17.93	28%	21.98	35%
46	Gangkhar	33/0.415/0.240 kV	63.00	3.19	5%	7.43	12%	9.11	14%
47	Jabda	33/0.415/0.240 kV	63.00	1.89	3%	4.40	7%	5.40	9%
48	Baney	33/0.415 kV	25.00	5.44	22%	12.68	51%	15.55	62%
49	Chungdue	33/0.240 kV	16.00	1.29	8%	3.01	19%	3.70	23%
50	Renja	33/0.415 kV	25.00	3.89	16%	9.06	36%	11.11	44%
51	Old Dzong	33/0.415 kV	30.00	6.06	20%	14.13	47%	17.32	58%
52	Lechen	33/0.415/0.240 kV	63.00	2.32	4%	5.41	9%	6.64	11%
53	Tongsing	33/0.415/0.240 kV	63.00	6.76	11%	15.75	25%	19.31	31%
54	Wongla	33/0.415/0.240 kV	63.00	6.04	10%	14.08	22%	17.27	27%
55	Phurdung	33/0.240 kV	16.00	3.65	23%	8.50	53%	10.43	65%
56	Drisa	33/0.240 kV	10.00	2.35	23%	5.47	55%	6.70	67%
57	Shakshing	33/0.240 kV	10.00	1.73	17%	4.03	40%	4.94	49%
58	Bhimkhar	33/0.415 kV	100.00	5.39	5%	12.56	13%	15.40	15%
59	TYLSS (Yangtse lower School)	33/0.415 kV	250.00	75.81	30%	176.65	71%	216.60	**87%**
60	Yangtse Town 'B' (Yangtse Lower Market)	33/0.400 kV	100.00	32.83	33%	76.50	76%	93.80	**94%**
61	Yangtse Town CSS	33/0.415kV	1,000.00	-	0%	0.00	0%	-	0%
62	New Dzong	33/0.400 kV	500.00	61.15	12%	142.48	28%	174.70	35%
63	RBP	33/0.400 kV	63.00	21.68	34%	50.53	**80%**	61.95	**98%**
64	North Baylling	33/0.415 kV	63.00	12.21	19%	28.44	45%	34.88	55%
65	Yangtse Seip	33/0.415 kV	63.00	2.57	4%	5.99	10%	7.34	12%
66	Regom	33/0.415 kV	25.00	5.00	20%	11.65	47%	14.28	57%
67	Womana	33/0.415 kV	25.00	1.59	6%	3.71	15%	4.55	18%
68	Womana CPS	33/0.415 kV	25.00	2.63	11%	6.14	25%	7.53	30%
69	Lokmey	33/0.240 kV	16.00	1.56	10%	3.64	23%	4.46	28%
70	Keylling	33/0.415 kV	25.00	2.11	8%	4.91	20%	6.02	24%
71	Dechenphodrang	33/0.415 kV	25.00	2.76	11%	6.44	26%	7.89	32%
72	Shelling	33/0.415 kV	25.00	1.07	4%	2.49	10%	3.05	12%
73	Barteng	33/0.415 kV	25.00	3.99	16%	9.29	37%	11.39	46%
74	Bamdir	33/0.415 kV	25.00	3.64	15%	8.48	34%	10.40	42%
75	Pukturgang (South)	33/0.415 kV	25.00	5.13	21%	11.94	48%	14.65	59%
76	Gangkhardung	33/0.415 kV	63.00	2.21	4%	5.15	8%	6.32	10%
77	Tshaling	33/0.415/0.240kV	63.00	4.00	6%	9.32	15%	11.43	18%
78	Daksa	33/0.415 kV	63.00	3.97	6%	9.26	15%	11.35	18%
79	Phanteng	33/0.415 kV	63.00	2.11	3%	4.91	8%	6.02	10%
80	Garkhang	33/0.415 kV	25.00	0.35	1%	0.81	3%	0.99	4%

81		Ngangphu	33/0.415 kV	25.00	0.34	1%	0.80	3%	0.98	4%
82		Ratsho	33/0.415 kV	63.00	10.11	16%	23.56	37%	28.89	46%
83		Samteling	33/0.415 kV	25.00	2.29	9%	5.34	21%	6.55	26%
84		Shoong	33/0.415 kV	25.00	1.22	5%	2.83	11%	3.48	14%
85		Dungzam	33/0.415 kV	100.00	12.29	12%	28.63	29%	35.10	35%
86		Sothi	33/0.415 kV	63.00	1.86	3%	4.33	7%	5.31	8%
87		Phubdung	33/0.415 kV	25.00	1.21	5%	2.81	11%	3.45	14%
88	33kV Yangtse Feeder	Baringmo	33/0.415 kV	63.00	4.04	6%	9.41	15%	11.54	18%
89		Phuncheling	33/0.415 kV	25.00	1.75	7%	4.07	16%	4.99	20%
90		Pramadung	33/0.240kV	10.00	1.32	13%	3.08	31%	3.78	38%
91		Bramadung	33/0.240kV	16.00	0.83	5%	1.94	12%	2.38	15%
92		Zhapang	33/0.415 kV	25.00	0.99	4%	2.31	9%	2.83	11%
93		Rigsumgonpa	33/0.415 kV	25.00	0.70	3%	1.64	7%	2.01	8%
94		Cheng	33/0.415 kV	25.00	5.57	22%	12.98	52%	15.91	64%
95		Panglewa	33/0.415 kV	25.00	0.83	3%	1.94	8%	2.38	10%
96		Lulu School	33/0.415 kV	25.00	1.76	7%	4.10	16%	5.02	20%
97		Pangkhar	33/0.415 kV	25.00	0.32	1%	0.75	3%	0.92	4%
98		Dramadung	33/0.240 kV	16.00	0.37	2%	0.87	5%	1.06	7%
99		Khardung	33/0.415 kV	25.00	0.37	1%	0.86	3%	1.05	4%
100		Tarphel	33/0.415 kV	25.00	5.47	22%	12.74	51%	15.62	62%
101		Trobrang	33/0.240kV	16.00	0.49	3%	1.14	7%	1.40	9%
102		Longkhar	33/0.415 kV	25.00	2.72	11%	6.33	25%	7.76	31%
103		Wombu	33/0.415kV	25.00	6.50	26%	15.15	61%	18.57	74%
104		Manla	33/0.415kV	25.00	6.38	26%	14.87	59%	18.23	73%
105		Lower Khamdang	33/0.400kV	63.00	13.91	22%	32.41	51%	39.74	63%
106		Upper Khamdang	33/0.415kV	63.00	13.79	22%	32.13	51%	39.40	63%
107		Tshankharla	33/0.415kV	250.00	58.66	23%	136.69	55%	167.61	67%
108		Nombari	33/0.400kV	63.00	13.67	22%	31.85	51%	39.06	62%
109		Shaazom	33/0.415kV	63.00	6.48	10%	15.10	24%	18.52	29%
110		Karmazom	33/0.415kV	63.00	7.75	12%	18.06	29%	22.15	35%
111		Braktsha	33/0.415/0.240kV	63.00	16.53	26%	38.52	61%	47.23	75%
112		Sertsho	33/0.415kV	63.00	13.54	21%	31.55	50%	38.69	61%
113		Toetsho Seip	33/0.415kV	100.00	24.77	25%	57.72	58%	70.77	71%
114		Cholaptsa	33/0.415kV	63.00	15.52	25%	36.16	57%	44.34	70%
115		Omba A	33/0.240kV	10.00	0.64	6%	1.50	15%	1.84	18%
116		Omba B	33/0.240kV	16.00	0.65	4%	1.51	9%	1.85	12%
117		Omba Ney	33/0.240kV	10.00	0.41	4%	0.94	9%	1.16	12%
118		Phagti	33/0.240kV	10.00	0.42	4%	0.97	10%	1.19	12%
119		Kheni	33/0.415kV	160.00	55.40	35%	129.09	**81%**	158.28	**99%**
120		Chemkhar	33/0.415kV	25.00	6.43	26%	14.98	60%	18.37	73%
121		Gongza Ney	33/0.240kV	10.00	0.18	2%	0.41	4%	0.50	5%
122		Jangphutse	33/0.415kV	63.00	8.93	14%	20.80	33%	25.51	40%
123		Thangbrang	33/0.240kV	16.00	2.20	14%	5.12	32%	6.28	39%
124		Manam	33/0.415kV	25.00	6.25	25%	14.56	58%	17.86	71%
125		Phungyang	33/0.415/0.240kV	63.00	10.26	16%	23.90	38%	29.31	47%
126		Phelfolung	33/0.415/0.240kV	63.00	7.22	11%	16.83	27%	20.64	33%
127		Yallang	33/0.415/0.240kV	63.00	13.03	21%	30.36	48%	37.23	59%
128		Thragom	33/0.415/0.240kV	63.00	14.69	23%	34.22	54%	41.96	67%
129		Rolam Khatserma	33/0.240kV	16.00	1.82	11%	4.24	27%	5.20	33%
130		Rolam Famung	33/0.240kV	10.00	2.08	21%	4.85	48%	5.95	59%
131		Dungsingma	33/0.415kV	25.00	2.66	11%	6.20	25%	7.60	30%
132		Rolam- A	33/0.415kV	25.00	3.86	15%	8.99	36%	11.03	44%

133		Rolam- B	33/0.415kV	25.00	3.24	13%	7.55	30%	9.26	37%
134		Rolam Goenpa	33/0.240kV	16.00	1.84	12%	4.29	27%	5.26	33%
135		Rolam Shokang	33/0.415kV	25.00	2.88	12%	6.70	27%	8.22	33%
136		Bamchang	33/0.415kV	25.00	3.48	14%	8.11	32%	9.94	40%
137		Upper Namthi	33/0.240kV	10.00	0.84	8%	1.95	19%	2.39	24%
138		Middle Namthi	33/0.415kV	25.00	6.27	25%	14.62	58%	17.92	72%
139		Lower Namthi	33/0.415kV	25.00	5.76	23%	13.43	54%	16.47	66%
140		Yerphel- I	33/0.415kV	25.00	5.20	21%	12.11	48%	14.85	59%
141		Yarphel - II (Redaza)	33/0.415kV	25.00	4.82	19%	11.23	45%	13.77	55%
142		Yarphel - III	33/0.415kV	25.00	3.16	13%	7.35	29%	9.02	36%
143		Yarphel Goenpa	33/0.240kV	10.00	1.06	11%	2.48	25%	3.04	30%
144		Yarphel Thongram	33/0.415kV	25.00	4.94	20%	11.51	46%	14.11	56%
145		Upper Thongram	33/0.240kV	16.00	3.34	21%	7.79	49%	9.55	60%
146		Melongkhar School	33/0.415kV	25.00	3.84	15%	8.94	36%	10.96	44%
147		Lower Melongkhar	33/0.415kV	25.00	3.99	16%	9.30	37%	11.40	46%
148		Middle Melongkhar	33/0.240kV	16.00	3.86	24%	8.98	56%	11.02	69%
149		Upper Melongkhar	33/0.240kV	16.00	2.28	14%	5.31	33%	6.51	41%
150		Chema -A	33/0.415kV	25.00	2.46	10%	5.73	23%	7.02	28%
151		Chema -B	33/0.415kV	25.00	3.16	13%	7.37	29%	9.03	36%
152		Chema Meth	33/0.415kV	25.00	5.20	21%	12.12	48%	14.86	59%
153		Chema Lungkhar	33/0.240kV	10.00	0.37	4%	0.86	9%	1.06	11%
154		Chema Pek	33/0.240kV	10.00	1.68	17%	3.91	39%	4.79	48%
155		Dukti RBP	33/0.415kV	25.00	3.31	13%	7.71	31%	9.45	38%
156		Dukti School	33/0.415kV	25.00	3.59	14%	8.36	33%	10.25	41%
157		Dukti Middle	33/0.415kV	25.00	3.90	16%	9.08	36%	11.14	45%
158		Dukti Gonpa	33/0.415kV	25.00	3.70	15%	8.62	34%	10.57	42%
159		Dukti Reynangkhar	33/0.230kV	10.00	1.30	13%	3.02	30%	3.70	37%
160		Khitshang New Town	33/0.415kV	500.00	16.04	3%	37.38	7%	45.84	9%
161		Darchen	33/0.400 kV	25.00	7.02	28%	16.35	65%	20.04	**80%**
162		Brenglum	33/0.415 kV	63.00	13.93	22%	32.45	52%	39.79	63%
163		Lakurung	33/ 0.415 kV	63.00	9.66	15%	22.52	36%	27.61	44%
164		Bainangkhar	33/ 0.415 kV	63.00	5.75	9%	13.39	21%	16.42	26%
165		Shakpa	33/ 0.415 kV	30.00	5.86	20%	13.65	45%	16.73	56%
166		Bakpa	33/ 0.415 kV	63.00	18.55	29%	43.21	69%	52.99	**84%**
167		Gomkora	33/0.415kV	100.00	46.70	47%	108.81	**109%**	133.43	**133%**
168		Khitshang	33/0.415kV	250.00	55.11	22%	128.40	51%	157.45	63%
169		Ramjar MSS (RMSS), Pvt.	33/ 0.415 kV	125.00	9.18	7%	21.40	17%	26.24	21%
170		Tshitsiri, Pvt.	33/0.415kV	500.00	71.55	14%	166.71	33%	204.42	41%
171		Sawmill, Pvt.	33/0.415 kV	63.00	6.70	11%	15.61	25%	19.14	30%
172		RBA (Army Camp), Pvt.	33/0.400 kV	63.00	10.04	16%	23.40	37%	28.69	46%
173		Zorig Chusum (Rigney), Pvt.	33/0.433 kV	500.00	60.01	12%	139.82	28%	171.44	34%
174		NHDC (National Housing Colony), Pvt.	33/0.415 kV	100.00	16.43	16%	38.29	38%	46.95	47%
175		Bayling HSS, Pvt.	33/0.400 kV	500.00	9.24	2%	21.54	4%	26.41	5%
176		Kunzangling MSS, Pvt.	33/0.415 kV	125.00	37.99	30%	88.52	71%	108.54	**87%**
177		Mineral Water Plant, Pvt.	33/0.433kV	100.00	30.23	30%	70.44	70%	86.37	**86%**
178		Wongringmo, Pvt.	33/0.415kV	125.00	5.57	4%	12.98	10%	15.91	13%
179		SMCL, Pvt.	33/0.415kV	1,000.00	125.00	13%	291.26	29%	357.14	36%
				12,150.00	**1,619.49**					

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**