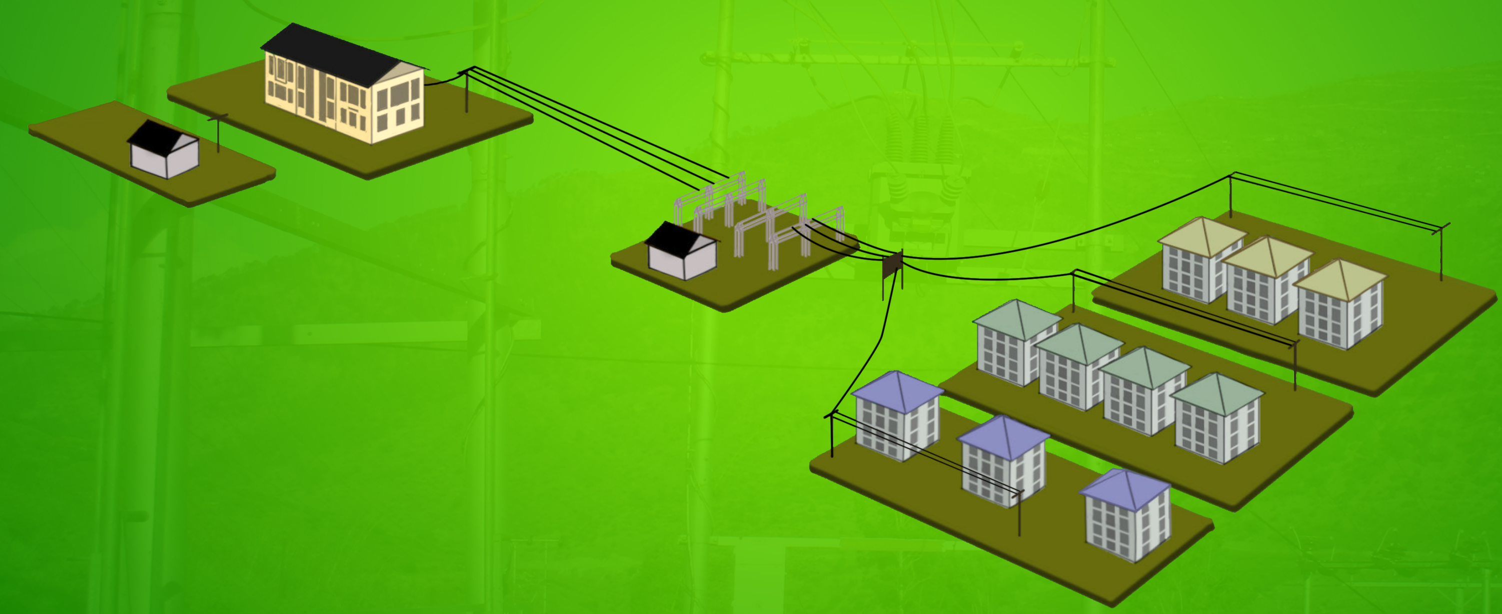
BHUTAN POWER CORPORATION LIMITED
(An ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 Certified Company)
P.O. Box : 580, Yarden Lam
Thimphu, Bhutan (Registered Office)
Website: www.bpc.bt

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

TRONGSA DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2019

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FOREWORD

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

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

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

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

(Sonam Tobjey)
Chief Executive Officer

Preparation, Review & Approval of the Document

Prepared by:	Distribution & Customer Services Department, Distribution Services, Bhutan Power Corporation Limited, Thimphu.	**GM, DCSD**
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

ICT: Interconnecting Transform

Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Load: 1) A device, or resistance of a device, to which power is delivered in a circuit. 2) The measure of electrical demand 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 kilowatt-hour sales by consumers.

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 a transmission and distribution network established across the country. Towards realizing the mission, vision, and destination statement of BPC as outlined in the Corporate Strategic Plan (2020-2030), 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 to 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 Plan 2019 including the investment (2020-20230). The identification of the system deficiencies and qualitative remedial measures that would require system automation and remote control as per the existing and projected load is only outlined in this report.

Similarly, the system study beyond the Distribution Transformers had to be captured during the annual rolling investment and budget approval.

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

2. Introduction

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

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

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

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

3. Objectives of the Master Plan

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

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

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

3.3 To come out with annual investment plans.

4. Scope of the Distribution System Master Plan

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

5. Methodology and Approach

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

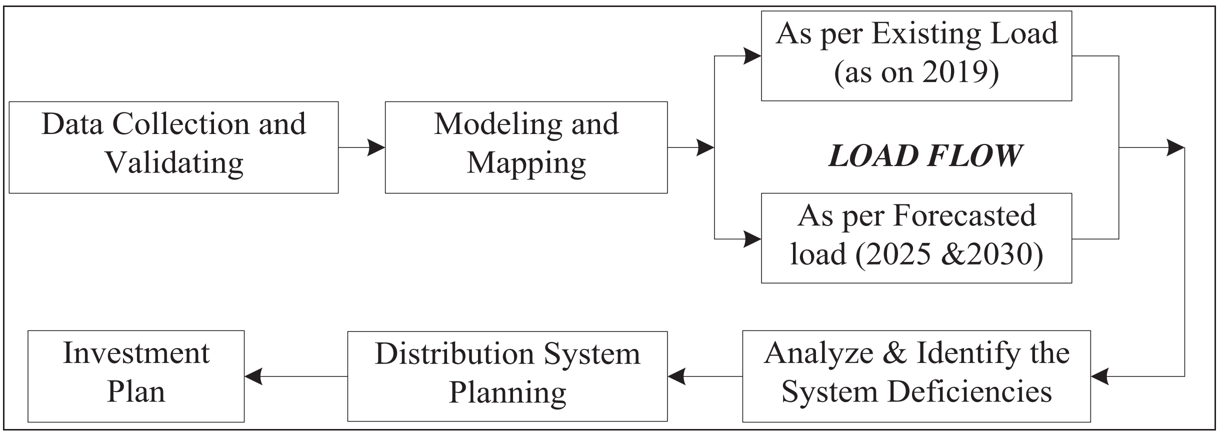


Figure 1: Block diagram for distribution system planning for thematic studies

5.1 Data Collection and Validation

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

5.2 Modeling and Mapping

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

5.3 Analysis and Identification of System Deficiencies

The existing distribution system model was analyzed in the ETAP involving balanced load flow to figure out the network capabilities against the set distribution standards. The load growth was projected using the commonly adopted methodology that is LRM in conjunction with TSA which is based on the historical data and accordingly the behavior of the distribution system was analyzed, and the system deficiencies were identified. The details on the load forecast methodology are 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 the reduction of losses, improving the reliability and power quality. Accordingly, any contingency plans, up gradation, and reinforcement plans are proposed along with the investment plans incorporating best fit technology.

5.5 Investment Plan

The approved investment plans (from 2020 to 2023) 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

Trongsa Dzongkhag is comprised of five (5) Gewogs (i.e. Nubi, Tangsibji, Draagteng, Langthel & Korphu). The power supply to Trongsa is being fed from the 2x15 MVA, 132/33 kV Yurmoo substation which has access from the 4x15 MW, Kurich hydropower plant at Mongar. There are also three micro hydropower plants, namely; (i) Sherubling (50 kW), (ii) Tangsebji (30 kW), and (iii) Chendebji (70 kW). The power generated from these micro power plants is synchronized and injected into the grid. Some of the villages of Trongsa (Korphu, Nimshong, and Nabji) is also fed from a 33 kV Zhemgang feeder emanating from the Tintibi substation of Zhemgang Dzongkhag. The basic electricity distribution network model is illustrated in the schematic diagram shown in **Figure 2.**

As seen reflected in the figure**,** the 132/33kV Yurmoo substation has five (5) number of 33kV outgoing feeders namely: (i) *Kewathang feeder, (ii) Nikachu feeder, (iii) Langthel feeder, (iv) MHPA Trunk Line Feeder, and (v) MHPA powerhouse feeder* (which meets the power requirement of Mangdichhu and Tangsibji Hydroelectric Project). The Nikachu feeder is also inter-linked with the 33/11 kV substation at Phobjikha under Wangdue Dzongkhag which meets the power requirement of Gangtey and Phobjikha Gewogs.

The 33 kV Kewathang feeder is the primary source for the 2x2.5 MVA, 33/11 kV Kewathang substation and caters to the power requirement of Trongsa town. The line is further extended to

2x2.5 MVA, 33/11 kV Garpang substation at Bumthang through the LILO arrangement which is used as a contingency power source for Bumthang Dzongkhag. There are also two 33 kV feeders at the Kewathang Substation (i.e. Sembji/Taktse feeder and MHPA feeder). The 33 kV Sembji/Taktse feeder meets the power supply coverage to all the villages under Sembji Gewog which is also interconnected with the 33 kV Nikachu feeder. The 33 kV MHPA feeder is maintained as a back-up supply to MHPA.

The generation from the power plants is synchronized at 415 voltage level and distributed to the local community. However, due to its small generating capacity, the micro hydel cannot be operated in isolation mode. A grid power supply is indispensable for the power plants to be up and running.

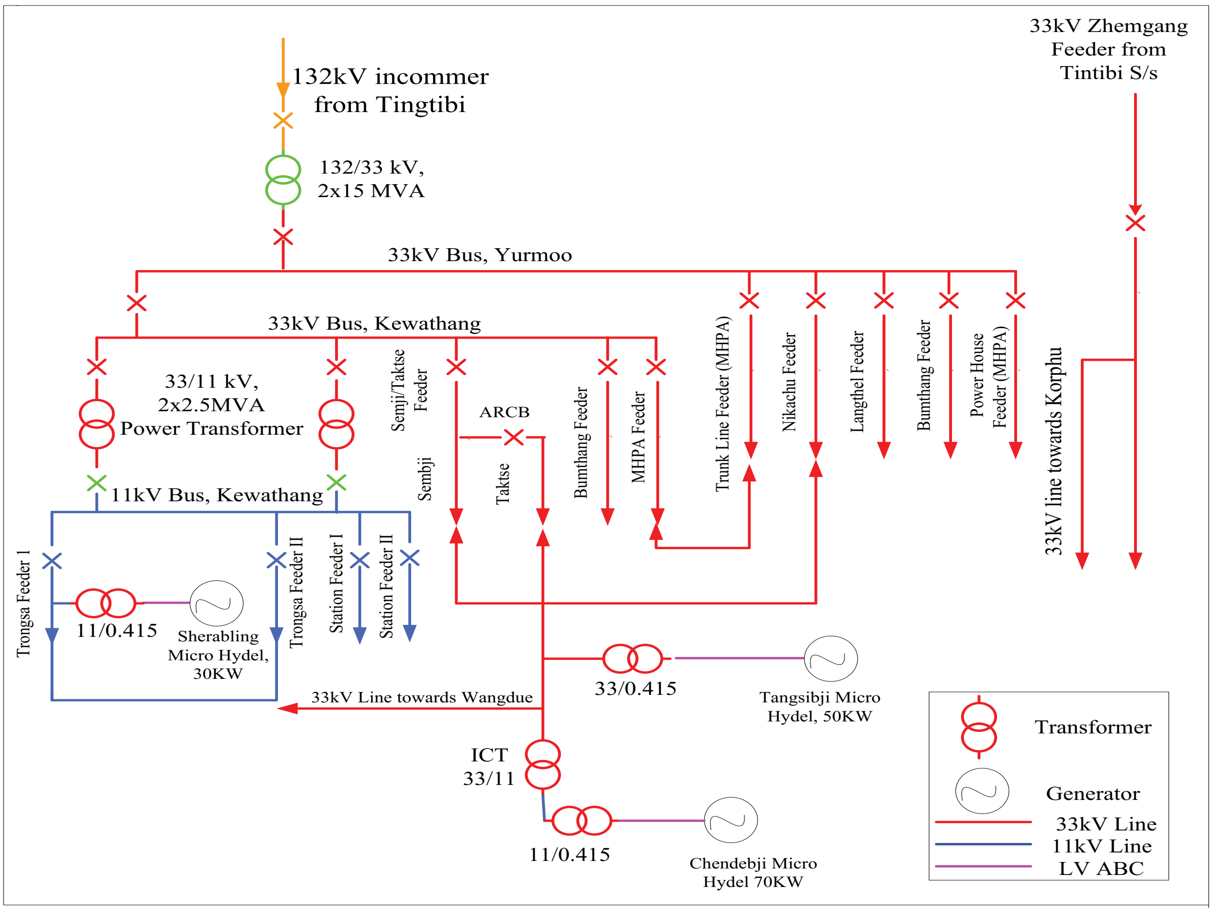


Figure 2: Electricity distribution schematic of Trongsa Dzongkhag

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Infrastructure Details

Sl. No	33kV (km)		11kV (km)		Total MV (km)		LV Line (km)		Total LV Line
	OH	UG	OH	UG	OH	UG	OH	UG	
1	166.049	0.228	20.105	0.430	186.150	0.658	217.106	-	217.106

As seen, the total MV line length is 186.828 km and the total LV line length is 217.106km. The ratio of LV to MV line length is 1.16: 1 which reflects a high proportion of LV distribution network resulting in high losses and low voltage profile at the consumer end. While the ratio of LV to MV line length would vary according to the site conditions, as a general rule, the ratio of 1.2:1 should be maintained which would balance the initial capex and optimize the running and maintenance costs. The MV distribution network is mainly through 33 kV and11 kV overhead lines.

6.3 Distribution Transformers

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

Table 2: Total numbers of transformers & installed capacity

<table>
<tr><th>Source</th><th>Capacity</th><th>Feeder</th><th>Peak Load (MW)</th><th>DTs</th><th>Connected kVA</th><th>Total no of Customer</th></tr>
<tr><td rowspan="4">132/33 kV Yurmoo substation</td><td rowspan="4">2x15MVA</td><td>33kV Langthel Feeder</td><td>1.00</td><td>27.00</td><td>1,504.00</td><td>808.00</td></tr>
<tr><td>33kV Taktse/Nikachu Feeder</td><td rowspan="2">5.10</td><td>44.00</td><td>10,106.00</td><td rowspan="2">1,714.00</td></tr>
<tr><td>11kV Chendebji Feeder</td><td>7.00</td><td>327.00</td></tr>
<tr><td>33kV Bumthang Feeder</td><td>3.40</td><td></td><td></td><td>-</td></tr>
</table>

Source	Capacity	Feeder	Peak Load (MW)	DTs	Connected kVA	Total no of Customer
		33kV Trunk Line Feeder (MHPA)	4.90	-	-	-
		33kV Power House Feeder (MHPA)				
33/11 kV Kewathang substation	2x2.5MVA	33kVBumthang Feeder	3.00	-	-	-
		33kV Semji Feeder	2.98	34.00	1,426.00	622.00
		11kV Trongsa Feeder	0.99	13.00	2,676.00	1,065.00
132/33 kV Tintibi substation	2x3MVA	Korphu Feeder via Zhemgang Feeder	0.01	23.00	492.00	261.00
				148.00	**16,547.00**	**4,470.00**

As of November 2020, there were 149 distribution transformers with a total capacity of 16,547 kVA. As can be inferred from **Table 2,** the installed capacity of the transformer per customer is 3.70 kVA.

7. Analysis of Distribution System

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

7.1 Assessment of Power Sources

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

7.1.1 HV Substation (132/33kV)

132/33 kV Yurmoo and Tintibi substations are the primary power sources to the Dzongkhag. To assess the capacity of the substation, the peak power consumed has been compiled based on the historical data. The details on the installed capacity of substations, existing peak load, and anticipated load in the future are tabulated in **Table 3.**

Table 3: Peak load of Yurmoo substation

Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
		MVA	MW	2019	2025	2030
Yurmoo SS	132/33	2x15	25.5	14.4	21.028	26.313
Tingtibi SS	132/33	2x3	5.1	3.66		

Note: *The detailed assessment of the Tintibi substation will be cover in the DSMP report of ESD Zhemgang*

As seen from **Table 3**, the recorded peak load at the Yurmoo substation in the year 2019 is 14.4 MW which is 57 % loaded against its installed capacity (i.e. 25.5 MW). The substation has adequate capacity to cater to the existing electricity demand. Conversely, the time series load forecast anticipated a load of 26.313 whereby the capacity of the substation needs to be upgraded. However, it is pertinent to mention that with the commissioning of the Mangdechhu and Tangsibji Hydropower Project, the power requirement will be significantly reduced. A huge amount of energy is consumed by this mega project to meet the construction power supply. Hence, the load growth may not be as forecasted and the substation might not be required to upgrade.

7.1.2 MV Substation (132/33/11 kV)

The power imported from the Yurmoo substation is further distributed to various parts of the Dzongkhag through the 33/11kV Kewathang substation. The detail of the installed capacity of substations, existing peak load, and the anticipated load in the future are exhibited in **Table 4.**

Table 4: Peak load of Kewathang 33/11kV Substation

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW	2020	2025	2030
1	Kewathang substation	33/11	2x2.5	4.25	0.993	2.66	3.719

Note: *Power factor of 0.85 is considered for study purpose*

As seen from **Table 4,** the recorded peak load at the Kewathang substation is 0.993 MW (as of 2020) which 23% is loaded against the installed capacity (i.e. 4.25 MW) and is forecasted to reach 3.719 MW by 2030 with the development of LAPs. Therefore, the substation would be adequate to cater to the existing and forecasted electricity demand.

7.2 Assessment of MV Feeder

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

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

7.2.1 Assessment of MV Feeder Capacity

The load profile of MV feeders emanating from the Yurmoo and Kewathang substation had been compiled based on the historical data. The array of daily and monthly peak demand was sorted to obtain the annual peak demand. The feeder-wise peak demand recorded at the source is presented in **Table 5** and the corresponding feeder-wise annual load curve is presented in **Figures 3 and 4.**

Table 5: Historical feeder wise peak power demand of ESD Trongsa

Sl. No.	Substation	Feeder Name	Peak Load (MW)				
			2015	2016	2017	2018	2019
1	132/33kV, 2x15MVA Yurmo substation	132/33KV Incommer	10.75	12.5	14.1	16.3	14.4
		33kV Langthel Feeder	1.00	1.00	1.00	0.50	0.60
		33kV Taktse/Nikachu Feeder			3.90	4.30	4.70
		11kV Chendebji Feeder					
		33kV Bumthang Feeder	3.40	3.40	3.20	3.50	3.80
		33kV Trunk Line Feeder (MHPA)	4.50	4.90	3.90	3.70	2.50
		33kV Power House Feeder (MHPA)					
2	33/11kV, 2x2.5MVA Kewathang substation	132/33KV Incomer		4.70	5.46	3.83	4.40
		33KV Bumthang Feeder		3.40	3.2	3.5	3.80
		33kV Semji/Taktse Feeder		0.71	0.76	0.16	2.98
		11kV Trongsa Feeder 1		0.84	0.84	0.90	0.99

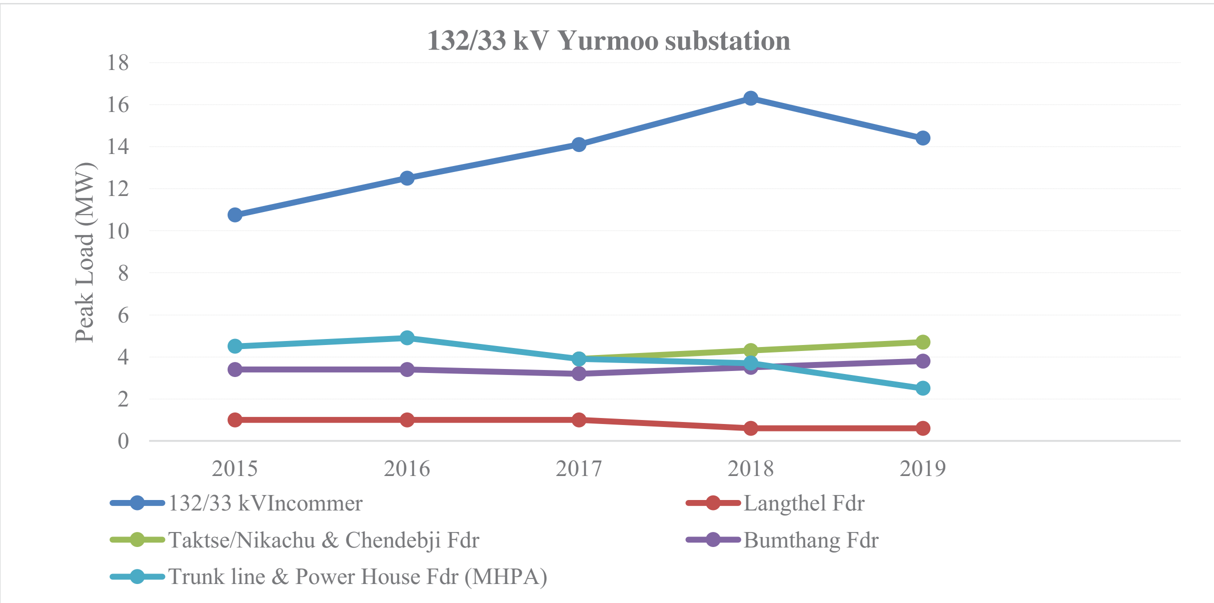


Figure 3: Peak load of Yurmoo substation outgoing feeders

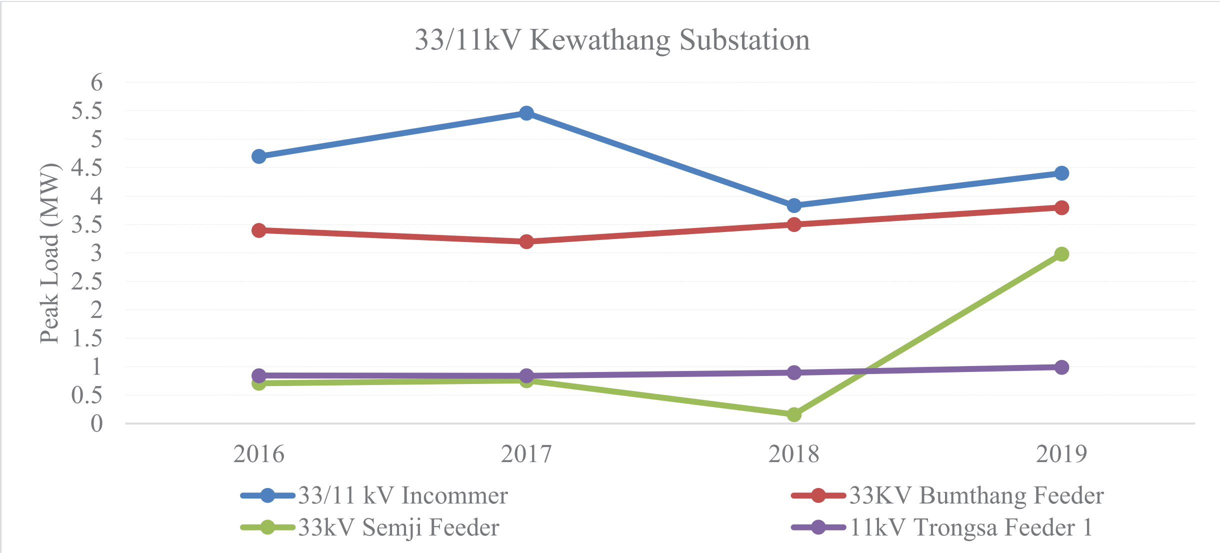


Figure 4: Peak load of Kewathang substation outgoing feeders

As can be seen from **Figure 3**, the overall load on the 132/33kV Yurmoo substation has gradually increased over the last four (4) years. However, there is a sudden drop in the peak load from the year 2018-19 which is because of the completion of the Mangdechhu Hydropower Project.

From **Figure 4,** it is noted that there is a lot of irregularity in the recorded peak load of the 33 kV incoming and Semji feeders. The inconsistency in the peak load is due to the change of source on the 33 kV Bumthang feeder when the power supply from the Yurmoo substation is interrupted. Similarly, the variation in the Semji feeder is because of the ring connection. The said feeder is connected with a 33 kV Nikachu feeder originating from the Yurmoo substation. However, the peak load data has been normalized to forecast energy demand for the next 10 years.

The load carrying capacity of a feeder is determined by the line length and degree of load connected in addition to other parameters like ampacity capability. As evident from **Table 2,** the power distribution is 33kV and 11kV system. The types of conductors used are mostly ACSR-Rabbit and Dog. **Table 6** exhibits the ampacity capability of the conductors at different voltage levels. Ampacity capability (thermal loading) of the lines have been calculated based on IS 398 (Part-II): 1996 for maximum conductor temperature 85°C for ACSR conductors considering an ambient temperature of 40°C.

Table 6: Thermal loading of ACSR conductor at different voltage levels

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

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

a) System Study with Existing System
b) System Study with future load: 2025 scenario
c) System Study with future load: 2030 scenario
d) System Study when Sherubling Micro Hydropower Plant is down
e) System Study when Tangsibji and Chendebji Micro Hydropower Plant is down

a) System Study (Existing Load)

A load flow analysis of the existing system was carried out considering the 2019-20 peak load. From the simulation result, it shows that all the feeders would experience an optimal voltage drop (within ±10%) at the substation bus as well as at the end of feeders. Hence, it is evident that the distribution network has adequate capacity to deliver the power to the customers without any additional investment. The feeder wise voltage profile of the existing scenario is presented in **Table 7.**

Table 7: Voltage Profile of the Feeders (Existing Scenario)

Feeder Name	Load (MW)	Bus Voltage (%)	End Voltage (%)
Kewathang Bus	**1.2601**	**99.48**	
11kV Trongsa feeder 1	0.472	97.74	96.21
33kV Semji Feeder	0.748	99.41	98.93
33kV Yurmoo Bus		**99.55**	
33kV Langthel feeder	0.313	99.55	99.47
33kV Nikachu feeder	0.855	99.46	97.7

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

The peak power demand presented in **Table 5** has been considered to forecast the power demand for the next 10 years (2020-2030). Linear Regression Method (LRM) in conjunction with Time Series Analysis (TSA) is adopted to forecast the load as detailed in **Annexure- 3**. The summary of the forecasted load for the feeders is tabulated in **Table 8**.

Table 8: Feeder wise load forecast of ESD Trongsa

Feeder Name	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Yurmoo substation											
132/33KV-I/C	15.60	16.80	17.86	18.91	19.97	21.03	22.08	23.14	24.20	25.26	26.31
33kV Langthel	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20
33kV Taktse/Nikachu 11kV Chendebji	5.10	5.50	5.90	0.98	1.03	1.09	1.14	1.20	1.25	1.31	1.36
33kV Bumthang	3.26	3.50	3.74	3.98	4.22	4.45	4.69	4.93	5.17	5.41	5.65
33kV Trunk Line Feeder (MHPA)	3.40	3.06	2.72	2.34	2.04	1.70	1.36	1.02	0.68	0.34	

Feeder Name	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Power House Feeder (MHPA)											
Kewathang substation											
132/33KV-I/C	4.75	5.02	5.30	5.57	5.84	6.12	6.39	6.66	6.93	7.21	7.48
33KV Bumthang	3.26	3.50	3.74	3.98	4.22	4.45	4.69	4.93	5.17	5.41	5.65
33kV Semji/Taktse	0.18	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.24	0.25	0.26
11kV Trongsa Feeder 1	1.02	1.07	1.12	1.17	1.22	1.27	1.32	1.37	1.42	1.47	1.52

From the power flow analysis of the 2025 and 2030 loading scenarios, the 11 kV Trongsa feeder-1 is anticipated to experience a marginal voltage drop in the year 2025 and a critical voltage drop in the year 2030. No abnormality was observed in the rest of the feeders. **Table 9** represents the voltage profile of the feeders at 2025 and 2030 loading.

Table 9: Voltage Profile of the Feeders (2025 and 2030 Loading)

Year	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage		
Feeder Name	**Load**	**Bus**	**End**	**Load**	**Bus**	**End**
Kewathang Bus	**1.774**	**99.16**		**1.929**	**99.03**	
11kV Trongsa feeder 1	0.878	97.13	92.94	1.028	96.74	92.02
33kV Semji Feeder	0.821	99.08	98.75	0.898	98.94	98.57
33kV Yurmoo Bus		**99.26**			**99.14**	
33kV Langthel feeder	0.889	99.25	99.00	1.112	99.13	98.81
33kV Nikachu feeder	0.900	99.16	97.34	0.941	99.04	97.13

The voltage profile of the Trongsa feeder -I can be improved by distributing some of its load to the Trongsa ring feeder. At present, although the two feeders are interconnected, the entire load of Trongsa town is catered from feeder-I. The ring feeder is maintained as a backup source. Therefore, it is recommended to redistribute the load for the quality power supply and optimal utilization of the assets.

c) System Study when the Sherubling Micro Hydropower Plant is down

The 11kV voltage of the Trongsa 1 feeder emanating from the Kewathang substation is stepped down to 0.415 kV and synchronized with the generation from the miro hydel. When the power plant is up and running, the generation is injected into the grid and caters to the customers of its vicinity. However, when the power plant is down, the whole of the load should be catered by the Trongsa feeder 1. A power flow study anticipated a critical voltage drop by the end customer of the Trongsa 1 feeder as presented in **Table 10**. While the voltage profile can be improved by changing the transformer tap position, the long-term solution would be transferring some of the load to the Trongsa ring feeder as stated.

Table 10: Voltage Profile of the Trongsa Feeder when the Sherubling Power Plant is down

Feeder Name	2025				2030			
	Load (MW)	Bus Voltage (%)	End Voltage (%)	% Voltage Drop	Load (MW)	Bus Voltage (%)	End Voltage (%)	% Voltage Drop
11 kV Trongsa Feeder 1	0.878	97.13	92.59	7.41	1.028	96.74	91.61	8.39

d) System Study when Tangsibji and Chendebji Micro Hydropower Plant is down

Similarly, the generation from the Tangsibji and Chendebji power plant is synchronized with the 33 kV Nikachu feeder and delivers the power to the community within its vicinity. A system study was carried out to check the behavior of the distribution network when these two power plant is down. No abnormality was observed in the system. Hence it is evident that the 33 kV Nikachu feeder has adequate capacity to deliver quality power.

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

7.2.2 Energy Loss Assessment of MV Feeders

Energy losses in the distribution network are inherent as the power transmission and distribution system are associated with the transformer and line loss. However, it is crucial to maintain the energy loss at an optimal level by engaging in timely improvement of the distribution infrastructures and not reacting to the localized system deficiencies. The objective of the energy loss assessment is to single out the feeder (s) with maximum loss (es) and put in additional corrective measures to minimize to the acceptable range. **Table 11** below shows the energy sales, purchase, and loss profile.

Table 11: Energy Sales-Purchase-Loss Trend

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
1	**Energy Requirement (MU)**						
i)	Purchase from GenCos as per TD bill	43.43	47.86	46.50	43.35	41.96	
ii)	Mini/Micro Hydel Generation	0.03	0.05	0.02	0.20	0.13	
iii)	Net Import Bumthang			0.04	0.18	0.43	
iv)	Net Import Zhemgang	0.16	0.16	0.17		0.18	
v	Net Export to Bumthang	(10.96)	(11.02)	(11.16)	(9.00)	(11.40)	
vi)	Net Export to Wangdue	-		(0.11)			
	Total	**32.66**	**37.05**	**35.46**	**34.72**	**31.30**	
	% growth over previous year	-	13.45%	-4.28%	-2.08%	-9.85%	**-0.69%**
2	**Energy Sales (MU)**						
i)	LV Total	5.65	6.38	7.04	7.71	7.40	
ii)	Medium Voltage	25.94	29.46	26.60	24.81	21.39	
	Total Energy Sales	**31.59**	**35.84**	**33.64**	**32.52**	**28.79**	
	% growth over previous year	-	13.46%	-6.15%	-3.34%	-11.45%	**-1.87%**
3	Total Loss (MU)	1.07	1.21	1.82	2.21	2.51	1.76
4	Total Loss (%)	2.44%	2.51%	3.91%	5.05%	5.87%	3.96%

Source: Adapted from Power Data Book 2019, BPC

Note:

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

The plot of the energy requirement data presented in **Table 11** yields the trend graphs shown in **Figure 5.** The energy requirement and the energy consumed has decreased over the years. The decreased in energy is because of the completion of the Mangdechhu Project. A huge amount of energy is consumed by this mega project to meet the construction power supply. The requirement is further expected to decrease with the completion of the Tangsibji Hydroelectric Power Project.

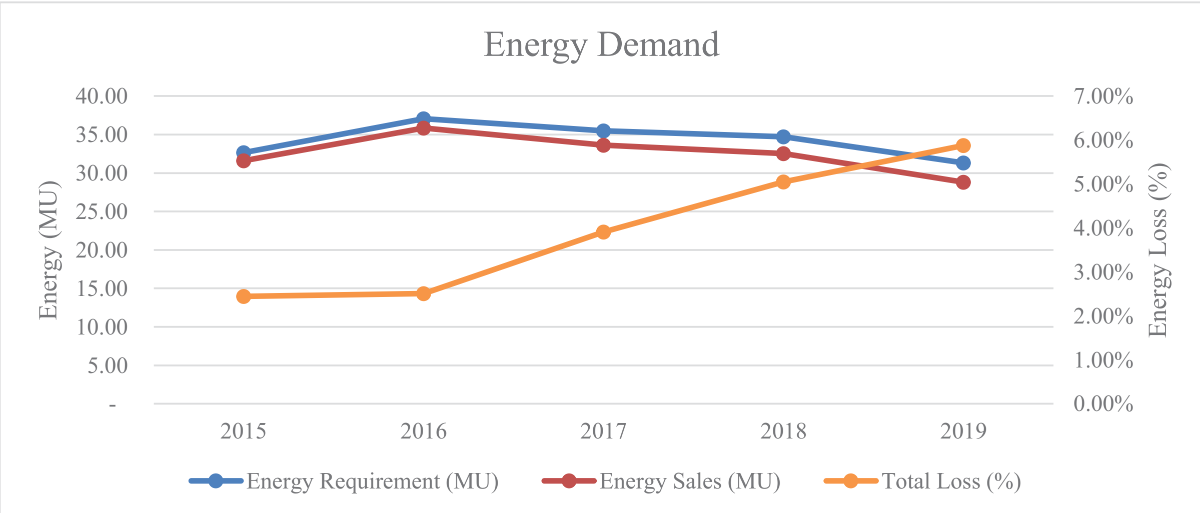


Figure 5: Energy Demand and Energy Losses Trend

Generally, the technical loss is 8.9% for the distribution network and any loss more than this range is due to commercial loss. An independent study carried out by 19 ESDs for 38 feeders in 2017 (two feeders each in ESD with more loss) showed that an average of 6.84% is due to technical loss. The study also showed that the loss pattern was never consistent because of variant characteristics of a distribution network and loading pattern. The average loss index of the Dzongkhag (2015-2019) is 3.96% (1.76 million units on average) which is relatively low. For a better understanding of the loss profile, the aggregate technical and commercial loss (AT&C) which is accounted based on the difference of energy purchase from the Transmission Department and energy sale to the customers for the year 2019 is worked out as presented in **Table 12** and **Figure 6.**

Table 12: Feeder Wise Energy Loss

Sl.No.	Feeder name	Energy purchase (kWh)	Energy Sales (kWh)	Losses %
1	11kV Trongsa Feeder	2.7	2.60	3.74%
2	33kV Semji Feeder	0.76	0.69	9.37%
3	33KV Langthel Feeder	1.68	1.57	6.54%
4	33KV Nikachu/Taktse Feeder	16.12	13.47	16.42%
5	11kV Chendebji Feeder			
6	MHPA Trunk Line	10.07	10.06	0.03%
	Total	**31.33**	**28.57**	**6.01%**

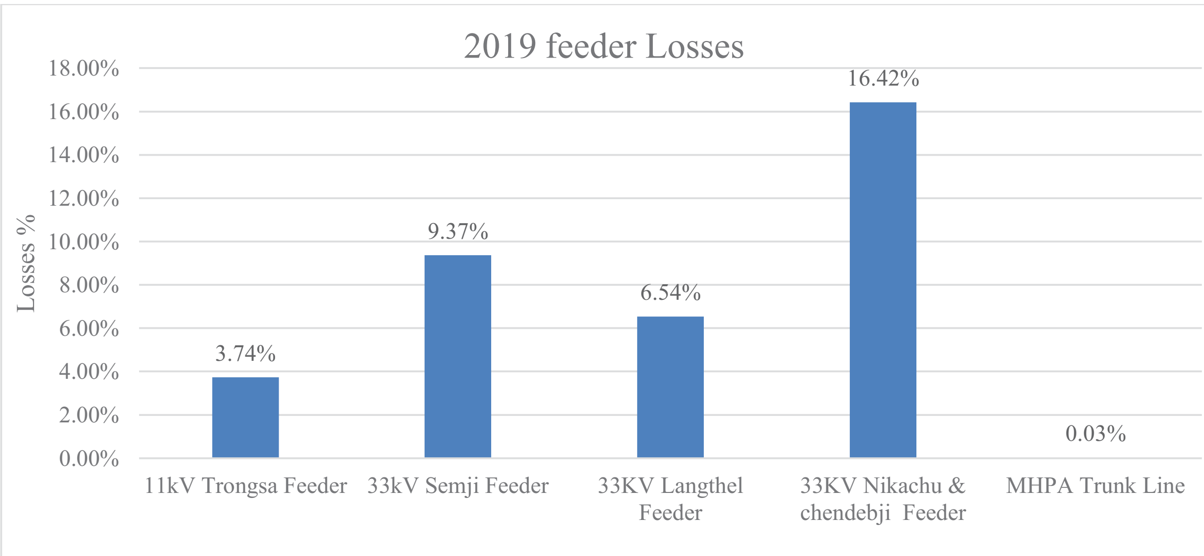


Figure 6: Feeder Wise Energy Loss of ESD Trongsa

As can be seen in **Figure 6**, it is noted that the 33 kV Nikacchu feeder has contributed the maximum loss (16.42 %) followed by the 33 kV Semji feeder (9.37%). The high loss is because of longer feeder circuit length resulting in high line resistance and therefore high I^2R losses in the line. The Nikachu feeder has a total line length of 61.343 km and the Semji has a total line length of 48.713 km.

The ETAP software was used to compute the technical loss of the system, however, as the system study is till DT, the technical loss obtained through the ETAP does not account for the loss due to the LV network and transmission system. The simulation result shows that only 1.46% constitute MV technical loss including the loss due to DT. The remaining (2.5%) is due to LV and commercial loss. The feeder wise MV and DT technical loss is as shown in **Table 13.**

Table 13: Technical losses from ETAP simulation

Sl. No.	Feeder name	Power Demand (MW)	Apparent Loss (MW)	Loss (%)
A	**Kewathang Substation**			
1	Station Feeder	0.04	0.00	0.00%
2	Bumthang Feeder	0.001	0.00	0.00%
3	Semji/Taktse Feeder	0.753	0.011	1.46%
4	Trongsa feeder 1	0.524	0.01	1.91%
B	**Yurmoo substation**			
1	Station Feeder	0.01	0	0.00%
2	Langthel Feeder	0.315	0.003	0.95%
3	Nikachu Feeder	0.893	0.013	1.46%
	Overall System Loss	**2.536**	**0.037**	**1.46%**

7.2.3 Reliability Assessment of the MV Feeders

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

In addition to ensuring that the MV feeders have the required capacity, it is also very important to ensure that the MV feeders are reliable. The yearly average feeder reliability assessment (2017-2019) is summarized in **Table 14.** The individual feeder reliability details used to derive the summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered to compute the actual representation of the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2017-2019 are 2.17 & 1.49 respectively which indicates that the power supply to the customers of the Dzongkhag is exceptionally reliable.

Table 14: Feeder wise reliability indices of ESD Trongsa for 2017-2019

Feeder name	2017		2018		2019		Average	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
33/11 kV Kewthang substation								
11kV Trongsa Feeder	0.53	0.35	0.40	0.53	0.14	0.06	0.36	0.31
33kV Semji Feeder	1.44	1.16	1.70	1.10	0.84	0.32	1.33	0.86
132/33 Yurmoo substation								
33KV Langthel Feeder	0.15	0.10	0.03	0.02	0.03	0.01	0.07	0.04
33KV Nikachu/Taktse Feeder	0.75	0.60	0.43	0.02	0.07	0.21	0.42	0.28
Total SAIFI & SAIDI	2.87	2.21	2.56	1.67	1.08	0.60		
Average SAIFI								**2.17**
Average SAIDI								**1.49**

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

Notes:

(a) ***SAIFI*** *(System Average Interruption Frequency Index) = (Total no. of customer interruption per year)/ (Total no. of customers served)*

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

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

Plotting the reliability indices data presented in **Table 14** above yields the bar graph as shown in **Figure 7** which indicates that the 33 kV Semji Feeder has the highest value of both the indices and is more susceptible to interruptions. The high interruption frequency and the duration index is because the said feeder passes through thick forest and comprises of multiple spur lines. These compounded factors lead to line faults, especially during the summer monsoon season. The feeder has a total circuit line length of around 49 km catering to 1,183 customers.

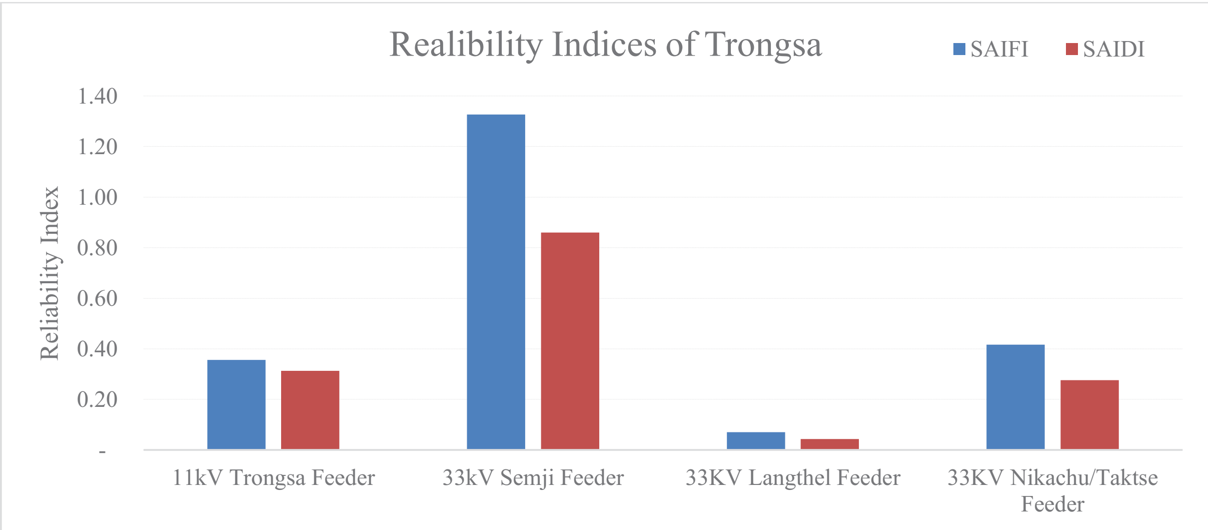
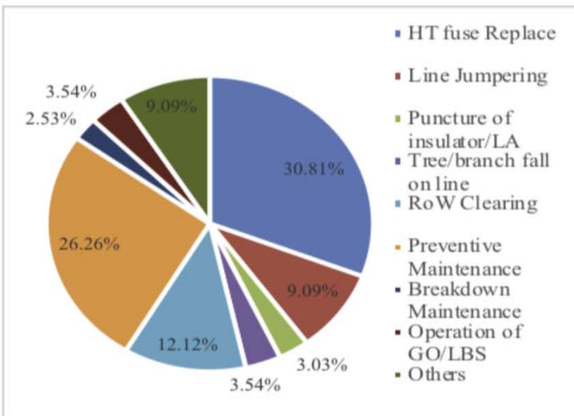


Figure 7*: Average Feeder Wise Reliability Indices*

To get a better understanding of the reliability index, the detailed root cause outages of the feeders had been computed in **Table 15**.

Table 15: The Root Cause Outages

Causes of Outages	Freq. (Nos)	Interruption (%)
HT fuse Replace	61	30.81%
Line Jumpering	18	9.09%
Puncture of insulator/Leakage	6	3.03%
Tree/branch fall on line	7	3.54%
RoW Clearing	24	12.12%
Preventive Maintenance	52	26.26%
Breakdown Maintenance	5	2.53%
Close and Open of GO/LBS	7	3.54%
Others	18	9.09%



From Table 15, it is noted that most of the outages are caused due to the HT fuse replacement which is directly correlated to the transient fault. The transient fault which leads to the HT fuse being blown off was attributed mainly due to the birds landing on the fuses and tree/branches touching on lines. A fuse barrel is recommended to protect from the birds and RoW clearing should be done as mandated in the O&M manual.

7.2.4 Single Phase to Three Phase Conversion

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

i. **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.

ii. **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.

iii. **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 the 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 upgradation across the country would amount to Nu. 97.00 million (Detail in **Annexure-6**) excluding the cost of three-phase transformers which have to be procured on need-basis, rather than one-time conversion in general.

The total single phase line length in the Dzongkhag is 5.38 km (33 kV). The estimated cost for the conversion of such is Nu. 0.89 million.

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

7.3 Assessment of Distribution Transformers

7.3.1 Distribution Transformer Loading

The DTs are one of the most critical equipment of the distribution network and assessment of existing loading pattern along with the remaining asset life are crucial to ascertain the capability of the transformers for the future. The capability evaluation is based on the historical peak load loading pattern and forecasted peak load growth of the feeder.
Some of the existing transformer capacities would not be adequate to cater to the forecasted load growth for the next ten (10) years. Accordingly, the capacities of the transformers need to be upgraded and such a proposal is tabulated **in Table 16.** The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Table 16: List of Overloaded Distribution Transformers

Sl. No.	DT Location Name	kVA	Existing Loading		Forecasted Loading %		Remarks
			kVA	%	2025	2030	
1	Bagochen	250	100.576	40%	77%	88%	New 500kVA
2	Sherabling Hospital	250	99.705	40%	77%	87%	New 500kVA

Sl. No.	DT Location Name	kVA	Existing Loading		Forecasted Loading %		Remarks
			kVA	%	2025	2030	
3	willing Village	63	29.126	46%	89%	101%	125kVA to be cross swap from indocholing
4	Taphe Gonpa	25	14.55	58%	112%	127%	Load growth not expected
5	Sephuchen	25	25.40	101.6 %	107%	113%	New 63kVA
6	Taktsi Top	63	50.00	79.37 %	84%	88%	New 125kVA
7	Bubja	25	20.5	82%	87%	91%	63kVA to be cross swap from Yulling Village
8	Chakarzur Lhakhang	63	53.5	84.92 %	90%	95%	New 125kVA to be cross swap from Gangphel
11	Indocholing	125	54.12	43%	126%	159%	250kVA to be cross swap from Sherabling Hospital
12	Lower Belling	63	23.42	37%	108%	137%	Load growth not expected
13	Gangphel	125	30.76	25%	71%	91%	New 250kVA
14	Taksila	63	27.51	44%	127%	161%	Load growth not expected
15	Dangdung	63	27.70	44%	127%	162%	New 125kVA
16	Thrisar	63	15.05	24%	69%	88%	New 125kVA
17	Koshala	63	20.28	32%	93%	118%	New 125kVA
18	Barsa	10	2.43	24%	71%	89%	Load growth not expected
19	Ngorme	25	6.21	25%	72%	91%	
20	Shingling	25	5.95	24%	69%	88%	
21	Wangling-I	25	7.37	29%	86%	108%	
22	Lower Jangbi	10	2.31	23%	67%	85%	
23	Yourmo BTN	25	8.61	34%	100%	127%	
24	Dangdung I	63	15.61	25%	72%	91%	New 125kVA

Assuming that the load growth of the rural homes is not expected to grow similar to that of urban dwellings, it is strongly recommended to closely monitor the actual load growth and accordingly plan remedial measures for those transformers. Nevertheless, considering the actual site-specific growth rate and judgment of the field offices, it is recommended to up-grade 24 transformers. However, cross-swapping of the existing transformers before procurement of new transformers would mean that only 10 transformers would require procurement.

7.3.2 Asset life of Distribution Transformers

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

Although, as listed in **Table 17**, 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 17: List of outlived Distribution Transformers

Sl. No.	DT Location name	Transformer Ratio	Capacity	MFD	2019	2025	2030
1	Tangsibjee Power House	0.415/6.6	50	1987	32	38	43
2	Tangsibjee Village	6.6/0.415	50	1987	32	38	43
3	DOR(Trongsa)	11/0.415	125	1994	25	31	36
4	Dorji Gonpa	11/0.415	25	1995	24	30	35
5	Chendibjee-III	11/0.415	63	1990	29	35	40

7.3.3 Replacement of Single Phase Transformer

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

There are around 27 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu. 5.72 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 municipal boundary of Trongsa canvasses 461 acres (i.e. 1.87 km^2) most of which is comprised of the steep slopes on the two sides of the small river Thruelpangchu that flows into the much larger river Mangdechu. The growth of the Dzongkhag would be constrained by its steep terrain and limited area. However, the Municipal Authority had intensified the willing area as a possible expansion of the town which consists of around 200 plots. Assuming a coincidental peak of 2 kW per unit, a total load of around 2.4 MW is anticipated (supposing 6 units in each plot) when the LAP is fully developed and realized.

However, the Dzongkhag apparently does not have much development potential in terms of industries and commercial centers as evident from the relatively low growth of LV power demand. The growing power demand is only because of the MV customers (Mangdechhu and Tangsibji Hydroelectric Project). Although a portion of the new LAP has been designated as an industrial area, only small enterprises such as sawmills, incense units, vehicle workshops, bakeries, etc are expected. Hence, the construction of a 500 kVA substation is provisioned to cater to the power requirement of evolving LAP. **Figure 8** depicts the proposed location of 500kVA, 11/0.415kV substation, and 11 kV overhead line extension (approximately 0.065 km) to the new town.

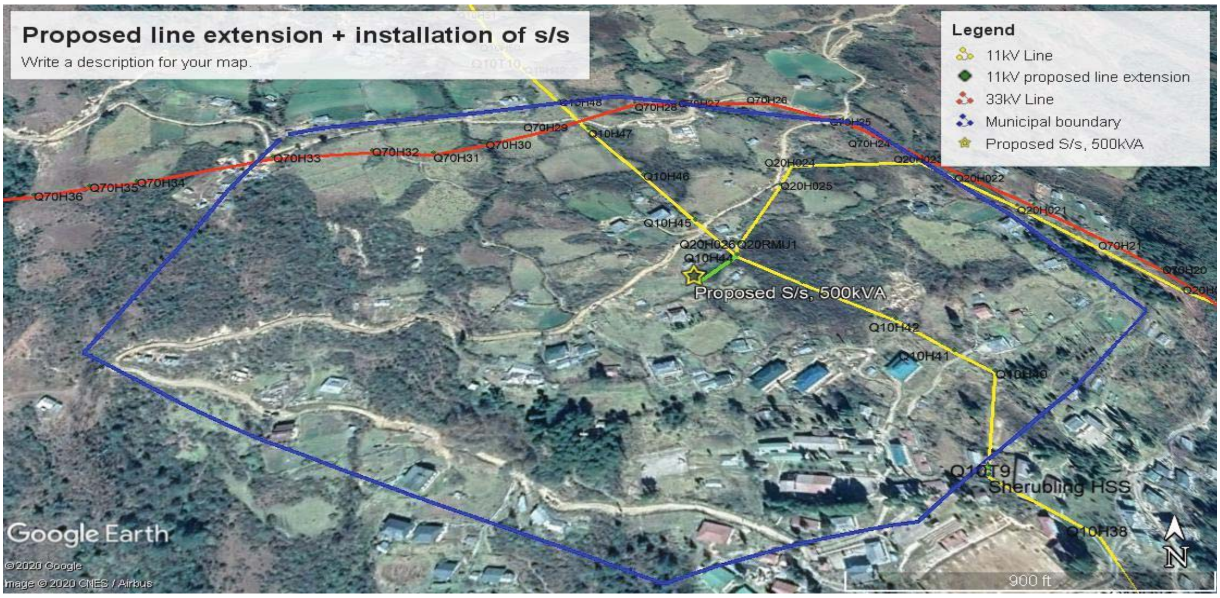


Figure 8: Proposed Distribution Infrastructure for the New LAP

As a transitional phase, in urban areas of Trongsa, it would be prudent to opt for 11 kV ABC lines considering that ACSR conductors pose serious RoW and safety constraints instead of the UG system which is exceptionally expensive.

8. Distribution System Planning until 2030

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

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

8.1 Power Supply Source

8.1.1 HV substation

As per the power source assessment made in **section 7.1.2**, the 132/33, 2x15 MVA Yurmoo substation has adequate capacity to cater to the present and forecasted electricity demand without having to invest.

8.1.2 MV Substations

Similarly, consistent with the assessment made in section 7.1.2, the 2x2.5 MVA, 33/11 kV Kewathang substation has adequate capacity to cater to the present and projected electricity demand.

8.2 MV Lines

The detailed MV line assessment made in **section 7.2** shows that the MV distribution lines of ESD Trongsa have enough capacity to cater to the existing as well as future load growth till 2030. However, the line extension to the new LAP should be incorporated into the investment plan.

8.3 Distribution Transformers

As detailed in **Section 7.3.1,** the DTs of urban areas might get overloaded as forecasted, and considering the plans of the LAPs, the following are the list of DTs which would require either up-gradation or installation of new substations.

a) Up-grade 25 kVA, 11/0.415kV transformer at Sephuchen to 63 kVA.
b) Up-grade 250 kVA, 11/0.415kV transformer at Bagochen to 500 kVA.
c) Up-grade 250 kVA, 11/0.415kV transformer at Sherabling hospital to 500 kVA.
d) Up-grade 125 kVA, 33/0.415kV transformer at Gangphel to 250 kVA.
e) Up-grade 63 kVA, 33/0.415kV transformer at Dangdung to 125 kVA.
f) Up-grade 63 kVA, 33/0.415kV transformer at Thrisar to 125kVA.
g) Up-grade 63 kVA, 33/0.415 transformer at Koshala to 125kVA.
h) Up-grade 63 kVA, 33/0.415 transformer at Dangdung-I to 125 kVA.
i) Up-grade 63 kVA, 33/0.415 transformer at Taktse Top to 125 kVA
j) Construction of 500 kVA, 11/0.415 transformer at Yulling area
k) Construction of 2 nos of 125 KVA, 33/0.415kV at Upper Samcholing and Namthar

8.4 Switching and Control

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

8.4.1 Intelligent Switching Devices

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

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

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

Table 18, shows the existing and proposed switching devices to be installed in the respective feeders.

Table 18: List of Switching Equipment under ESD Trongsa

Sl. No	Name of Feeder	ARCBs		LBS		FPIs	
		Existing	Proposed	Existing	Proposed	Existing	Proposed
1	11kV Tongsa feeder	0	0	2	0	0	1
2	11kV Chendebji feeder	0	0	4	0	0	1
3	33kV Semji/Taktse feeder	1	0	4	3	0	1
4	33kV Nikachu feeder	2	0	9	0	0	1
5	33kV Langthel feeder	0	0	4	3	0	1
6	33kV Bumthang feeder	1	0	1	1	0	1
	Total	**4**	**0**	**24**	**7**	**0**	**6**

8.4.2 Distribution System Smart Grid

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

9. Investment Plan

Following the above-mentioned contingency plans targeted to improve the power quality, reduce losses, and improve reliability indices of the Dzongkhag, an investment proposal is developed.
The investment plan has been confined to power supply sources, MV lines, DTs, switching and control equipment, and RoW. The proposed/approved (2019-2023) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 9.**

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

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

Figure 9: 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 are not limited to improving the reliability, reducing losses, and reconfiguration of lines and substations to reduce the losses and improving the power quality. The activities which are not so important but are highly urgent have to be also planned in a later stage of the period.

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 19** as an investment plan. The cost estimates have been worked out based on the BPC ESR-2016 and annual inflation is cumulatively applied to arrive at the actual investment cost for the following years.

In the span of the next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers is Nu. 18.40 million.

Table 19: Investment Plan until 2030

Sl. No.	Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1	**Distribution Transformer**	-	-	-	-	-	-	-	-	-	-	-	**-**
1.1	Construction 2 nos of 125 KVA, 33/0.415kV at Upper Samcholing and Namthar	-	-	-	-	3.42	-	-	-	-	-	-	**3.42**
1.2	Construction of 11/0.415kV, 500kVA transformer with line extension of 0.060km for new town planning at Yulling area	-	-	-	-	-	2.00	-	-	-	-	-	**2.00**
1.3	Up-grade 11/0.415kV, 250kVA transformer at Bagochen to 500kVA	-	-	-	-	-	-	-	-	1.20	-	-	**1.20**
1.4	Up-grade 11/0.415kV, 250kVA transformer at Sherabling hospital to 500kVA	-	-	-	-	-	-	-	-	1.20	-	-	**1.20**
1.5	Up-grade 11/0.415kV, 25kVA transformer at Sephuchen to 63kVA	-	-	0.29	-	-	-	-	-	-	-	-	**0.29**
1.6	Up-grade 33/0.415kV, 63kVA transformer at Taktse Top to 125kVA	-	-	-	-	-	-	-	-	0.49	-	-	**0.49**
1.7	Up-grade 33/0.415kV, 125kVA transformer at Gangphel to 250kVA	-	-	-	-	-	0.58	-	-	-	-	-	**0.58**
1.8	Up-grade 33/0.415kV, 63kVA transformer at Dangdung to 125kVA	-	-	-	-	0.37		-	-	-	-	-	**0.37**
1.9	Up-grade 33/0.415kV, 63kVA transformer at Thrisar to 125kVA	-	-	-	-	-	-	-	-	-	-	0.50	**0.50**
1.10	Up-grade 33/0.415kV, 63kVA transformer at Koshala to 125kVA	-	-	-	-	0.37	-	-	-	-	-	-	**0.37**
1.11	Up-grade 33/0.415kV, 63kVA transformer at Dangdung I to 125kVA	-	-	-	-	-	-	-	-	-	0.49	-	**0.49**
2	**Conversion**												**-**
2.1	Single phase transformer to three phase conversion	-	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	**5.72**
2.2	Single phase to three phase line conversion	-	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	**0.89**
3	**Switching and control**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.1	Installation of 33kV LBS	-	0.28	-	-	0.30	0.30	-	-	-	-	-	**0.88**
	Total	**-**	**0.94**	**0.95**	**0.66**	**5.12**	**3.54**	**0.66**	**0.66**	**3.55**	**1.15**	**1.16**	**18.40**

10. Conclusion

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

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

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

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

11. Recommendation

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	Both HV and MV substations have adequate capacity to cater to the present and future electricity demand.
2	MV Substations	
B. MV and LV Lines		
1	MV Lines	The MV line plans as discussed in section 8.2 are recommended.
2	LV Lines	Assessment of LV infrastructure is not in the scope of this study. Actual requirements must be studied according to the prevailing circumstances and proposed separately
C. Distribution Transformers		
1	Distribution Transformer	As reflected in **Section 7.3.1** of this report, it is proposed to regularly monitor the loading pattern especially of the urban transformers. It is desired to load the transformers less than 85% to ensure that transformer is operated at maximum efficiency. The system study is restricted to DTs, the loads need to be uniformly distributed amongst the LV feeders to balance the load.
2	Single to Three Phase Transformers	As reported in the "Technical and Financial Proposal on Converting Single Phase Power Supply to Three Phase in Rural Areas", it is recommended to replace the single to three phase transformers on a need basis.
D. Switching and Control Equipment		
1	Switching and Control Equipment	It is recommended to install Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers, and FPIs as proposed which would reduce the downtime for clearing faults. 1) Install FPI, Sectionalizes, and ARCBs at various identified locations. 2) Installation of 11kV& 33kV RMUs at various identified locations.
E. others		

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

Sl. No.	Parameters	Recommendations
		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 the construction of feeders with customized 11kV & 33kV towers; and 3) To increase the frequency of Row clearing in a year.

12. Annexure

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

13. References

1. The FWPL and CPL from TD, BPC as of 2018.
2. BPC Power Data Book 2018.
3. BPC Distribution Design and Construction Standards (DDCS)-2016.
4. BPC Smart Grid Master Plan (2019-2027).
5. BPC National Transmission Grid Master Plan (2020 & 2030).
6. BPC Operation and Maintenance Manual for Distribution System (2012).
7. BPC Corporate Strategic Plan (2019-2030).
8. Population and Housing Census of Bhutan 2019.

9. The Structural Plan (2004-2027) for every Dzongkhag.
10. Industrial Parks (Department of Industry).
11. BPC Electrical Schedule of Rates 2015.

14. Assumptions

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

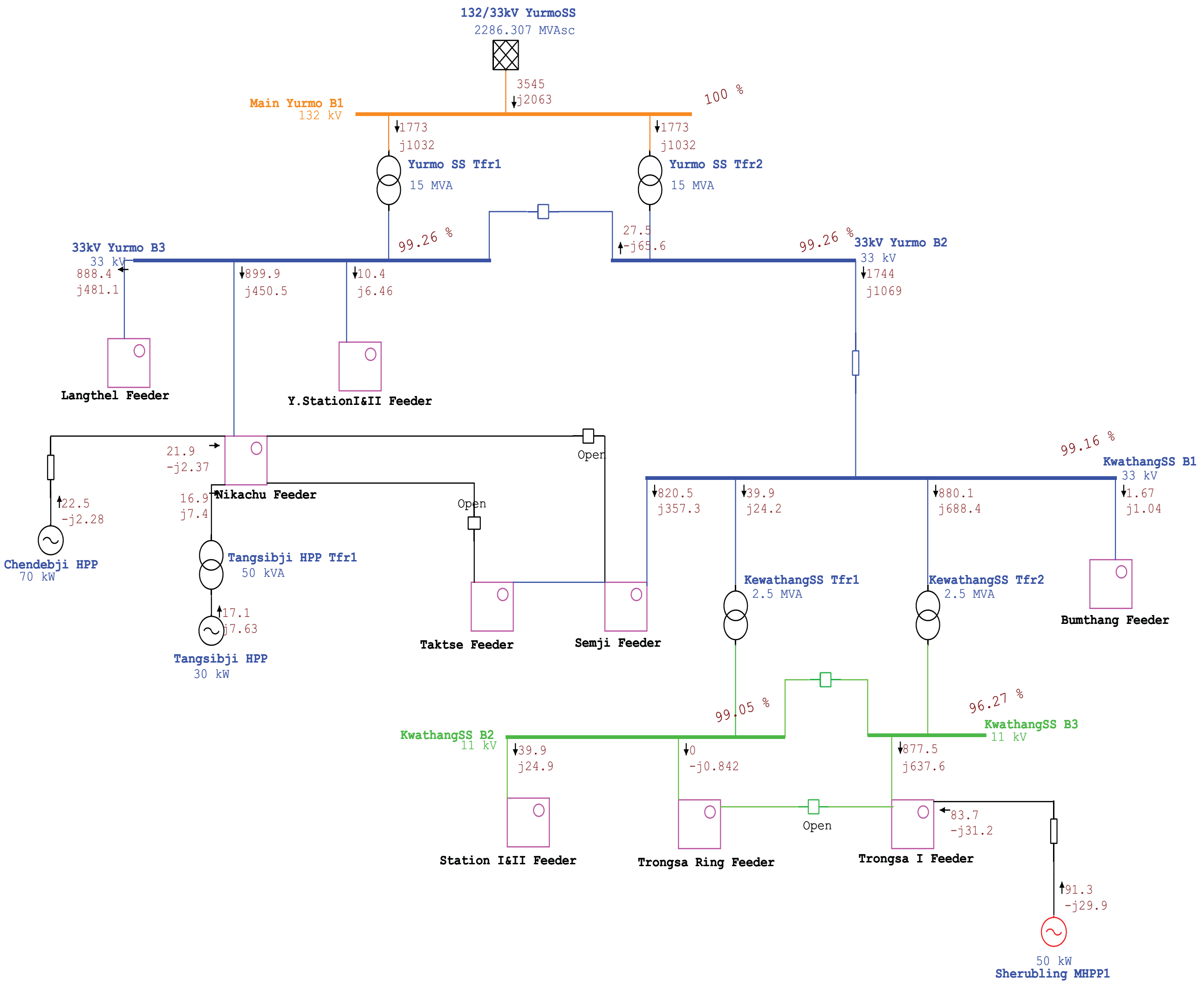
15. Challenges

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

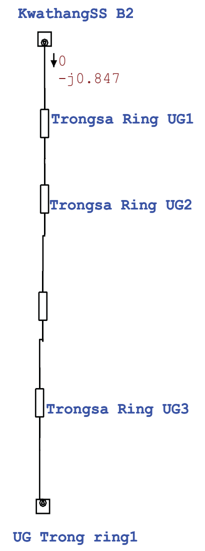
Sl. No.	Parameters	Challenges	Opportunities/Proposals
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to timing and number of DTs.	b) To get the accurate Transformer Load Management (TLM)/loading, it is proposed to install DT meters which could also have additional features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

Annexure-1: MV Line Details and Single Line Diagram

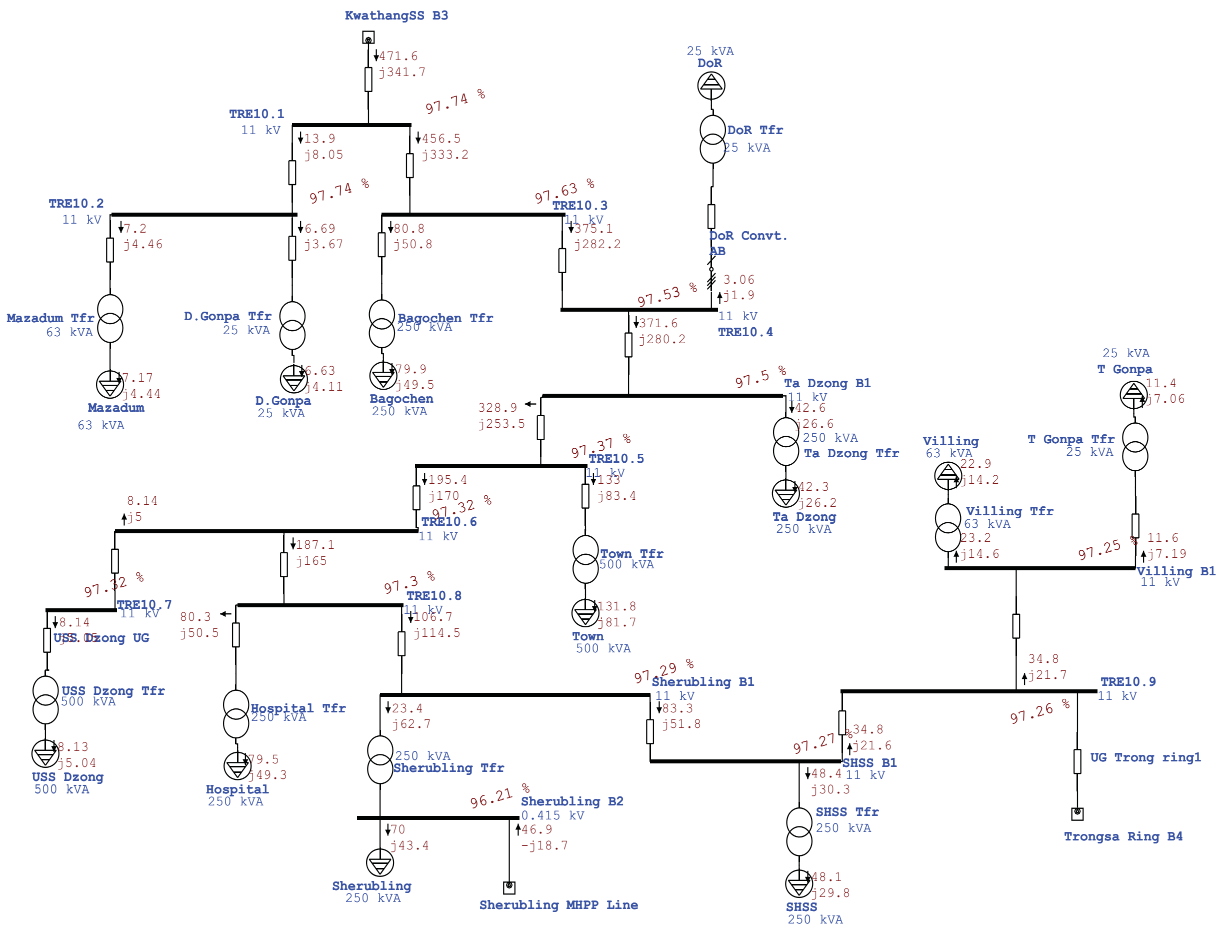
One-Line Diagram - OLV1 (Load Flow Analysis)



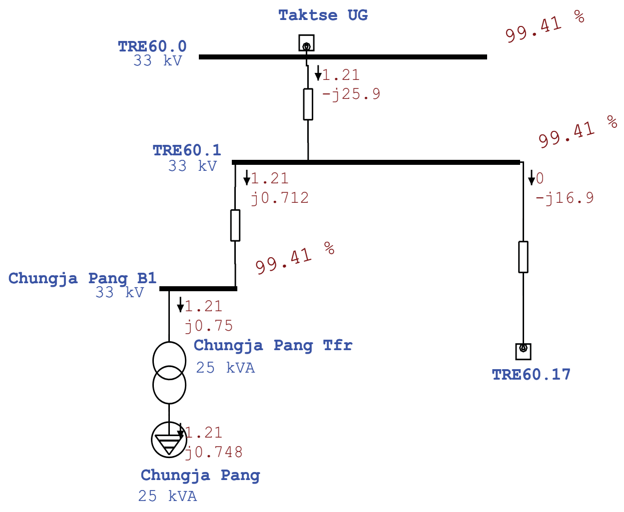
One-Line Diagram - OLV1=>Trongsa Ring Feeder (Load Flow Analysis)

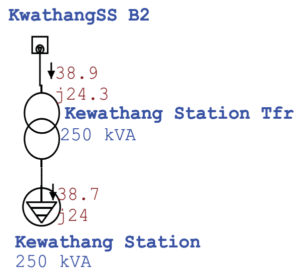


One-Line Diagram - OLV1=>Trongsa I Feeder (Load Flow Analysis)

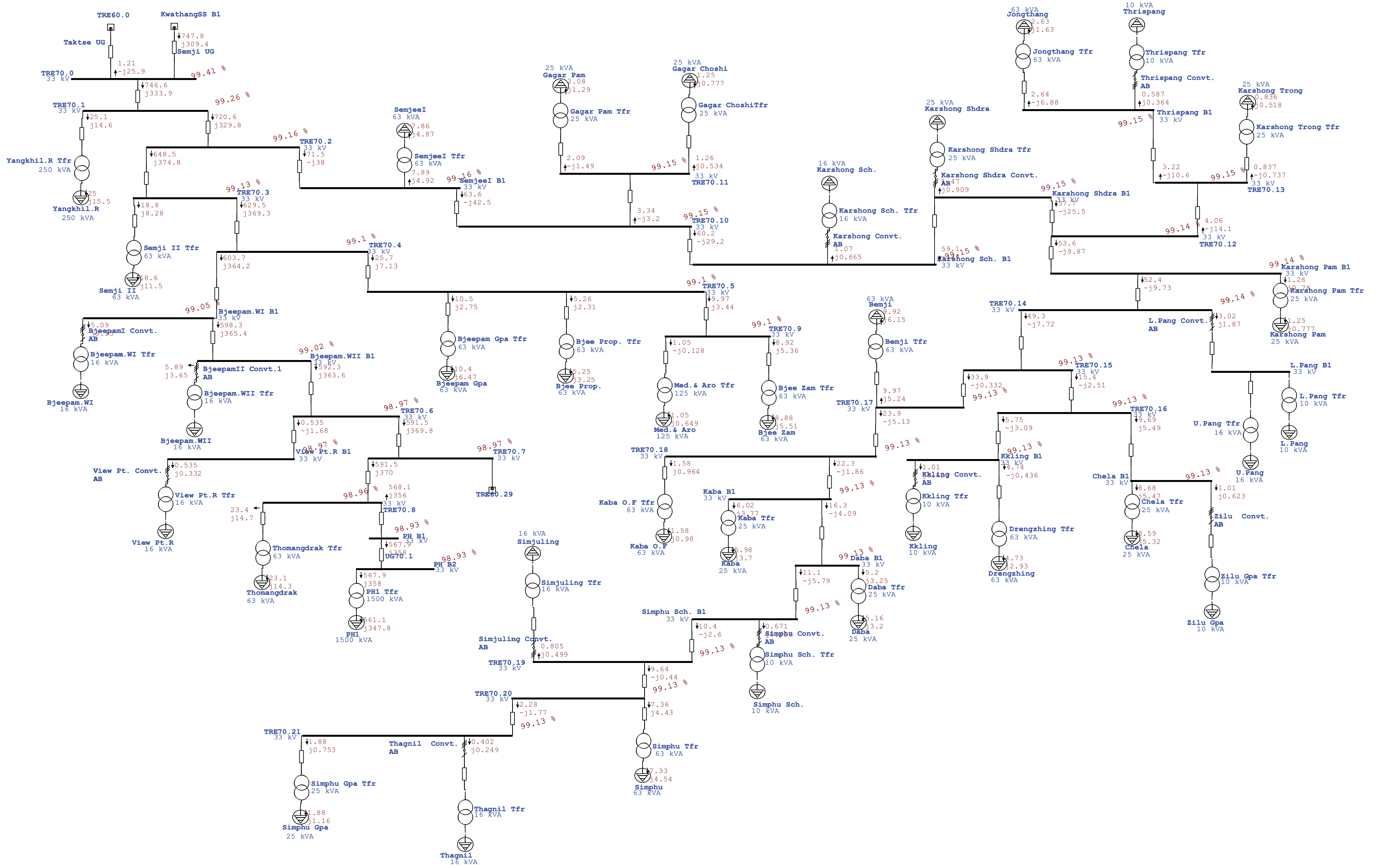


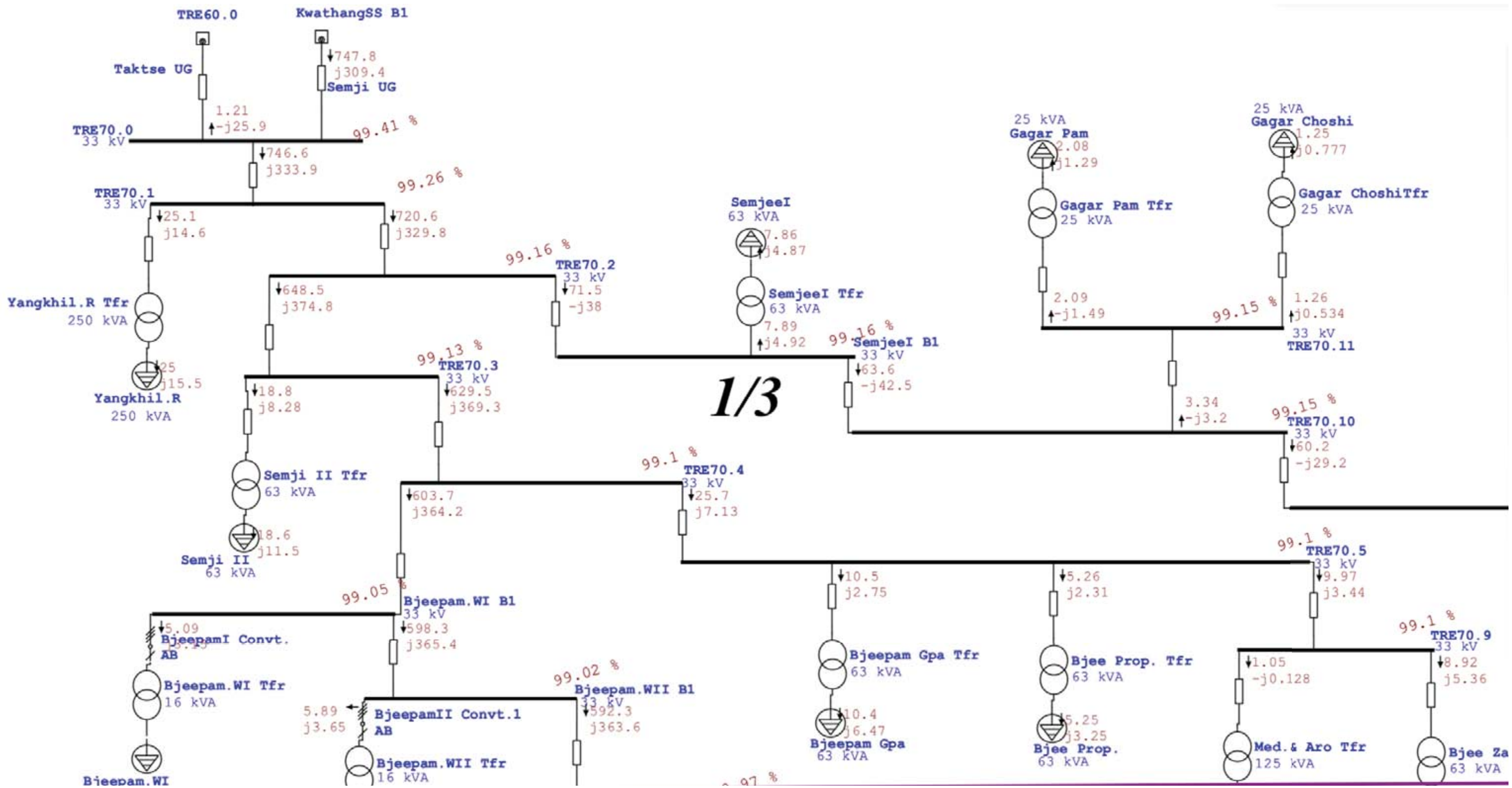
One-Line Diagram - OLV1=>Taktse Feeder (Load Flow Analysis)

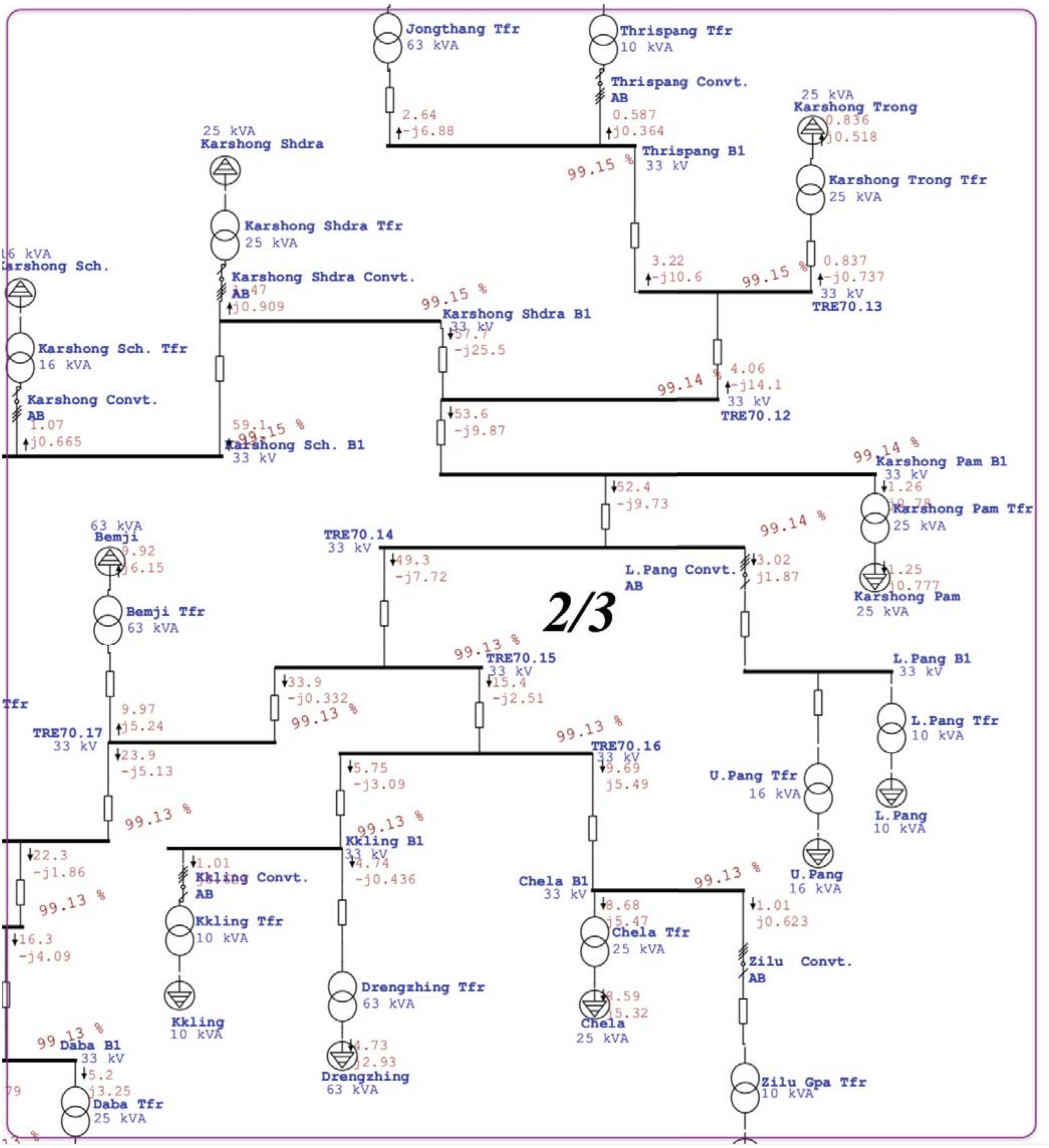



KwathangSS B2
38.9
j24.3
Kewathang Station Tfr
250 kVA
38.7
j24
Kewathang Station
250 kVA

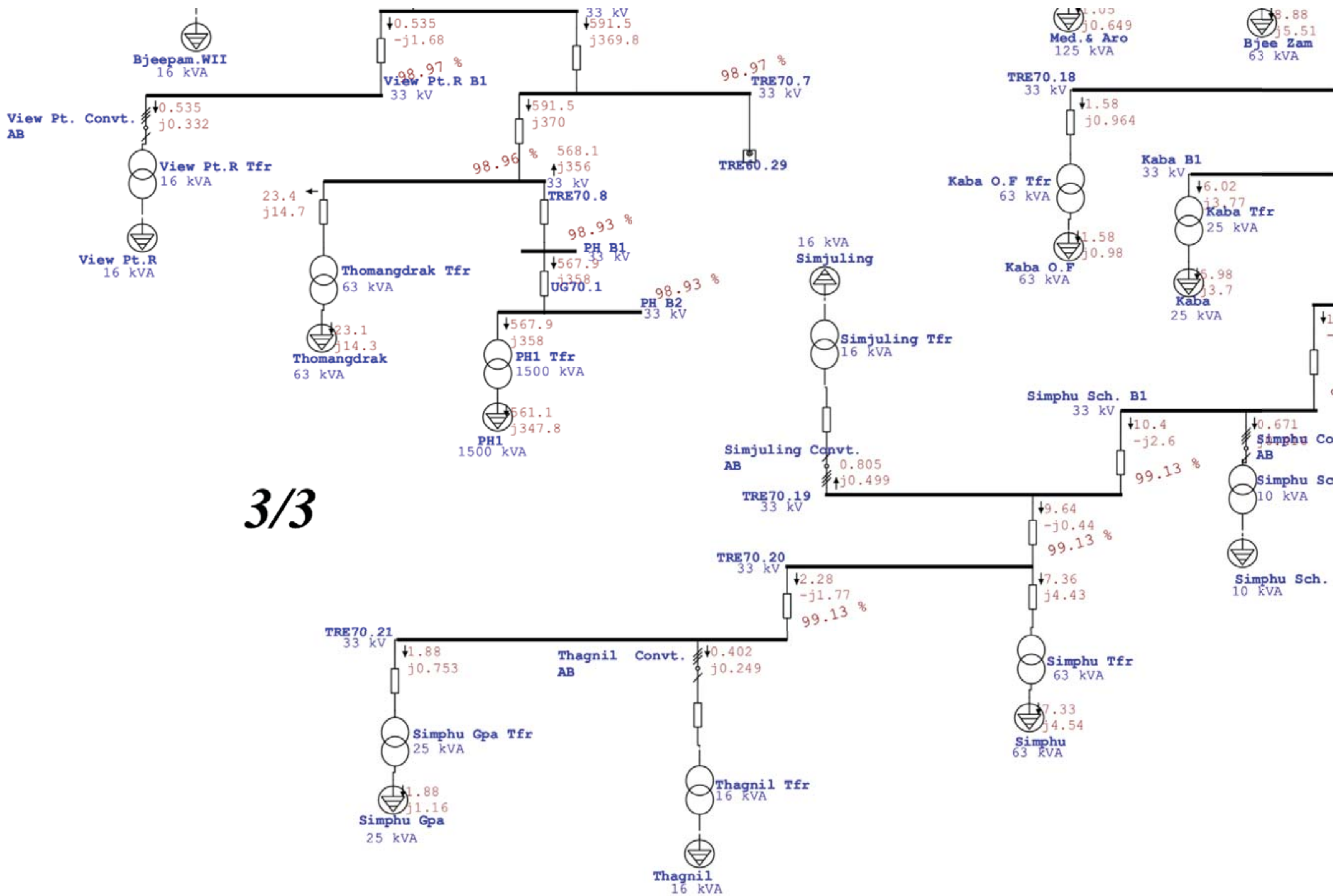
One-Line Diagram - OLV1=>Semji Feeder (Load Flow Analysis)




TRE60.0
KwathangSS B1
Taktse UG
Semji UG
TRE70.0
33 kV
99.41 %
TRE70.1
33 kV
99.26 %
Yangkhil.R Tfr
250 kVA
Yangkhil.R
250 kVA
TRE70.2
33 kV
99.16 %
SemjeeI
63 kVA
SemjeeI Tfr
63 kVA
SemjeeI B1
33 kV
99.16 %
1/3
TRE70.3
33 kV
99.13 %
Semji II Tfr
63 kVA
Semji II
63 kVA
TRE70.4
33 kV
99.1 %
Bjeepam.WI B1
33 kV
99.05 %
BjeepamI Convt.
AB
Bjeepam.WI Tfr
16 kVA
Bjeepam.WI
BjeepamII Convt.1
AB
Bjeepam.WII Tfr
16 kVA
Bjeepam.WII B1
33 kV
99.02 %
Gagar Pam
25 kVA
Gagar Pam Tfr
25 kVA
Gagar Choshi
25 kVA
Gagar ChoshiTfr
25 kVA
TRE70.11
33 kV
99.15 %
TRE70.10
33 kV
99.15 %
TRE70.5
33 kV
99.1 %
Bjeepam Gpa Tfr
63 kVA
Bjeepam Gpa
63 kVA
Bjee Prop. Tfr
63 kVA
Bjee Prop.
63 kVA
TRE70.9
33 kV
99.1 %
Med.& Aro Tfr
125 kVA
Bjee Za
63 kVA



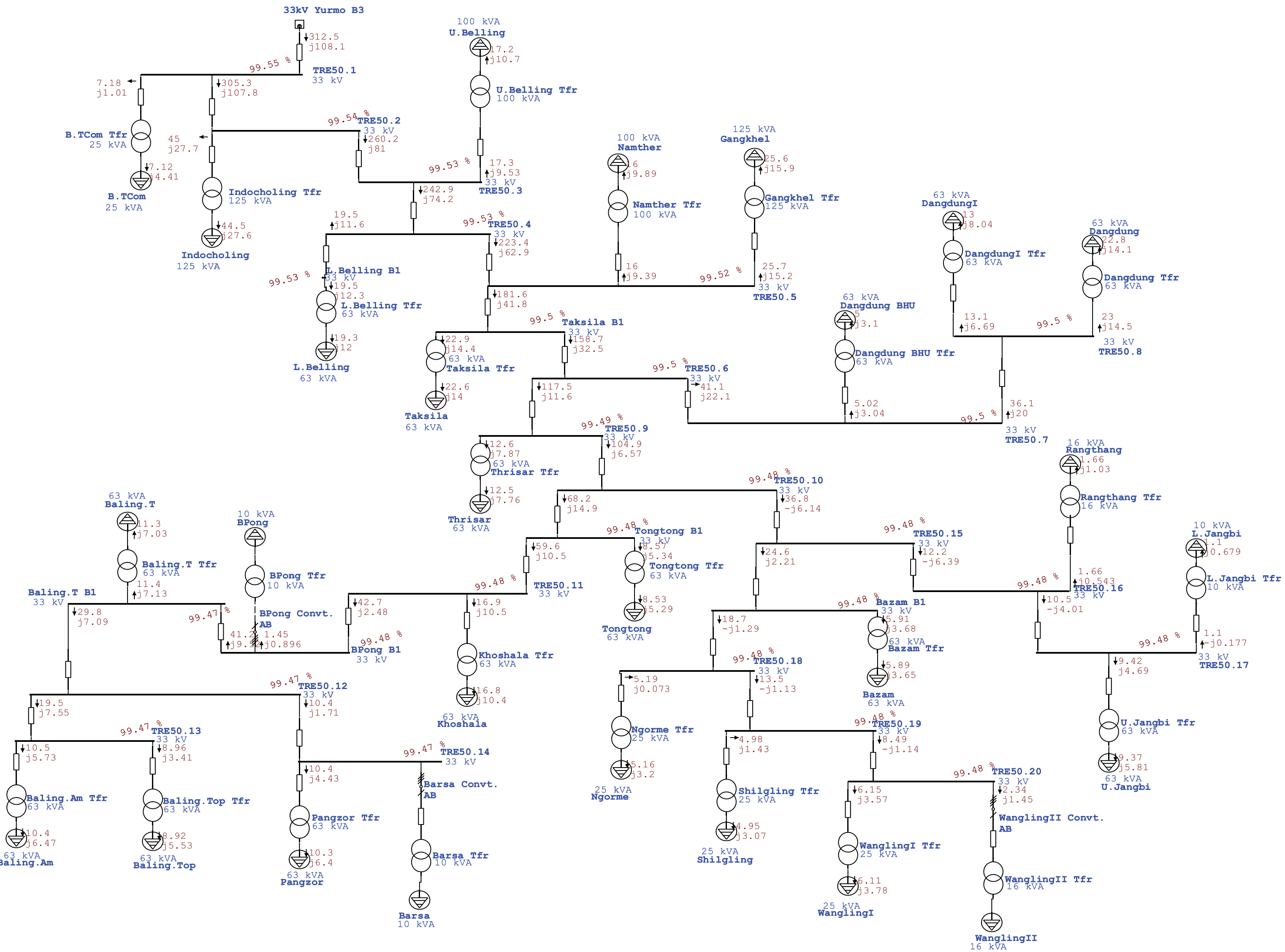
Jongthang Tfr
63 kVA
2.64
-j6.88
Thrispang Tfr
10 kVA
Thrispang Convt.
AB
0.587
j0.364
Thrispang B1
33 kV
99.15 %
25 kVA
Karshong Trong
0.836
j0.518
Karshong Trong Tfr
25 kVA
3.22
-j10.6
99.15 %
0.837
-j0.737
33 kV
TRE70.13
25 kVA
Karshong Shdra
Karshong Shdra Tfr
25 kVA
Karshong Shdra Convt.
AB
j0.909
99.15 %
Karshong Shdra B1
33 kV
57.7
-j25.5
16 kVA
Karshong Sch.
Karshong Sch. Tfr
16 kVA
Karshong Convt.
AB
1.07
j0.665
59.1
99.15 %
Karshong Sch. B1
33 kV
99.14 %
4.06
-j14.1
33 kV
TRE70.12
53.6
-j9.87
99.14 %
Karshong Pam B1
33 kV
1.26
Karshong Pam Tfr
25 kVA
52.4
-j9.73
99.14 %
1.25
j0.777
Karshong Pam
25 kVA
63 kVA
Bemji
9.92
j6.15
Bemji Tfr
63 kVA
TRE70.14
33 kV
49.3
-j7.72
L.Pang Convt.
AB
3.02
j1.87
2/3
99.13 %
TRE70.15
33 kV
15.4
-j2.51
33.9
-j0.332
L.Pang B1
33 kV
L.Pang Tfr
10 kVA
Tfr
9.97
j5.24
TRE70.17
33 kV
99.13 %
23.9
-j5.13
99.13 %
TRE70.16
33 kV
9.69
j5.49
U.Pang Tfr
16 kVA
L.Pang
10 kVA
5.75
-j3.09
99.13 %
99.13 %
Kkling B1
33 kV
4.74
-j0.436
U.Pang
16 kVA
22.3
-j1.86
99.13 %
1.01
Kkling Convt.
AB
Chela B1
33 kV
99.13 %
8.68
j5.47
1.01
j0.623
16.3
-j4.09
Kkling Tfr
10 kVA
Chela Tfr
25 kVA
Zilu Convt.
AB
Kkling
10 kVA
Drengzhing Tfr
63 kVA
8.59
j5.32
Chela
25 kVA
99.13 %
Daba B1
33 kV
5.2
j3.25
4.73
j2.93
Drengzhing
63 kVA
Daba Tfr
25 kVA
Zilu Gpa Tfr
10 kVA

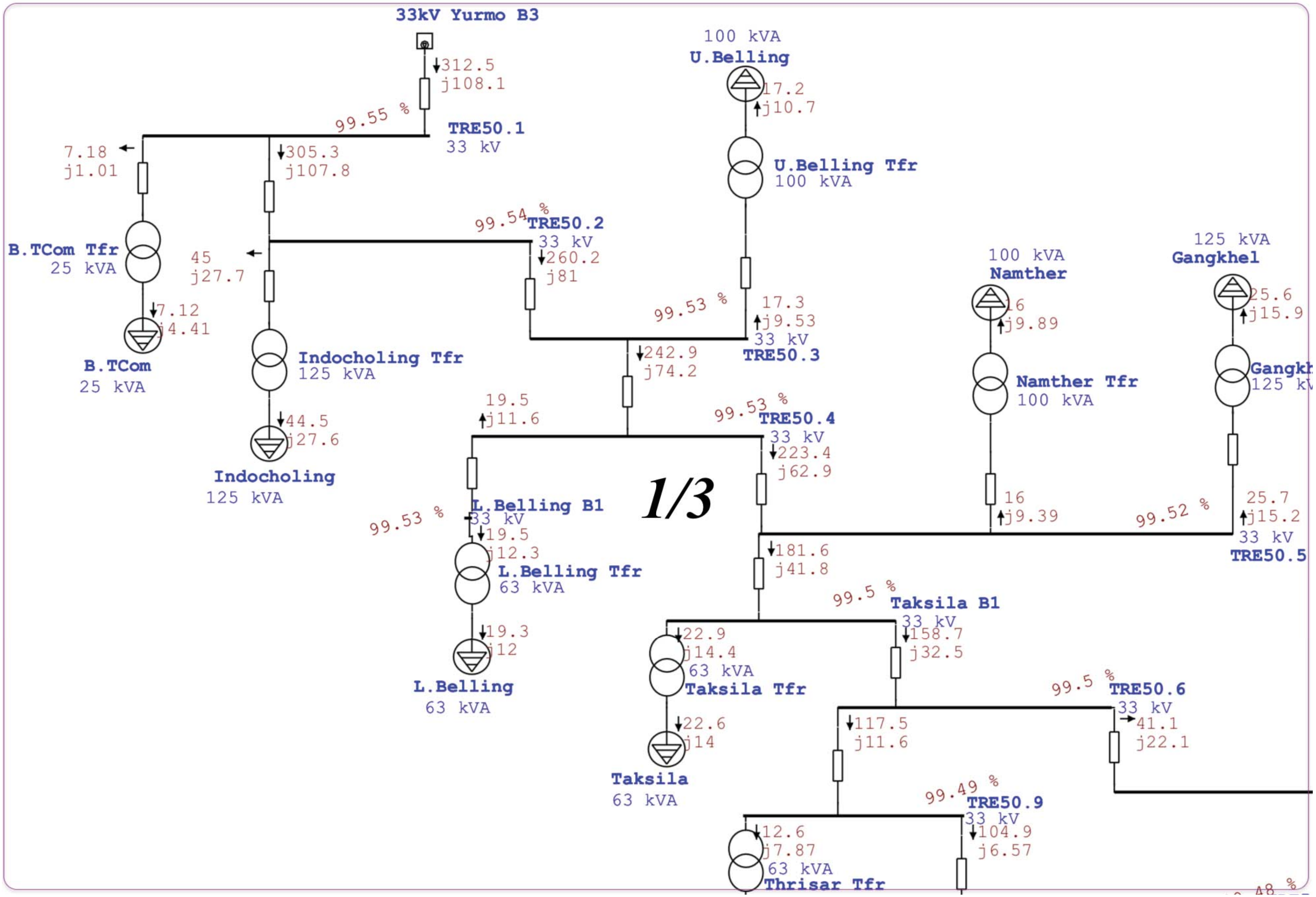


Bjeepam.WII
16 kVA
View Pt. Convt.
AB
0.535
j0.332
View Pt.R Tfr
16 kVA
View Pt.R
16 kVA
0.535
-j1.68
98.97 %
View Pt.R B1
33 kV
33 kV
591.5
j369.8
591.5
j370
98.96 %
568.1
j356
33 kV
TRE70.8
23.4
j14.7
Thomangdrak Tfr
63 kVA
23.1
j14.3
Thomangdrak
63 kVA
98.93 %
PH B1
33 kV
567.9
j358
UG70.1
98.93 %
PH B2
33 kV
567.9
j358
PH1 Tfr
1500 kVA
561.1
j347.8
PH1
1500 kVA
98.97 %
TRE70.7
33 kV
TRE60.29
16 kVA
Simjuling
Simjuling Tfr
16 kVA
Simjuling Convt.
AB
0.805
j0.499
TRE70.19
33 kV
Med.& Aro
125 kVA
j0.649
Bjee Zam
63 kVA
8.88
j5.51
TRE70.18
33 kV
1.58
j0.964
Kaba O.F Tfr
63 kVA
1.58
j0.98
Kaba O.F
63 kVA
Kaba B1
33 kV
6.02
j3.77
Kaba Tfr
25 kVA
5.98
j3.7
Kaba
25 kVA
Simphu Sch. B1
33 kV
10.4
-j2.6
99.13 %
0.671
Simphu Co
AB
Simphu Sc
10 kVA
Simphu Sch.
10 kVA
9.64
-j0.44
99.13 %
7.36
j4.43
Simphu Tfr
63 kVA
7.33
j4.54
Simphu
63 kVA
TRE70.20
33 kV
2.28
-j1.77
99.13 %
TRE70.21
33 kV
1.88
j0.753
Simphu Gpa Tfr
25 kVA
1.88
j1.16
Simphu Gpa
25 kVA
Thagnil Convt.
AB
0.402
j0.249
Thagnil Tfr
16 kVA
Thagnil
16 kVA

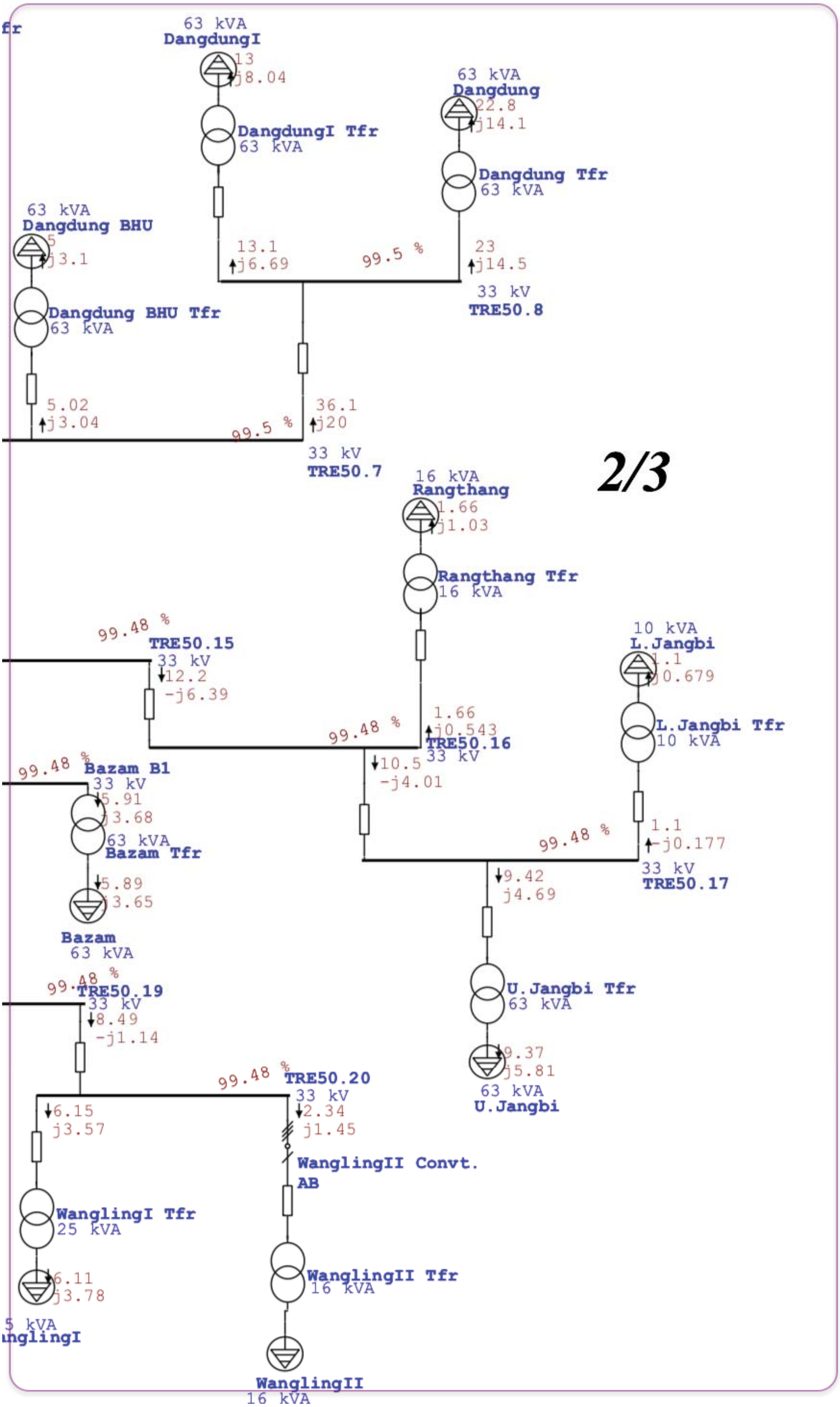
3/3

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

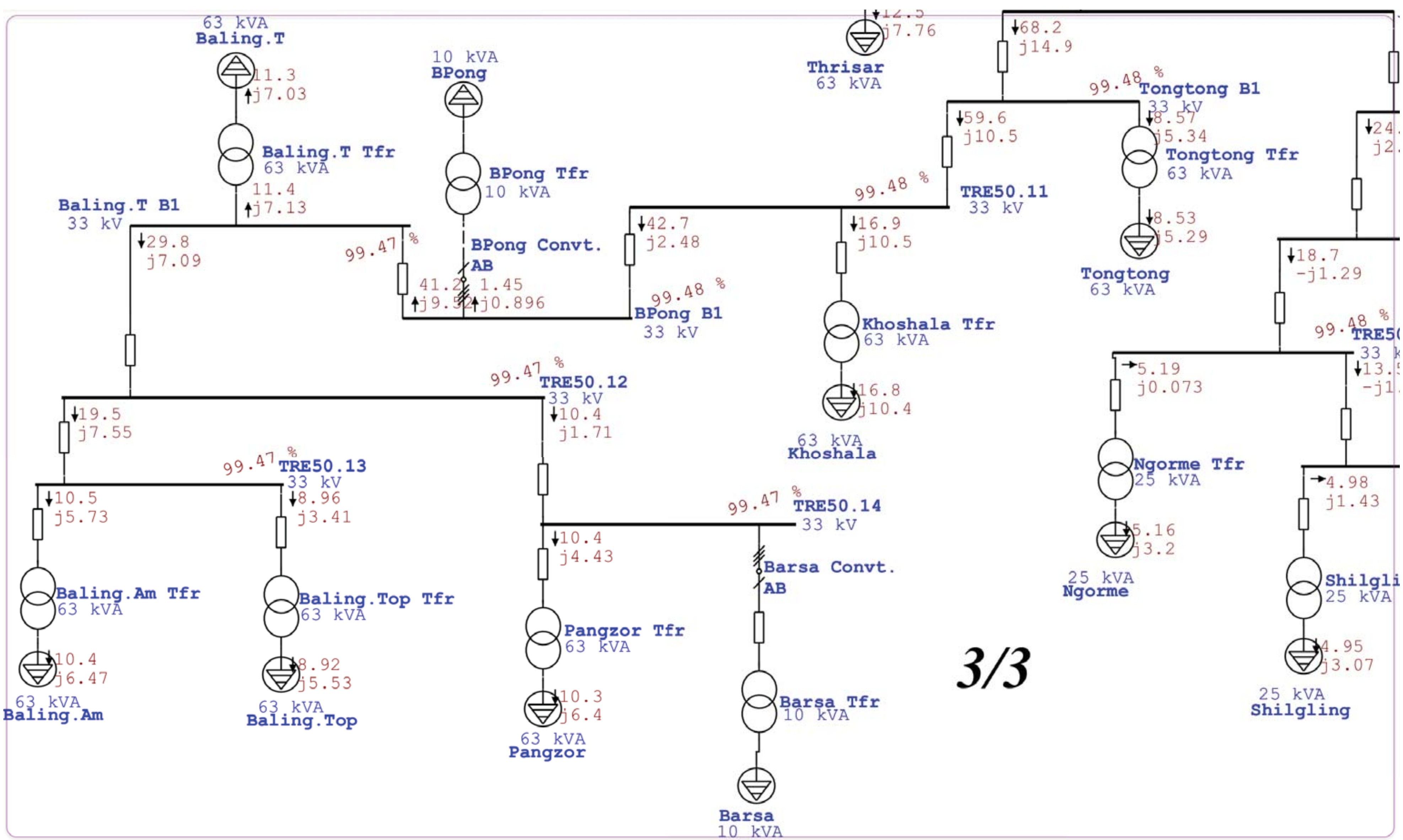




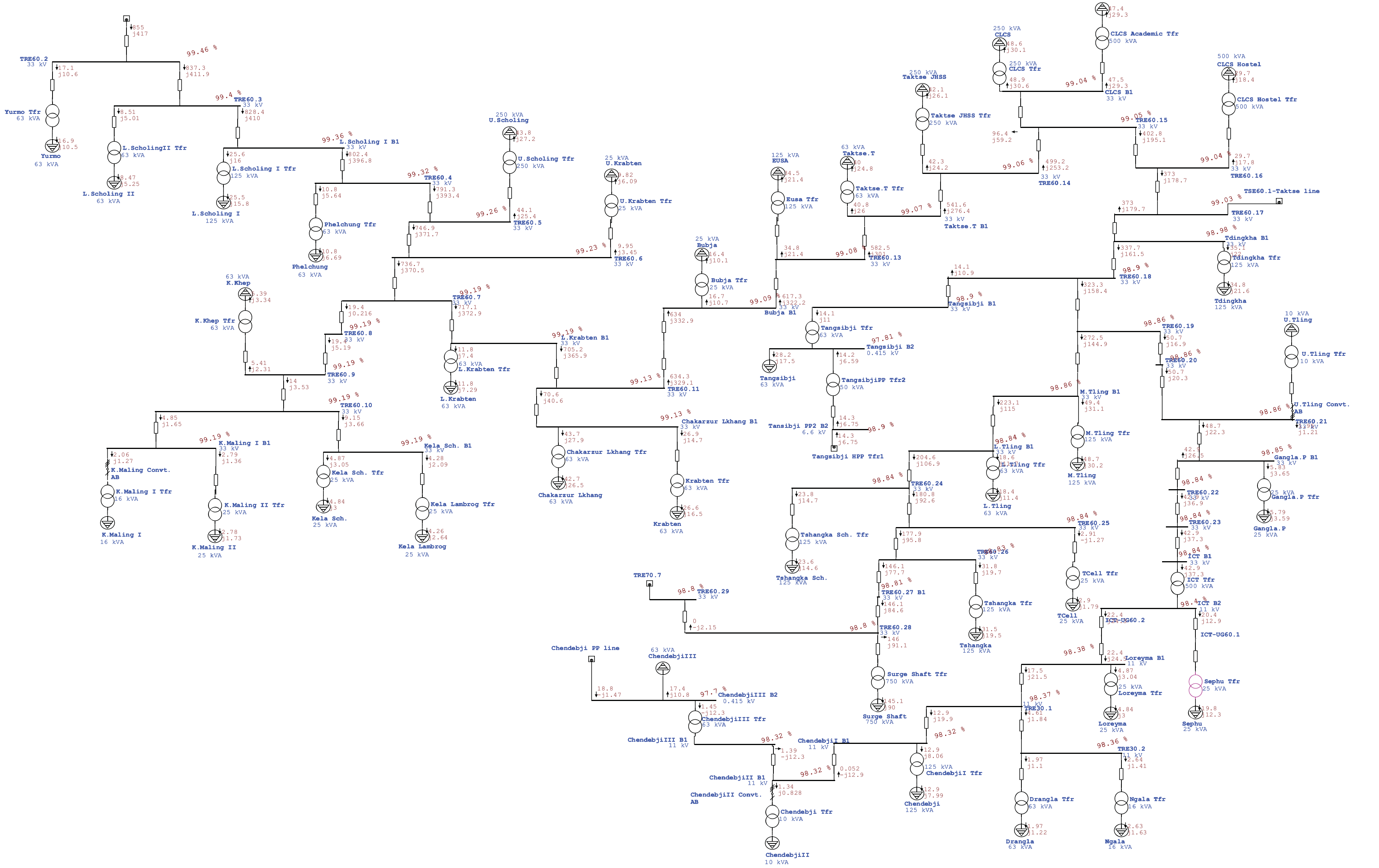
33kV Yurmo B3
312.5
j108.1
99.55 %
TRE50.1
33 kV
7.18
j1.01
305.3
j107.8
B.TCom Tfr
25 kVA
7.12
j4.41
B.TCom
25 kVA
45
j27.7
Indocholing Tfr
125 kVA
44.5
j27.6
Indocholing
125 kVA
99.54 %
TRE50.2
33 kV
260.2
j81
100 kVA
U.Belling
17.2
j10.7
U.Belling Tfr
100 kVA
99.53 %
17.3
j9.53
33 kV
TRE50.3
242.9
j74.2
19.5
j11.6
99.53 %
TRE50.4
33 kV
223.4
j62.9
1/3
99.53 %
L.Belling B1
33 kV
19.5
j12.3
L.Belling Tfr
63 kVA
19.3
j12
L.Belling
63 kVA
100 kVA
Namther
16
j9.89
Namther Tfr
100 kVA
16
j9.39
125 kVA
Gangkhel
25.6
j15.9
125 kVA
99.52 %
25.7
j15.2
33 kV
TRE50.5
181.6
j41.8
99.5 %
Taksila B1
33 kV
158.7
j32.5
22.9
j14.4
63 kVA
Taksila Tfr
22.6
j14
Taksila
63 kVA
99.5 %
TRE50.6
33 kV
41.1
j22.1
117.5
j11.6
99.49 %
TRE50.9
33 kV
104.9
j6.57
12.6
j7.87
63 kVA
Thrisar Tfr

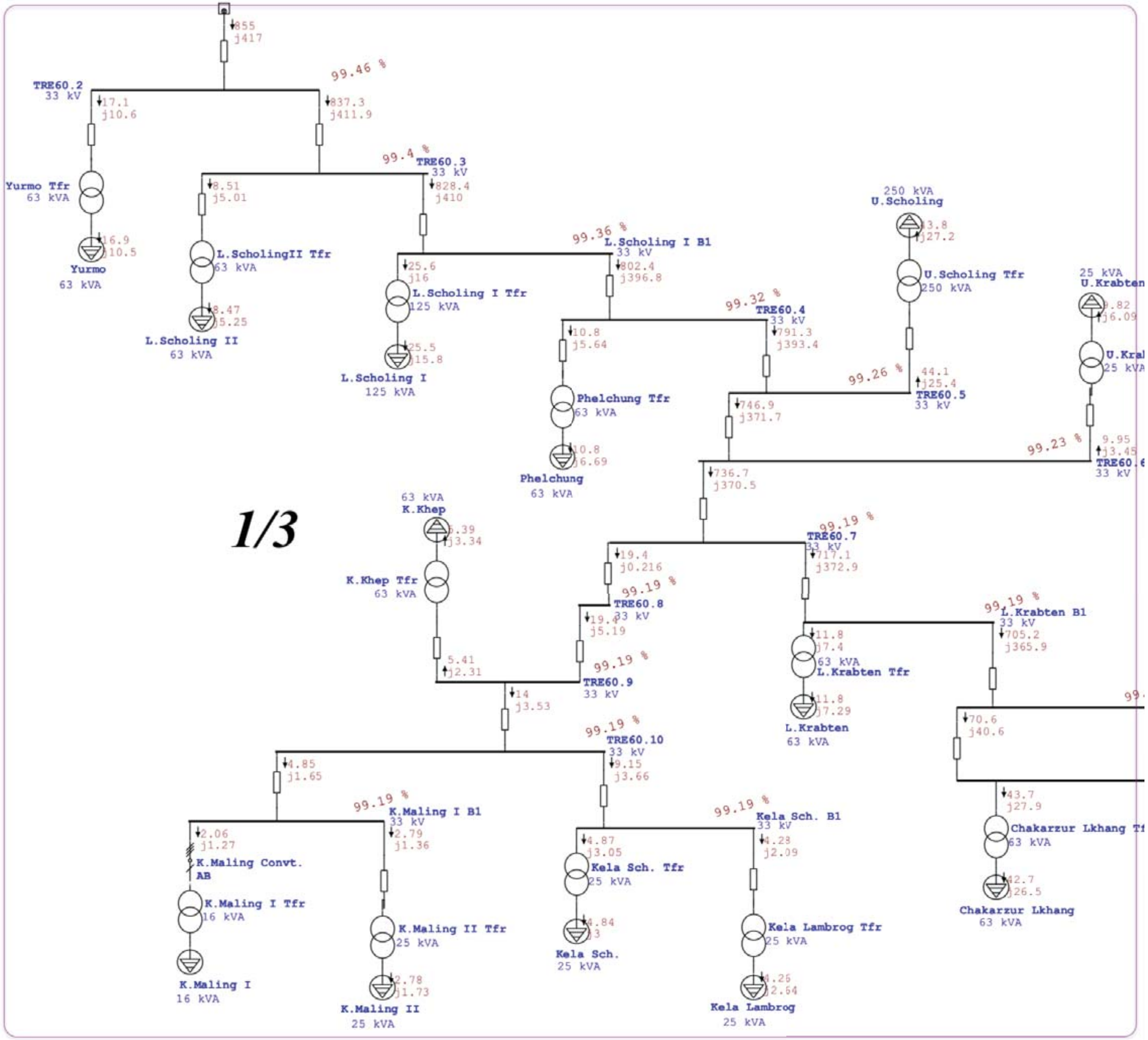


fr
63 kVA
DangdungI
13
j8.04
DangdungI Tfr
63 kVA
63 kVA
Dangdung
22.8
j14.1
Dangdung Tfr
63 kVA
63 kVA
Dangdung BHU
5
j3.1
Dangdung BHU Tfr
63 kVA
13.1
j6.69
99.5 %
23
j14.5
33 kV
TRE50.8
5.02
j3.04
99.5 %
36.1
j20
33 kV
TRE50.7
2/3
16 kVA
Rangthang
1.66
j1.03
Rangthang Tfr
16 kVA
10 kVA
L.Jangbi
1.1
j0.679
99.48 %
TRE50.15
33 kV
12.2
-j6.39
99.48 %
1.66
j0.543
TRE50.16
33 kV
L.Jangbi Tfr
10 kVA
99.48 %
Bazam B1
33 kV
5.91
j3.68
63 kVA
Bazam Tfr
10.5
-j4.01
1.1
-j0.177
99.48 %
33 kV
TRE50.17
9.42
j4.69
5.89
j3.65
Bazam
63 kVA
99.48 %
TRE50.19
33 kV
8.49
-j1.14
U.Jangbi Tfr
63 kVA
9.37
j5.81
63 kVA
U.Jangbi
99.48 %
TRE50.20
33 kV
6.15
j3.57
2.34
j1.45
WanglingII Convt.
AB
WanglingI Tfr
25 kVA
6.11
j3.78
5 kVA
nglingI
WanglingII Tfr
16 kVA
WanglingII
16 kVA

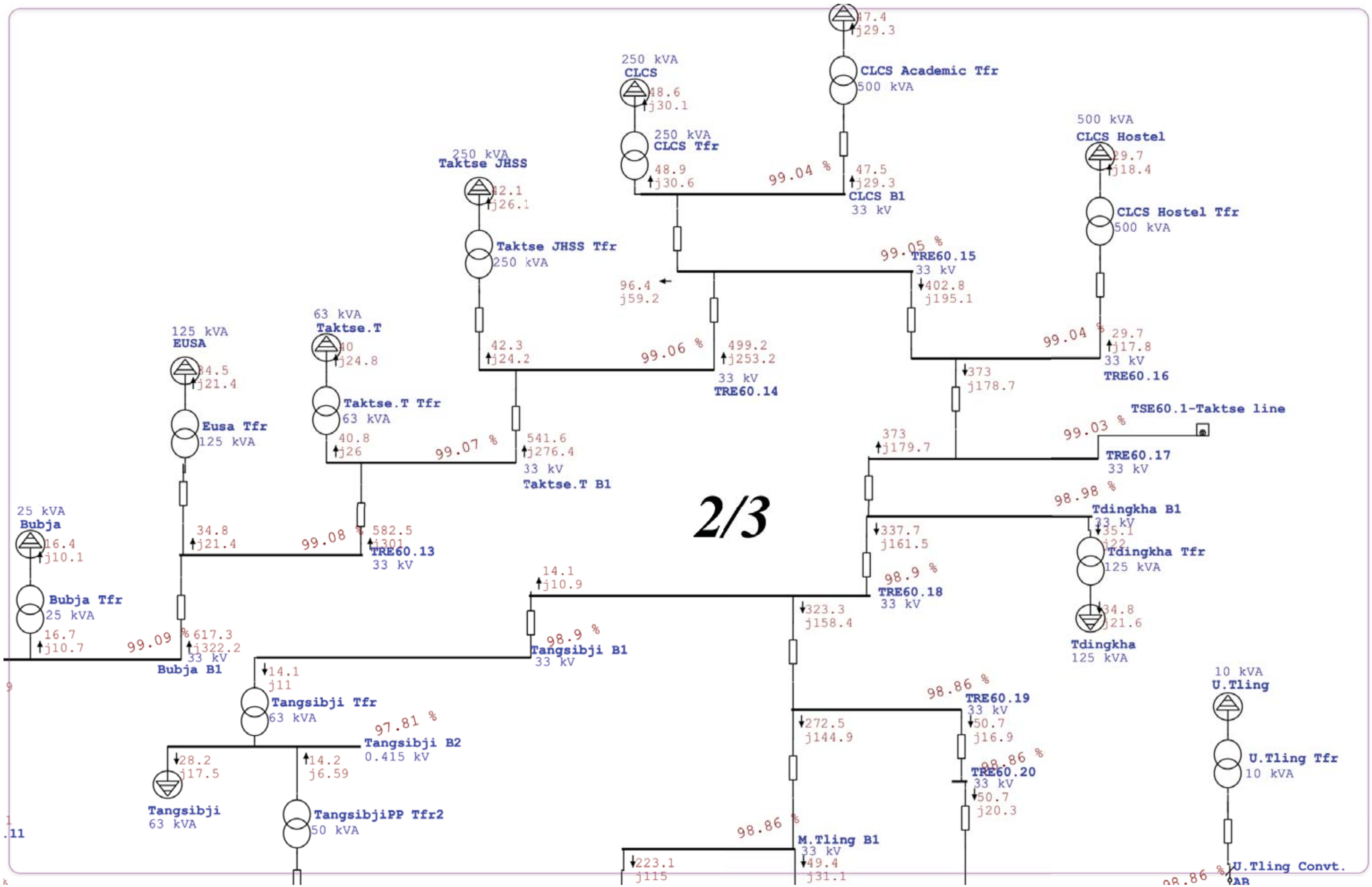

63 kVA
Baling.T
11.3
j7.03
Baling.T Tfr
63 kVA
11.4
j7.13
Baling.T B1
33 kV
29.8
j7.09
99.47 %
10 kVA
BPong
BPong Tfr
10 kVA
BPong Convt.
AB
41.2
j9.32
1.45
j0.896
42.7
j2.48
99.48 %
BPong B1
33 kV
16.9
j10.5
Khoshala Tfr
63 kVA
16.8
j10.4
63 kVA
Khoshala
99.48 %
TRE50.11
33 kV
59.6
j10.5
j7.76
Thrisar
63 kVA
68.2
j14.9
99.48 %
Tongtong B1
33 kV
8.57
j5.34
Tongtong Tfr
63 kVA
8.53
j5.29
Tongtong
63 kVA
18.7
-j1.29
99.48 %
33
5.19
j0.073
Ngorme Tfr
25 kVA
5.16
j3.2
25 kVA
Ngorme
4.98
j1.43
25 kVA
4.95
j3.07
25 kVA
Shilgling
99.47 %
TRE50.12
33 kV
10.4
j1.71
19.5
j7.55
99.47 %
TRE50.13
33 kV
10.5
j5.73
8.96
j3.41
Baling.Am Tfr
63 kVA
10.4
j6.47
63 kVA
Baling.Am
Baling.Top Tfr
63 kVA
8.92
j5.53
63 kVA
Baling.Top
99.47 %
TRE50.14
33 kV
10.4
j4.43
Pangzor Tfr
63 kVA
10.3
j6.4
63 kVA
Pangzor
Barsa Convt.
AB
Barsa Tfr
10 kVA
Barsa
10 kVA
3/3

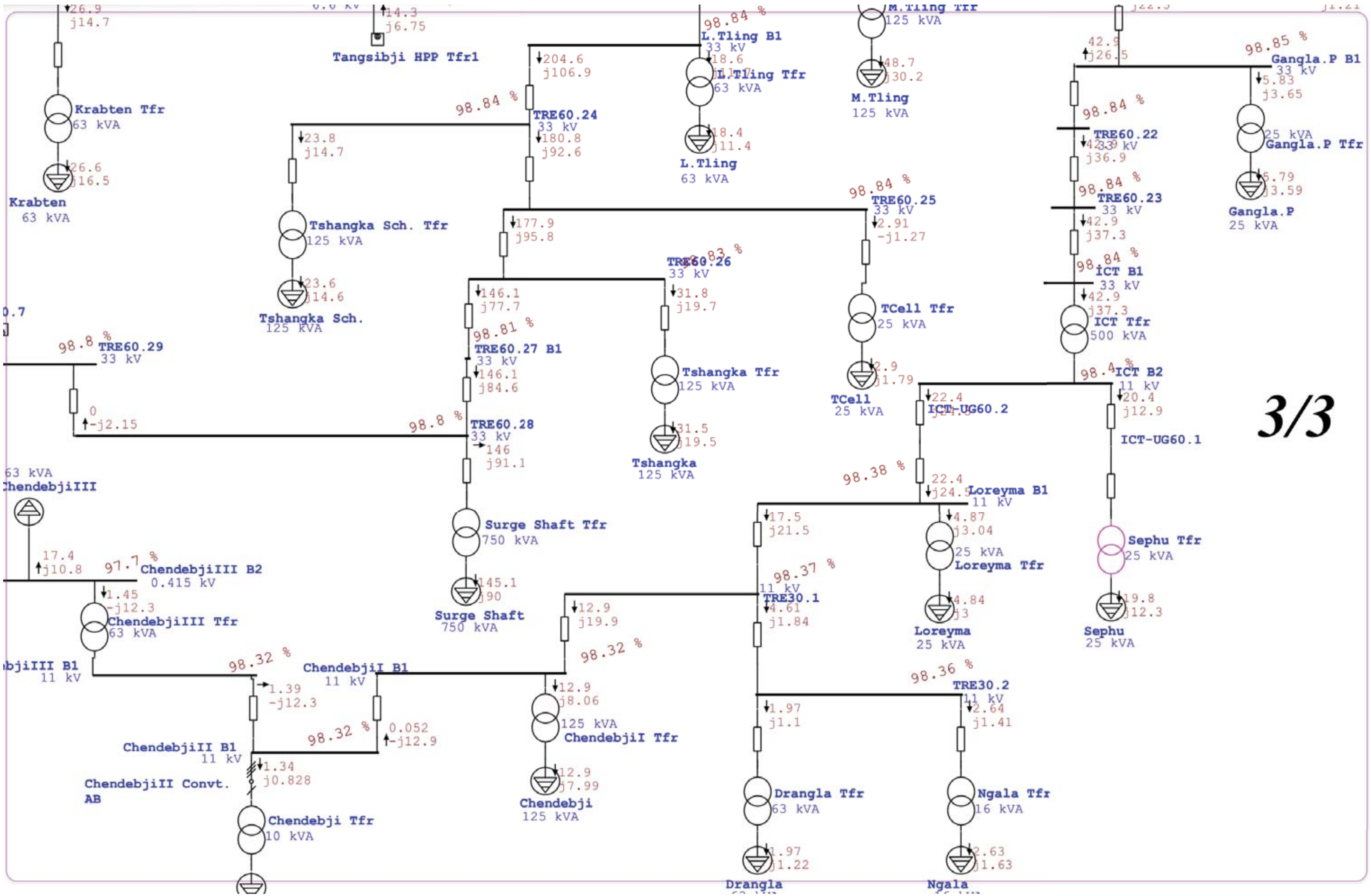
One-Line Diagram - OLV1=>Nikachu Feeder (Load Flow Analysis)





1/3
TRE60.2
33 kV
TRE60.3
33 kV
TRE60.4
33 kV
TRE60.5
33 kV
TRE60.7
33 kV
TRE60.8
33 kV
TRE60.9
33 kV
TRE60.10
33 kV
Yurmo Tfr
63 kVA
Yurmo
63 kVA
L.ScholingII Tfr
63 kVA
L.Scholing II
63 kVA
L.Scholing I B1
33 kV
L.Scholing I Tfr
125 kVA
L.Scholing I
125 kVA
Phelchung Tfr
63 kVA
Phelchung
63 kVA
U.Scholing Tfr
250 kVA
250 kVA
U.Scholing
25 kVA
U.Krabten
L.Krabten B1
33 kV
L.Krabten Tfr
63 kVA
L.Krabten
63 kVA
Chakarzur Lkhang
63 kVA
63 kVA
K.Khep
K.Khep Tfr
63 kVA
Kela Sch. B1
33 kV
Kela Sch. Tfr
25 kVA
Kela Sch.
25 kVA
Kela Lambrog Tfr
25 kVA
Kela Lambrog
25 kVA
K.Maling I B1
33 kV
K.Maling II Tfr
25 kVA
K.Maling II
25 kVA
K.Maling Convt.
AB
K.Maling I Tfr
16 kVA
K.Maling I
16 kVA
99.46 %
99.4 %
99.36 %
99.32 %
99.26 %
99.23 %
99.19 %


2/3
CLCS Academic Tfr
500 kVA
250 kVA
CLCS
250 kVA
CLCS Tfr
CLCS B1
33 kV
99.04 %
500 kVA
CLCS Hostel
CLCS Hostel Tfr
500 kVA
250 kVA
Taktse JHSS
Taktse JHSS Tfr
250 kVA
TRE60.15
33 kV
99.05 %
TRE60.14
33 kV
99.06 %
TRE60.16
33 kV
99.04 %
TSE60.1-Taktse line
TRE60.17
33 kV
99.03 %
125 kVA
EUSA
Eusa Tfr
125 kVA
63 kVA
Taktse.T
Taktse.T Tfr
63 kVA
Taktse.T B1
33 kV
99.07 %
TRE60.13
33 kV
99.08 %
Tdingkha B1
33 kV
98.98 %
Tdingkha Tfr
125 kVA
Tdingkha
125 kVA
TRE60.18
33 kV
98.9 %
25 kVA
Bubja
Bubja Tfr
25 kVA
Bubja B1
33 kV
99.09 %
Tangsibji B1
33 kV
98.9 %
Tangsibji Tfr
63 kVA
Tangsibji B2
0.415 kV
97.81 %
Tangsibji
63 kVA
TangsibjiPP Tfr2
50 kVA
TRE60.19
33 kV
98.86 %
TRE60.20
33 kV
98.86 %
M.Tling B1
33 kV
98.86 %
10 kVA
U.Tling
U.Tling Tfr
10 kVA
U.Tling Convt.
AR
98.86 %


3/3
Krabten Tfr
63 kVA
Krabten
63 kVA
Tangsibji HPP Tfr1
TRE60.24
33 kV
L.Tling B1
33 kV
L.Tling Tfr
63 kVA
L.Tling
63 kVA
M.Tling
125 kVA
Gangla.P B1
33 kV
Gangla.P Tfr
25 kVA
Gangla.P
25 kVA
TRE60.22
TRE60.23
ICT B1
ICT Tfr
500 kVA
ICT B2
11 kV
ICT-UG60.1
ICT-UG60.2
Tshangka Sch. Tfr
125 kVA
Tshangka Sch.
125 kVA
TRE60.25
33 kV
TCell Tfr
25 kVA
TCell
25 kVA
TRE60.26
33 kV
Tshangka Tfr
125 kVA
Tshangka
125 kVA
TRE60.27 B1
33 kV
TRE60.28
33 kV
TRE60.29
33 kV
Surge Shaft Tfr
750 kVA
Surge Shaft
750 kVA
Loreyma B1
11 kV
Loreyma Tfr
25 kVA
Loreyma
25 kVA
Sephu Tfr
25 kVA
Sephu
25 kVA
TRE30.1
11 kV
TRE30.2
11 kV
Drangla Tfr
63 kVA
Drangla
Ngala Tfr
16 kVA
Ngala
ChendebjiIII
63 kVA
ChendebjiIII B2
0.415 kV
ChendebjiIII Tfr
63 kVA
ChendebjiIII B1
11 kV
ChendebjiI B1
11 kV
ChendebjiI Tfr
125 kVA
Chendebji
125 kVA
ChendebjiII B1
11 kV
ChendebjiII Convt.
AB
Chendebji Tfr
10 kVA

Location	AAAC conductor (Line length Km)					ACSR Conductor (Line length Km)					
	150 sq mm, 3P	111.3 sqmm, 3P	111.3 sqmm, 1P	49.48 sq mm, 3P	49.48 sq mm, 1P	Dog, 3 P	Dog, 1P	Rabbit, 3P	Rabbit, 1P	XLPE 3P	CCOC 3P
Bumthang Feeder-33 kV											
Kewathang to Yotula Bumthang Interconnection	9.150										
Korphu Feeder - 33 kV											
Wangdigang 4 pole to Nimshong LBS		1.777									
LBS to Nimshong I tapping		0.023									
Nimshong I tapping to Nimshong III Tapping		0.152									
Nimshong III tapping to Nimshong I s/s		0.071									
Nimshong I s/s to Nimshong II s/s		0.091									
Nimshong III tapping to Nimshong III s/s		0.097									
Nimshong I tapping to Nimshong IV tapping		0.065									
Nimshong IV tapping to Nimshong IV s/s		0.064									
Nimshong IV tapping to Nimshong V s/s		0.081									
Nimshong V s/s to Nimshong VI s/s		0.137									
Nimshong VI s/s to Nimshong VII tapping		0.038									
Nimshong VII tapping to Nimshong VII s/s		0.040									
Nimshong VII tapping to Nimshong VIII tapping		0.056									
Nimshong VIII tapping to Nimshong VIII s/s		0.051									
Nimshong VIII tapping to LBS		0.114									
Nimshong LBS to Pam Kharandung Tapping		6.485									
Pamkharangdung tapping to Pam kharangdung s/s					0.030						
Pamkharangdung tapping to Korphu Tapping		0.491									
Korphu Tapping to Korphu LBS		0.208									
Korphu LBS to Korphu I s/s		1.467									
Korphu I s/s to Korphu II tapping		0.265									
Korphu II tapping to Korphu II s/s					0.027						
Korhpu II s/s to Korphu III s/s					0.039						
Korphu III s/s to Korphu IV s/s					0.038						
Korphu II tapping to Korphu V s/s		0.057									
Korphu V s/s to Korphu VI s/s		0.075									
Korphu VI s/s to Dingling tapping		0.099									
Dinling Tapping to Korphu VII s/s		0.019									
Korphu VII s/s to Korphu VIII s/s					0.119						
Dingling tapping to Dinling s/s					1.153						
Korphu tapping to Nabji LBS		0.177									
Nabji LBS to Nabji I s/s		0.633									
Nabji I s/s to Nabji II s/s		1.383									
Nabji II s/s to Nabji III tapping		0.034									
Nabji III tapping to Nabji III s/s		0.197									
Nabji III s/s to Nabji IV s/s		0.040									
Nabji III tapping to Nabji V s/s		0.072									
Nabji V s/s to Nabji VI s/s		0.194									
Langthel Feeder -33 kV											
Yormu 132/33 s/s to BT tapping						0.232					
BT Tapping to BT S/s (Deposit Work)						1.120					
BT Tapping to Indocholing tapping						0.326					
Indocholing tapping to Indocholing s/s								0.200			
Indocholing tapping to U. Belling tapping						0.875					
U. Belling Tapping to U. Belling S/s								0.408			
U. Belling Tapping to L. Belling Tapping						0.094					
L/Belling Tapping to L.belling s/s								0.221			
L. Belling s/s to Bashiling s/s									0.622		
L. Belling Tapping to Namther Tapping						1.121					
Namther Tapping to Namther s/s								0.212			
Namther Tapping to Gangphel S/s								0.306			
Namther Tapping to Taksila s/s						1.643					
Taksila s/s to Thrisa Tapping						0.413					
Thrisa Tapping to Dangdung BHU Tapping								0.320			

Location	AAAC conductor (Line length Km)					ACSR Conductor (Line length Km)					
	150 sq mm, 3P	111.3 sqmm, 3P	111.3 sqmm, 1P	49.48 sq mm, 3P	49.48 sq mm, 1P	Dog, 3 P	Dog, 1P	Rabbit, 3P	Rabbit, 1P	XLPE 3P	CCOC 3P
Dangdung BHU Tapping to Dangdung BHU s/s								0.026			
Dangdung BHU Tapping to Dangdung s/s								0.396			
Dandung s/s to Dangdung I s/s								0.500			
Thrisa Tapping to Thrisa s/s								0.948			
Thrisa s/s to Thrisa LBS								0.551			
Thrisa LBS to Bazam LBS tapping								0.178			
Bazam LBS Tapping to Bazam LBS						0.118					
Bazam LBS to Bazam tapping						0.512					
BazamTapping to Bazam s/s						0.056					
Bazam Tapping to Rangthang Tapping								0.993			
Rangthang Tapping to Rangthang s/s								0.167			
Rangthang Tapping to Lower Jangbi tapping								2.889			
Lowe Jangbi tapping to Lower Jangbi s/s								0.292			
Lower Jangbi Tapping to Upper.Jangbi s/s								0.400			
Bazam s/s to Ngormey tapping		0.077									
Ngormey tapping to Ngormey s/s		1.026									
Ngormey tapping to Shingling tapping		0.457									
Shingling Tapping to Shinling S/s		0.545									
Shingling tapping to Wangling I tapping		1.991									
Wangling I tapping to Wangling I S/s		0.092									
Wangling I Tapping to Wangling II S/s			0.599								
Bazam LBS Tapping to Tontongphey s/s								0.332			
Tongtong phey s/s to Koshala LBS						0.608					
Koshala LBS to Koshala tapping						0.195					
Koshala tapping to Koshala S/s						0.032					
Koshala tapping to Barpong s/s						2.546					
Barpong s/s to Baling Trongther LBS						1.165					
Baling Trongher LBS to Baling Trongther S/s						0.342					
Baling Trongher s/s to Pangzur Tapping						0.695					
Pangzur tapping to Baling Amling tapping						0.511					
Baling Amling tapping to Baling Amling S/s						0.262					
Baling Amling Tapping to Baling Top s/s						0.699					
Pangzur tapping to Barsa tapping						0.874					
Barsa tapping to Barsa s/s									0.909		
Barsa tapping to Pangzur s/s						0.655					
Sembjee Feeder-33 kV											
Kewathang to Yangkhil tapping						3.685					
Yangkhil tapping to Yangkhil S/s						0.329					
Yangkhil tapping to Semji I tapping						2.452					
Semji I tapping to Sembji I S/s						0.138					
Semji I Tapping to Semji II tapping						0.951					
Semji II tapping to Semji II S/s						1.138					
Semji II tapping to Bjee LBS						0.317					
Bjee LBS to Bjeepam Wongma I Tapping						0.389					
Bjeepam Wongma I Tapping to Bjee Pam Wongma I s/s						1.509					
Bjeepam Wogma I s/s to Bjeepam Wogma II s/s						0.611					
Bjeepam Wogma II s/s to Veiw point resort tapping						1.575					
View point tapping to View point S/s						0.651					
View point Tapping to View point LBS						0.053					
View point LBS to Thongmangdrak tapping						0.219					
Thongmangdrak tapping to Thongmangdrak S/s						0.020					
Thongmangdrak tapping to Power House UG tappping						0.691					
Power House UG tapping to Power House S/s										0.067	
Bjeepam Wongma I Tapping to Bjee Pam Gongma tapping						0.446					
Bjeepam Gongma tapping to Bjeepam Gongma s/s								0.328			
Bjeepam Gongma tapping to Bjee zam tapping						0.579					
Bjee zam tapping to Bjee zam S/s						0.066					
Bjeepam gongma tapping to Bjee Proper s/s								1.297			
Bjeezam tapping to Aromatic S/s (Deposit)						0.251					
Semji I s/s to Semji I LBS								0.173			

Location	AAAC conductor (Line length Km)					ACSR Conductor (Line length Km)					
	150 sq mm, 3P	**111.3 sqmm, 3P**	**111.3 sqmm, 1P**	**49.48 sq mm, 3P**	**49.48 sq mm, 1P**	**Dog, 3 P**	**Dog, 1P**	**Rabbit, 3P**	**Rabbit, 1P**	**XLPE 3P**	**CCOC 3P**
Semji LBS to Karshong school tapping								3.252			
karshong school tapping to Gagar Choshi tapping								0.767			
Gagar Choshi tapping to Gagar Choshi S/s								0.084			
Gagar choshi tapping to Gagar Pam s/s								0.952			
Karshong school tapping to Karshong school s/s								0.990			
Karshong school to Karshong Shedra s/s								0.830			
Kashong shedra to Karshong pam tapping								0.523			
Karshong pam tapping to Karshong Trong tapping								0.924			
karshong Trong Tapping to Karshong Trong S/s								0.429			
Karshong Trong Tapping to Thrispang s/s								1.404			
Thrispang s/s to Jongthang s/s								2.908			
Karshong Pam tapping to Karshong pam s/s								0.315			
Karshong pam S/s to Pang LBS								1.282			
Pang LBS to Lower pang tapping								0.043			
Lower pang tapping to Lower Pang s/s									0.130		
Lower Pang s/s to Upper pang s/s									1.015		
Lower Pang tapping to Chela tapping 1								1.666			
Chela tapping 1 to Bemji tapping								0.152			
Bemji tapping to Bemji S/s								0.335			
Chela tapping 1 to Chela tapping								1.674			
Chela tapping to Chela s/s								0.205			
Chela s/s to Zelu Gompa									1.163		
Chela tapping to Kakaling s/s								1.119			
Kakaling s/s to Drenshing s/s								1.155			
Bemji tapping to Kaba Organice farm tapping								1.445			
Kaba Organic farm tapping to Kaba S/s								0.528			
Kaba Organic farm tapping to Kaba Organic farm s/s								0.006			
Kaba s/s to Daba s/s								0.452			
Daba s/s to Simphu School s/s								1.232			
Simphu School s/s to Simjuling tapping								0.907			
Simjuling tapping to Simjuling s/s									0.191		
Simjuling tapping to Simphu tapping								1.060			
Simphu tapping to Simphu S/s								0.053			
Simphu tapping to Simphu Goenpa tapping								0.945			
Simphu Goenpa tapping to Simphu Goenpa S/s								0.142			
Simphu Goenpa tapping to Thangyel s/s									0.500		
Taktse Feeder - 33 kV											
Kewathang to chunjapang tapping						3.121					
Chunjapang tapping to chunjapang S/s								0.013			
Chunjapang tapping to Chunjapang LBS						2.202					
Chunjapang LBS to Tashidingkha tapping						3.224					
Tashidingkha tapping to Tashidingkha s/s								1.327			
Tashidingkha tapping to CLCS 1 Hostel tapping						0.331					
CLCS 1 Hostel tapping to CLCS 2 tapping						0.451					
CLCS 2 tapping to Taktse JHSS tapping						0.366					
Taktse JHSS tapping to Taktse JHSS S/s						0.716					
CLCS 1 Hostel Tapping to CLCS Hostel s/s								0.236			
CLCS 2 Tapping to CLCS S/s								0.164			
Acadamic 1 ss to CLCS Acadamic s/s								0.090			
Tatsi JHSS tapping to Taksi Top s/s						0.333					
Taksi Top s/s to Eusa Tapping						0.515					
Esa tapping to Eusa s/s								0.165			
Eusa tapping to Bubja s/s						1.576					
Bubja s/s to Bubja LBS						1.280					
Bubja LBS to Lower Kungarabten tapping						0.044					
Lower Kungarabten tapping to Lower Kungarabten S/s						1.313					
Lower kungarabten tapping to Chakarzur Lhakhang s/s											0.637
Chakarzur Lhakhang s/s to Kungarabten S/s											0.754
L. Kungarabten s/s to Kela LBS tapping						0.131					
Kela LBS tapping to Upper Kungarabten tapping						0.914					

Location	AAAC conductor (Line length Km)					ACSR Conductor (Line length Km)					
	150 sq mm, 3P	111.3 sqmm, 3P	111.3 sqmm, 1P	49.48 sq mm, 3P	49.48 sq mm, 1P	Dog, 3 P	Dog, 1P	Rabbit, 3P	Rabbit, 1P	XLPE 3P	CCOC 3P
U. Kuengarabten tapping to U. Kuengarabten s/s								0.962			
U.Kuengarabten Tapping to U.Samcholing tapping						0.816					
U. Samcholing tapping to U. Samcholing S/s						0.670					
U. Samcholing Tapping to Phelchung Tapping						1.316					
Pelchung tapping to Pelchung S/s						0.364					
Phelchung tapping to L.Samcholing I s/s						0.793					
L. Samcholing I s/s to L.Samcholing II tapping						1.003					
L. Samcholing II tapping to L.Samcholing II S/s						0.095					
L.Samcholing II tapping to Yurmo tapping						1.116					
Yurmoo tapping to Yurmo S/s						0.043					
Kela LBS tapping to Kela LBS		1.618									
Kela LBS to Kela Khep tapping		0.211									
Kela khapTapping to kelakahp s/s								0.358			
Kelakhap tapping to Kela Maling I tapping		0.578									
Kela Maling I Tapping to Kela Maling I s/s								0.337			
Kela Maling I S/s to Kela Maling II S/s								0.130			
Kela Maling I tapping to Kela School S/s		0.481									
Kela School S/s to Kela Lambrog		0.188									
Tashidingkha to Tashidingkha ARCB								0.045			
Tashidingkha ARCB to Tashidingkha LBS								0.068			
Tashidingkha LBS to Tangsibji tapping								2.630			
Tangsibji tapping to Tashiling LBS								0.763			
Tashiling LBS to Mid Tashiling LBS/Upper Tashiling LBS tapping								0.387			
Tangsibjee tapping to Grid Transformer(Tangsibji S/s)						0.057					
Mid Tashiling LBS/Upper Tashiling LBS tapping to Mid Tashiling LBS		0.180									
Mid Tashiling LBS to Mid Tashiling s/s		0.236									
Mid Tashiling s/s to Lower Tashiling S/s		1.172									
Tshangkha School taping to Tshangkha School s/s				-				0.052			
L.Tashiling to Tshangkha school tapping		0.121									
Tshangkha school tapping to Tashicell tapping		0.646									
Tashi Cell tapping to Tshangkha tapping		0.521									
Tshangkha tapping to Tshangkha S/s		0.069									
Tashi cell tapping to Tashi cell S/s											
Mid tashiling /Upper Tashiling LBS tapping to Upper Tashiling LBS		2.040									
Upper Tashiling LBS to Upper Tsahling tapping		0.148									
U.Tashiling Tapping to U. Tashiling s/s									0.202		
U.tashiling Tapping to Ganglapokto s/s		2.547									
Interconnection 33 kV line											
Tsangkha tapping tapping to Shurge shaft tapping						3.678					
Shurge shaft tapping to Shurge shaft S/s						0.033					
Shurge shaft tapping to View point LBS						0.700					
Ganglapokto s/s to Ganglapokto LBS						0.014					
Ganglapokto LBS to Wangdue line tapping						3.369					
Wangdue Line tapping to Dam tapping						0.135					
Dam tapping to Dam s/s						0.024					
Wangdi LineTapping to Chuserboo (Wangduephodrang)								8.546			
132/33 s/s Yurmoo to Yurmo s/s tapping						1.962					
Dam tapping to ICT at THyE Dam								0.016			
Total A 33kV Line	**9.150**	**29.697**	**0.599**	**-**	**1.406**	**63.869**	**-**	**55.205**	**4.732**	**0.067**	**1.391**
Chendibjee 11 kV feeder											
ICT at THyE Dam to ICT LBS 1										0.009	
ICT LBS 1 to Sephuchen s/s								0.760			
ICT at THyE Dam to ICT LBS 2										0.010	
ICT LBS 2 to Loreyma s/s								0.915			
Loremay to Ngala-Drabgla LBS Tapping								0.691			
Ngala-Drangla LBS Tapping to Ngala-Drangla LBS								0.152			
Ngala-Drangla LBS to Drangla Tapping								1.945			
Drangla Tapping to Ngala Goenpa								0.738			

Location	AAAC conductor (Line length Km)					ACSR Conductor (Line length Km)					
	150 sq mm, 3P	111.3 sqmm, 3P	111.3 sqmm, 1P	49.48 sq mm, 3P	49.48 sq mm, 1P	Dog, 3 P	Dog, 1P	Rabbit, 3P	Rabbit, 1P	XLPE 3P	CCOC 3P
Drangla tapping to Drangla S/s								0.382			
Ngala-Drangla LBS Tapping to Chendibjee I LBS								1.819			
Chendebji I LBS to Chendebji I S/s								1.001			
Chendibjee I S/s to Chendibjee II s/s								0.680			
Chendibjee II s/s to Chendibjee III s/s								0.693			
Trongsa 11 kV feeder											
Kawathang 33/11 s/s to 4 Pole								0.511			
4 Pole to Mazadumsum LBS								0.135			
Mazadumsum LBS to Mazadumsum tapping								0.118			
Mazadumsum tapping to Mazadumsum S/s								0.088			
Mazadumsum Tapping to Dorji Goenpa s/s								1.670			
4 Pole to Bagochen tapping								0.257			
Bagochen Tapping to Bagochen S/s								0.143			
Bagochen Tapping to LBS								0.111			
LBS to DoR tapping								0.178			
DoR Tapping to DoR s/s								0.188			
DoR Tapping to Tadzong s/s								0.078			
Tadzong s/s to Town tapping								0.431			
Town Tapping to Town S/s								0.149			
Town Tapping to USS Dzong tapping								0.251			
USS Dzong tapping to 11 kV UG Point								0.161			
11kV UG point to USS Dzong S/s										0.204	
USS Dzong tapping to Hospital tapping								0.119			
Hospital tapping to Hospital S/s								0.068			
Hospital tapping to Sherabling s/s								0.117			
Sherabling s/s to Sherabling High School s/s								0.179			
Sherabling High School to RMU tapping								0.380			
RMU tapping to Villing S/s								0.399			
Villing s/s to proposed Taskabi s/s								1.557			
Taskabi s/s to Taphey Goenpa								0.450			
Kewathang s/s (trongsa feeder 2) to 11kV UG										0.030	
11kV UG point to RMU UG point								2.591			
RMU UG point to RMU UG										0.012	
RMU tapping to RMU (11kV Ring)										0.017	
Total B	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**20.105**	**-**	**0.282**	**-**
Total	**9.150**	**29.697**	**0.599**	**-**	**1.406**	**63.869**	**-**	**75.310**	**4.732**	**0.349**	**1.391**

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

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

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

1. Load Forecast

1.1 Type of Load Forecast and Power System Planning

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

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

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

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

1.2 Methods of Load (LTLF) Forecast

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

1.2.1 Trend Analysis

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

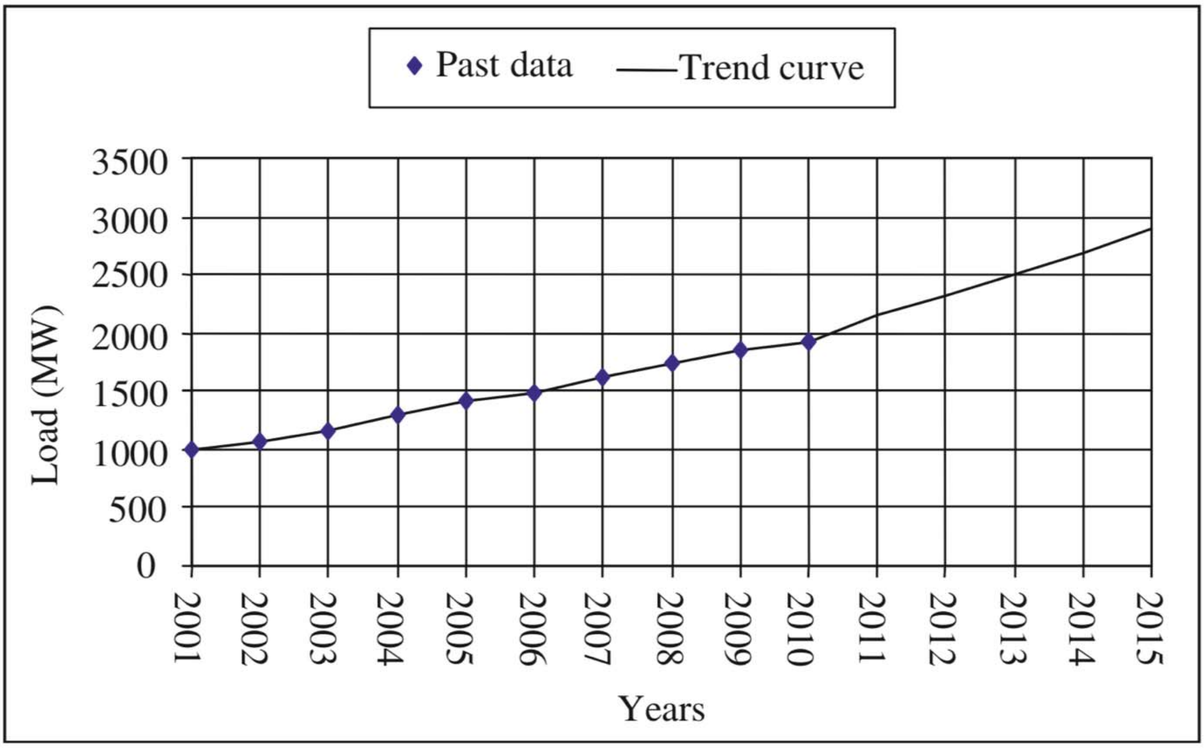


Figure 1: Typical trend curve[1]

1.2.2 Economic Modelling

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

1.2.3 End-use Analysis

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

1.2.4 Hybrid Analysis

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

1.3 Trend Line Analysis

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

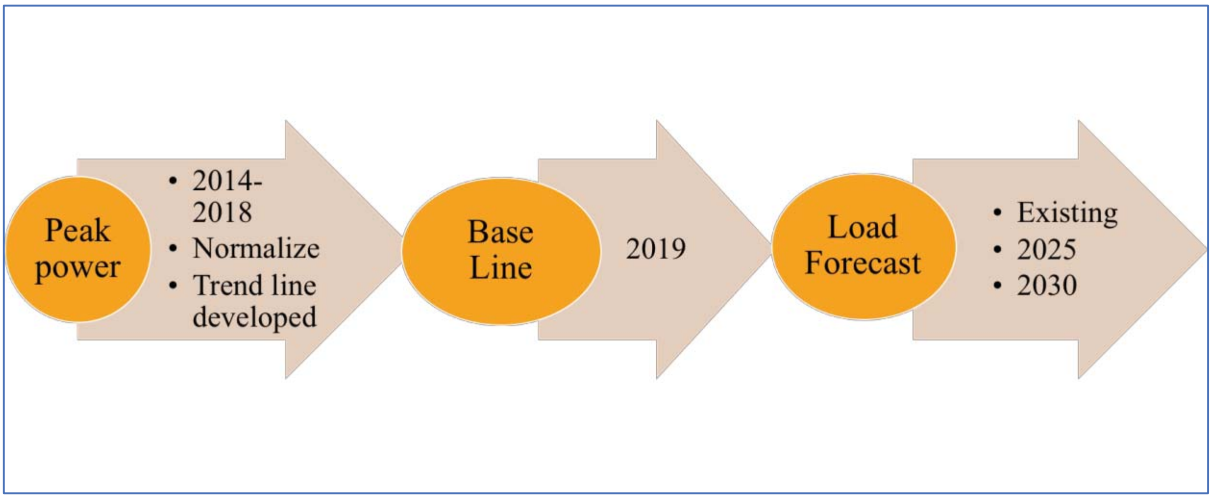


Figure 2: Flow diagram for load forecast

1.3.1 Normalizing the Data

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

Table 1: Actual power data of Punakha Dzongkhag

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

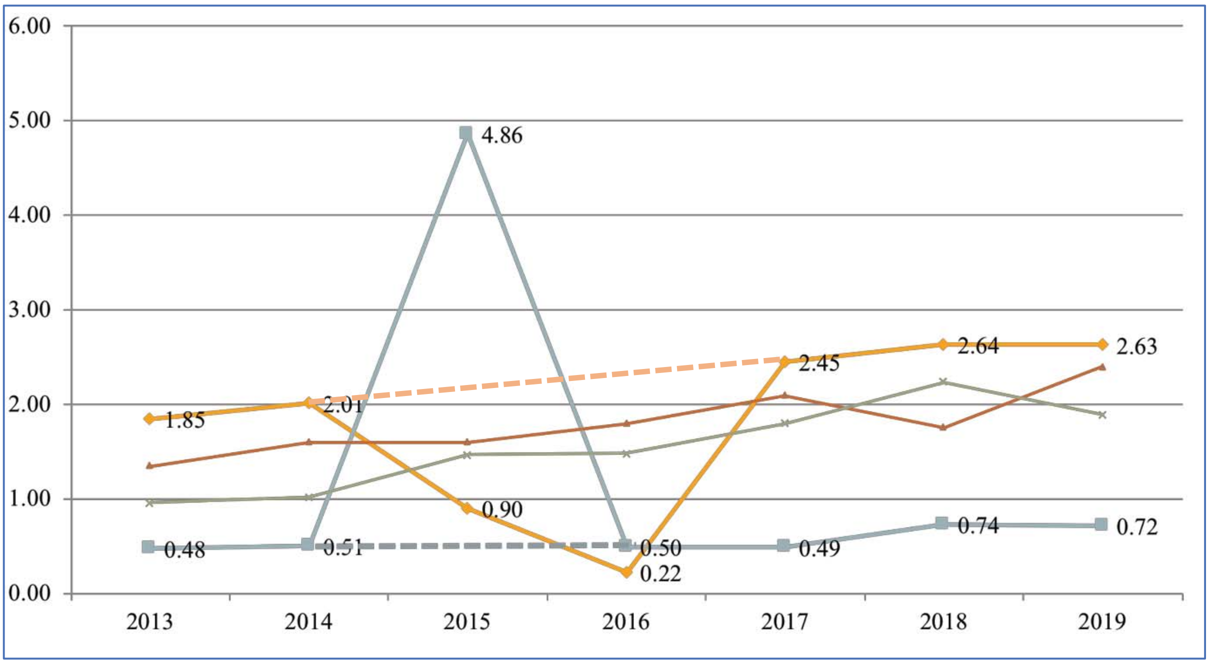


Figure 3: Actual data of Punakha Dzongkhag

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

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

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

Table 2: Normalized power data of Punakha Dzongkhag

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

1.3.2 Trend Line and Load Forecast

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

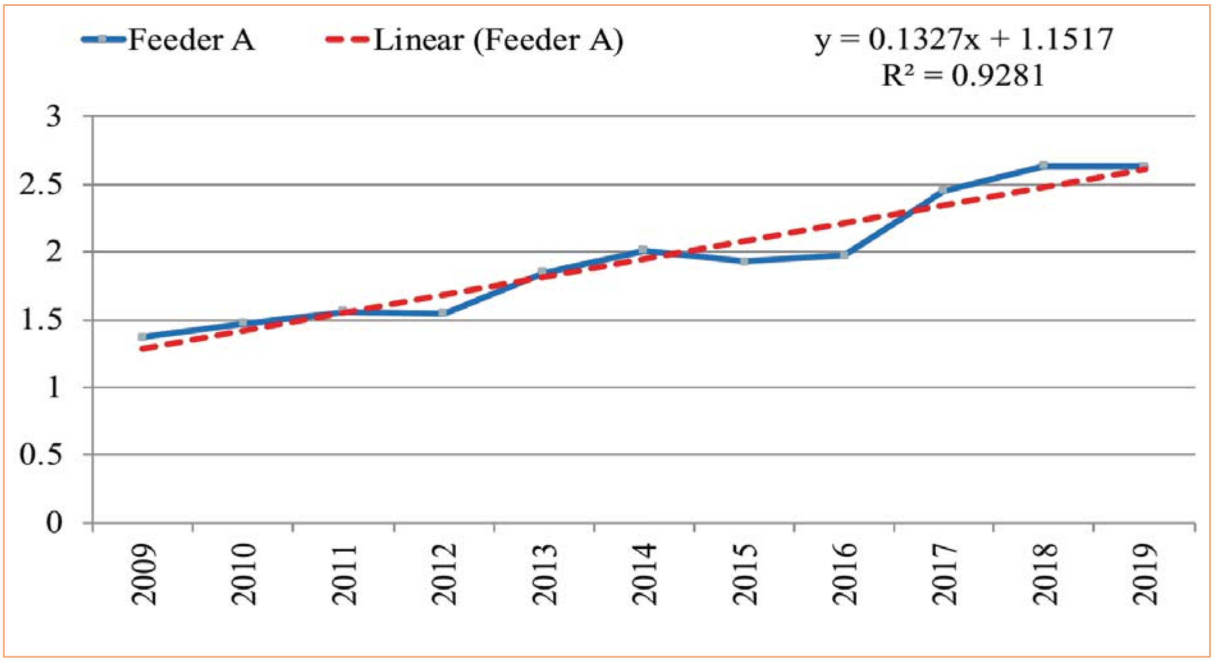


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$y = ax + b$

$Where:$

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

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

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

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

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

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

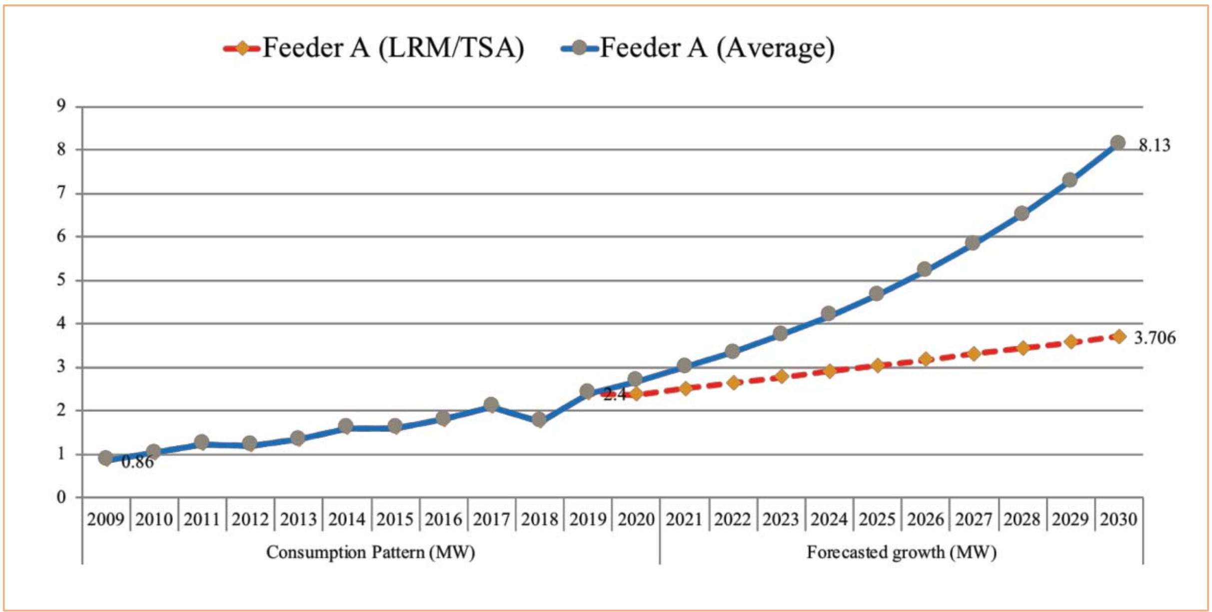


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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

2.1 ETAP Software

"**ETAP** is an analytical engineering solution tool specializing in the simulation, design, monitoring, control, operator training, optimizing, and automating power systems[3]. ETAP's integrated digital platform offers the best comprehensive suite of enterprise solutions."
ETAP software is used in DSMP for modelling/designing, network simulation and to carry out the technical evaluation for distribution power system. The modelled network is fed with the essential data (such as specifications, constraints and parameters for network components) and the simulation results are assessed and analysed. Conclusively, different measures are considered and performed in ETAP for improving the efficiency of a system.

2.2 Load Flow Analysis (ETAP)

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

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

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

2.2.1 Creating the Library

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

a) Transmission Cable

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

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

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

c) Set Loading and Generation Categories.

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

2.2.2 Network Modelling and Load Flow Analysis

a) Draw Distribution Network (SLD).
b) Enter the height=8 and spacing =1.25 in the Transmission line table.
c) Enter the electrical parameters (kW, kVA, kV, etc.) ratings for power sources, transformers, line type, bus kV and loading details.

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

2.3 Consideration/Assumptions made while simulating in ETAP software

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

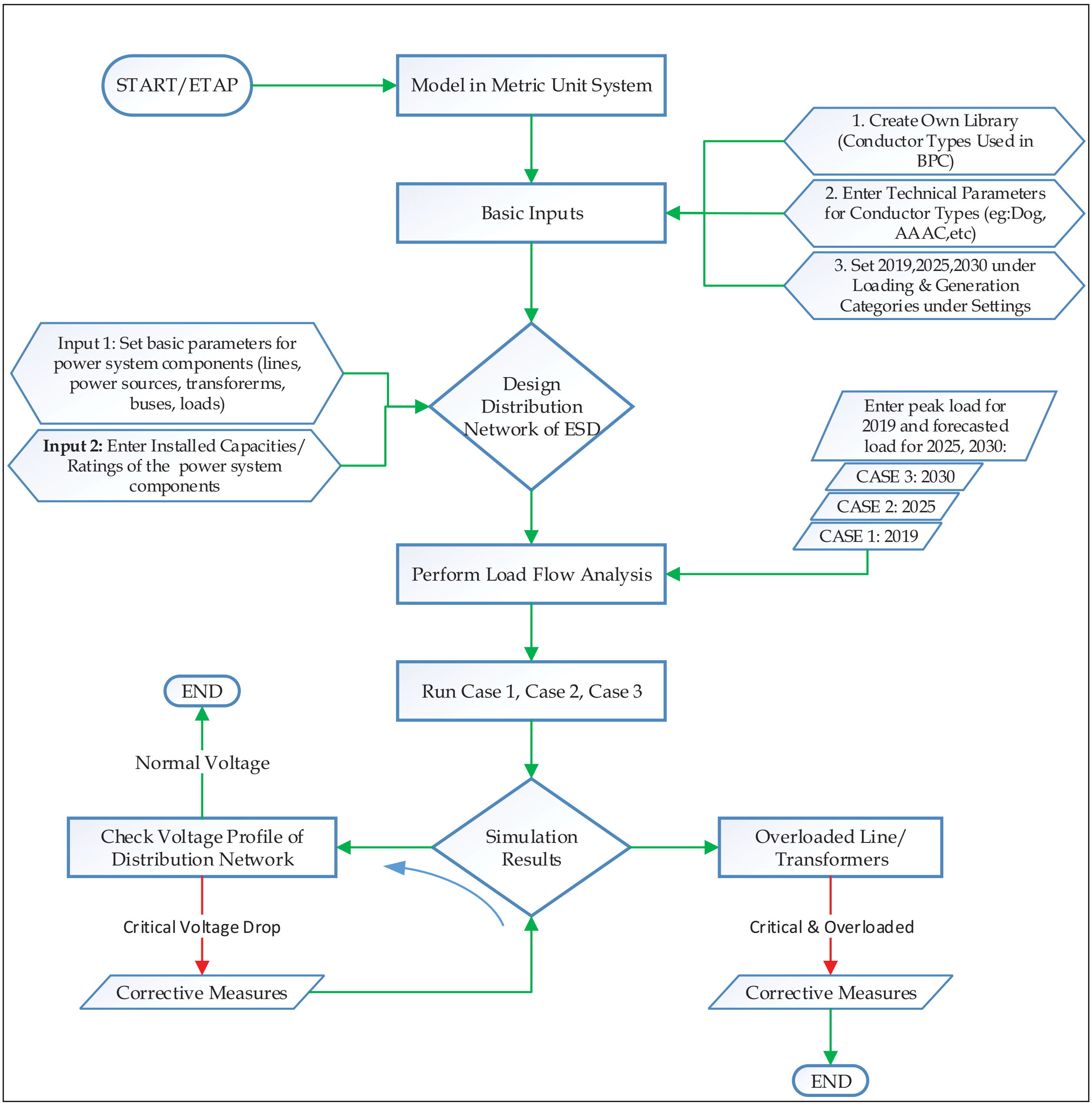


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

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

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

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

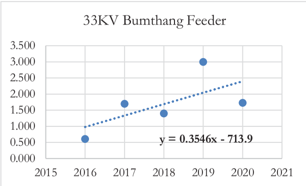
33/11kV, 2.5MVA Substation, Kewathang

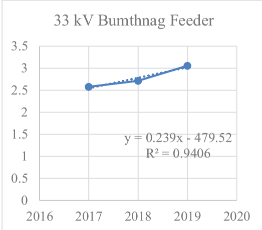
1

Feeder Name	33KV Bumthang Feeder

		3.4	3.4	3.2	3.5	3.8		Load Forecast 2020-2030										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)			0.607	1.700	1.398	3.000	1.730	**2.747**	**3.101**	**3.456**	**3.810**	**4.165**	**4.520**	**4.874**	**5.229**	**5.583**	**5.938**

year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)	2.579	2.714	3.057	3.26	3.499	3.738	3.977	4.216	4.455	4.694	4.933	5.172	5.411	5.65





2

Feeder Name	33kV Semji Feeder

							Load Forecast 2020-2030										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)			0.143	0.145	0.15	0.16	0.180	0.1819	0.1908	0.1997	0.2086	0.2175	0.2264	0.2353	0.2442	0.2531	0.262

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)	0.7	0.75	0.78												

2

Feeder Name	11kV Station Feeder 1
	11kV Station Feeder 2

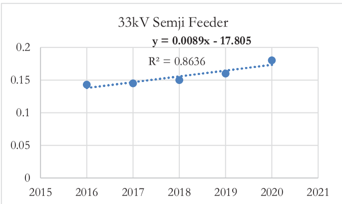
							Load Forecast 2020-2030										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)			0.026	0.023	0.030	0.041	0.037	**0.039**	**0.043**	**0.047**	**0.051**	**0.055**	**0.058**	**0.062**	**0.066**	**0.070**	**0.074**

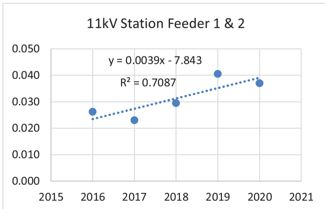
2

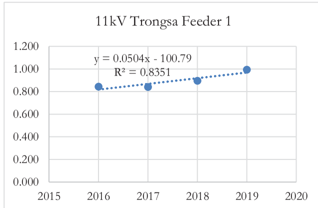
Feeder Name	11kV Trongsa Feeder 1

							Load Forecast 2020-2030										
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load (MW)			0.843	0.841	0.895	0.993	1.018	1.068	1.119	1.169	1.220	1.270	1.320	1.371	1.421	1.472	1.522

1294.1176





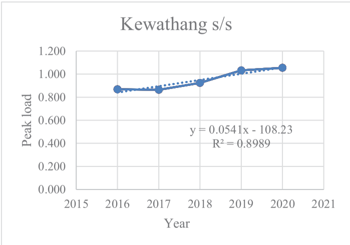


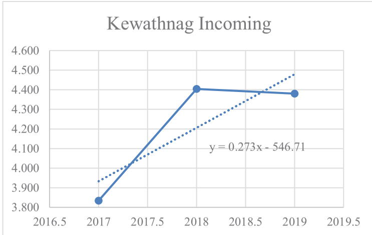
									Load Forecast 2020-2030											
2	Substation	Kewathang S/s, 33/11 (11kV line)	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			Peak Load (MW)			0.869	0.864	0.925	1.034	1.055	1.023	1.056	1.089	1.122	1.155	1.187	1.220	1.253	1.286	1.319

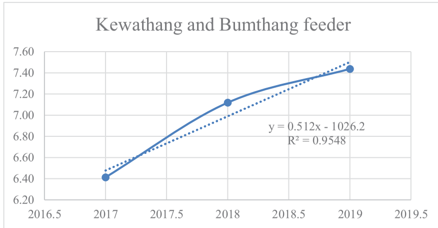
2016	2017	2018	2019	2020
5.1	5.9	4	4.9	4.7
4.700	5.460	3.834	4.404	4.380

									Load Forecast 2020-2030											
2	Substation	Kewathang incommer	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			Peak Load (MW)				3.834	4.404	4.380	4.750	5.023	5.296	5.569	5.842	6.115	6.388	6.661	6.934	7.207	7.480

									Load Forecast 2020-2030											
2	Substation	Kewathang Incommer and Bumthang Feeder load forcasted for Yurmoo line till Gaytsa incase yurmoo to kewathang incommer line breaks down	Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			Peak Load (MW)				6.41	7.12	7.44	8.040	8.552	9.064	9.576	10.088	10.600	11.112	11.624	12.136	12.648	13.160







Annexure-4: Detailed Simulation Results

Bus Loading Summary Report

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
33kV Yurmo B2	33.000										2.343	86.1	41.3	
33kV Yurmo B3	33.000										2.364	87.3	41.7	
B.TCom B1	33.000										0.030	83.9	0.5	
B.TCom B2	11.000		0.005	0.003	0.019	0.012					0.029	85.0	1.6	
Bagochen B1	11.000										0.204	84.2	11.1	
Bagochen B2	0.415		0.037	0.023	0.131	0.081					0.198	85.0	294.5	
Baling.Am B2	0.415		0.008	0.005	0.029	0.018					0.043	85.0	62.5	
Baling.Aml B1	33.000										0.044	84.4	0.8	
Baling.T B1	33.000										0.169	87.3	3.0	
Baling.T B2	0.415		0.009	0.005	0.032	0.020					0.047	85.0	68.4	
Baling.Top B1	33.000										0.038	84.5	0.7	
Baling.Top B2	0.415		0.007	0.004	0.025	0.015					0.037	85.0	53.2	
Bazam B1	33.000										0.098	89.8	1.7	
Bazam B2	0.415		0.004	0.003	0.017	0.010					0.025	85.0	35.4	
Bemji B1	33.000										0.018	84.7	0.3	
Bemji B2	0.415		0.003	0.002	0.012	0.008					0.018	85.0	25.9	
Bjee prop. B1	33.000										0.010	84.9	0.2	
Bjee Prop. B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	13.9	
Bjee Zam B1	33.000										0.017	84.8	0.3	
Bjee Zam B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	23.3	
Bjeepam Gpa B1	33.000										0.019	84.7	0.3	
Bjeepam Gpa B2	0.415		0.003	0.002	0.013	0.008					0.019	85.0	26.8	
Bjeepam.WI B1	33.000		0.002	0.001	0.006	0.004					0.795	85.2	14.1	
Bjeepam.WII B1	33.000		0.002	0.001	0.007	0.005					0.787	85.1	14.0	
BPong B1	33.000		0.001	0.001	0.004	0.003					0.173	88.3	3.1	
Bubja B1	33.000										0.792	87.8	14.1	
Bubja B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	30.8	
Bus1	0.415										0.020	91.6	28.0	
Chakarzur Lkhang B1	33.000										0.092	85.4	1.6	
Chakarzur Lkhang B2	0.415		0.010	0.006	0.037	0.023					0.055	85.0	81.0	
Chela B1	33.000		0.000	0.000	0.001	0.001					0.018	84.5	0.3	
Chela B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	22.1	
Chendebji B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.0	
Chendebji PP B1	0.415										0.024	99.4	34.0	
ChendebjiI B1	11.000										0.028	50.7	1.5	
ChendebjiII B1	11.000		0.000	0.000	0.001	0.001					0.016	25.1	0.9	
ChendebjiIII B1	11.000										0.015	26.2	0.8	
ChendebjiIII B2	0.415		0.004	0.003	0.015	0.010					0.028	84.7	39.9	
Chungja Pang B1	33.000										0.001	84.9	-	

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
Chungja Pang B2	0.415		0.000	0.000	0.001	0.001					0.001	85.0	2.1	
CLCS Academic B1	33.000										0.063	84.9	1.1	
CLCS Academic B2	0.415		0.011	0.007	0.043	0.026					0.063	85.0	89.4	
CLCS B1	33.000										0.126	84.9	2.2	
CLCS B2	0.415		0.011	0.007	0.042	0.026					0.063	85.0	89.2	
CLCS Hostel B1	33.000										0.039	84.9	0.7	
CLCS Hostel B2	0.415		0.007	0.004	0.026	0.016					0.039	85.0	55.1	
D.Gonpa B1	11.000										0.017	84.4	0.9	
D.Gonpa B2	0.415		0.003	0.002	0.011	0.007					0.016	85.0	24.2	
Daba B1	33.000										0.025	98.0	0.4	
Daba B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.3	
Dangdung B2	0.415		0.017	0.011	0.060	0.037					0.091	85.0	136.4	
Dangdung BHU B1	33.000										0.022	84.7	0.4	
Dangdung BHU B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	30.3	
DangdungI B1	33.000										0.055	84.2	1.0	
DangdungI B2	0.415		0.010	0.006	0.036	0.022					0.053	85.0	77.7	
Drangla B1	11.000										0.002	85.0	0.1	
Drangla B2	0.415		0.000	0.000	0.002	0.001					0.002	85.0	3.5	
Drengzhing B1	33.000										0.009	84.9	0.2	
Drengzhing B2	0.415		0.001	0.001	0.006	0.004					0.009	85.0	12.1	
Eusa B1	33.000										0.045	84.7	0.8	
Eusa B2	0.415		0.008	0.005	0.030	0.018					0.044	85.0	63.3	
Gagar Choshi B1	33.000										0.002	84.9	-	
Gagar Choshi B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	3.1	
Gagar Pam B1	33.000										0.004	84.9	0.1	
Gagar Pam B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.5	
Gangkhel B1	33.000										0.110	84.2	1.9	
Gangkhel B2	0.415		0.019	0.012	0.071	0.044					0.106	85.0	154.3	
Gangla.P B1	33.000										0.062	81.7	1.1	
Gangla.P B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.6	
Hospital B1	11.000										0.200	84.2	10.9	
Hospital B2	0.415		0.037	0.023	0.128	0.079					0.194	85.0	289.9	
ICT B1	33.000										0.062	72.1	1.1	
ICT B2	11.000										0.061	72.2	3.3	
Indocholing B1	33.000										0.189	83.6	3.3	
Indocholing B2	0.415		0.034	0.021	0.118	0.073					0.179	85.0	266.0	
Jongthang B1	33.000										0.004	84.9	0.1	
Jongthang B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.1	
K.Khep B1	33.000										0.007	84.9	0.1	
K.Khep B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.5	
K.Maling I B1	33.000		0.000	0.000	0.002	0.001					0.006	87.6	0.1	
K.Maling II B1	33.000										0.004	84.9	0.1	

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
K.Maling II B2	0.415		0.001	0.000	0.002	0.002					0.004	85.0	5.2	
Kaba B1	33.000										0.034	97.9	0.6	
Kaba B2	0.415		0.002	0.001	0.007	0.004					0.011	85.0	15.4	
Kaba O.F B1	33.000										0.002	85.0	-	
Kaba O.F B2	0.415		0.000	0.000	0.002	0.001					0.002	85.0	3.5	
Karshong Pam B1	33.000										0.082	99.4	1.5	
Karshong Pam B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	3.1	
Karshong Sch. B1	33.000		0.000	0.000	0.001	0.001					0.092	99.7	1.6	
Karshong Shdra B1	33.000		0.000	0.000	0.002	0.001					0.090	99.8	1.6	
Karshong Trong B1	33.000										0.002	84.9	-	
Karshong Trong B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.4	
Kela Lambrog B1	33.000										0.006	84.8	0.1	
Kela Lambrog B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	7.9	
Kela Sch. B1	33.000										0.012	86.9	0.2	
Kela Sch. B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
Kewathang Station B1	0.415		0.008	0.005	0.031	0.019					0.047	85.0	67.5	
Khoshala B1	33.000										0.065	84.1	1.2	
Khoshala B2	0.415		0.012	0.007	0.042	0.026					0.063	85.0	91.9	
Kkling B1	33.000		0.000	0.000	0.001	0.001					0.009	97.1	0.2	
Krabten B1	33.000										0.035	84.5	0.6	
Krabten B2	0.415		0.006	0.004	0.023	0.014					0.035	85.0	49.8	
KwathangSS B1	33.000										2.302	85.6	40.7	
KwathangSS B2	11.000										0.652	81.9	35.1	
KwathangSS B3	11.000										1.256	81.9	67.7	
L.Belling B1	33.000										0.083	83.8	1.5	
L.Belling B2	0.415		0.015	0.009	0.052	0.032					0.079	85.0	116.0	
L.Jangbi B1	33.000										0.008	84.3	0.1	
L.Jangbi B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.5	
L.Krabten B1	33.000										0.895	88.0	15.9	
L.Krabten B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.6	
L.Scholing I B1	33.000										1.027	88.8	18.2	
L.Scholing I B2	0.415		0.006	0.004	0.022	0.014					0.033	85.0	46.4	
L.Scholing II B2	0.415		0.002	0.001	0.007	0.005					0.011	85.0	15.6	
L.ScholingII B1	33.000										0.011	84.8	0.2	
L.Tling B1	33.000										0.279	87.9	5.0	
L.Tling B2	0.415		0.004	0.003	0.016	0.010					0.024	85.0	34.4	
Loreyma B1	11.000										0.036	61.0	1.9	
Loreyma B2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
M.Tling B1	33.000										0.342	87.8	6.1	
M.Tling B2	0.415		0.011	0.007	0.043	0.026					0.064	85.0	91.9	
Main Yurmo B1	132.000										4.688	86.2	20.5	
Mazadum B1	11.000										0.018	84.7	1.0	

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
Mazadum B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	25.6	
Med.& Aro B1	33.000										0.001	85.0	-	
Med.& Aro B2	0.415		0.000	0.000	0.001	0.001					0.001	85.0	1.7	
Namther B1	33.000										0.068	84.4	1.2	
Namther B2	0.415		0.012	0.007	0.044	0.027					0.066	85.0	95.4	
Ngala B1	11.000										0.003	84.8	0.2	
Ngala B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
Ngorme B1	33.000										0.022	84.2	0.4	
Ngorme B2	0.415		0.004	0.002	0.014	0.009					0.021	85.0	30.8	
Pangzor B1	33.000										0.044	84.4	0.8	
Pangzor B2	0.415		0.008	0.005	0.029	0.018					0.043	85.0	61.7	
PH B1	33.000										0.737	84.6	13.1	
PH B2	33.000										0.737	84.6	13.1	
PH1 B2	0.415		0.130	0.081	0.485	0.301					0.724	85.0	1042.6	
Phelchung B1	33.000										0.014	84.8	0.3	
Phelchung B2	0.415		0.002	0.002	0.009	0.006					0.014	85.0	19.9	
Rangthang B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.1	
RangthangB1	33.000										0.007	84.6	0.1	
SemjeeI B1	33.000										0.111	98.3	2.0	
SemjeeI B2	0.415		0.003	0.002	0.010	0.006					0.015	85.0	20.8	
Semji II B1	33.000										0.034	84.5	0.6	
Semji II B2	0.415		0.006	0.004	0.022	0.014					0.033	85.0	48.1	
Sephu B1	11.000										0.027	84.0	1.4	
Sephu B2	0.415		0.005	0.003	0.017	0.010					0.026	85.0	37.9	
Sherubling B1	11.000										0.342	73.8	18.7	
Sherubling B2	0.415		0.033	0.020	0.115	0.071					0.186	79.0	277.3	
Sherubling MHPP B1	0.415										0.085	96.6	118.1	
Shilgling B1	33.000										0.021	84.2	0.4	
Shilgling B2	0.415		0.004	0.002	0.014	0.008					0.021	85.0	29.8	
SHSS B1	11.000										0.212	84.4	11.6	
SHSS B2	0.415		0.023	0.014	0.081	0.050					0.122	85.0	181.1	
Simphu B1	33.000										0.013	84.8	0.2	
Simphu B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.2	
Simphu Gpa B1	33.000										0.003	84.9	0.1	
Simphu Gpa B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
Simphu Sch. B1	33.000		0.000	0.000	0.001	-					0.017	99.7	0.3	
Surge Shaft B2	0.415		0.033	0.021	0.126	0.078					0.187	85.0	267.1	
T Gonpa B1	11.000										0.029	83.9	1.6	
T Gonpa B2	0.415		0.005	0.003	0.018	0.011					0.028	85.0	42.0	
Ta Dzong B1	11.000										0.998	81.1	54.4	
Ta Dzong B2	0.415		0.019	0.012	0.069	0.043					0.103	85.0	151.7	
Taksila B1	33.000										0.733	88.0	13.0	

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
Taksila B2	0.415		0.017	0.011	0.060	0.037					0.091	85.0	135.6	
Taktse JHSS B1	33.000										0.056	84.8	1.0	
Taktse JHSS B2	0.415		0.010	0.006	0.037	0.023					0.055	85.0	78.9	
Taktse.T B1	33.000										0.727	88.0	12.9	
Taktse.T B2	0.415		0.009	0.006	0.034	0.021					0.052	85.0	75.1	
Tangsibji B1	33.000										0.018	74.2	0.3	
Tangsibji B2	0.415		0.007	0.004	0.025	0.015					0.037	85.0	52.6	
Tangsibji PP2 B1	6.600										0.020	91.9	1.8	
Tansibji PP2 B2	6.600										0.020	92.0	1.8	
TCell B1	33.000										0.004	84.9	0.1	
TCell B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.5	
Tdingkha B1	33.000										0.458	88.7	8.1	
Tdingkha B2	0.415		0.008	0.005	0.030	0.019					0.045	85.0	65.0	
Thomangdrak B1	33.000										0.042	84.4	0.8	
Thomangdrak B2	0.415		0.007	0.005	0.028	0.017					0.041	85.0	59.9	
Thrisar B2	0.415		0.009	0.006	0.035	0.021					0.052	85.0	75.2	
Thrispang B1	33.000		0.000	0.000	0.001	-					0.008	60.3	0.1	
Tongtong B1	33.000										0.270	88.5	4.8	
Tongtong B2	0.415		0.006	0.004	0.024	0.015					0.036	85.0	51.6	
Town B1	11.000										0.328	84.4	17.9	
Town B2	0.415		0.060	0.037	0.211	0.131					0.319	85.0	475.2	
TRE10.1	11.000										1.250	81.8	67.7	
TRE10.2	11.000										0.034	85.3	1.9	
TRE10.3	11.000										1.213	81.7	65.9	
TRE10.4	11.000		0.001	0.001	0.005	0.003					1.006	81.1	54.8	
TRE10.5	11.000										0.891	80.6	48.7	
TRE10.6	11.000										0.563	78.2	30.8	
TRE10.7	11.000										0.023	85.0	1.3	
TRE10.8	11.000										0.540	77.9	29.5	
TRE10.9	11.000										0.087	84.2	4.8	
TRE30.1	11.000										0.030	54.7	1.6	
TRE30.2	11.000										0.006	87.6	0.3	
TRE50.1	33.000										1.278	87.0	22.6	
TRE50.2	33.000										1.249	86.9	22.1	
TRE50.3	33.000										1.061	87.3	18.7	
TRE50.4	33.000										0.989	87.5	17.5	
TRE50.5	33.000										0.908	87.6	16.0	
TRE50.6	33.000										0.638	88.5	11.3	
TRE50.7	33.000										0.172	84.6	3.0	
TRE50.8	33.000										0.151	84.3	2.7	
TRE50.9	33.000										0.468	89.5	8.3	
TRE50.10	33.000										0.415	89.9	7.3	

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
TRE50.11	33.000										0.234	88.6	4.1	
TRE50.12	33.000										0.121	87.7	2.1	
TRE50.13	33.000										0.081	86.0	1.4	
TRE50.14	33.000										0.043	86.4	0.8	
TRE50.15	33.000										0.147	91.6	2.6	
TRE50.16	33.000										0.051	92.8	0.9	
TRE50.17	33.000										0.047	86.3	0.8	
TRE50.18	33.000										0.073	91.2	1.3	
TRE50.19	33.000										0.053	90.4	0.9	
TRE50.20	33.000		0.002	0.001	0.007	0.004					0.036	84.7	0.6	
TRE60.0	33.000										0.026	4.9	0.5	
TRE60.1	33.000										0.017	7.5	0.3	
TRE60.2	33.000										1.058	88.9	18.7	
TRE60.3	33.000										1.037	88.8	18.3	
TRE60.4	33.000										0.994	88.8	17.6	
TRE60.5	33.000										0.982	88.6	17.4	
TRE60.6	33.000										0.925	88.7	16.4	
TRE60.7	33.000										0.915	88.5	16.2	
TRE60.8	33.000										0.022	95.7	0.4	
TRE60.9	33.000										0.022	94.9	0.4	
TRE60.10	33.000										0.017	92.7	0.3	
TRE60.11	33.000										0.881	87.9	15.6	
TRE60.12	33.000										0.791	88.0	14.0	
TRE60.13	33.000										0.771	87.9	13.7	
TRE60.14	33.000										0.674	88.2	12.0	
TRE60.15	33.000										0.620	88.3	11.0	
TRE60.16	33.000										0.494	88.9	8.8	
TRE60.17	33.000										0.456	89.1	8.1	
TRE60.18	33.000										0.415	88.4	7.4	
TRE60.19	33.000										0.399	88.5	7.1	
TRE60.20	33.000										0.059	89.5	1.1	
TRE60.21	33.000		0.000	0.000	0.002	0.001					0.061	87.3	1.1	
TRE60.22	33.000										0.061	72.5	1.1	
TRE60.23	33.000										0.062	72.2	1.1	
TRE60.24	33.000										0.255	88.2	4.5	
TRE60.25	33.000										0.225	88.0	4.0	
TRE60.26	33.000										0.223	87.4	4.0	
TRE60.27 B1	33.000										0.185	86.3	3.3	
TRE60.28	33.000										0.189	84.8	3.4	
TRE60.29	33.000												-	
TRE70.0	33.000										0.997	90.1	17.6	
TRE70.1	33.000										0.999	89.7	17.7	

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
TRE70.2	33.000										0.962	89.0	17.1	
TRE70.3	33.000										0.867	86.1	15.4	
TRE70.4	33.000										0.835	85.9	14.8	
TRE70.5	33.000										0.043	91.6	0.8	
TRE70.6	33.000										0.779	84.7	13.8	
TRE70.7	33.000										0.778	84.7	13.8	
TRE70.8	33.000										0.779	84.7	13.8	
TRE70.9	33.000										0.017	86.9	0.3	
TRE70.10	33.000										0.097	99.4	1.7	
TRE70.11	33.000										0.005	98.5	0.1	
TRE70.12	33.000										0.089	99.0	1.6	
TRE70.13	33.000										0.012	52.3	0.2	
TRE70.14	33.000		0.001	0.001	0.004	0.002					0.081	98.9	1.4	
TRE70.15	33.000										0.076	98.3	1.4	
TRE70.16	33.000										0.025	93.8	0.4	
TRE70.17	33.000										0.053	97.6	0.9	
TRE70.18	33.000										0.036	98.2	0.6	
TRE70.19	33.000		0.000	0.000	0.001	0.001					0.016	97.8	0.3	
TRE70.20	33.000										0.016	90.7	0.3	
TRE70.21	33.000		0.000	0.000	0.000	-					0.004	89.4	0.1	
Trongsa Ring B1	11.000										0.001	-	-	
Trongsa Ring B2	11.000										0.001	-	-	
Trongsa Ring B3	11.000												-	
Trongsa Ring B4	11.000													
Tshangka B1	33.000										0.041	84.7	0.7	
Tshangka B2	0.415		0.007	0.004	0.027	0.017					0.041	85.0	58.1	
Tshangka B3	33.000										0.189	84.8	3.4	
Tshangka Sch. B1	33.000										0.031	84.8	0.6	
Tshangka Sch. B2	0.415		0.006	0.003	0.021	0.013					0.031	85.0	44.5	
U.Belling B1	33.000										0.074	84.3	1.3	
U.Belling B2	0.415		0.013	0.008	0.048	0.030					0.072	85.0	103.4	
U.Jangbi B1	33.000										0.040	84.4	0.7	
U.Jangbi B2	0.415		0.007	0.004	0.026	0.016					0.039	85.0	56.6	
U.Krabten B1	33.000										0.013	84.5	0.2	
U.Krabten B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.4	
U.Scholing B1	33.000										0.059	84.8	1.0	
U.Scholing B2	0.415		0.010	0.006	0.039	0.024					0.058	85.0	82.5	
UG60.1	11.000										0.027	84.4	1.4	
UG60.2	11.000										0.036	61.4	1.9	
USS Dzong B1	11.000										0.023	85.0	1.3	
USS Dzong B2	0.415		0.004	0.003	0.016	0.010					0.023	85.0	33.9	
View Pt.R B1	33.000		0.000	0.000	0.001	-					0.001	85.0	-	

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
Villing B1	11.000										0.087	84.1	4.8	
Villing B2	0.415		0.011	0.007	0.037	0.023					0.056	85.0	84.5	
WanglingI B1	33.000										0.026	84.1	0.5	
WanglingI B2	0.415		0.005	0.003	0.017	0.010					0.025	85.0	36.5	
Yangkhil.R B1	33.000										0.046	84.8	0.8	
Yangkhil.R B2	0.415		0.008	0.005	0.031	0.019					0.046	85.0	64.6	
Yotola B1	0.415		0.000	0.000	0.002	0.001					0.002	85.0	3.2	
Yurmo B1	33.000										0.022	84.7	0.4	
Yurmo B2	0.415		0.004	0.002	0.015	0.009					0.022	85.0	31.1	
Yurmo Station B1	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.1	

* 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	%
ICT-UG60.1	Cable	229.86	1.42	0.62					
ICT-UG60.2	Cable	229.86	1.92	0.84					
Semji UG	Cable	190.58	17.43	9.15					
Taktse UG	Cable	124.10	0.45	0.37					
Trongsa Ring UG1	Cable	229.86	0.04	0.02					
Trongsa Ring UG2	Cable	229.86	0.04	0.02					
Trongsa Ring UG3	Cable	229.86							
UG70.1	Cable	124.10	13.11	10.57					
USS Dzong UG	Cable	229.86	1.28	0.56					
* B.TCom Tfr	Transformer				0.025	0.030	121.9	0.029	116.4
Bagochen Tfr	Transformer				0.250	0.204	81.8	0.198	79.2
Baling.Am Tfr	Transformer				0.063	0.044	70.5	0.043	68.7
Baling.T Tfr	Transformer				0.063	0.049	77.2	0.047	74.9
Baling.Top Tfr	Transformer				0.063	0.038	60.0	0.037	58.7
Bazam Tfr	Transformer				0.063	0.025	39.9	0.025	39.3
Bemji Tfr	Transformer				0.063	0.018	29.1	0.018	28.8
Bjee Prop. Tfr	Transformer				0.063	0.010	15.6	0.010	15.5
Bjee Zam Tfr	Transformer				0.063	0.017	26.2	0.016	26.0
Bjeepam Gpa Tfr	Transformer				0.063	0.019	30.1	0.019	29.8
Bubja Tfr	Transformer				0.025	0.022	87.3	0.021	84.5
Bum.Yotola Tfr	Transformer				0.016	0.002	14.1	0.002	14.0
Chakarzur Lkhang Tfr	Transformer				0.063	0.057	91.2	0.055	88.0
Chela Tfr	Transformer				0.025	0.016	62.7	0.015	61.2
ChendebjiI Tfr	Transformer				0.125	0.017	13.5	0.017	13.4
ChendebjiIII Tfr	Transformer				0.063	0.015	24.6	0.015	24.4
Chungja Pang Tfr	Transformer				0.025	0.001	5.9	0.001	5.9
CLCS Academic Tfr	Transformer				0.500	0.063	12.7	0.063	12.6
CLCS Hostel Tfr	Transformer				0.500	0.039	7.8	0.039	7.8
CLCS Tfr	Transformer				0.250	0.063	25.3	0.063	25.0
D.Gonpa Tfr	Transformer				0.025	0.017	67.4	0.016	65.6
Daba Tfr	Transformer				0.025	0.009	37.8	0.009	37.3
Dangdung BHU Tfr	Transformer				0.063	0.022	34.1	0.021	33.7
* Dangdung Tfr	Transformer				0.063	0.097	153.9	0.091	145.0

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
DangdungI Tfr	Transformer				0.063	0.055	87.7	0.053	84.9
Drangla Tfr	Transformer				0.063	0.002	3.9	0.002	3.9
Drengzhing Tfr	Transformer				0.063	0.009	13.6	0.009	13.6
Eusa Tfr	Transformer				0.125	0.045	35.9	0.044	35.4
Gagar ChoshiTfr	Transformer				0.025	0.002	8.8	0.002	8.8
Gagar Pam Tfr	Transformer				0.025	0.004	15.6	0.004	15.5
Gangkhel Tfr	Transformer				0.125	0.110	87.8	0.106	85.0
Gangla.P Tfr	Transformer				0.025	0.007	30.0	0.007	29.7
Hospital Tfr	Transformer				0.250	0.200	79.9	0.194	77.4
ICT Tfr	Transformer				0.500	0.062	12.3	0.061	12.3
* Indocholing Tfr	Transformer				0.125	0.189	151.6	0.179	143.0
Jongthang Tfr	Transformer				0.063	0.004	6.8	0.004	6.8
K.Khep Tfr	Transformer				0.063	0.007	10.8	0.007	10.7
K.Maling II Tfr	Transformer				0.025	0.004	14.7	0.004	14.6
Kaba O.F Tfr	Transformer				0.063	0.002	3.9	0.002	3.9
Kaba Tfr	Transformer				0.025	0.011	43.6	0.011	42.8
Karshong Pam Tfr	Transformer				0.025	0.002	8.8	0.002	8.8
Karshong Trong Tfr	Transformer				0.025	0.002	6.8	0.002	6.8
Kela Lambrog Tfr	Transformer				0.025	0.006	22.4	0.006	22.2
Kela Sch. Tfr	Transformer				0.025	0.006	25.3	0.006	25.1
Kewathang Station Tfr	Transformer				0.250	0.047	18.9	0.047	18.8
KewathangSS Tfr1	Transformer				2.500	0.663	26.5	0.652	26.1
KewathangSS Tfr2	Transformer				2.500	0.663	26.5	0.652	26.1
* Khoshala Tfr	Transformer				0.063	0.065	103.6	0.063	99.6
Krabten Tfr	Transformer				0.063	0.035	56.1	0.035	54.9
* L.Belling Tfr	Transformer				0.063	0.083	131.1	0.079	124.7
L.Jangbi Tfr	Transformer				0.010	0.008	82.0	0.008	79.4
L.Krabten Tfr	Transformer				0.063	0.015	24.4	0.015	24.1
L.Scholing I Tfr	Transformer				0.125	0.033	26.4	0.033	26.1
L.ScholingII Tfr	Transformer				0.063	0.011	17.6	0.011	17.5
L.Tling Tfr	Transformer				0.063	0.024	38.6	0.024	38.1
Loreyma Tfr	Transformer				0.025	0.006	25.0	0.006	24.7
M.Tling Tfr	Transformer				0.125	0.065	52.0	0.064	51.0
Mazadum Tfr	Transformer				0.063	0.018	28.3	0.018	28.0
Med.& Aro Tfr	Transformer				0.125	0.001	1.0	0.001	1.0

CKT / Branch		Cable & Reactor			Transformer				
					Capability	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	(MVA)	MVA	%	MVA	%
Namther Tfr	Transformer				0.100	0.068	67.9	0.066	66.2
Ngala Tfr	Transformer				0.016	0.003	21.1	0.003	21.0
Ngorme Tfr	Transformer				0.025	0.022	87.6	0.021	84.8
Pangzor Tfr	Transformer				0.063	0.044	69.6	0.043	67.8
PH1 Tfr	Transformer				1.500	0.737	49.2	0.724	48.2
Phelchung Tfr	Transformer				0.063	0.014	22.5	0.014	22.3
Rangthang Tfr	Transformer				0.016	0.007	44.7	0.007	44.0
SemjeeI Tfr	Transformer				0.063	0.015	23.4	0.015	23.2
Semji II Tfr	Transformer				0.063	0.034	54.1	0.033	53.0
* Sephu Tfr	Transformer				0.025	0.027	106.6	0.026	102.3
Sherubling Tfr	Transformer				0.250	0.138	55.2	0.135	53.9
Shilgling Tfr	Transformer				0.025	0.021	84.8	0.021	82.1
SHSS Tfr	Transformer				0.250	0.125	49.9	0.122	48.9
Simphu Gpa Tfr	Transformer				0.025	0.003	13.6	0.003	13.6
Simphu Tfr	Transformer				0.063	0.013	20.4	0.013	20.3
Surge Shaft Tfr	Transformer				0.750	0.189	25.2	0.187	24.9
* T Gonpa Tfr	Transformer				0.025	0.029	115.5	0.028	110.2
Ta Dzong Tfr	Transformer				0.250	0.105	42.0	0.103	41.3
* Taksila Tfr	Transformer				0.063	0.096	153.0	0.091	144.3
Taktse JHSS Tfr	Transformer				0.250	0.056	22.4	0.055	22.2
Taktse.T Tfr	Transformer				0.063	0.053	84.5	0.052	81.8
Tangsibji HPP Tfr1	Transformer				0.050	0.020	40.3	0.020	39.7
Tangsibji Tfr	Transformer				0.063	0.018	28.5	0.018	28.1
TangsibjiPP Tfr2	Transformer				0.050	0.020	39.7	0.020	39.2
TCell Tfr	Transformer				0.025	0.004	15.5	0.004	15.4
Tdingkha Tfr	Transformer				0.125	0.046	36.8	0.045	36.3
Thomangdrak Tfr	Transformer				0.063	0.042	67.2	0.041	65.5
Thrisar Tfr	Transformer				0.063	0.053	84.9	0.052	82.2
Tongtong Tfr	Transformer				0.063	0.037	58.2	0.036	56.9
Town Tfr	Transformer				0.500	0.328	65.6	0.319	63.9
Tshangka Sch. Tfr	Transformer				0.125	0.031	25.2	0.031	24.9
Tshangka Tfr	Transformer				0.125	0.041	32.9	0.041	32.5
U.Belling Tfr	Transformer				0.100	0.074	73.7	0.072	71.6
U.Jangbi Tfr	Transformer				0.063	0.040	63.9	0.039	62.4
U.Krabten Tfr	Transformer				0.025	0.013	52.4	0.013	51.3

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
U.Scholing Tfr	Transformer				0.250	0.059	23.4	0.058	23.2
USS Dzong Tfr	Transformer				0.500	0.023	4.7	0.023	4.7
Villing Tfr	Transformer				0.063	0.058	92.4	0.056	89.0
* WanglingI Tfr	Transformer				0.025	0.026	103.6	0.025	99.6
Yangkhil.R Tfr	Transformer				0.250	0.046	18.4	0.046	18.2
Yurmo SS Tfr1	Transformer				15.000	2.344	15.6	2.324	15.5
Yurmo SS Tfr2	Transformer				15.000	2.344	15.6	2.324	15.5
Yurmo Station Tfr	Transformer				0.100	0.013	12.9	0.013	12.8
Yurmo Tfr	Transformer				0.063	0.022	35.2	0.022	34.7

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

Branch Losses Summary Report

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	
YurmoSS-KwathangSS	1.973	1.190	-1.971	-1.191	2.0	-1.1	99.1	99.0	0.12
Yurmo SS Tfr2	-2.018	-1.153	2.020	1.189	1.8	36.6	99.1	100.0	0.85
L1-TRE50.1	1.112	0.630	-1.112	-0.630	0.1	-0.6	99.1	99.1	0.02
L1-TRE60.2	0.941	0.479	-0.940	-0.484	0.8	-5.3	99.1	99.0	0.10
Yurmo SS Tfr1	-2.018	-1.153	2.020	1.189	1.8	36.6	99.1	100.0	0.85
Yurmo Station Tfr	0.011	0.007	-0.011	-0.007	0.0	0.1	99.1	98.7	0.47
TRE50.1-B.TCom	-0.026	-0.017	0.026	0.013	0.0	-3.5	99.1	99.1	0.00
B.TCom Tfr	0.026	0.017	-0.025	-0.015	0.8	1.3	99.1	94.6	4.50
TRE10.3-Bagochen	-0.172	-0.110	0.172	0.110	0.0	0.0	96.6	96.6	0.02
Bagochen Tfr	0.172	0.110	-0.168	-0.104	4.0	6.0	96.6	93.5	3.09
Baling.Am Tfr	-0.037	-0.023	0.037	0.024	0.7	1.1	96.2	98.8	2.60
TRE50.13-Baling.Am	-0.037	-0.024	0.037	0.023	0.0	-0.8	98.8	98.8	0.00
Baling.T-TRE50.12	0.106	0.056	-0.106	-0.058	0.0	-2.1	98.8	98.8	0.00
BPong-Baling.T	-0.147	-0.082	0.147	0.078	0.0	-4.6	98.8	98.8	0.01
Baling.T Tfr	0.041	0.026	-0.040	-0.025	0.9	1.3	98.8	96.0	2.85
TRE50.13-Baling.Top	-0.032	-0.020	0.032	0.018	0.0	-2.2	98.8	98.8	0.00
Baling.Top Tfr	0.032	0.020	-0.031	-0.019	0.5	0.8	98.8	96.6	2.22
Bazam-TRE50.18	0.067	0.030	-0.067	-0.030	0.0	-0.2	98.9	98.9	0.00
TRE50.15-Bazam	-0.088	-0.043	0.088	0.043	0.0	-0.2	98.9	98.9	0.00
Bazam Tfr	0.021	0.013	-0.021	-0.013	0.2	0.3	98.9	97.4	1.47
TRe70.17-Bemji	-0.016	-0.010	0.016	0.009	0.0	-1.0	98.6	98.6	0.00
Bemji Tfr	0.016	0.010	-0.015	-0.010	0.1	0.2	98.6	97.5	1.08
TRE70.5-Bjee Prop.	-0.008	-0.005	0.008	0.004	0.0	-0.9	98.6	98.6	0.00
Bjee Prop. Tfr	0.008	0.005	-0.008	-0.005	0.0	0.1	98.6	98.0	0.58
TRE70.9-Bjee Zam	-0.014	-0.009	0.014	0.009	0.0	-0.2	98.6	98.6	0.00
Bjee Zam Tfr	0.014	0.009	-0.014	-0.009	0.1	0.1	98.6	97.6	0.97
TRE70.5-Bjeepam.Gpa	-0.016	-0.010	0.016	0.006	0.0	-3.8	98.6	98.6	0.00
Bjeepam Gpa Tfr	0.016	0.010	-0.016	-0.010	0.1	0.2	98.6	97.5	1.11
Bjeepam(I-II)	0.670	0.412	-0.670	-0.413	0.1	-1.7	98.5	98.5	0.02
TRE70.5-Bjeepam.WI	-0.678	-0.416	0.678	0.412	0.4	-4.3	98.5	98.6	0.06
Bjeepam.WII-TRE70.6	0.660	0.408	-0.660	-0.412	0.4	-4.5	98.5	98.4	0.06
TRE50.11-Bpong	-0.153	-0.081	0.153	0.073	0.0	-7.8	98.8	98.9	0.02
TRE60(11-12)2	0.678	0.367	-0.677	-0.367	0.0	-0.1	98.6	98.6	0.00
TRE60.12-Bubja	-0.696	-0.379	0.696	0.375	0.3	-3.6	98.6	98.7	0.05

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
Bubja Tfr	0.018	0.012	-0.018	-0.011	0.4	0.7	98.6	95.4	3.23
Tangsibji HPP Tfr1	0.018	0.008	-0.018	-0.008	0.2	0.3	100.0	98.6	1.35
Chakarzur Lkhang-Krabten	0.030	0.017	-0.030	-0.019	0.0	-2.3	98.7	98.7	0.00
TRE60.11-Chakarzur Lkhang	-0.078	-0.048	0.078	0.046	0.0	-2.0	98.7	98.7	0.00
Chakarzur Lkhang Tfr	0.048	0.031	-0.047	-0.029	1.2	1.8	98.7	95.3	3.37
TRE70.16-Chela	-0.015	-0.009	0.015	0.009	0.0	-0.6	98.6	98.6	0.00
Chela Tfr	0.013	0.008	-0.013	-0.008	0.2	0.3	98.6	96.3	2.32
ChendebjiI Tfr	-0.014	-0.009	0.014	0.009	0.1	0.1	97.3	97.8	0.50
Chendebji PP line	0.024	-0.003	-0.024	0.003	0.7	0.1	100.0	97.1	2.87
Chendebji(I-II)	-0.003	0.015	0.003	-0.016	0.0	-0.2	97.8	97.8	0.00
TRE30.1-Chendebji	-0.012	-0.024	0.012	0.023	0.0	-0.9	97.8	97.8	0.05
Chendebji(II-III)	-0.004	0.015	0.004	-0.015	0.0	-0.2	97.8	97.8	0.00
ChendebjiIII Tfr	-0.004	0.015	0.004	-0.015	0.1	0.1	97.8	97.1	0.66
TSE60.1-Chungja	-0.001	-0.001	0.001	0.001	0.0	0.0	98.9	98.9	0.00
Chungja Pang Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	98.9	98.7	0.22
CLCS-CLCS Academic	-0.054	-0.033	0.054	0.033	0.0	-0.3	98.6	98.6	0.00
CLCS Academic Tfr	0.054	0.033	-0.054	-0.033	0.2	0.3	98.6	98.1	0.47
TRE60.15-CLCS	-0.107	-0.067	0.107	0.066	0.0	-0.7	98.6	98.6	0.00
CLCS Tfr	0.054	0.034	-0.053	-0.033	0.4	0.5	98.6	97.7	0.93
TRE60.16-CLCS Hostel	-0.033	-0.021	0.033	0.020	0.0	-0.7	98.6	98.6	0.00
CLCS Hostel Tfr	0.033	0.021	-0.033	-0.020	0.1	0.1	98.6	98.3	0.29
TRE10.2-D.Gonpa	-0.014	-0.009	0.014	0.009	0.0	-0.5	96.9	96.9	0.02
D.Gonpa Tfr	0.014	0.009	-0.014	-0.009	0.3	0.4	96.9	94.3	2.54
Daba-Simphu Sch.	0.017	-0.002	-0.017	-0.001	0.0	-3.6	98.6	98.6	0.00
TRE70.18-Kaba1	-0.025	-0.003	0.025	0.001	0.0	-1.5	98.6	98.6	0.00
Daba Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	98.6	97.2	1.40
Dangdung Tfr	-0.078	-0.048	0.081	0.053	3.4	5.1	93.2	98.9	5.70
TRE50.7-Dangdung BHU	-0.018	-0.011	0.018	0.011	0.0	-0.1	98.9	98.9	0.00
Dangdung BHU Tfr	0.018	0.011	-0.018	-0.011	0.2	0.2	98.9	97.7	1.26
TRE50.8-DangdungI	-0.047	-0.030	0.047	0.028	0.0	-1.5	98.9	98.9	0.00
DangdungI Tfr	0.047	0.030	-0.045	-0.028	1.1	1.6	98.9	95.7	3.24
TRE30.2-Drangla	-0.002	-0.001	0.002	0.001	0.0	-0.1	97.8	97.8	0.00
Drangla Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.8	97.7	0.14
Kkling-Drengzhing	-0.007	-0.005	0.007	0.001	0.0	-3.3	98.6	98.6	0.00
Drengzhing Tfr	0.007	0.005	-0.007	-0.005	0.0	0.0	98.6	98.1	0.50
TRE60.13-Eusa	-0.038	-0.024	0.038	0.023	0.0	-0.5	98.6	98.6	0.00
Eusa Tfr	0.038	0.024	-0.038	-0.023	0.4	0.6	98.6	97.3	1.33

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
TRE70.11-Gagar Choshi	-0.002	-0.001	0.002	0.001	0.0	-0.2	98.6	98.6	0.00
Gagar ChoshiTfr	0.002	0.001	-0.002	-0.001	0.0	0.0	98.6	98.3	0.32
TRE70.11-Gagar Pam	-0.003	-0.002	0.003	-0.001	0.0	-2.8	98.6	98.6	0.00
Gagar Pam Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.6	98.0	0.58
TRE50.5-Gangkhel	-0.092	-0.059	0.092	0.058	0.0	-0.9	99.0	99.0	0.00
Gangkhel Tfr	0.092	0.059	-0.090	-0.056	2.2	3.3	99.0	95.8	3.24
Gangla.P-TRE60.22	0.045	0.032	-0.045	-0.042	0.0	-10.3	98.4	98.4	0.01
TRE60.21-Gangla.P	-0.051	-0.036	0.051	0.028	0.0	-7.7	98.4	98.4	0.01
Gangla.P Tfr	0.006	0.004	-0.006	-0.004	0.1	0.1	98.4	97.3	1.11
TRE10.8-Hospital	-0.168	-0.108	0.168	0.108	0.0	0.0	95.9	95.9	0.01
Hospital Tfr	0.168	0.108	-0.164	-0.102	3.9	5.8	95.9	92.9	3.04
TRE60.23-ICT	-0.045	-0.043	0.045	0.043	0.0	0.0	98.4	98.4	0.00
ICT Tfr	0.045	0.043	-0.044	-0.042	0.2	0.3	98.4	97.9	0.49
ICT-UG60.1	0.022	0.014	-0.022	-0.014	0.0	0.0	97.9	97.9	0.00
ICT-UG60.2	0.022	0.028	-0.022	-0.028	0.0	0.0	97.9	97.9	0.00
TRE50.2-Indocholing	-0.158	-0.104	0.158	0.103	0.0	-0.6	99.1	99.1	0.00
Indocholing Tfr	0.158	0.104	-0.152	-0.094	6.5	9.7	99.1	93.5	5.60
Thrispang-Jongthang	-0.004	-0.002	0.004	-0.006	0.0	-8.4	98.6	98.6	0.00
Jongthang Tfr	0.004	0.002	-0.004	-0.002	0.0	0.0	98.6	98.4	0.25
TRE60.9-K.Khep	-0.006	-0.004	0.006	0.003	0.0	-1.0	98.7	98.7	0.00
K.Khep Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	98.7	98.4	0.40
K.Maling(I-II)	0.003	0.002	-0.003	-0.002	0.0	-0.4	98.7	98.7	0.00
TRE60.10-K.Maling I	-0.005	-0.003	0.005	0.002	0.0	-1.0	98.7	98.7	0.00
K.Maling II Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.7	98.2	0.54
TRE70.18-Kaba	-0.034	-0.007	0.034	0.006	0.0	-1.5	98.6	98.6	0.00
Kaba Tfr	0.009	0.006	-0.009	-0.006	0.1	0.2	98.6	97.0	1.61
TRE70.18-Kaba O.F	-0.002	-0.001	0.002	0.001	0.0	0.0	98.6	98.6	0.00
Kaba O.F Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	98.6	98.4	0.14
Karshong Pam-TRE70.14	0.080	0.008	-0.080	-0.012	0.0	-3.8	98.6	98.6	0.01
TRE70.12-Karshong Pam	-0.082	-0.009	0.082	0.008	0.0	-0.9	98.6	98.6	0.00
Karshong Pam Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	98.6	98.3	0.32
Karshong(Sch.-Shdra)	0.090	-0.007	-0.090	0.004	0.0	-2.4	98.6	98.6	0.01
TRE70.10-Karshong Sch.	-0.092	0.006	0.092	-0.009	0.0	-2.9	98.6	98.6	0.01
Karshong Shdra-TRE70.12	0.088	-0.006	-0.088	0.004	0.0	-1.5	98.6	98.6	0.00
TRE70.13-Karshong Trong	-0.001	-0.001	0.001	0.000	0.0	-1.2	98.6	98.6	0.00
Karshong Trong Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	98.6	98.4	0.25
Kela Sch.-Kela Lambrog	-0.005	-0.003	0.005	0.002	0.0	-0.6	98.7	98.7	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
Kela Lambrog Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	98.7	97.9	0.83
TRE60.3-L.Scholing I1	-0.010	-0.006	0.010	0.004	0.0	-1.5	98.7	98.7	0.00
Kela Sch. Tfr	0.005	0.003	-0.005	-0.003	0.0	0.1	98.7	97.8	0.93
Kewathang Station Tfr	-0.040	-0.025	0.040	0.025	0.2	0.3	96.7	97.4	0.71
TRE50.11-Khoshala	-0.055	-0.035	0.055	0.035	0.0	-0.1	98.9	98.9	0.00
Khoshala Tfr	0.055	0.035	-0.053	-0.033	1.5	2.3	98.9	95.0	3.83
TRE70.16-Kkling	-0.009	-0.002	0.009	-0.001	0.0	-3.2	98.6	98.6	0.00
Krabten Tfr	0.030	0.019	-0.029	-0.018	0.5	0.7	98.7	96.6	2.07
Semji UG	0.898	0.408	-0.898	-0.406	0.0	2.1	99.0	98.9	0.09
Bum.Yotola Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	99.0	98.5	0.52
KewathangSS Tfr1	0.535	0.391	-0.534	-0.373	0.9	17.9	99.0	97.4	1.66
KewathangSS Tfr2	0.535	0.391	-0.534	-0.373	0.9	17.9	99.0	97.4	1.66
Trongsa Ring UG1	0.000	-0.001	0.000	0.001	0.0	0.0	97.4	97.4	0.00
L1-TRE10.1	1.028	0.722	-1.023	-0.719	5.6	2.8	97.4	96.9	0.49
TRE50.4-L.Belling	-0.069	-0.045	0.069	0.044	0.0	-0.6	99.1	99.1	0.00
L.Belling Tfr	0.069	0.045	-0.067	-0.041	2.4	3.7	99.1	94.2	4.84
TRE50.17-L.Jangbi	-0.007	-0.004	0.007	0.004	0.0	-0.9	98.9	98.9	0.00
L.Jangbi Tfr	0.007	0.004	-0.007	-0.004	0.2	0.2	98.9	95.8	3.03
L.Krabten-TRE60.11	0.775	0.417	-0.774	-0.421	0.4	-3.6	98.7	98.7	0.06
TRE60.7-L.Krabten	-0.788	-0.425	0.788	0.425	0.0	-0.4	98.7	98.7	0.01
L.Krabten Tfr	0.013	0.008	-0.013	-0.008	0.1	0.1	98.7	97.8	0.90
L.Scholing I-TRE60.4	0.883	0.455	-0.883	-0.458	0.3	-2.2	98.9	98.9	0.04
TRE60.3-L.Scholing I	-0.911	-0.473	0.912	0.470	0.4	-2.7	98.9	99.0	0.05
L.Scholing I Tfr	0.028	0.018	-0.028	-0.017	0.2	0.3	98.9	98.0	0.97
L.ScholingII Tfr	-0.009	-0.006	0.009	0.006	0.0	0.1	98.3	99.0	0.65
TRE60.3-L.Scholing II	-0.009	-0.006	0.009	0.006	0.0	-0.3	99.0	99.0	0.00
L.Tling-TRE60.26	0.225	0.120	-0.225	-0.120	0.0	-0.4	98.4	98.4	0.00
Tling(M-L)	-0.245	-0.133	0.245	0.129	0.0	-3.5	98.4	98.4	0.01
L.Tling Tfr	0.021	0.013	-0.020	-0.013	0.2	0.3	98.4	96.9	1.43
Loreyma-TRE30.1	0.017	0.025	-0.017	-0.025	0.0	-0.2	97.8	97.8	0.01
UG60.2-Loreyma	-0.022	-0.029	0.022	0.028	0.0	-0.3	97.8	97.9	0.02
Loreyma Tfr	0.005	0.003	-0.005	-0.003	0.0	0.1	97.8	96.9	0.93
TRE60.19-M.Tling	-0.300	-0.164	0.300	0.163	0.0	-1.2	98.4	98.4	0.01
M.Tling Tfr	0.055	0.035	-0.054	-0.034	0.8	1.2	98.4	96.4	1.93
TRE10.2-Mazadum	-0.015	-0.009	0.015	0.009	0.0	0.0	96.9	96.9	0.00
Mazadum Tfr	0.015	0.009	-0.015	-0.009	0.1	0.2	96.9	95.8	1.07
TRE70.9-Med.& Aro	-0.001	-0.001	0.001	0.000	0.0	-0.8	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
Med.& Aro Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	98.6	98.5	0.04
TRE50.5-Namther	-0.057	-0.036	0.057	0.036	0.0	-0.6	99.0	99.0	0.00
Namther Tfr	0.057	0.036	-0.056	-0.035	1.0	1.6	99.0	96.5	2.50
TRE30.2-Ngala	-0.003	-0.002	0.003	0.002	0.0	-0.2	97.8	97.8	0.00
Ngala Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	97.8	97.0	0.79
TRE50.18-Ngorme	-0.018	-0.012	0.018	0.009	0.0	-3.1	98.9	98.9	0.00
Ngorme Tfr	0.018	0.012	-0.018	-0.011	0.4	0.7	98.9	95.6	3.24
TRE50.14-Pangzor	-0.037	-0.024	0.037	0.022	0.0	-2.0	98.8	98.8	0.00
Pangzor Tfr	0.037	0.024	-0.036	-0.022	0.7	1.0	98.8	96.2	2.57
UG70.1	0.623	0.394	-0.623	-0.394		0.0	98.4	98.4	0.00
TRE70.8-PH	-0.623	-0.394	0.624	0.392	0.1	-2.0	98.4	98.4	0.03
PH1 Tfr	0.623	0.394	-0.615	-0.381	8.3	12.5	98.4	96.6	1.82
TRE60.4-Phelchung	-0.012	-0.008	0.012	0.006	0.0	-1.1	98.9	98.9	0.00
Phelchung Tfr	0.012	0.008	-0.012	-0.007	0.1	0.1	98.9	98.1	0.83
Rangthang Tfr	-0.006	-0.004	0.006	0.004	0.1	0.1	97.2	98.9	1.65
TRE50.16-Rangthang	-0.006	-0.004	0.006	0.003	0.0	-0.5	98.9	98.9	0.00
SemjeeI-TRE70.10	0.097	-0.021	-0.097	0.011	0.0	-9.9	98.6	98.6	0.02
TRE70.2-SemjeeI	-0.109	0.013	0.109	-0.013	0.0	-0.4	98.6	98.6	0.00
SemjeeI Tfr	0.012	0.008	-0.012	-0.008	0.1	0.1	98.6	97.8	0.86
TRE70.3-Semji II	-0.029	-0.018	0.029	0.015	0.0	-3.5	98.6	98.6	0.00
Semji II Tfr	0.029	0.018	-0.028	-0.018	0.4	0.6	98.6	96.6	2.00
UG60.1-Sephu	-0.022	-0.014	0.022	0.014	0.0	-0.2	97.9	97.9	0.02
Sephu Tfr	0.022	0.014	-0.022	-0.013	0.7	1.0	97.9	93.9	3.98
Sherubling-SHSS	0.179	0.114	-0.179	-0.114	0.1	0.0	95.9	95.8	0.03
TRE10.8-Sherubling	-0.252	-0.231	0.252	0.231	0.1	0.0	95.9	95.9	0.03
Sherubling Tfr	0.073	0.117	-0.071	-0.114	1.8	2.8	95.9	93.6	2.30
Sherubling MHPP Line	-0.076	0.023	0.082	-0.022	6.0	1.0	93.6	100.0	6.43
TRE50.19-Shilgling	-0.018	-0.011	0.018	0.010	0.0	-1.7	98.9	98.9	0.00
Shilgling Tfr	0.018	0.011	-0.017	-0.011	0.4	0.6	98.9	95.7	3.13
SHSS-TRE10.9	0.073	0.047	-0.073	-0.047	0.0	-0.1	95.8	95.8	0.03
SHSS Tfr	0.105	0.067	-0.104	-0.064	1.5	2.3	95.8	93.9	1.90
TRE70.20-Simphu	-0.011	-0.007	0.011	0.007	0.0	-0.2	98.6	98.6	0.00
Simphu Tfr	0.011	0.007	-0.011	-0.007	0.1	0.1	98.6	97.8	0.75
TRE70.21-Simphu Gpa	-0.003	-0.002	0.003	0.001	0.0	-0.4	98.6	98.6	0.00
Simphu Gpa Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.6	98.1	0.50
Simphu Sch.-TRE70.19	0.016	0.001	-0.016	-0.003	0.0	-2.6	98.6	98.6	0.00
Surge Shaft Tfr	-0.159	-0.098	0.160	0.100	1.1	1.6	97.4	98.3	0.93

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
Villing-T Gonpa	-0.024	-0.016	0.024	0.016	0.0	-0.1	95.8	95.8	0.01
T Gonpa Tfr	0.024	0.016	-0.023	-0.015	0.8	1.2	95.8	91.4	4.41
Ta Dzong-TRE10.5	0.720	0.528	-0.718	-0.527	2.5	1.2	96.4	96.1	0.30
TRE10.4-Ta-Dzong	-0.809	-0.584	0.810	0.584	0.6	0.3	96.4	96.4	0.06
Ta Dzong Tfr	0.089	0.056	-0.088	-0.054	1.1	1.6	96.4	94.8	1.59
Taksila-TRE50.6	0.565	0.295	-0.565	-0.297	0.1	-1.2	98.9	98.9	0.01
TRE50.5-Taksila	-0.645	-0.348	0.646	0.344	0.3	-4.7	98.9	99.0	0.06
Taksila Tfr	0.081	0.053	-0.077	-0.048	3.3	5.0	98.9	93.3	5.66
TRE60.14-Taktse JHSS	-0.047	-0.030	0.047	0.027	0.0	-2.2	98.6	98.6	0.00
Taktse JHSS Tfr	0.047	0.030	-0.047	-0.029	0.3	0.4	98.6	97.8	0.83
Taktse.T-TRE60.14	0.595	0.317	-0.595	-0.318	0.1	-1.0	98.6	98.6	0.01
TRE60.13-Taktse.T	-0.639	-0.345	0.639	0.344	0.1	-1.5	98.6	98.6	0.02
Taktse.T Tfr	0.045	0.029	-0.044	-0.027	1.0	1.5	98.6	95.5	3.13
TRE60.18-Tangsibji	-0.013	-0.012	0.013	0.012	0.0	-0.2	98.4	98.4	0.00
Tangsibji Tfr	0.013	0.012	-0.013	-0.012	0.1	0.2	98.4	97.3	1.12
TangsibjiPP Tfr2	-0.018	-0.008	0.018	0.008	0.2	0.3	97.3	98.6	1.35
TangsibjiPP L	-0.018	-0.008	0.018	0.008	0.0	0.0	98.6	98.6	0.00
TRE60.25-TCell	-0.003	-0.002	0.003	-0.001	0.0	-3.0	98.4	98.4	0.00
TCell Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	98.4	97.8	0.57
TRE60(17-18)	0.367	0.187	-0.367	-0.194	0.4	-7.7	98.5	98.4	0.10
TRE60.17-Tdingkhka	-0.406	-0.211	0.406	0.207	0.2	-3.7	98.5	98.6	0.05
Tdingkha Tfr	0.039	0.024	-0.039	-0.024	0.4	0.6	98.5	97.2	1.36
TRE70.8-Thomangdrak	-0.036	-0.023	0.036	0.023	0.0	-0.1	98.4	98.4	0.00
Thomangdrak Tfr	0.036	0.023	-0.035	-0.022	0.7	1.0	98.4	95.9	2.49
Thrisar Tfr	-0.044	-0.027	0.045	0.029	1.0	1.5	95.8	98.9	3.13
TRE70.13-Thrispang	-0.005	0.006	0.005	-0.010	0.0	-4.1	98.6	98.6	0.00
Tongtong-TRE50.11	0.208	0.106	-0.208	-0.109	0.0	-2.5	98.9	98.9	0.01
TRE50.10-Tongtong	-0.239	-0.126	0.239	0.125	0.0	-1.0	98.9	98.9	0.01
Tongtong Tfr	0.031	0.020	-0.030	-0.019	0.5	0.7	98.9	96.7	2.15
TRE10.5-Town	-0.277	-0.176	0.277	0.176	0.1	0.0	96.0	96.1	0.04
Town Tfr	0.277	0.176	-0.272	-0.168	5.2	7.8	96.0	93.5	2.49
TRE10(1-2)	0.029	0.018	-0.029	-0.018	0.0	-0.1	96.9	96.9	0.01
TRE10(1-3)	0.993	0.701	-0.991	-0.700	2.7	1.3	96.9	96.6	0.24
TRE10(3-4)	0.818	0.590	-0.816	-0.589	2.1	1.0	96.6	96.4	0.22
TRE10(5-6)	0.441	0.351	-0.440	-0.351	0.6	0.2	96.1	96.0	0.11
TRE10(6-7)	0.020	0.012	-0.020	-0.012	0.0	0.0	96.0	96.0	0.00
TRE10(6-8)	0.421	0.338	-0.420	-0.338	0.2	0.1	96.0	95.9	0.05

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
USS Dzong UG	0.020	0.012	-0.020	-0.012	0.0	0.0	96.0	95.9	0.00
TRE10.9-Villing	0.073	0.047	-0.073	-0.047	0.0	-0.1	95.8	95.8	0.03
TRE30(1-2)	0.005	0.002	-0.005	-0.003	0.0	-0.7	97.8	97.8	0.01
TRE50(1-2)	1.086	0.617	-1.086	-0.618	0.2	-0.8	99.1	99.1	0.02
TRE50(2-3)	0.927	0.515	-0.927	-0.517	0.4	-2.3	99.1	99.1	0.05
TRE50(3-4)	0.865	0.479	-0.865	-0.479	0.0	-0.3	99.1	99.1	0.00
TRE50.3-U.Belling	0.062	0.038	-0.062	-0.040	0.0	-1.3	99.1	99.1	0.00
TRE50(4-5)	0.796	0.435	-0.795	-0.438	0.4	-3.1	99.1	99.0	0.05
TRE50(6-7)	0.146	0.091	-0.146	-0.092	0.0	-0.9	98.9	98.9	0.00
TRE50.6-Thrisar	0.419	0.206	-0.419	-0.208	0.2	-2.7	98.9	98.9	0.04
TRE50(7-8)	0.128	0.080	-0.128	-0.082	0.0	-1.2	98.9	98.9	0.01
TRE50(9-10)	0.374	0.180	-0.373	-0.182	0.1	-2.1	98.9	98.9	0.03
TRE50(10-15)	0.135	0.057	-0.135	-0.059	0.0	-1.9	98.9	98.9	0.00
TRE50(12-13)	0.069	0.040	-0.069	-0.041	0.0	-1.6	98.8	98.8	0.00
TRE50(12-14)	0.037	0.019	-0.037	-0.022	0.0	-2.7	98.8	98.8	0.00
TRE50(15-16)	0.047	0.016	-0.047	-0.019	0.0	-2.9	98.9	98.9	0.00
TRE50(16-17)	0.041	0.016	-0.041	-0.024	0.0	-8.4	98.9	98.9	0.01
TRE50.17-U.Jangbi	0.034	0.020	-0.034	-0.022	0.0	-1.2	98.9	98.9	0.00
TRE50(18-19)	0.048	0.021	-0.048	-0.023	0.0	-1.4	98.9	98.9	0.00
TRE50(19-20)	0.030	0.013	-0.030	-0.019	0.0	-6.1	98.9	98.9	0.00
TRE50.20-WanglingI	0.022	0.014	-0.022	-0.014	0.0	-0.3	98.9	98.9	0.00
Taktse UG	-0.001	0.026	0.001	-0.026	0.0	0.0	98.9	98.9	0.00
L1-TSE60.1	0.001	-0.026	-0.001	0.016	0.0	-9.6	98.9	98.9	0.00
TSE60.1-Taktse line	0.000	-0.017	0.000	0.000	0.0	-16.7	98.9	98.9	0.00
TRE60(2-3)	0.921	0.473	-0.921	-0.476	0.5	-3.0	99.0	99.0	0.06
TRE60.2-Yurmo	0.019	0.012	-0.019	-0.012	0.0	-0.1	99.0	99.0	0.00
TRE60(4-5)	0.871	0.451	-0.870	-0.455	0.5	-3.6	98.9	98.8	0.07
TRE60(5-6)	0.821	0.426	-0.820	-0.428	0.3	-2.2	98.8	98.8	0.04
TRE60.5-U.Scholing	0.050	0.029	-0.050	-0.031	0.0	-2.1	98.8	98.8	0.00
TRE60(6-7)	0.809	0.424	-0.809	-0.426	0.3	-2.5	98.8	98.7	0.04
TRE60.6-U.Krabten	0.011	0.004	-0.011	-0.007	0.0	-2.8	98.8	98.8	0.00
TRE60(7-8)	0.021	0.001	-0.021	-0.006	0.0	-4.9	98.7	98.7	0.00
TRE60(8-9)	0.021	0.006	-0.021	-0.007	0.0	-0.6	98.7	98.7	0.00
TRE60(9-10)	0.016	0.005	-0.016	-0.006	0.0	-1.8	98.7	98.7	0.00
TRE60(11-12)	0.696	0.375	-0.696	-0.375	0.0	-0.1	98.7	98.7	0.00
TRE60(14-15)	0.547	0.290	-0.547	-0.291	0.1	-1.1	98.6	98.6	0.01
TRE60(15-16)	0.440	0.225	-0.440	-0.226	0.0	-1.3	98.6	98.6	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
TRE60(16-17)	0.406	0.206	-0.406	-0.207	0.0	-1.0	98.6	98.6	0.01
TRE60(18-19)	0.354	0.183	-0.353	-0.186	0.1	-3.2	98.4	98.4	0.04
TRE60(19-20)	0.053	0.023	-0.053	-0.026	0.0	-3.4	98.4	98.4	0.00
TRE60(20-21)	0.053	0.026	-0.053	-0.030	0.0	-3.2	98.4	98.4	0.00
TRE60(22-23)	0.045	0.042	-0.045	-0.043	0.0	-0.4	98.4	98.4	0.00
TRE60(24-25)	0.198	0.104	-0.198	-0.106	0.0	-1.9	98.4	98.4	0.01
TRE60.24-Tshangka Sch.	0.027	0.017	-0.027	-0.017	0.0	-0.1	98.4	98.4	0.00
TRE60(25-26)	0.195	0.107	-0.195	-0.108	0.0	-1.6	98.4	98.3	0.01
TRE60(26-27)	0.160	0.087	-0.160	-0.093	0.0	-6.8	98.3	98.3	0.02
TRE60.26-Tshangka	0.035	0.022	-0.035	-0.022	0.0	-0.2	98.3	98.3	0.00
TRE60(27-28)	0.160	0.093	-0.160	-0.098	0.0	-4.3	98.3	98.3	0.01
TRE60(28-29)	0.000	-0.002	0.000	0.000	0.0	-2.1	98.3	98.3	0.00
TRE60.28-Tshangka1	0.160	0.100	-0.160	-0.100	0.0	-0.2	98.3	98.3	0.00
TRE70(0-1)	0.897	0.431	-0.896	-0.441	1.4	-10.0	98.9	98.8	0.18
TRE70(1-2)	0.857	0.418	-0.856	-0.425	0.9	-6.7	98.8	98.6	0.12
TRE70.1-Yangkhil.R	0.039	0.023	-0.039	-0.024	0.0	-1.0	98.8	98.8	0.00
TRE70(2-3)	0.747	0.438	-0.746	-0.441	0.3	-2.6	98.6	98.6	0.04
TRE70(3-4)	0.718	0.426	-0.717	-0.428	0.2	-2.0	98.6	98.6	0.03
TRE70(4-5)	0.039	0.016	-0.039	-0.017	0.0	-1.4	98.6	98.6	0.00
TRE70(5-9)	0.015	0.007	-0.015	-0.008	0.0	-1.8	98.6	98.6	0.00
TRE70(6-7)	0.659	0.414	-0.659	-0.414	0.0	-0.1	98.4	98.4	0.00
TRE70.6-View Pt.R	0.001	-0.001	-0.001	0.000	0.0	-2.0	98.4	98.4	0.00
TRE70(7-8)	0.659	0.414	-0.659	-0.414	0.1	-0.6	98.4	98.4	0.01
TRE70(10-11)	0.005	-0.002	-0.005	0.000	0.0	-2.2	98.6	98.6	0.00
TRE70(12-13)	0.006	-0.013	-0.006	0.010	0.0	-2.7	98.6	98.6	0.00
TRE70(14-15)	0.075	0.009	-0.075	-0.014	0.0	-4.8	98.6	98.6	0.01
TRE70(15-16)	0.024	0.003	-0.024	-0.008	0.0	-4.8	98.6	98.6	0.00
TRE70(15-17)	0.051	0.011	-0.051	-0.011	0.0	-0.4	98.6	98.6	0.00
TRE70(17-18)	0.036	0.003	-0.036	-0.007	0.0	-4.2	98.6	98.6	0.00
TRE(19-20)	0.014	0.003	-0.014	-0.006	0.0	-3.1	98.6	98.6	0.00
TRE(20-21)	0.003	-0.001	-0.003	-0.002	0.0	-2.7	98.6	98.6	0.00
Trongsa Ring UG2	0.000	-0.001	0.000	0.001	0.0	0.0	97.4	97.4	0.00
Trong Ring L1	0.000	-0.001	0.000	0.000	0.0	-0.8	97.4	97.4	0.00
Trongsa Ring UG3	0.000	0.000	0.000	0.000			97.4	97.4	
Tshangka Tfr	0.035	0.022	-0.034	-0.021	0.3	0.5	98.3	97.1	1.22
Tshangka Sch. Tfr	0.027	0.017	-0.027	-0.016	0.2	0.3	98.4	97.4	0.93
U.Belling Tfr	0.062	0.040	-0.061	-0.038	1.2	1.8	99.1	96.4	2.71

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
U.Jangbi Tfr	0.034	0.022	-0.033	-0.021	0.6	0.9	98.9	96.5	2.36
U.Krabten Tfr	0.011	0.007	-0.011	-0.007	0.2	0.2	98.8	96.9	1.93
U.Scholing Tfr	0.050	0.031	-0.049	-0.031	0.3	0.5	98.8	98.0	0.86
USS Dzong Tfr	0.020	0.012	-0.020	-0.012	0.0	0.0	95.9	95.8	0.18
Villing Tfr	0.049	0.031	-0.048	-0.030	1.3	2.0	95.8	92.3	3.52
WanglingI Tfr	0.022	0.014	-0.021	-0.013	0.6	0.9	98.9	95.0	3.83
Yangkhil.R Tfr	0.039	0.024	-0.039	-0.024	0.2	0.3	98.8	98.1	0.68
Yurmo Tfr	0.019	0.012	-0.019	-0.012	0.2	0.3	99.0	97.8	1.29
					110.8	-150.2			

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.)		

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
B.TCom Tfr	Transformer	Overload	0.025	MVA	0.030	121.9	3-Phase
Dangdung Tfr	Transformer	Overload	0.063	MVA	0.10	153.9	3-Phase
Indocholing Tfr	Transformer	Overload	0.125	MVA	0.19	151.6	3-Phase
Khoshala Tfr	Transformer	Overload	0.063	MVA	0.07	103.6	3-Phase
L.Belling Tfr	Transformer	Overload	0.063	MVA	0.08	131.1	3-Phase
Sephu Tfr	Transformer	Overload	0.025	MVA	0.03	106.6	3-Phase
Sherubling MHPP1	Generator	Overload	0.050	MW	0.08	164.0	3-Phase
T Gonpa Tfr	Transformer	Overload	0.025	MVA	0.03	115.5	3-Phase
Taksila Tfr	Transformer	Overload	0.063	MVA	0.10	153.0	3-Phase
WanglingI Tfr	Transformer	Overload	0.025	MVA	0.03	103.6	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
B.TCom B2	Bus	Under Voltage	11.000	kV	10.410	94.6	3-Phase
Bagochen B2	Bus	Under Voltage	0.415	kV	0.39	93.5	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
D.Gonpa B2	Bus	Under Voltage	0.415	kV	0.391	94.3	3-Phase
Dangdung B2	Bus	Under Voltage	0.415	kV	0.39	93.2	3-Phase
Hospital B2	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
Indocholing B2	Bus	Under Voltage	0.415	kV	0.39	93.5	3-Phase
L.Belling B2	Bus	Under Voltage	0.415	kV	0.39	94.2	3-Phase
Sephu B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
Sherubling B2	Bus	Under Voltage	0.415	kV	0.39	93.6	3-Phase
SHSS B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
T Gonpa B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Ta Dzong B2	Bus	Under Voltage	0.415	kV	0.39	94.8	3-Phase
Taksila B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
Town B2	Bus	Under Voltage	0.415	kV	0.39	93.5	3-Phase
Villing B2	Bus	Under Voltage	0.415	kV	0.38	92.3	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	4.165	2.362	4.788	86.98 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	4.165	2.362	4.788	86.98 Lagging
Total Motor Load:	0.871	0.540	1.025	85.00 Lagging
Total Static Load:	3.183	1.973	3.745	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.111	-0.150		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure-5: Feeder Wise Reliability Indices

Sl.No.	Year	Reliability Indices	11kV Station Feeder	11kV Trongsa Feeder 1	11kV Trongsa Feeder 2	33KV Bumthang Feeder	33kV Langthel Feeder	33kV Semji Feeder	33kV Taktse/Nikachu Feeder
1	2017	SAIFI	-	0.528	-	-	0.153	1.439	0.747
		SAIDI	-	0.349	-	-	0.099	1.162	0.603
2	2018	SAIFI	-	0.402	-	0.000	0.029	1.704	0.433
		SAIDI	-	0.533	-	0.001	0.025	1.098	0.021
3	2019	SAIFI	-	0.142	-	0.000	0.030	0.835	0.065
		SAIDI	-	0.060	-	0.000	0.007	0.324	0.209
	Total *	SAIFI	-	1.072	-	0.001	0.211	3.978	1.245
		SAIDI	-	0.942	-	0.001	0.131	2.584	0.834
Average Reliability			**SAIFI**	**0.930**		**SAIDI**	**0.642**		

Feeder Name: 11kV Trongsa Feeder, No of

Sl.No.	Cause of Outages	Frequency of Interuption (Times)																									
		2018													2019												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace							2						2					1					2			3
2	Line Jumpering													0			2										2
3	Collaps of Pole-Breakdown													0													0
4	Snap of Conductor													0													0
5	Puncture of insulator/Leakage													0													0
6	Puncture of LA/LA Maintenance													0													0
7	Ligtining & Strom/Rain													0													0
8	Tree/branch fall on line			2	1									3													0
9	RoW Clearing								4					4													0
10	Land Slide													0													0
11	Forest fire/house fire													0	1												1
12	Preventive Maintenance of Line/LBS/GO/ARCB							1	2	2	1			6	1												1
13	Preventive Maintenance of substation/Switchyard											1		1			1										1
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0													0
15	Breakdown Maintenance of Substation/Switchyard													0													0
16	SMD Planned shutdown													0													0
17	Adhoc Shutdown (Tapping, Emergency request)													0							1						1
18	Momentary/Traisent fault													0													0
19	Trace of fault on line													0													0
20	Because of Bird/Animals													0	1												1
21	Close and Open of GO/LBS													0													0
22	Puncture of UG cable													0													
23	Trip of CB/ Burn MCCB/change of MCCB		1								1			2													
24	Extend the line																										
25	Installation/Charging/Testing of Transformer				4														1								
26	Because of Vehicle																										
	SAIFI	**0.000**	**0.246**	**0.243**	**0.971**	**0.000**	**0.000**	**0.724**	**1.440**	**0.480**	**0.482**	**0.242**	**0.000**	**0.402**	**0.744**	**0.000**	**0.718**	**0.000**	**0.237**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.142**
	SAIDI	**0.000**	**0.066**	**0.364**	**0.794**	**0.000**	**0.000**	**0.099**	**3.848**	**0.084**	**0.137**	**1.004**	**0.000**	**0.533**	**0.303**	**0.000**	**0.136**	**0.000**	**0.213**	**0.000**	**0.064**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.060**

Feeder Name: 33kV Bumthang feeder, No.

Sl.No.	Cause of Outages	Frequency of Interuption (Times)																									
		2018													2019												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace										1			1	1		1										2
2	Line Jumpering			1										1													0
3	Collaps of Pole-Breakdown													0													0
4	Snap of Conductor													0													0
5	Puncture of insulator/Leakage													0													0
6	Puncture of LA/LA Maintenance													0													0
7	Ligtining & Strom/Rain													0													0
8	Tree/branch fall on line		1											1								1					1
9	RoW Clearing			1					1					2													0
10	Land Slide													0													0
11	Forest fire/house fire													0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB								1					1													0
13	Preventive Maintenance of substation/Switchyard												1	1	1												1
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0													0
15	Breakdown Maintenance of Substation/Switchyard													0													0
16	SMD Planned shutdown													0													0
17	Adhoc Shutdown (Tapping, Emergency request)													0													0
18	Momentary/Traisent fault													0													0
19	Trace of fault on line								1					1													0
20	Because of Bird/Animals													0													0
21	Close and Open of GO/LBS													0													0
22	Puncture of UG Cable																										
23	Trip of CB/ Burn MCCB																										
24	Extend the line																										
25	Installation/Charging/Testing of Transformer																										
26	Because of Vehicle																										
	SAIFI	**0.000**	**0.000**	**0.001**	**0.001**	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	SAIDI	**0.000**	**0.002**	**0.003**	**0.003**	**0.000**	**0.000**	**0.000**	**0.007**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

Feeder Name: 33kV Langthel feeder, No. o

Sl.No.	Cause of Outages	Frequency of Interuption (Times)																									
		2018													2019												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0			1										1
2	Line Jumpering													0													0
3	Collaps of Pole-Breakdown													0													0
4	Snap of Conductor													0													0
5	Puncture of insulator/Leakage													0													0
6	Puncture of LA/LA Maintenance													0													0
7	Ligtining & Strom/Rain													0													0
8	Tree/branch fall on line				1									1													0
9	RoW Clearing													0													0
10	Land Slide													0													0
11	Forest fire/house fire													0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB													0													0
13	Preventive Maintenance of substation/Switchyard			1										1													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0													0
15	Breakdown Maintenance of Substation/Switchyard													0													0
16	SMD Planned shutdown													0													0
17	Adhoc Shutdown (Tapping, Emergency request)													0													0
18	Momentary/Traisent fault													0													0
19	Trace of fault on line													0													0
20	Because of Bird/Animals													0													0
21	Close and Open of GO/LBS													0													0
22	Puncture of UG Cable																										
23	Trip of CB/ Burn MCCB																										
24	Extend the line																										
25	Installation/Charging/Testing of Transformer																										
26	Because of Vehicle																										
	SAIFI	**0.000**	**0.000**	**0.171**	**0.171**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.029**	**0.000**	**0.000**	**0.169**	**0.000**	**0.000**	**0.188**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.030**
	SAIDI	**0.000**	**0.000**	**0.243**	**0.056**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.025**	**0.000**	**0.000**	**0.081**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.007**

Feeder Name: 33kV Sembji Feeder, No. of

Sl.No.	Cause of Outages	Frequency of Interuption (Times)																									
		2018													2019												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace				2	7	2	6	1	4	4	1	2	29	1		2	1	1		6	3	2	3		2	21
2	Line Jumpering						3					1		4				2	1		1			1		2	7
3	Collaps of Pole-Breakdown													0													0
4	Snap of Conductor													0													0
5	Puncture of insulator/Leakage													0													0
6	Puncture of LA/LA Maintenance/ change LA					1						1		2								1		1			2
7	Ligtining & Strom/Rain													0													0
8	Tree/branch fall on line													0													0
9	RoW Clearing								15					15			1										1
10	Land Slide													0													0
11	Forest fire/house fire													0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB				1	2	4				3	2		12	1			3	1				1	2			8
13	Preventive Maintenance of substation/Switchyard					1		2			2	1		6						5				2		1	8
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0										3			3
15	Breakdown Maintenance of Substation/Switchyard													0				1			1						2
16	SMD Planned shutdown													0					1								1
17	Adhoc Shutdown (Tapping, Emergency request)													0													0
18	Momentary/Traisent fault				1									1									1				1
19	Trace of fault on line													0													0
20	Because of Bird/Animals													0	2			2		1							5
21	Close and Open of GO/LBS						1	1	1					3										1			1
22	Puncture of UG cable	1												1													
23	Trip of CB/ Burn MCCB		1											1													
24	Extend the Line																										
25	Installation/Charging/Testing of Transformer				1			1										3	2								
26	Because of vehicle																	1									
	SAIFI	**0.260**	**0.283**		**1.083**	**2.920**	**2.702**	**2.690**	**4.839**	**1.080**	**2.430**	**1.617**	**0.542**	**1.704**	**1.085**	**0.000**	**0.815**	**3.533**	**1.354**	**1.620**	**1.620**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.835**
	SAIDI	**0.256**	**0.256**		**0.804**	**0.608**	**1.402**	**0.823**	**5.537**	**1.067**	**1.580**	**0.741**	**0.098**	**1.098**	**0.312**	**0.000**	**0.369**	**1.422**	**0.801**	**0.427**	**0.513**	**0.000**	**0.010**	**0.000**	**0.000**	**0.036**	**0.324**

Feeder Name: 33kV Taktse Feeder, No of (

Sl.No.	Cause of Outages	Frequency of Interuption (Times)																								
		2018													2019												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace			2										2													0
2	Line Jumpering							2	1				1	4													0
3	Collaps of Pole-Breakdown													0													0
4	Snap of Conductor													0													0
5	Puncture of insulator/Leakage						2							2													0
6	Puncture of LA/LA Maintenance													0													0
7	Ligtining & Strom/Rain													0													0
8	Tree/branch fall on line						1							1													0
9	RoW Clearing			1				1						2													0
10	Land Slide													0													0
11	Forest fire/house fire													0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB			1			2	1				1		5													0
13	Preventive Maintenance of substation/Switchyard													0													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0													0
15	Breakdown Maintenance of Substation/Switchyard													0													0
16	SMD Planned shutdown													0													0
17	Adhoc Shutdown (Tapping, Emergency request)													0													0
18	Momentary/Traisent fault													0													0
19	Trace of fault on line						1							1		1											1
20	Because of Bird/Animals													0													0
21	Close and Open of GO/LBS								2					2				1									1
22	Puncture of UG Cable																										
23	Trip of CB/ Burn MCCB																										
24	Extend the Line			1																							
25	Installation/Charging/Testing of Transformer												1														
26	Because of Vehicle															1		1									
	SAIFI	**0.000**	**0.000**	**1.303**	**0.000**	**0.000**	**1.555**	**1.040**	**0.779**	**0.000**	**0.000**	**0.260**	**0.260**	**0.433**	**0.000**	**0.000**	**0.521**	**0.261**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.065**
	SAIDI	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.257**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.021**	**0.000**	**0.000**	**1.802**	**0.710**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.209**

Sl no	Casues of Outages	Frequency of interruption	Interruption %
1	HT fuse Replace	61	30.81%
2	Line Jumpering	18	9.09%
5	Puncture of insulator/Leakage	2	1.01%
6	Puncture of LA/LA Maintenance	4	2.02%
8	Tree/branch fall on line	7	3.54%
9	RoW Clearing	24	12.12%
11	Forest fire/house fire	1	0.51%
12	Preventive Maintenance of Line/LBS/GO/ARCB	33	16.67%
13	Preventive Maintenance of substation/Switchyard	19	9.60%
14	Breakdown Maintenance of Line/LBS/GO/ARCB	3	1.52%
15	Breakdown Maintenance of Substation/Switchyard	2	1.01%
16	SMD Planned shutdown	1	0.51%
17	Adhoc Shutdown (Tapping, Emergency request)	1	0.51%
18	Momentary/Traisent fault	2	1.01%
19	Trace of fault on line	3	1.52%
20	Because of Bird/Animals	6	3.03%
21	Close and Open of GO/LBS	7	3.54%
22	Puncture of UG Cable	1	0.51%
23	Trip of CB/ Burn MCCB	3	1.52%

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

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

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

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

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

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

Annexure-7: Distribution Transformer Loading

Transformers Details									Load Forcast			
Name of Feeder	**DT Location Name**	**Transformer Ratio**	**Transformer Details**				**Peak Load (kVA)****	**% Loading**	**2025 peak Load (kVA)**	**% Loading 2025**	**2030 peak Load (kVA)**	**% Loading 2030**
			kVA	**Installed Yr/MFD***	**Serial Number**	**Trans ID**	**2019-2020**					
Kewathang 33/11kV, Power Transformer 1	**Kewathang**	**33/11**	**2500**	**2008**	PT-5790	TREPT1						
Kewathang 33/11kV, Power Transformer 2	**Kewathang**	**33/11**	**2500**	**2008**	PT-5791	TREPT2						
							64.706	**0.377**			**87.06**	**0.8526**
								1.377				**1.8526**
11kV Station Feeder 1	Kewathang Station transformer I	11/0.415	250	2008	PO.NO.SP/0/00605155-919A3	TRE90T1	46.993	18.80%	64.706	25.88%	87.059	34.82%
11kV Station Feeder 2	Kewathang Station transformer II	11/0.415	125	2016	2016.125.11.17661	TRE100T2						
								1294.118	**0.923**		**1464.706**	**1.177**
									1.923			**2.177**
	Bagochen	11/0.415	250	2009	72236	TRE10T1	100.576	40%	193.43	77%	218.929	88%
	DOR(Trongsa)	11/0.415	250	1994	94CD-003	TRE10T3	37.72	15%	72.54	29%	82.107	33%
	Taa Dzong	11/0.415	250	2010	2010.250.11.12281	TRE10T4	51.424	21%	98.90	40%	111.937	45%
	Town	11/0.415	500	2003	15231	TRE10T5	162.653	33%	312.82	63%	354.056	71%
	Sherabling Hopital	11/0.415	250	2003	TEC03-01	TRE10T7	99.705	40%	191.76	77%	217.033	87%
11kV Trongsa Feeder 1	Sherabling	11/0.415	250	2003	78272	TRE10T8	88.254	35%	169.73	68%	192.107	77%
	Sherabling HSS	11/0.415	250	2010	D.0.NO.SP/G/00605	TRE10T9	60.11	24%	115.61	46%	130.845	52%
	Vlling Village	11/0.415	63	2003	TECB03-01	TER10T10	29.126	46%	56.02	89%	63.400	101%
	Taphe Gonpa	11/0.415	25	2006	29132	TRE10T11	14.55	58%	27.98	112%	31.672	127%
	Maza damtsum	11/0.415	63	2001	2001-02/77	TRE10T12	8.74	14%	16.81	27%	19.025	30%
	Dorji Gonpa	11/0.415	25	1995	1995-21	TRE10T13	8.2269	33%	15.82	63%	17.908	72%
	USS Dzong	11/0.415	500	2014	TBI - 625000402/3	TRE10T6	11.8	2%	22.69	5%	25.68571447	5%
							672.8849		**1271.42**			
								255.882	**0.225**		**308.235**	**0.555**
									1.225			**1.555**
	Yangkhil Resort	33/0.415	250	2010	2010.250.33.12326	TRE70T1	30.2163	12%	37.029	15%	46.993	19%
	Semji I	33/0.415	63	2010	2010.63.33.11529	TRE70T2	9.74	15%	11.936	19%	15.148	24%
	Semji II	33/0.415	25	2009	2009.25.33.10967	TRE70T3	8.93	36%	10.943	44%	13.888	56%
	Bjee pam Gongma	33/0.415	63	2010	2010.63.33.11495	TRE70T6	12.56	20%	15.392	24%	19.534	31%
	Bjee Zam	33/0.415	63	2010	2010.63.33.11480	TRE70T5	10.768	17%	13.196	21%	16.747	27%
	Bjee Proper	33/0.415	63	2010	2010.63.33.11497	TRE70T4	6.561	10%	8.040	13%	10.204	16%
	Bjee Pam Wogma-I	33/0.240	16	2010	2010.16.33.10899	TRE70T7	6.102	38%	7.478	47%	9.490	59%
	Bjee Pam Wogma-II	33/0.240	16	2010	2010.16.33.10868	TRE70T8	7.074	44%	8.669	54%	11.002	69%
	View Point Resort	33/0.240	25	2009	O9112834	TRE70T9	1.03	4%	1.262	5%	1.602	6%
	Thomangdrak	33/0.415	63	2019	2019.63.33.20683	TRE70T10	28.35	45%	34.742	55%	44.091	70%
	Gagar Choshi	33/0.415	25	2014	B92	TRE70T11	1.416	6%	1.735	7%	2.202	9%
	Gagar Pam	33/0.415	25	2014	B126	TRE70T12	2.587	10%	3.170	13%	4.023	16%
	Karshong School	33/0.240	16	2014	B53	TRE70T13	1.214	8%	1.488	9%	1.888	12%
	Karshong Shedra	33/0.415	25	2014	B129	TRE70T14	1.727	7%	2.116	8%	2.686	11%
	Karshomg Trong	33/0.415	25	2014	B100	TRE70T15	1.118	4%	1.370	5%	1.739	7%
	Thrispang	33/0.240	10	2014	B16	TRE70T16	0.7424	7%	0.910	9%	1.155	12%
33kV Sembji	Jongthang	33/0.415	63	2013	3878/13-14	TRE70T17	2.913	5%	3.570	6%	4.530	7%

Transformers Details								% Loading	Load Forcast			
Name of Feeder	DT Location Name	Transformer Ratio	Transformer Details				Peak Load (kVA)**	% Loading	2025 peak Load (kVA)	% Loading 2025	2030 peak Load (kVA)	% Loading 2030
			kVA	Installed Yr/MFD*	Serial Number	Trans ID	2019-2020					
Feeder	Karshong Pam	33/0.415	25	2014	B127	TRE70T18	1.476	6%	1.809	7%	2.296	9%
	Lower Pang	33/0.240	10	2014	B8	TRE70T19	2.02	20%	2.475	25%	3.142	31%
	Upper Pang	33/0.240	16	2014	B15	TRE70T20	1.541	10%	1.888	12%	2.397	15%
	Bemji	33/0.415	63	2014	B185	TRE70T21	12.21	19%	14.963	24%	18.989	30%
	Kaba	33/0.415	25	2014	B104	TRE70T22	7.19	29%	8.811	35%	11.182	45%
	Daba	33/0.415	25	2014	B99	TRE70T23	6.26	25%	7.671	31%	9.736	39%
	Simphu School	33/0.240	10	2014	B24	TRE70T24	0.789	8%	0.967	10%	1.227	12%
	Semjungling	33/0.240	16	2014	B50	TRE70T25	0.969	6%	1.187	7%	1.507	9%
	Simphu	33/0.415	63	2014	B181	TRE70T26	8.616	14%	10.559	17%	13.400	21%
	Simphu Gonpa	33/0.415	25	2014	B111	TRE70T27	2.242	9%	2.747	11%	3.487	14%
	Thagnil	33/0.240	16	2014	B52	TRE70T28	0.447	3%	0.548	3%	0.695	4%
	Chela	33/0.415	25	2014	B157	TRE70T29	10.434	42%	12.786	51%	16.227	65%
	Zilu Gonpa	33/0.240	10	2014	B12	TRE70T30	1.228	12%	1.505	15%	1.910	19%
	Kakaling	33/0.240	10	2014	B22	TRE70T31	1.248	12%	1.529	15%	1.941	19%
	Drengzhing	33/0.415	63	2010	2010.63.33.11515	TRE70T32	5.494	9%	6.733	11%	8.544	14%
	Kaba Organic farm	33/0.415	63	2018		TRE70T33	1.82	3%	2.230	4%	2.831	4%
	Medical and Aromatic Plants	33/0.415	125	2014	3868/13-14	TRET7034	1.16	1%	1.422	1%	1.804	1%
							198.1927					

MFD*: If the installed year is not known

** You have to sort out the highest recorded load of the transformer

Transformers Details									Load Forcast			
Name of Feeder	DT Location Name	Transformer Ratio	Transformer Details				Peak Load (kVA)**	% Loading	2025 peak Load (kVA)	% Loading 2025	2030 peak Load (kVA)	% Loading 2030
			kVA	Installed Yr/MFD*	Serial Number	Trans ID	2019-2020					
								2,235.29	0.058		2,352.94	0.114
									1.058			1.114
ICT Tranfromer, Alubari		**33/11**	**500**									
6.6 Tangsibji Micro Feeder	Tangsibjee Power House	0.415/6.6	50	1987	862130104	TRETMHPT1		0.00%	0.00	0%	0.000	0%
	Tangsibjee Village	6.6/0.415	50	1987	862130106	TRE120T1		0.00%	0.00	0%	0.000	0%
11kV Chendipjee feeer.	Sephuchen	11/0.415	25	2005	30505	TRE30T1	25.4	101.60%	26.87	107.48%	28.285	113%
	Loreyma	11/0.415	25	2005	30500	TRE30T2	5.92	23.68%	6.26	25%	6.592	26%
	Ngala	11/0.415	16	2005	KT-16/25	TRE30T3	3.21	20.06%	3.40	21%	3.575	22%
	Drangla	11/0.415	63	2001	2001-0277	TRE30T4	2.385	3.79%	2.52	4%	2.656	4%
	Chendibjee -I	11/0.415	125	1999	1999.04	TRE30T5	15.694	12.56%	16.60	13%	17.477	14%
	Chendibjee -II	11/0.240	10	2005	KT-10251	TRE30T6	1.615	16.15%	1.71	17%	1.798	18%
	Chendibjee-III	11/0.415	63	1990	184-04	TRE30T7	21.243	33.72%	22.47	36%	23.656	38%
	Chendibjee-IV	0.415/11	400	2019	2019	TRECMHPT1		0.00%	0.00	0%	0.000	0%
33kV Taaktse/Nikachu Feeder	Tashidingkha	33/0.415	125	2010	2010.125.11550	TRE60T1	42.416	33.93%	44.87	36%	47.234	38%
	Mid Tashiling	33/0.415	125	2010	2010.125.33.11562	TRE60T2	60.063	48.05%	63.54	51%	66.885	54%
	Lower Tashiling	33/0.415	63	2010	2010.63.33.11508	TRE60T3	22.5	35.71%	23.80	38%	25.056	40%
	Tshangkha	33/0.415	125	2010	2010.125.33.11563	TRE60T4	38.47	30.78%	40.70	33%	42.840	34%
	Upper Tashiling	33/0.240	10	2009	2009.10.33.10762	TRE60T5	2.34	23.40%	2.48	25%	2.606	26%
	Gangla Pokto	33/0.415	25	2009	2009.25.33.11111	TRE60T6	7.051	28.20%	7.46	30%	7.852	31%
	Taktsi JHSS	33/0.415	250	2010	2010.63.11471	TRE60T7	50.895	20.36%	53.84	22%	56.676	23%
	Taktsi Top	33/0.415	63	2009	2009.250.11572	TRE60T8	50.000	79.37%	52.90	84%	55.679	88%
	Eusa	33/0.415	125	2011	11535	TRE60T9	42.043	33.63%	44.48	36%	46.819	37%
	Bubja	33/0.415	25	2009	2009.25.33.11131	TRE60T10	20.5	82.00%	21.69	87%	22.829	91%
	Lower Kingarabten	33/0.415	63	2010	2010.63.33.11487	TRE60T11	14.21	22.56%	15.03	24%	15.824	25%
	Upper Kingarabten	33/0.415	25	2009	2009.25.33.0607	TRE60T12	12.03	48.12%	12.73	51%	13.396	54%
	Upper Samcholing	33/0.415	250	2009	2009.250.33.11570	TRE60T13	52.792	21.12%	55.85	22%	58.788	24%
	Phelchung	33/0.415	63	2008	2008.63.33.11500	TRE60T14	12.984	20.61%	13.74	22%	14.459	23%
	Lower Samcholing I	33/0.415	125	2010	2010.125.33.11564	TRE60T15	30.725	24.58%	32.50	26%	34.215	27%
	Lower Samcholing II	33/0.415	63	2010	2010.63.33.11526	TRE60T16	10.157	16.12%	10.75	17%	11.311	18%
	Yurmung	33/0.415	63	2010	2010.63.33.11498	TRE60T17	20.459	32.47%	21.64	34%	22.783	36%
	Kela Khep	33/0.415	63	2010	2010.63.33.11493	TRE60T18	6.462	10.26%	6.84	11%	7.196	11%
	Kela Maling I	33/0.240	16	2010	2010.16.33.10943	TRE60T19	2.451	15.32%	2.59	16%	2.729	17%
	Kela Maling II	33/0.415	25	2009	2009.25.33.11027	TRE60T20	3.345	13.38%	3.54	14%	3.725	15%
	Kela School Area	33/0.415	25	2009	2009.25.33.11059	TRE60T21	5.852	23.41%	6.19	25%	6.517	26%
	Kela Lambrong	33/0.415	25	2009	2009.25.33.11034	TRE60T22	5.132	20.53%	5.43	22%	5.715	23%
	Chakarzur Lhakhang	33/0.415	63	2002	KT-63/2438	TRE60T23	53.5	84.92%	56.60	90%	59.577	95%
	Kingarabten	33/0.415	63	2011	6000	TRE60T24	32.663	51.85%	34.55	55%	36.373	58%
	Tangsibjee	33/0.415	63	2015	281012	TRE60T25	34.326	54.49%	36.31	58%	38.225	61%
	Chunjaphang	33/0.415	25	2012	B147	TRE60T29	1.437	5.75%	1.52	6%	1.600	6%
	CLCS Hostel	33/0.415	500	2017	Name plate missing	TRE60T26	35.6	7.12%	37.66	8%	39.644	8%
	CLCS	33/0.415	250	2009	2009-250-33-10473	TRE60T27	58.82	23.53%	62.23	25%	65.501	26%
	CLCS Academic	33/0.415	500	2012	33-120	TRE60T28	56.941	11.39%	60.24	12%	63.409	13%
	Tsangkha school	33/0.415	125	2019	2019.125.33.20690	TRE60T30	28.698	22.96%	30.36	24%	31.958	26%
	THyE Dam	33/0.415	2x750	2015	16634/16635		352.94	23.53%	373.38	25%	393.029	26%
	Adit 1	33/0.415	750	2015	16638			0.00%	0.00	0%	0.000	0%
	Adit 2	33/0.415	2x250	2015	16627/16628				0.00		0.000	
	Adit 3	33/0.415	2x250	2015	16626/16631				0.00		0.000	
	Adit 4	33/0.415	2x250	2015	16629/16630				0.00		0.000	
	Adit 5	33/0.415	750	2015	16637			0.00%	0.00	0%	0.000	0%

Transformers Details									Load Forcast			
Name of Feeder	DT Location Name	Transformer Ratio	Transformer Details				Peak Load (kVA)**	% Loading	2025 peak Load (kVA)	% Loading 2025	2030 peak Load (kVA)	% Loading 2030
			kVA	Installed Yr/MFD*	Serial Number	Trans ID	2019-2020					
	Shurge shaft	33/0.415	750	2015	16639		176.47	23.53%	186.69	25%	196.515	26%
	Nikachu Power House	33/0.415	2x750	2015	2015.750.33.16633/2015.750.33.16636		689.7	45.98%	729.64	49%	768.041	51%
	Tashi Cell (Tsangkha)	33/0.415	25				3.5	14.00%	3.70	15%	3.898	16%
							2112.939					
								1,094.12	**1.900**		**1,388.24**	**2.680**
									2.900			**3.680**
33kV Langthel Feeder	Indocholing	33/0.415	125	2006	2006.125.33.7918	TRE50T1	54.12	43.30%	156.951	126%	199.143	159%
	Upper Belling	33/0.415	100	2006	2006.100.33.7915	TRE50T2	20.6394	20.64%	59.856	60%	75.946	76%
	Lower Belling	33/0.415	63	2006	2006.63.33.7904	TRE50T3	23.422	37.18%	67.925	108%	86.185	137%
	Bashling	33/0.240	10	2009	2009.1905/0.230	TRE50T4		0.00%	0.000	0%	0.000	0%
	Namther	33/0.415	100	2006	2006.100.33.7913	TRE50T5	19.141	19.14%	55.510	56%	70.432	70%
	Gangphel	33/0.415	125	2006	2006.125.33.7917	TRE50T6	30.757	24.61%	89.197	71%	113.175	91%
	Taksila	33/0.415	63	2006	2006.63.33.7910	TRE50T7	27.51	43.67%	79.781	127%	101.227	161%
	Dangdung	33/0.415	63	2006	2006.63.33.7905	TRE50T8	27.696	43.96%	80.320	127%	101.912	162%
	Thrisar	33/0.415	63	2007	2007.63.33.8819	TRE50T9	15.05	23.89%	43.646	69%	55.379	88%
	Tongtongphe	33/0.415	63	2007	2007.63.33.8817	TRE50T10	10.22	16.22%	29.639	47%	37.606	60%
	Koshala	33/0.415	63	2010	2010.63.33.11479	TRE50T11	20.284	32.20%	58.825	93%	74.638	118%
	Barpong	33/0.240	10	2009	2009.10.33.12025	TRE50T12	1.715	17.15%	4.974	50%	6.311	63%
	Baling Trongther	33/0.415	63	2010	2010.63.33.11484	TRE50T13	13.63	21.63%	39.528	63%	50.154	80%
	Baling Amling	33/0.415	63	2010	2010.63.33.11512	TRE50T14	12.532	19.89%	36.343	58%	46.112	73%
	Baling Top	33/0.415	63	2010	2010.63.33.11473	TRE50T15	10.693	16.97%	31.010	49%	39.346	62%
	Barsa	33/0.240	10	2010	2010.10.33.10769	TRE50T16	2.431	24.31%	7.050	71%	8.945	89%
	Pangzor	33/0.415	63	2010	2010.63.33.11509	TRE50T17	12.386	19.66%	35.920	57%	45.576	72%
	Bazam	33/0.415	63	2010	2010.63.33.11490	TRE50T18	7.034	11.17%	20.399	32%	25.883	41%
	Ngorme	33/0.415	25	2009	2009.25.33.11123	TRE50T19	6.208	24.83%	18.004	72%	22.843	91%
	Shilgling	33/0.415	25	2009	2009.25.33.11062	TRE50T20	5.953	23.81%	17.264	69%	21.905	88%
	Wangling-I	33/0.415	25	2009	2009.25.33.11014	TRE50T21	7.371	29.48%	21.376	86%	27.123	108%
	Wangling-II	33/0.240	16	2009	2009.16.33.10821	TRE50T22	2.776	17.35%	8.051	50%	10.215	64%
	Rangthang	33/0.240	16	2016	9112834	TRE50T23	1.98	12.38%	5.742	36%	7.286	46%
	Lower Jangbi	33/0.240	10	2015	2015.10.33.72646	TRE50T24	2.309	23.09%	6.696	67%	8.496	85%
	Upper Jangbi	33/0.415	63	2015	2015.63.33.11506	TRE50T25	11.234	17.83%	32.579	52%	41.337	66%
	Yourmo BTN	33/0.415	25	2010	2010.33.11361	TRE50T26	8.605	34.42%	24.955	100%	31.663	127%
	Dangdung BHU	33/0.415	63	2018	KD-2298/C	TRE50T27	5.965	9.47%	17.299	27%	21.949	35%
	Dangdung I	33/0.415	63	2018	KD-2385/c	TRE50T28	15.613	24.78%	45.279	72%	57.450	91%
							377.27396					

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**