BHUTAN POWER CORPORATION LIMITED

(An ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 Certified Company)

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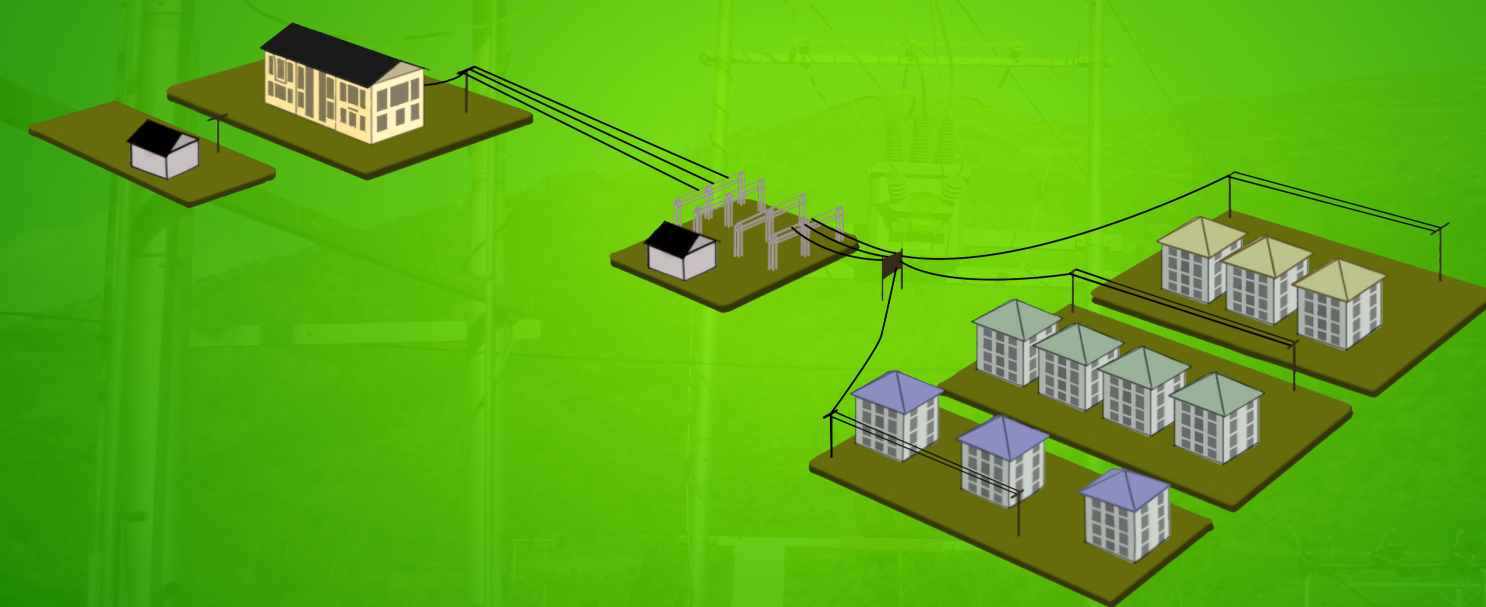
BPC

dhi Company

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

BUMTHANG 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

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Reviewed& Vetted by:	Management, Bhutan Power Corporation Limited, Thimphu. (18th September, 2020 – Meeting No. 584)	**CEO, BPC**
Approved by:	Board Tender & Technical Committee (BTTC), Bhutan Power Corporation Limited, Thimphu. (8th October, 2020 – 23rdBTTC 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 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 transmission and distribution networks established across the country. Towards realizing the mission, vision, and destination statement of BPC as outlined in the Corporate Strategic Plan (2019-2030), there is a need to carry out comprehensive studies of the distribution system to address the system deficiencies as the ground realities are different triggered by technological advancement and economic growth.

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

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

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

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

2. Introduction

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

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

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

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

3. Objectives of the Master Plan

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

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

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

3.3 To come out with annual investment plans.

4. Scope of the Distribution System Master Plan

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

5. Methodology and Approach

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

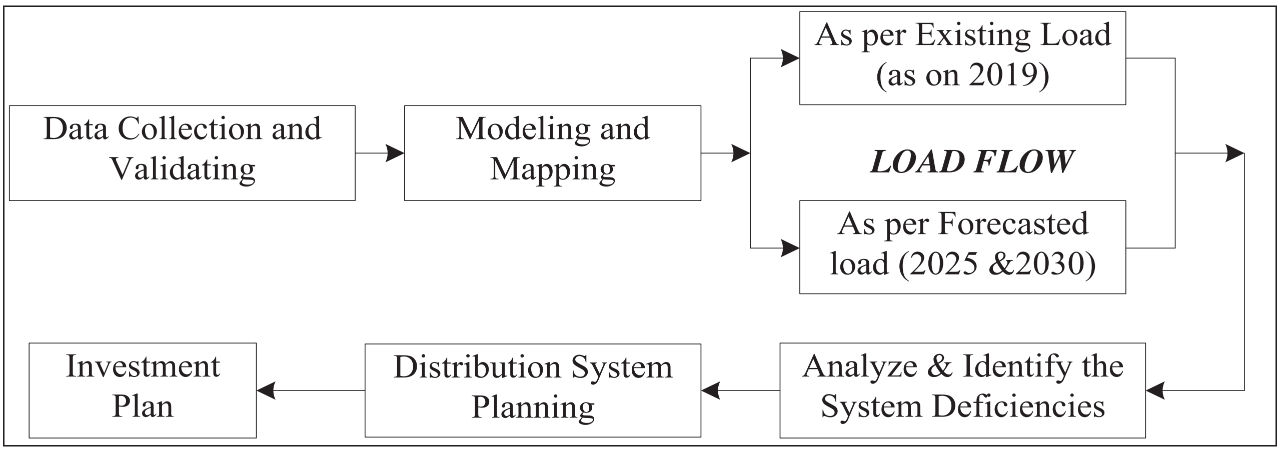


Figure 1: Block Diagram for Distribution System Planning for Thematic Studies

5.1 Data Collection and Validation

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

5.2 Modeling and Mapping

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

5.3 Analysis and Identification of System Deficiencies

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

5.4 Distribution System Planning

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

5.5 Investment Plan

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

6. Existing Electricity Distribution Network

6.1 Overview of Power supply sources

The power supply to four (4) Gewogs (Chekhor, Tang, Ura, and Chumey) of Bumthang Dzongkhag is from the 4x15 MW, Kurich hydropower plant at Mongar. 132kV line has been constructed from the KHP (4x15 MW) to Yurmoo where a 132/33 kV, 2x15 MVA transformation substation has been installed. The power from the Yurmoo substation is transmitted through a 66 kV tower line which is charged at a 33 kV voltage system and is distributed through various 33/11 kV substations (Garpang, RNR-RC, and Dawathang) in and around Bumthang. There are also three mini/micro hydropower plants, namely: (i) a 30kW plant at Tamshing, (ii) a 50kW plant at Ura, and (iii) a 1737kW (3x479) plant at Chumey. The overall power distribution network of Bumthang Dzongkhag is illustrated in the schematic diagram shown in **Figure 2.**

As can be seen from the figure, the 2x2.5 MVA, 33/11 kV Garpang substation has three (3) 33kV outgoing feeders (*i.e. 33kV Tang, 33kV Ura, and 33kV RNR-RC*) and three (3) 11kV outgoing feeders (*i.e.11kV Shuri-Kertshok feeder, 11kV Chumey feeder, and 11kV Chamkhar*). The 33 kV Tang and 33 kV Ura feeders cater power supply to the customers of Tang & Ura Gewogs while the 33 kV RNR-RC feeder is a source to RNR-RC and Dawathang substations. Similarly, the 11kV Chamkhar feeder caters power supply to the customers of Chamkhar town and nearby villages. This feeder is further interconnected with 11 kV Dekeling and 11kV Chakar feeders via 11 kV RMU installed at Dekeling which acts as a secondary 11kV incomer to RNR-RC & Dawathang substations. The 11kV Chumey feeder is the bidirectional feeder that is interconnected with the

Chumey Mini hydropower and caters power supply to the customers of Chumey Gewog. The 11 kV Shuri-Kertshok feeder meets the power supply of Shuri and Kertshok villages.

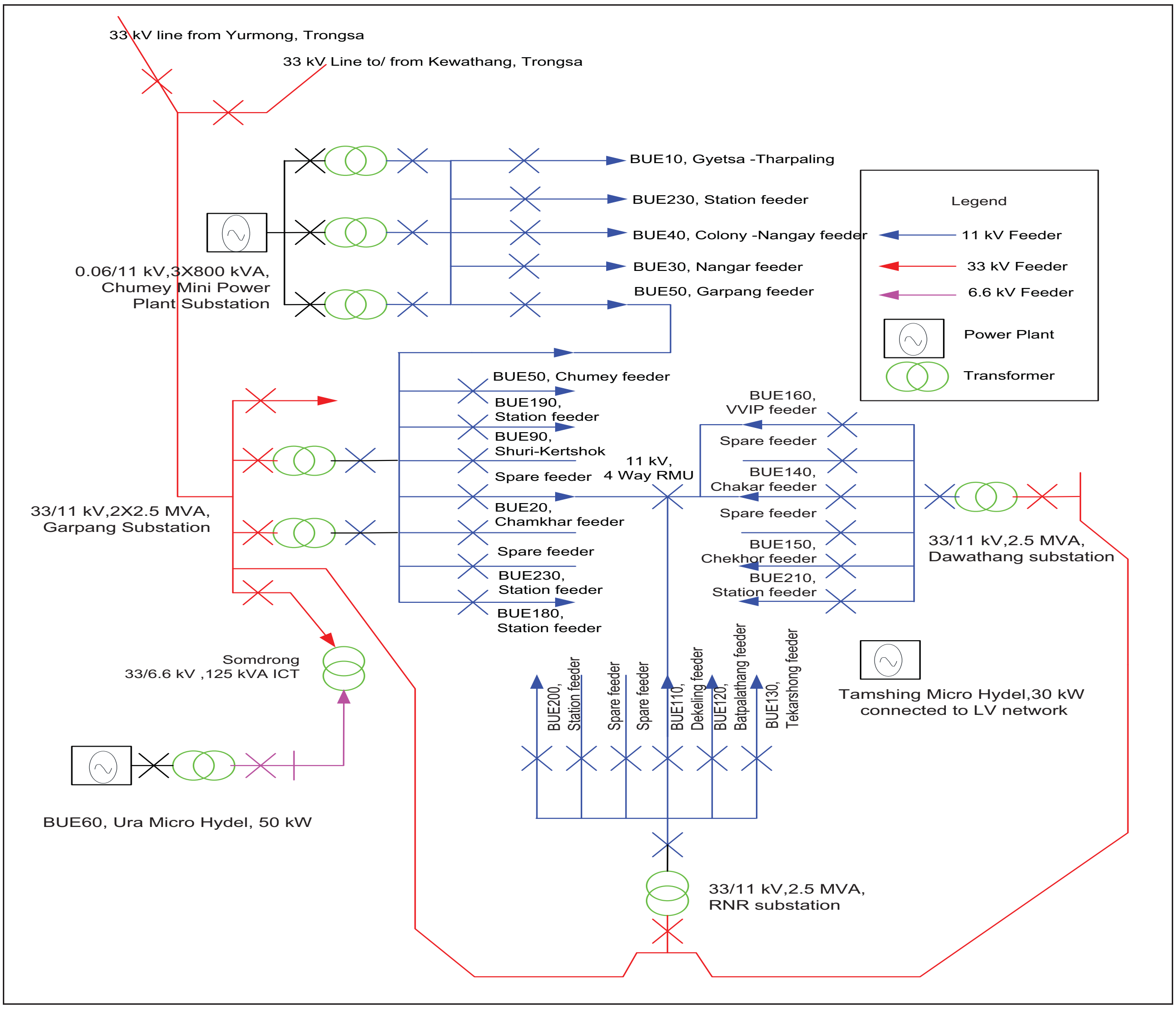


Figure 2: Electricity distribution schematic of Bumthang Dzongkhag

Likewise, there are three (3) 11 kV feeders at the RNR-RC substation and two (2) numbers of 11 kV feeders at the Dawathang substation. The power requirement of the Dekeling area and nearby villages under Chekhor Gewog, Tekarshong Village and, the Batpalathang area is met from the RNR-RC substation. While the power requirement of the Chekhor Gewog, Chakar village, and the Kujey area is met from the Dawathang substation. The Dawathang substation is also linked with the Garpang substation through an 11 kV system.

The power generated from the 1.737 MW Chumey Mini hydropower plant is distributed to Chumey Gewog through three (3) 11 kV feeders (Gyetas-Tharpaling, Colony-Nangay, and Nangar feeders). This generation is also synced with the 11 kV Chumey feeder emanating from the Garpang substation and excess energy generated is injected into the grid. Similarly, the power generated from the Ura micro power plant is step up to 6.6 kV and distributed to Ura Gewog, and power generated from Ura micro hydel is also synchronized with 33 kV Ura feeder through 125 kVA, 33/6.6 kV Inter-Connection Transformer (ICT) at Somdrong.

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Infrastructure Details

Sl. No.	33 kV(km)		11 kV(km)		6.6 kV(km)		Total MV line(km)		LV lines(km)		Total LV length(km)
	OH	UG	OH	UG	OH	UG	OH	UG	OH	UG	
1	93.420	0.190	104.538	0.680	9.990	0.040	202.310	0.910	177.473	1.634	179.107

The total MV line length is 208.858 km and the total LV line length is 179.107 km. The ratio of MV to LV line length is 1:1.17, which reflects an equal proportion of power distribution through the LV and MV network. While the ratio of LV to MV line length would vary according to the site conditions, as a general rule, a 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, 11 kV, and 6.6 kV overhead lines.

6.3 Distribution Transformers

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

Table 2: Total numbers of transformers, installed capacity

Source	Capacity (MVA)	Peak Load (MW)	Name of Feeder	DTS (Nos.)	Connected (kVA)
	5	1.643	33 kV incomer	1	16

Source	Capacity (MVA)	Peak Load (MW)	Name of Feeder	DTS (Nos.)	Connected (kVA)
33/11kV, Garpang substation			33 kV Tang	26	1267
			33 kV Ura	20	1179
			33 kV RNR-RC	0	0
			11 kV Chamkhar	16	3571
			11 kV Shuri-Kertshok	8	229
			11 kV Chumey	1	63
33/11kV RNR-RC, Substation	2.5	0.642	11 kV Dekeling	8	2185
			11 kV Tekarshong	3	151
			11 kV Batpalathang	5	661
33/11 kV, Dawathang Substation	2.5	0.168	11 kV Chekhor	23	2472
			11 kV Chakar	5	786
1.737 MW Chumey Mini Hydro Power Plant	2.4	1.601	11 kV Gyetsa-Tharpaling	22	2459
			11 kV Colony-Nangay	2	41
			11 kV Nangar	4	267
50 MW Ura Micro Hydro Power Plant	0.075	0.037	6.6 kV Ura power House	0	0
				144	**15,347.00**

As of June 2020, there were 144 distribution transformers with a total capacity of 15,347.00 kVA. As can be inferred from **Table 2**, the installed capacity of the transformer per customer is 3.069 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 (132/33 kV)

The Yurmoo substation is the primary power source for Bumthang Dzongkhag. The substation has a transformation capacity of 2X15 MVA at 132/33kV voltage level. However, the detailed assessment is carried out in the DSMP of ESD Trongsa as the substation is administratively under Trongsa Dzongkhag. Therefore, there is no HV substation to be assed under Bumthang Dzongkhag.

7.1.2 MV Substation (33/11 kV)

The 66kV transmission line charged at 33kV is the power source for 33/11kV Garpang, RNR-RC, and Dawathang substations, and the power is distributed to the customers of Bumthang through 11kV outgoing feeders from these MV substations. The details on the installed capacity of substations, existing peak load, and anticipated load in the future are tabulated in **Table 3.**

Table 3: MV power sources

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW*	2019	2025	2030
1	Garpang Substation	33/11	2x2.5	4.25	1.643	2.280	2.862
2	Dawathang Substation	33/11	2.5	2.125	0.168	0.293	0.398
3	RNR-RC Substation	33/11	2.5	2.125	0.642	1.843	3.52
4	Chumey Power House	0.69/11	3x0.8	2.04	1.601	0.865	1.140
5	Ura Power House	0.415/6.6	0.075		0.037	0.028	0.029
6	Tamshing Power House	No generation					

Note: Power factor of 0.85 is considered for study purpose

As evident from **Table 3,** all the substations would be adequate to meet the present power requirement. However, with the developments of LAPs, the load of around 3.52 MW is anticipated by the year 2030 at the RNR-RC substation against its installed capacity of 2.125 MW. Hence, RNR-RC substation needs to be upgraded. However, load growth should be closely monitored, and accordingly plan remedial measures.

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 MV substations at Garpang, RNR-RC, Dawathang, and mini/micro hydel had been compiled based on the historical data. The array of daily and monthly peak demand was sorted to obtain the annual peak demand. The feeder-wise peak demand recorded at the source is presented in **Table 4** and the corresponding feeder-wise annual load curve is presented in **Figures 3, 4 and, 5.**

Table 4: Historical Feeder wise peak power demand of ESD Bumthang

Power Source	Feeder Name	Peak Load (MW)		
		2017	2018	2019
33/11kV Garpang Substation	33 kV Tang	0.342	0.350	0.365
	33 kV Ura	0.156	0.178	0.198
	11 kV Chamkhar	1.413	1.494	1.606
	11 kV Shuri-Kertshok	0.03	0.035	0.037
	11 kV Chumey	1.05	1.059	1.063
	11 kV Station Feeder I	0.0025	0.0027	0.0029
	11 kV Station Feeder II	0.022	0.021	0.022
33/11kV RNR-RC Substation	11 kV Dekeling	0.396	0.378	0.502
	11 kV Tekarshong	0.0106	0.0128	0.0149

Power Source	Feeder Name	Peak Load (MW)		
		2017	2018	2019
	11 kV Batpalathang	0.0886	0.116	0.125
	11 kV Station Feeder	0.0035	0.0032	0.0037
33/11 kV Dawathang Substation	11 kV Chekhor	0.0881	0.0921	0.0946
	11 kV Chakar	0.0378	0.0529	0.0733
	11 kV Station feeder	0.0030	0.0031	0.0034
1.737 MW Chumey Mini Hydro power Plant	11 kV Gyetsa-Tharpaling	0.35	0.42	0.44
	11 kV Colony-Nangay	0.0085	0.009	0.0095
	11 kV Nangar	0.061	0.07	0.08
	11 kV Switch Yard Feeder	0.0031	0.0029	0.0033
50 MW Ura Micro Hydro power Plant	6.6 kV Ura power House	0.0215	0.0372	0.0219

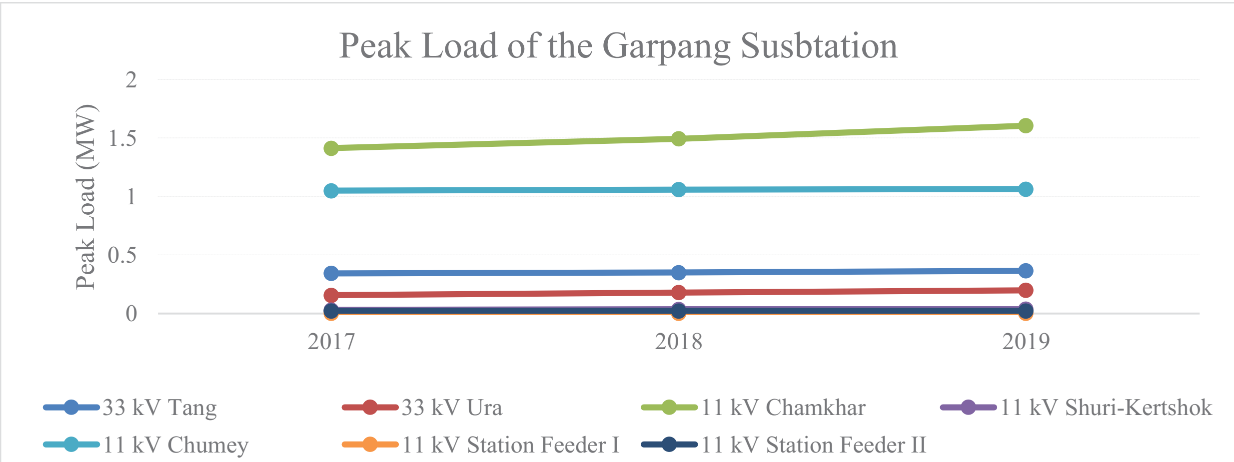


Figure 3: Peak Load of out-going feeders from Garpang Substation

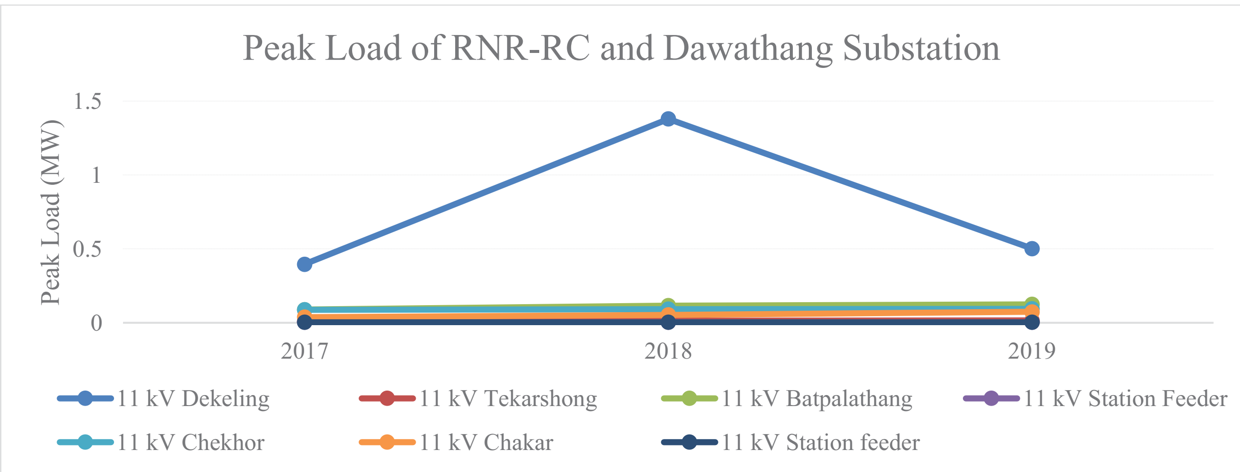


Figure 4: Peak Load of RNR-RC and Dawathang substation outgoing feeders

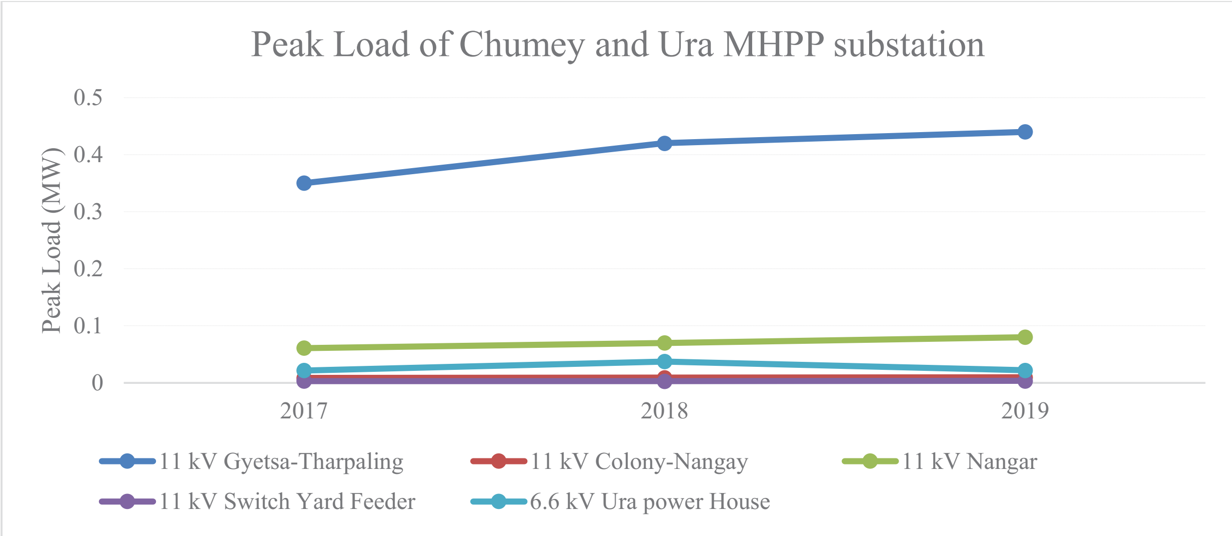


Figure 5: Peak load Chumey MPP substation's outgoing feeders

As seen from the figures above except for the Dekiling feeder, the load growth has gradually increased over the period. The unpredictability trend of the peak load of the Dekiling feeder is due to the ring connection. The feeder is interconnected with the 11 kV Chamkhar feeder. However, the highest recorded peak demand is within the feeder capacity. 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, t**he majority of MV lines under ESD Bumthang consist of a 33kV and 11kV voltage level. The types of conductors used are mostly ACSR-Rabbit and Dog. **Table 5** exhibits the ampacity capability of the conductors at different voltage levels. Ampacity capability (thermal loading) of the lines have been calculated based on IS 398 (Part-II): 1996 for maximum conductor temperature 85°C for ACSR conductors considering an ambient temperature of 40°C.

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

Sl. No.	ACSR Conductor Type	Ampacity of Conductor	MVA rating corresponding to the Ampacity
33 kV Voltage Level			
1	RABBIT	193	11.031

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

The distribution network is developed using the ETAP software based on the existing and the forecasted load for the assessment. The assessment is then carried out for the following case scenarios. The upcoming LAPs, bulk load/industrial load sanctioned by DCSD, BPC is also being considered. These power demands are added to the peak load forecast of that year when the load is anticipated to come 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 Chumey Mini Hydropower Plant is down
e) System Study when Ura Micro Hydropower Plant is down

a) System Study with Existing Load

A load flow analysis of the existing system was carried out considering the 2019-20 peak load. From the simulation 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.

b) Assessment of MV Feeder Capacities with Forecasted Load

The peak power demand presented in **Table 4** has been considered to forecast the power demand for the next 10 years (2020-2030). Linear Regression Method (LRM) in conjunction with Time

Series Analysis (TSA) is adopted to forecast the load as detailed in **Annexure- 3**. The summary of the forecasted load for the feeders is tabulated in Table 6.

Table 6: Feeder wise Load forecast of ESD Bumthang

Sl. No.	Name of Feeder	Forecasted Load Growth (MW)										
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Garpang Substation												
1	33 KV Tang feeders	0.41	0.43	0.45	0.47	0.49	0.51	0.52	0.54	0.56	0.58	0.60
2	33 KV Ura feeder	0.22	0.25	0.27	0.30	0.32	0.34	0.37	0.39	0.42	0.44	0.46
3	11 KV Chamkhar feeder	1.62	1.74	1.85	1.96	2.08	2.19	2.30	2.41	2.53	2.64	2.75
4	11 KV Chumey Feeder	1.06	1.07	1.08	1.08	1.09	1.10	1.10	1.11	1.12	1.12	1.13
5	11 KV Shuri- Kertshok Feeder	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11
6	11 kV Station Feeder I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	11 kV Station feeder II	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
RNR-RC Substation												
1	11 KV Tekarshong Feeder	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
2	11 KV Batpala Feeder	0.15	0.16	0.18	0.20	0.22	0.24	0.26	0.27	0.29	0.31	0.33
3	11 KV Dekeling Feeder	0.53	0.58	0.64	0.69	0.74	0.80	0.85	0.90	0.95	1.01	1.06
4	11 kV Station feeder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Dawathang substation												
1	11 KV Chekhor Feeder	0.20	0.20	0.21	0.21	0.21	0.22	0.22	0.22	0.23	0.23	0.23
2	11 KV Chakar Feeder	0.19	0.21	0.23	0.24	0.26	0.28	0.30	0.32	0.33	0.35	0.37
	11 kV Station Feeder	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Chumey Power Plant												
1	11 KV Gyetsa- Tharpaling	0.44	0.49	0.54	0.58	0.63	0.67	0.72	0.76	0.81	0.85	0.90
2	11 KV Colony- Nangay	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
3	11 KV Nangar	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18
4	11 kV Switch yard feeder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

From the power flow analysis of the 2025 and 2030 loading scenarios, some of the feeders would experience a significant drop in bus voltage as well as the feeder voltage. The voltage profile of the problematic feeders is presented in **Table 7.**

Table 7: Voltage Profile of the problematic feeders

Year	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage (%)		
Feeder Name	**Load**	**Bus**	**End**	**Load**	**Bus**	**End**
11 kV Garpang Bus	1.91			2.35		
11 kV Chamkhar	1.90	97.12	88.31	2.33	96.41	85.56
11 kV Power House Bus	0.86			1.07		
11 kV Gyetsa-Tharpaling	0.64	97.69	93.56	0.78	97.06	92.00

The marginal voltage drop of the 11 kV Gyetsa-Tharpaling bus can be improved by utilizing the transformer tap changer. However, the voltage profile of the 11kV Chamkhar feeder which caters power supply to the entire Chamkhar town cannot be improved just by making use of the tap changer. There are 16 distribution transformers with a total capacity of 3,571 kVA connected to this feeder and the projected load is 1.6 MW by 2030. This feeder would also cater to the load of identified LAPSs of Bumthang. Therefore, to improve the voltage profile, it is proposed to implement the following recommendations:

a) Extend the 11kV Batpalathang feeder to meet the power requirement of Jalikhar LAP. Currently, the Jalikhar area is fed from an 11kV Chamkhar feeder. Therefore, an arrangement can be made by extending the 11kV Batpalathang feeder to off-load the Chamkhar feeder; and

b) Upgrade the trunk line of 11kV Chamkhar feeder to Dog from the existing Rabbit conductor.

The above measures were modeled and the load flow was carried out to find out the behavior of the feeder which is shown in **Table 8.**

Table 8: Improved Voltage Profile

Sl. No.	Feeder Name	Voltage Profile (Before)	Voltage Profile (After)	Corrective Action
1	11kV Chamkhar	85.56	93.92	Resizing the conductor and transferring a load of Jalikar LAP to the Batpalathang feeder.
2	11kV Gyetsa-Tharpaling	92.00	95.35	Changing the transformer tap position

With the recommended corrective measures implemented, it is expected to improve the voltage profile of the feeder significantly as shown in **Table 8.**

a) Chumey Mini Hydropower Plant is down

The 3x579 kW Chumey mini hydropower plant caters to the power requirement of Chumey Gewog. The generation is synced with an 11 kV Garpang feeder and injects the excess power into the grid. When the power plant is down for maintenance, the energy requirement of Chumey Gewog is met from an 11 kV Garpang feeder emanating from a 33/11 kV Garpang substation. The line is constructed with an ACSR DOG conductor wherein it can carry a load of around 4.85 MW. A load of around 1 MW is forecasted by 2030. From the power flow analysis, the Gyetsa-Tharpaling feeder would experience a marginal voltage drop which can be improved by transformer tap changing. Hence, no additional investment is required.

b) Ura Micro Hydropower Plant is down

Similarly, part of Ura village is fed from a 50 kW Ura micro hydropower plant. The generation is stepped from 6.6 kV and interconnected with the 33 kV Ura feeder through 125 kVA, 6.6/33 kV ICT. Whenever the power plant is down, the whole load of the Ura Gewog is catered by a 33 kV Ura feeder which originates from the Garpang substation. A power flow study was carried out to check the behavior of the system when the Ura micro hydropower plant is down. No abnormality was observed in the system. Hence it is evident that the 33 kV Ura 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 9** below shows the energy sales, purchase, and loss profile of Bumthang**.**

Table 9: Energy Sales-Purchase-Loss Trend

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
1	**Energy Requirement (MU)**						
i)	Purchase from GenCos as per TD bill						
ii)	Mini/Micro Hydel Generation	0.17	0.00	0.02	4.64	5.15	
iii)	Diesel Generation	-	-	-	-	-	
iv)	Net Import from Trongsa	10.96	11.02	11.16	7.80	8.34	
v)	Net Export to Trongsa	-	-	(0.04)	(0.00)	(0.43)	
	Total	**11.14**	**11.02**	**11.14**	**12.45**	**13.05**	
	% growth over previous year	-	-1.02%	1.05%	11.72%	4.88%	4.16%
2	**Energy Sales (MU)**						
i)	LV	9.52	9.93	9.86	11.02	11.48	
ii)	Medium Voltage	-	-	-	-	-	
iii)	High Voltage	-	-	-	-	-	
	Total Energy Sales	**9.52**	**9.93**	**9.86**	**11.02**	**11.48**	
	% growth over previous year	-	4.31%	-0.67%	11.74%	4.13%	4.88%
	Energy Loss (1-2)	**1.62**	**1.09**	**1.28**	**1.42**	**1.58**	**1.398**
4	Total Loss (%)	14.53%	9.92%	11.45%	11.44%	12.07%	11.88%

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 9 yields the trend graphs shown in Figure 6. The energy requirement has increased steadily over the year @ 4.16 % and so is the energy consumed @ 4.88 % on the average from the year 2015-2019.

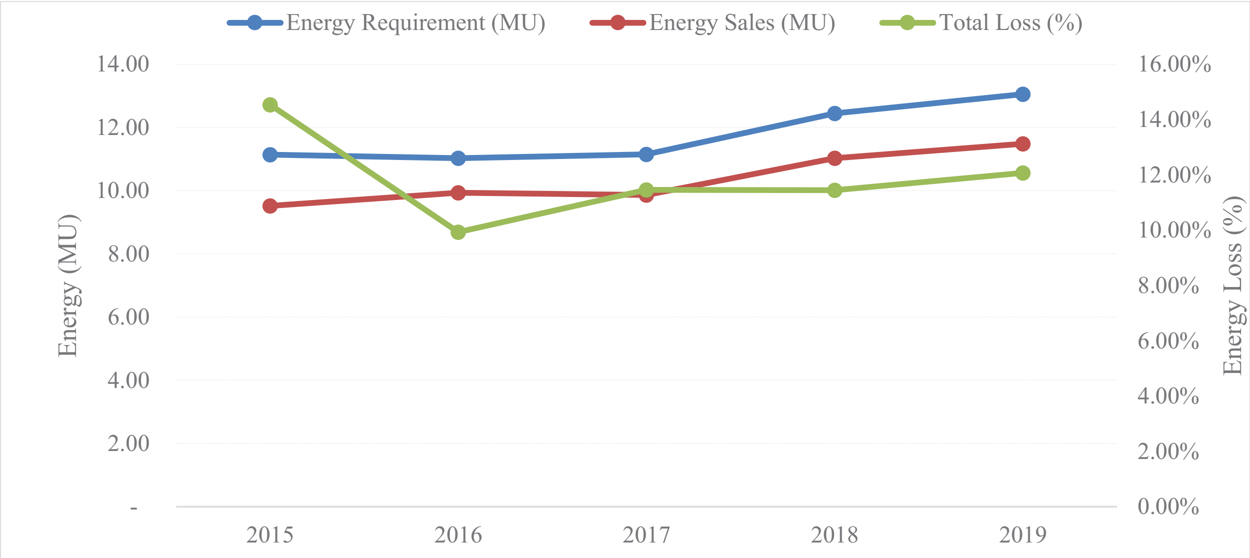


Figure 6: Energy requirement trend

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 Bumthang (2015-2019) is 11.88% (1.398 million units on average) which is quite high. Therefore, to better understand 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 for the year 2019 is worked out as presented in **Table 10** and **Figure 7.**

Table 10: Feeder wise energy loss

Sl. No.	Feeder Name	2019		
		Energy Purchase (kWh)	Energy Sales (kWh)	Energy Loss (%)
1	33 kV Tang	0.77	0.60	21.54%
2	33 kV Ura	0.64	0.53	15.95%
3	11 kV Chamkhar	4.25	4.04	4.83%
4	11 kV Shuri-Kertshok	0.07	0.06	21.51%
5	11 kV Chumey	1.98	1.73	12.89%
6	11kV Tekarshong	0.10	0.07	25.96%

Sl. No.	Feeder Name	2019		
		Energy Purchase (kWh)	Energy Sales (kWh)	Energy Loss (%)
7	11kV Batpalathang	0.64	0.60	5.42%
8	11kV Dekeling	2.82	1.95	31.01%
9	11 kV Chakar	0.33	0.55	-66.47%
10	11 kV Chekhor	0.95	0.79	16.64%
11	11 kV Colony -Nangay	0.01	0.01	-30.94%
12	11kV Gyetsa-Tharpaling	0.39	0.49	-25.22%
13	11 kV Nangar	0.06	0.07	-18.13%
	Total	13.0	11.5	11.55%

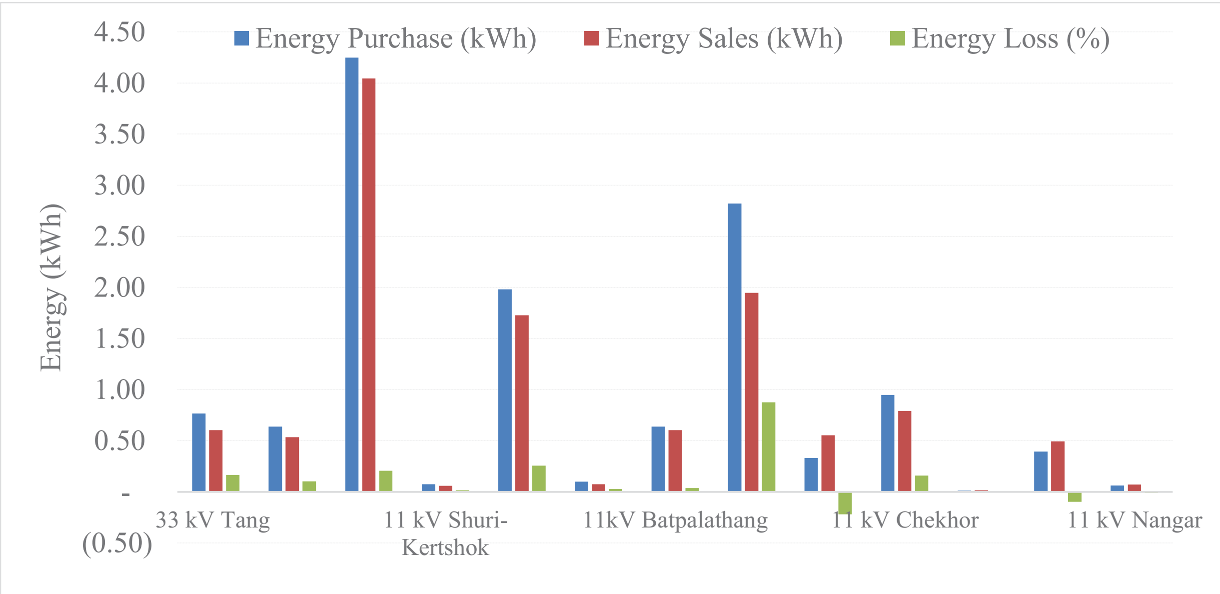


Figure 7: Feeder wise energy loss

As evident from Figure 7, the feeder wise energy losses are inconsistent and range from (-) 66.47% to 31.01%. The negative losses could be due to the ring connection and to some extent due to data anomalous in energy accounting. Except for 11kV Batpalathang and 11kV Chamkhar feeders, the rest of the feeders have losses beyond the acceptable range which requires an in-depth study by ESD Bumthang.

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 4.59% constitute MV technical loss. The remaining (7.29%) is due to LV and commercial loss. The feeder wise MV and DT technical loss is as shown in **Table 11.**

Table 11: Feeder wise Energy Losses (Technical)

Sl. No.	Feeder Name	Power Demand (MW)	Apparent Loss (MW)	Loss (%)
1	33 kV Tang	0.152	0.001	0.66%
2	33 kV Ura	0.271	0.003	1.11%
3	11 kV Chamkhar	1.337	0.098	7.33%
4	11 kV Shuri-Kertshok	0.024	0	0.00%
5	11 kV Chumey	0.003	0	0.00%
6	11kV Tekarshong	0.038	0	0.00%
7	11kV Batpalathang	0.12	0.001	0.83%
8	11kV Dekeling	0.831	0.024	2.89%
9	11 kV Chakar	0.208	0.003	1.44%
10	11 kV Chekhor	0.165	0.002	1.21%
11	11 kV Colony -Nangay	0.007	0	0.00%
12	11kV Gyetsa-Tharpaling	0.586	0.027	4.61%
13	11 kV Nangar	0.044	0	0.00%
	Overall System Loss	**3.969**	**0.182**	**4.59%**

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 3.98 & 3.14 respectively which indicates that the power supply to the customers of Bumthang Dzongkhag is exceptionally reliable.

Table 12: Feeder wise reliability indices of ESD Bumthang for 2017-2019

Sl. No.	Name of Feeder	2017		2018		2019		Average	
		SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
1	33 kV Tang	0.812	0.022	0.668	0.624	0.830	0.374	0.77	0.34
2	33 kV Ura	0.000	0.000	1.381	1.685	0.270	0.400	0.55	0.70
3	11 kV Chamkhar	0.300	0.000	1.898	3.062	1.750	0.590	1.32	1.22
4	11 kV Shuri-Kertshok	0.023	0.044	2.452	0.160	0.030	0.004	0.84	0.07
5	11 kV Chumey	0.180	0.001	0.184	0.064	0.190	0.015	0.18	0.03
6	11kV Tekarshong	0.000	0.000	0.000	0.000	0.000	0.000	-	-
7	11kV Batpalathang	0.000	0.000	0.000	0.000	0.000	0.000	-	-
8	11kV Dekeling	0.000	0.000	0.442	0.715	0.000	0.000	0.15	0.24
9	11 kV Chakar	0.000	0.000	0.000	0.000	0.000	0.000	-	-
10	11 kV Chekhor	0.000	0.000	0.000	0.000	0.000	0.000	-	-
11	11 kV Colony -Nangay	0.000	0.000	0.000	0.000	0.000	0.000	-	-
12	11kV Gyetsa-Tharpaling	0.000	0.000	0.000	0.000	0.450	1.228	0.15	0.41
13	11 kV Nangar	0.000	0.000	0.000	0.000	0.090	0.438	0.03	0.15
Total SAIFI & SAIDI		**1.315**	**0.068**	**7.025**	**6.310**	**3.610**	**3.049**		
Average SAIFI		**3.98**							
Average SAIDI		**3.14**							

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.

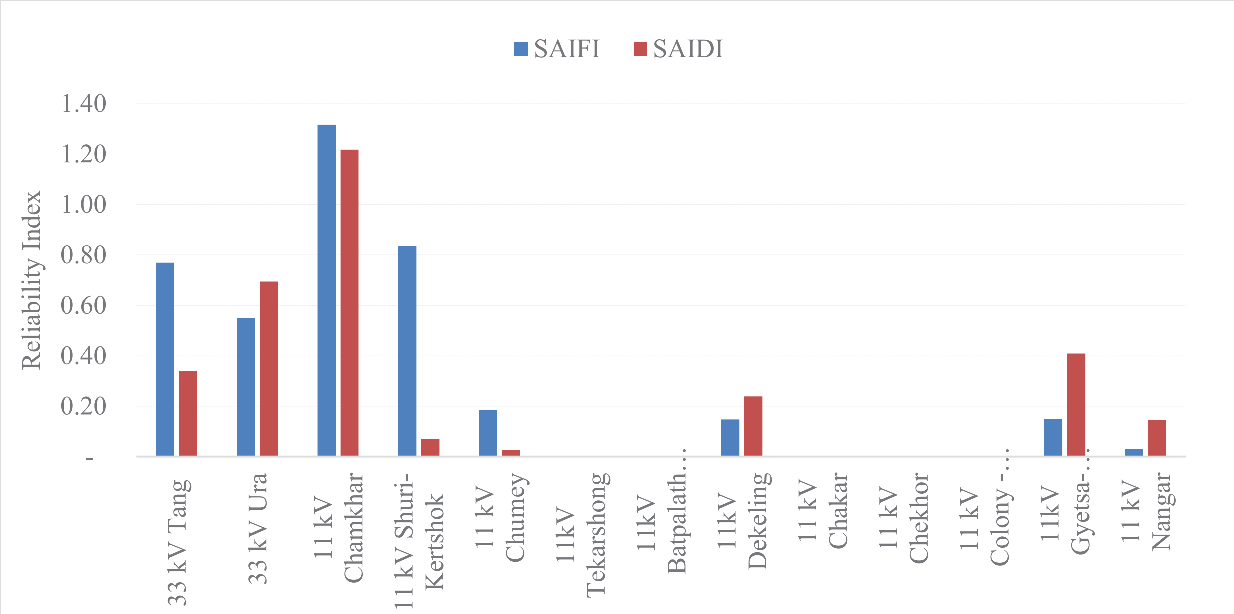
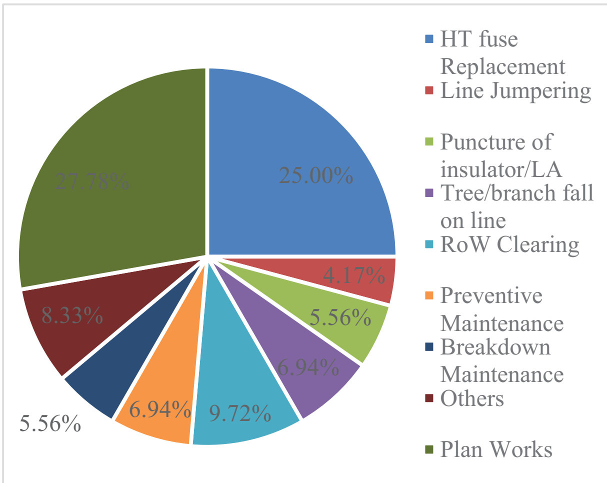


Figure 8: Graphical representation of reliability indices

To get a better understanding of the reliability index, the detailed root cause analysis for the feeders is carried and the inputs are as shown in **Table 13.**

Table 13: Root Cause Analysis Data

Causes of Outages	Freq. (Nos.)	Interruption (%)
HT fuse Replacement	18	25.00%
Line Jumpering	3	4.17%
Puncture of insulator/LA	4	5.56%
Tree/branch fall on line	5	6.94%
RoW Clearing	7	9.72%
Preventive Maintenance	5	6.94%
Breakdown Maintenance	4	5.56%
Others	6	8.33%
Plan Works	20	27.78%



From **Table 13**, it is noted the most of the outages are caused due to the shutdown undertaken for the plan works followed by HT fuse replacement which directly correlates to a transient fault and accordingly resulting in maintenance. However, unlike other areas, Bumthang is situated in the alpine zone, the transient fault due to tree/branches/bamboo touching the lines is not so rampant as it in tropical areas. Hence the power supply in the Dzongkhag is reliable and commendable.

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

7.2.4 Single Phase to Three Phase Conversion

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

a) Alternative -I

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

b) Alternative -II

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

c) Alternative -III

Option 3 is found to be a techno-commercially viable alternative as the lines can be easily upgraded to three phases by constructing a third conductor on existing pole structures. The transformer can be upgraded from a single phase to three phases as and when the demand for a 3-phase supply comes. The line up-gradation 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 12.59 km (33kV: 5.62 km, 11kV: 6.96 km). The estimated cost for the conversion of such is Nu. 1.78 million.

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

7.3 Assessment of the Existing Distribution Transformers

7.3.1 Distribution Transformer Loading

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

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

Assuming that the load growth of the rural homes is not expected to grow similar to that of urban dwellings, it is strongly recommended to closely monitor the actual load growth and accordingly plan remedial measures for those transformers. Nevertheless, considering the actual site-specific growth rate and cross-swapping of the existing transformers, it is recommended that arrangements be made for the procurement of only 15 new transformers from the 26 overloaded transformers.

Table 14: Forecasted Transformer Loading

DT Location Name	Capacity (kVA)	Existing (2019)		Forecasted Loading (%)		Remarks
		Peak Load (kVA)	% Loading	2025	2030	
BOD, Chamkhar	160	120.22	75.14%	111.12%	139.54%	Cross swap with 250 kVA Domkhar Village transformer in the year 2022
Chamkhar Town	500	495.34	99.07%	146.51%	183.98%	New 750 kVA USS will be installed in the year 2020
Wangdicholing LSS	160	72.93	45.58%	67.41%	84.65%	New 250 kVA need to be installed in the year 2030
Udee, Chamkhar	250	160.12	64.05%	94.72%	118.94%	New 500 kVA need to be installed in the year 2025
Gakiling	250	127.00	50.80%	75.13%	94.34%	New 500 kVA need to be installed in the year 2028
Gangrithang	125	120.28	96.22%	142.30%	178.69%	Cross swapping with 250 kVA Gyetsa school transformer which will be available by 2020
Jakar Dzong	315	151.20	48.00%	70.99%	89.14%	New 500 kVA need to be installed in the year 2030
Tekarshong	25	13.27	53.09%	78.67%	91.54%	Cross swapping with 63 kVA Nasiphel (Chekhortey) transformer in the year 2021
Dekiling	250	150.00	60.00%	70.10%	93.46%	New 500 kVA needs to be installed in the year 2026
W. Hospital	125	81.85	65.48%	76.49%	101.99%	Hospital to upgrade to 250/500 kVA PSS as planned
Dekeling Town	25	25.00	100.00%	116.83%	155.77%	Will be upgraded to 500 kVA using 500 kVA Chamkhar town transformer

DT Location Name	Capacity (kVA)	Existing (2019)		Forecasted Loading (%)		Remarks
		Peak Load (kVA)	% Loading	2025	2030	
Chakar	250	125.00	50.00%	65.87%	86.81%	Load growth not expected
Ane DrasangTang	63	14.43	22.90%	75.47%	89.36%	
Zhongphel	30	10.73	35.76%	117.84%	139.55%	
Mesithang	100	52.78	52.78%	173.92%	205.95%	Will be upgraded to 160 kVA
Ugyencholing	63	17.01	27.00%	88.97%	105.35%	Load growth not expected
Kharchu	250	100.00	40.00%	67.02%	92.76%	Will be upgraded to 500 kVA
Trongmanba	10	9.65	96.53%	124.36%	133.57%	Upgrade to 25 kVA which will be available from Drodrong substation in the year 2021
Dodrong	25	22.73	90.90%	117.10%	125.78%	Will be upgraded to 63 kVA in the year 2021
Gyetsa LSS	250	225.00	90.00%	101.76%	124.53%	Will be upgraded to 500 kVA using Telecom Transformer
Takar	16	5.79	36.16%	84.79%	122.54%	load growth not expected
Zungay	63	18.90	30.00%	70.34%	101.66%	
Phogo	63	18.90	30.00%	109.17%	132.75%	
Park (Ura)	30	14.17	47.22%	72.71%	96.12%	
Ura School	50	23.77	47.54%	73.19%	96.76%	
Yotola	16	8.00	50.00%	76.99%	101.78%	

7.3.2 Asset life of Distribution Transformers

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

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

Table 15: List of Outlived Distribution Transformers

Sl. No.	DT Location Name	Transformer Ratio	kVA	MFD	2019	2025	2030
1	BOD, Chamkhar	11/0.415kV	160	1990	29	35	40
2	Wangdicholing School	11/0.415kV	160	1989	30	36	41
3	Gakiling,Bumthang	11/0.415kV	250	1988	31	37	42
4	Lower Jalikhar	11/0.415kV	160	1988	31	37	42
5	Dekiling	11/0.415kV	250	1990	29	35	40
6	Jachungthang	11/0.415kV	160	1984	35	41	46
7	Tamzhing	11/0.415kV	160	1990	29	35	40
8	Bathpalathang	11/0.415kV	160	1989	30	36	41
9	Rangbi	11/0.415kV	25	1993	26	32	37
10	Gyetsa Village	11/0.415kV	250	1995	24	30	35
11	Domkhar Village	11/0.415kV	63	1990	29	35	40
12	Sibjur	11/0.415kV	63	1989	30	36	41
13	Hurchi Telecom	11/0.415kV	25	1996	23	29	34
14	Chudaypang	11/0.415kV	63	1995	24	30	35
15	Zungay	11/0.415kV	63	1988	31	37	42
16	Phogo	11/0.415kV	63	1995	24	30	35
17	Tangsibi NWF	33/0.400KV	25	1996	23	29	34
18	Thrumsingla N/Park	6.6/0.415KV	30	1986	33	39	44
19	Tralingthang	6.6/0.415	50	1986	33	39	44
20	Khekharthe	6.6/0.415	50	1996	23	29	34
21	Ura School	6.6/0.415	50	1986	33	39	44
22	Yurgang	6.6/0.415	50	1986	33	39	44
23	Lower Pangkhar	6.6/0.415	30	1990	29	35	40
24	Upper Pangkhar	6.6/0.415	30	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 5 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu.1.0 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 Bumthang Dzongkhag has recently found out that some of the inhabited areas are susceptible to flesh flood and therefore, categorized as red zones. Town expansions to these zones are not permitted. However, developments of Jalikhar, Chamkar, and Dekeling towns would continue as planned. Further, Chumey is identified as a satellite town and is anticipated to develop steadily over the years. Construction of commercial and residential buildings is restricted to G+2. Jalikhar, Chamkhar, and Dekeling each have 300, 150, and 250 plots respectively. **Figure 9** presents the local area plans (LAP) of Bumthang Dzongkhag.

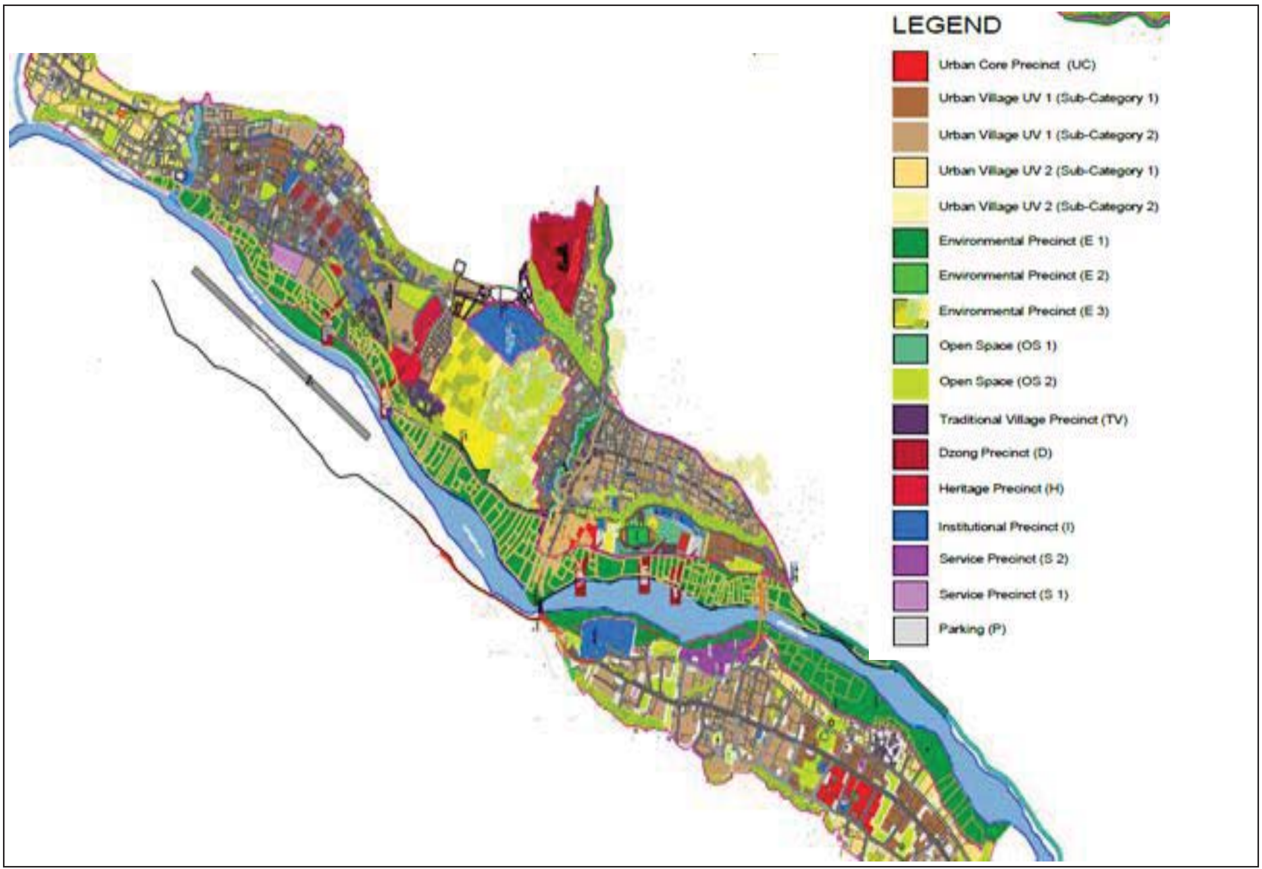


Figure 9: Bumthang Local Area Plan

Assuming a coincident peak power demand of 2 kW per unit, the LAP wise estimated power demand is tabulated in **Table 16.** A total load of around 5600 kW is anticipated when all the LAP are developed and realized. However, the development of the towns is steady over the years and therefore, a load factor of 50% is considered for the next ten years in terms of power requirement.

Table 16: LAP wise power estimation

Sl. No.	Number of Plot	Nos. of Units	Coincidental peak per unit (kW)	Total Load (kW)
Load under Jalikhar LAP				
1	300	4	2	2400
	Total expected load(kW) in the year 2025 expecting 20 % of construction	480		
	Total expected load(kW) in the year 2030 expecting 50 % of construction	1200		
Load under Dekeling LAP				
1	250	4	2	2000
	Total expected load(kW) in the year 2025 expecting 20 % of construction	400		
	Total expected load(kW) in the year 2030 expecting 50 % of construction	1000		
Load under Chamkhar LAP				
1	150	4	2	1200
	Total expected load(kW) in the year 2025 expecting 20 % of construction	240		
	Total expected load(kW) in the year 2030 expecting 50 % of construction	600		

a) Dekeling LAP

The power supply to the Deking LAP is fed from an 11kV Dekeling feeder which is on an ACSR RABBIT conductor which has a power capacity of 3.125 MW at ambient temperature. The feeder 0.502 MW as of 2019 and therefore can cater additional power of 2.125 MW. The Dekeling LAP is anticipated to draw an additional load of 1MW. Therefore, the existing 11kV Dekeling feeder would be adequate to cater the power to the LAP. **Figures 10** depicts the existing distribution networks of the Dekiling LAP.

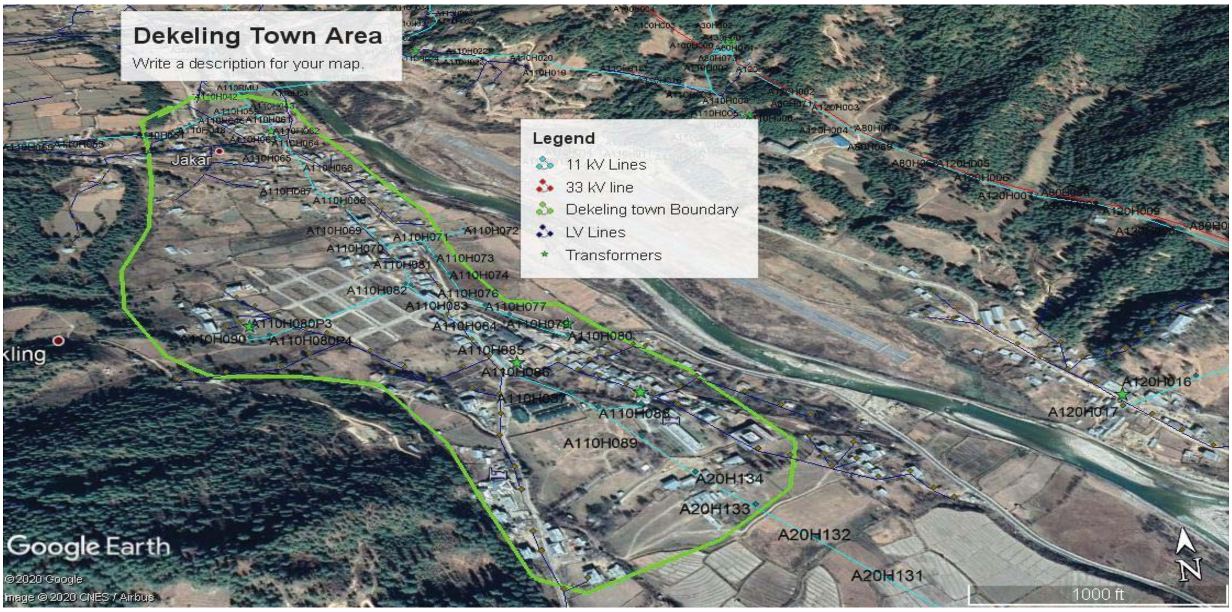


Figure 10: Distribution Network for Dekeling LAP

b) Chamkhar LAP

The power supply to the Chamkhar LAP is catered from an 11 kV Chamkhar feeder. As detailed in the MV feeder analysis with the forecasted load, it was found that section of the line has to be resized and off-load the feeder by catering some of the Jalikhar customers to the 11kV Batpalathang feeder. It is anticipated that load the peak load of 11kV Chamkhar feeder would reach 2.21 MW by 2030. **Figure 11** depicts the existing distribution networks of the Chamkhar LAP.

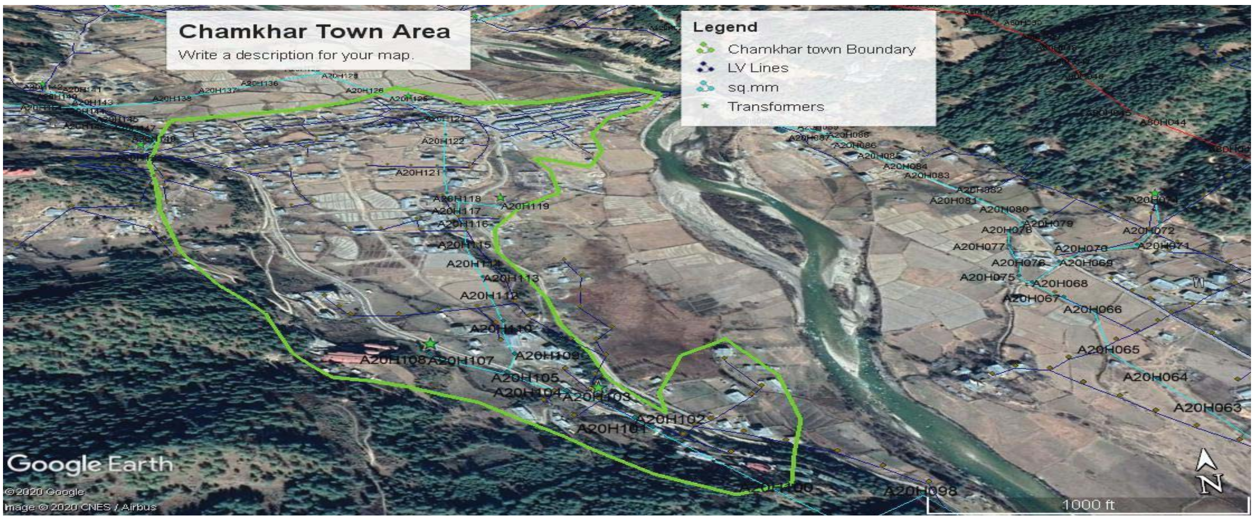


Figure 11: Distribution Network for Chamkhar LAP

c) Jalikhar LAP

The power supply to the Jalikhar LAP is currently fed from an 11kV Chamkhar feeder. Expecting developments in Jalikhar and Chamkhar LAPs, the 11kV Chamkhar feeder has to be offloaded as without reconfiguring the feeders the Chamkhar feeder would exceed its thermal limit. An additional load of around 1.2 MW is anticipated at Jalikhar LAP. **Figure 12** depicts the existing distribution networks of the Jalikhar LAP.

Figure 12: Distribution Network for Jalikhar LAP

The 11 kV Batpalathang and Dekeling feeders emanate from the 33/11kV, 2.5MVA RNR-RC substation. With the development of two LAPs, it is forecasted that the power requirement from the substation would reach 3.52 MW against the installed capacity of 2.125MW (@0.85 pf). Therefore, it is recommended to upgrade the RNR-RC substation. However, load growth should be closely monitored, and accordingly plan remedial measures.

Table 17 presents the list of DTs under various LAPs that require up-gradation to cater to the load requirement of LAPs.

Table 17: Existing DTs under Various LAPs

Sl.No.	Transformer Location	Capacity (kVA)	Proposed Capacity (kVA)	Remarks
DTs under Jalikhar LAP				
1	Gangrithang	125	250	Up-grade in 2021
2	Gongkhar	125	250	Up-grade in 2026
3	Lower Jalikhar	160	250	Up-grade in 2025
4	Jalikhar	250	500	
	Total	**660**	**1250**	
DTs under Dekeling LAP				
1	Dekeling town	25	500	Up-grade in 2021
2	Dekeling	250	500	Up-grade in 2026
3	Wangdicholing	500	500	
4	Wangdicholing Hospital	125	125	
5	Aman Kora	500	500	Private
	Total	**1400**	**2125**	
DTs under Chamkhar LAP				
1	Chamkhar Town	500	750	Up-grade in 2020
2	Gakeling	250	500	Up-grade in 2028
3	Udee, Chamkhar	250	500	Up-grade in 2025
4	Yugarling	500	500	
5	BOD, Chamkhar	160	250	Up-grade in 2022
	Total	**1660**	**2500**	

d) Chumey Satellite Town

Figure 13: Distribution Network for Chumey Satellite Town

Chumey is another area expected to grow since it is identified as the satellite town of Bumthang Dzongkhag. Although the structural plan has not been finalized, growth is expected due to the existence of educational institutions, medical facilities, and business centers. Therefore, the construction of a 33/11 kV, 500 kVA substation is provisioned to meet the power requirement in the future. **Figure 13** depicts the existing distribution network of Chumey Satellite town.

8. Distribution System Planning until 2030

The distribution network of Bumthang 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

Although the power source for Bumthang is from the Yoormo substation, as the substation is under Trongsa Dzongkhag, the HV assessment is carried out in the DSMP of Trongsa.

8.1.2 MV Substation

As detailed in **Section 7.1.2,** Bumthang would have adequate MV substation capacity except it might require to up-grade the 2.5 MVA, 33/11 kV RNR-RC substation to 2x2.5 MVA to cater to a load of Jalikhar LAP. However, it is recommended to closely monitor the load growth and accordingly up-grade the substation capacity (if need be).

8.2 MV Lines

Following the detailed MV lines assessment in **Section 7.2,** this section outlines the list of MV works that need to be executed as measures to meet the future power demand, improve the voltage profile, counter the reliability issue, and other associated problems.

a) Re-size the main trunk line of Chamkhar feeder to Dog from existing Rabbit conductor; and
b) Extend the 11kV Batpalathang feeder to meet the power requirement of Jalikhar LAP.

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 500 kVA, 11/0.415kV transformer at Chamkhar Market to 750 kVA USS.
b) Up-grade 160 kVA, 11/0.415kV transformer at Wangdicholing LSS to 250 kVA
c) Up-grade 250 kVA, 11/0.415kV transformer at Udee, Chamkhar to 500 kVA.
d) Up-grade 250 kVA, 11/0.415kV transformer at Gakeling to 500 kVA.
e) Up-grade 315 kVA, 11/0.415kV transformer at Jakar Dzong to 500 kVA.
f) Up-grade 250 kVA, 11/0.415kV transformer at Dekeling to 500 kVA.
g) Up-grade 100 kVA, 33/0.415kV transformer at Mesithang to 160 kVA.
h) Up-grade 250 kVA, 11/0.415kV transformer at Kharchu to 500 kVA.
i) Up-grade 10 kVA, 11/0.240kV transformer at Trongmenba to 25 kVA.
j) Up-grade 25 kVA, 11/0.415kV transformer at Drodrong to 63 kVA.
k) Construction of 500 kVA. 11/0.415 substation at Chumey satellite town
l) Construction of 63 kVA, 11/415 kV substation at Garpang.
m) Construction of 250 kVA,11/0.415kV substation at Norbugang, Chekhor.
n) Construction of 16 kVA, 33/0.415kV substation at Jog, Tang
o) Construction of 63 kVA,33/415 kV substation at Shingneer village.

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

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

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

Table 18: List of Switching Equipment under ESD Bumthang

Sl. No	Name of Feeder	ARCBs		FPIs	
		Existing	Proposed	Existing	Proposed
1	33 Incoming Feeder	2	0	0	1
2	11kV Gyetsa-Tharpaling Feeder	1	0	0	1
3	33 kV Ura feeder	1	0	0	1
4	33 kV Tang Feeder	1	0	0	1
5	11 kV Chekhor feeder	0	0	0	1
	Total	**5**	**0**	**0**	**5**

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

In accordance with 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 (2020-2024) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 14.**

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 14: 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-2015 and annual inflation is cumulatively applied to arrive at the actual investment cost for the following years.

In the span of the next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Bumthang Dzongkhag is Nu. 31.77 million (Nu. 3.12 million per year).

Table 19: Investment Plan until 2030 (Million Nu.)

Sl. No.	Project Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1	**Power Supply Source**	-	-	-	-	-	-	-	-	-	-	-	**-**
1.1	Installation of 2.5 MVA transformer at RNR-RC Substation	-	-	-	-	-	-	-	-	-	5.00	-	**5.00**
2	**MV Lines**	-	-	-	-	-	-	-	-	-	-	-	**-**
2.1	Extension of 2 KM of 11 kV Rabbit line form Batapalathang Feeder to Jalikhar town and installation of LBS at Jalikhar spur line on Chamkhar Feeder	-	-	-	-	2.40	-	-	-	-	-	-	**2.40**
2.2	Upgradation of 7 KM of main trunk line for Chamkhar Feeder from Rabbit to Dog conductor	-	-	-	-	-	1.25	-	-	1.25	-	-	**2.50**
2.3	Extension of 11 kV line at Norbugang of 0.5 kM	0.98	-	-	-	-	-	-	-	-		-	**0.98**
2.4	Extension of 33 kV line at Shingneer of 1.2 kM	-	-	-	-	0.90	-	-	-	-	-	-	**0.90**
3	**Distribution Transformers**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.1	Upgradation of 500 kVA transformer at Chamkhar Town to 750 kVA PSS	2.70	-	-	-	-	-	-	-	-	-	-	**2.70**
3.2	Upgradation of 160 kVA transformer at Wangdicholing LSS to 250 kVA	-	-	-	-	-	-	-	-	-	-	0.82	**0.82**
3.3	Upgradation of 250 kVA transformer at Udee, Chamkhar to 500 kVA	-	-	-	-	-	0.96	-	-	-	-	-	**0.96**
3.4	Upgradation of 250 kVA transformer at Gakiling to 500 kVA	-	-	-	-	-	-	-	-	1.03	-	-	**1.03**
3.5	Upgradation of 315 kVA transformer at Jakar Dzong to 500 kVA	-	-	-	-	-	-	-	-	-	-	1.07	**1.07**
3.6	Upgradation of 250 kVA transformer at Dekiling to 500 kVA	-	-	-	-	-	-	0.98	-	-	-	-	**0.98**
3.7	Upgradation of 100 kVA transformer at Mesithang to 160 kVA	-	-	-	-	0.50	-	-	-	-	-	-	**0.50**
3.8	Upgradation of 250 kVA transformer at Kharchu to 500 kVA	-	-	-	-	-	-	-	-	-	1.05	-	**1.05**

Sl. No.	Project Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
3.9	Upgradation of 25 kVA transformer at Dodrong to 63 kVA	-	-	0.37	-	-	-	-	-	-	-	-	**0.37**
3.10	Installation of 63 kVA transformer at Garpang	-	-	-	0.38	-	-	-	-	-	-	-	**0.38**
3.11	Installation of 250 kVA,11/0.415 kV transformer at Norbugang	0.98	-	-	-	-	-	-	-	-	-	-	**0.98**
3.12	Installation of 63 kVA, 33/0.415 kV transformer at Shingneer village	-	-	-	-	0.90	-	-	-	-	-	-	**0.90**
3.13	Installation of 16 kVA,33/0.415 kV transformer at Jog, Tang	-	3.07	-	-	-	-	-	-	-	-	-	**3.07**
3.14	construction of 63 kVA, 11/0.415 kV substation at Kharshing	-	-	0.90	-	-	-	-	-	-	-	-	**0.90**
3.15	Construction of 500 kVA, 11/0.415 kV substation at Chumey	-	-	-	-	-	-	-	-	-	1.20	-	**1.20**
3.16	up-grade 10 kVA, 11/0.240kV transformer at Trongmenba to 25 kVA.	-	-	-	-	0.30	-	-	-	-	-	-	**0.30**
4	**Conversion**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.2	Single Phase to Three Phase Line conversion	-	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	**1.78**
3.3	Single Phase Transformer to Three Phase conversion	-	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**1.00**
	Total	**4.66**	**3.35**	**1.55**	**0.66**	**5.28**	**2.49**	**1.26**	**0.28**	**2.56**	**7.53**	**2.17**	**31.77**

10. Conclusion

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

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

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

The proportion of LV is higher in comparison to MV line length, accordingly the independent study carried out by BPC in 2017 showed that a large portion of the loss is due to LV and DT. Therefore, a similar system 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		
2	MV Substations	Up-rating/construction of new 2.5 MVA transformer at 33/11 RNR-RC substation should be implemented as described in section 8.1.2
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		
1	Investment Plan	As reflected in **Section 9** of this report, the overall investment plan as proposed is recommended.

Sl. No.	Parameters	Recommendations
2	Review of the DSMP	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 restoration time and the number of customers affected. In this regard, the following initiatives are recommended:

Sl. No.	Parameters	Recommendations
		1) To install ISDs (communicable FPIs, Sectionalizers & ARCBs); 2) To explore the construction of feeders with customized 11kV & 33kV towers; and 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.

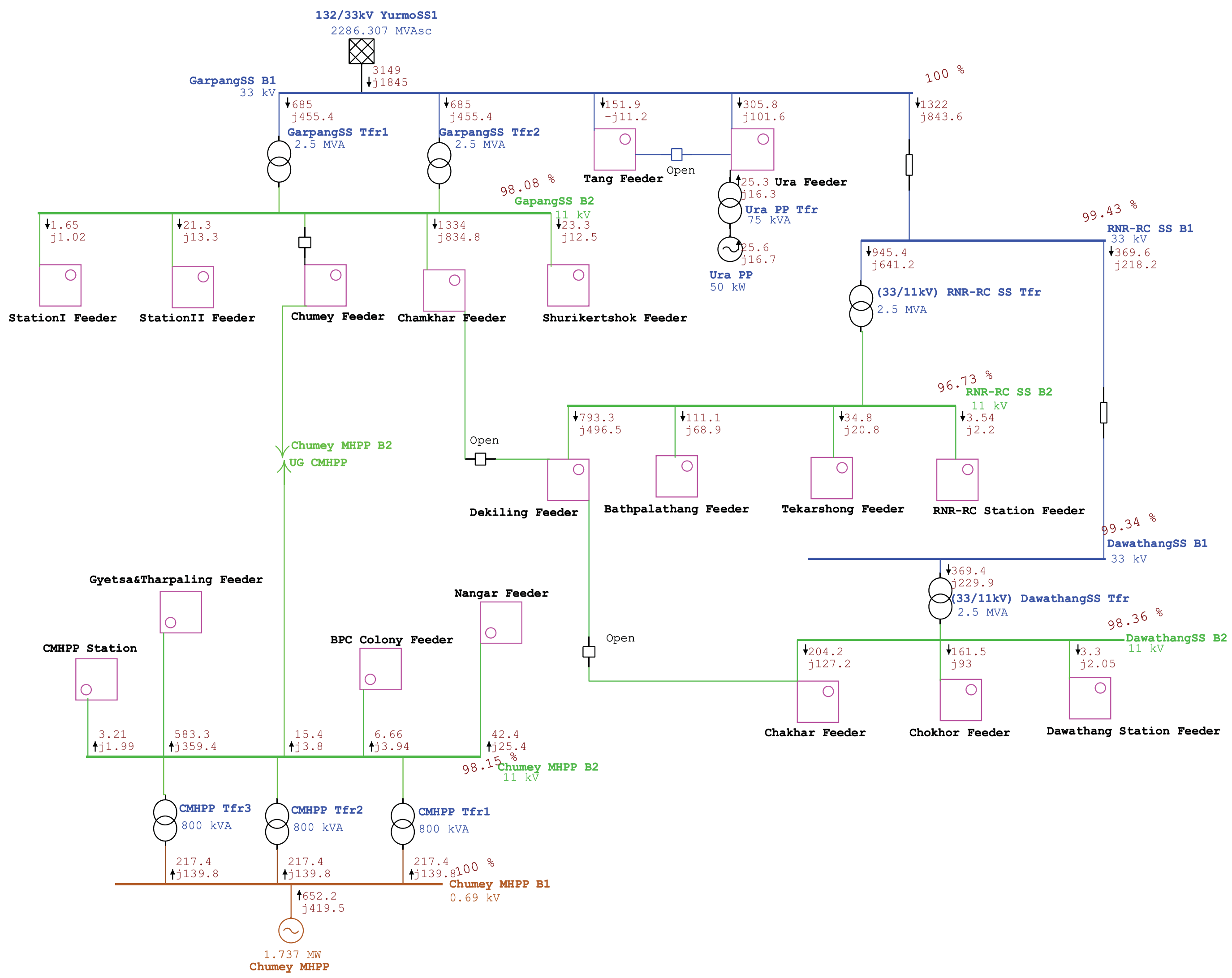
15. Challenges

Sl. No.	Parameters	Challenges	Opportunities/Proposals
1	Software Tool (ETAP)	a) Only one key & offline Key	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.
		b) Balanced Load Flow	
		c) Limitations of No. of buses (1000)	
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)
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to	b) To get the accurate Transformer Load Management (TLM)/loading, it is proposed to install DT meters which could also have

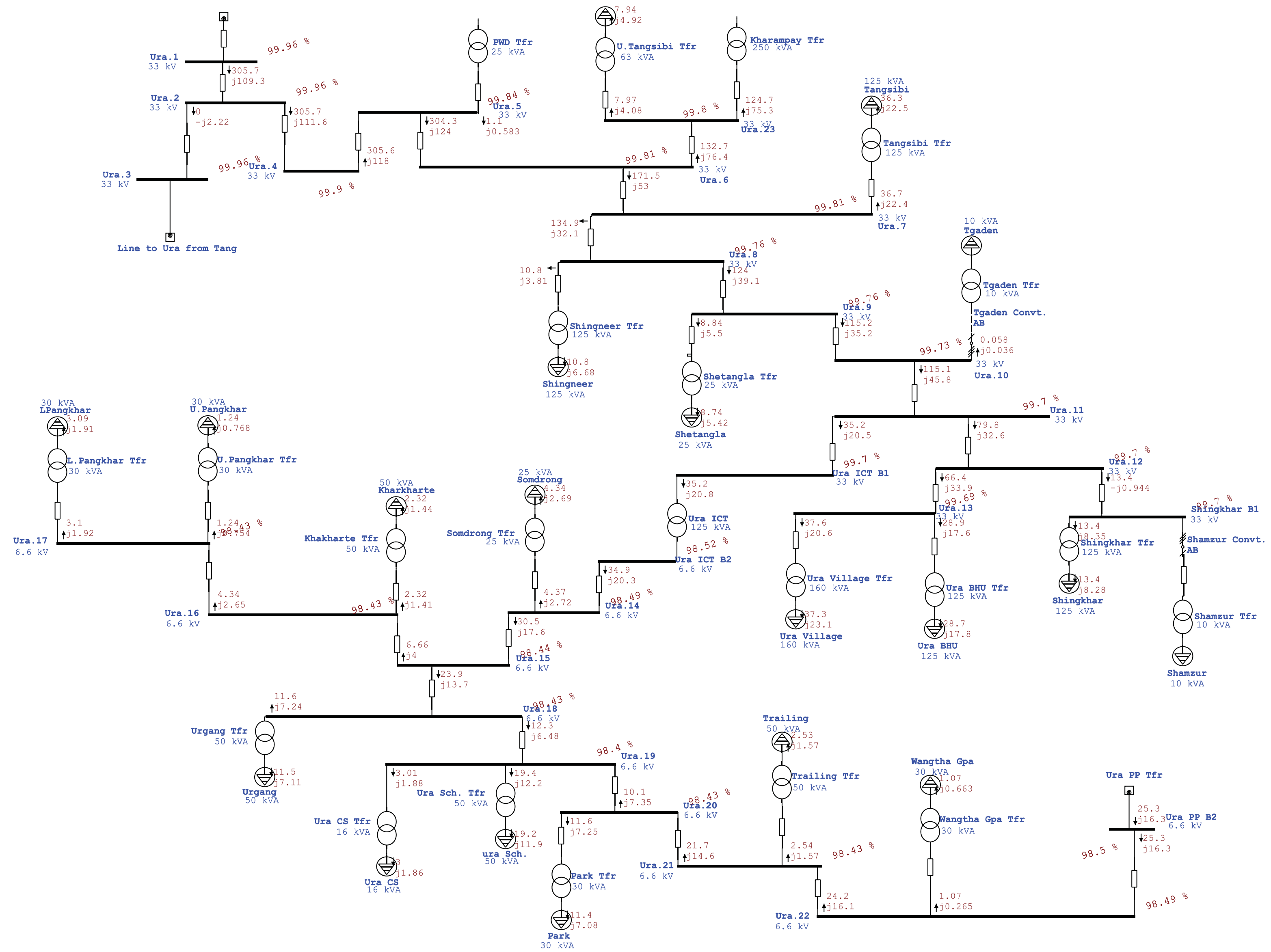
Sl. No.	Parameters	Challenges	Opportunities/Proposals
		timing and number of DTs.	additional features to capture other required information.
		c) No proper feeder and DT wise Customer Mapping recorded	c) Customer Information System (CIS) of the feeder/DT would enable us to have a proper TLM and replacement 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

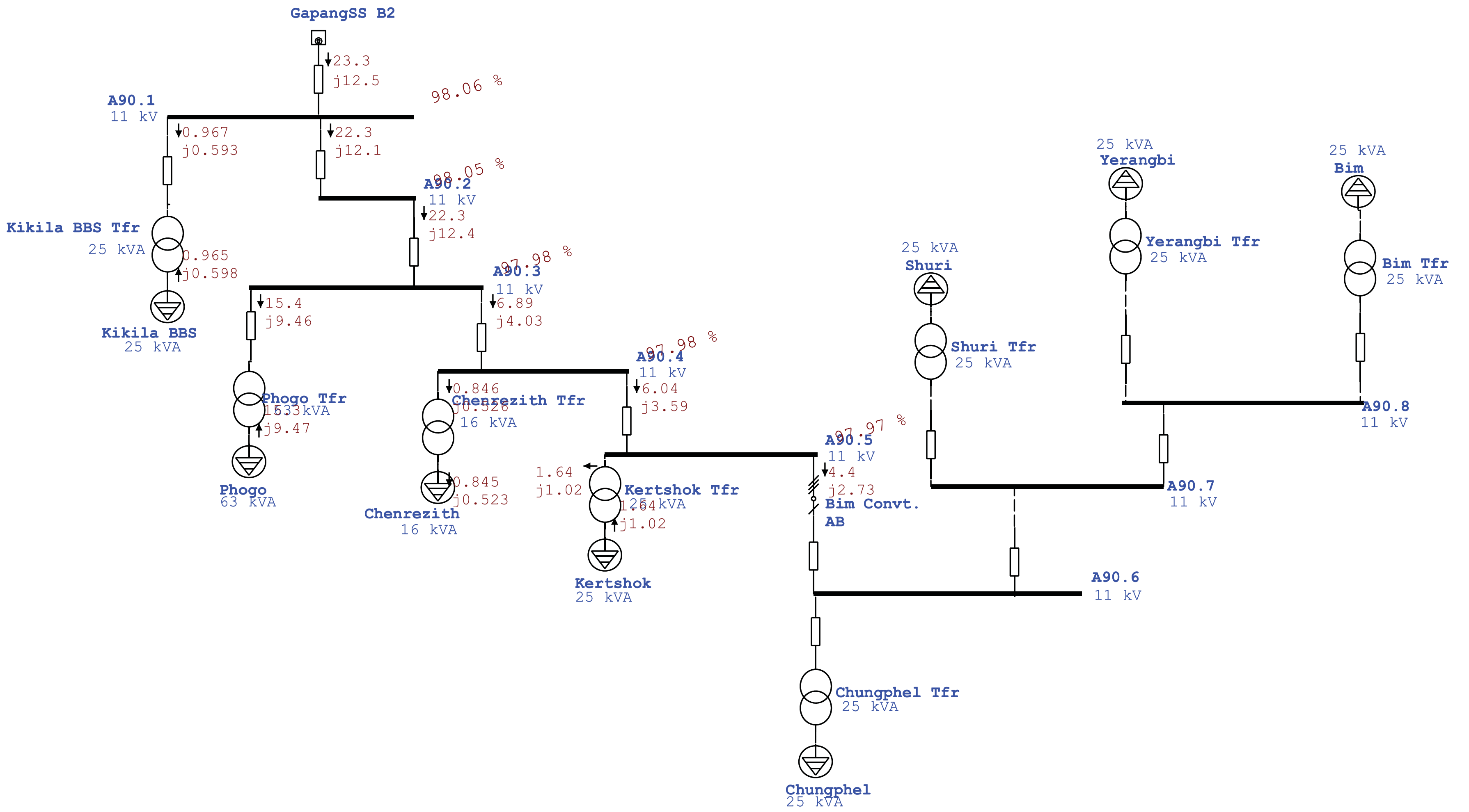
One-Line Diagram - OLV1 (Load Flow Analysis)



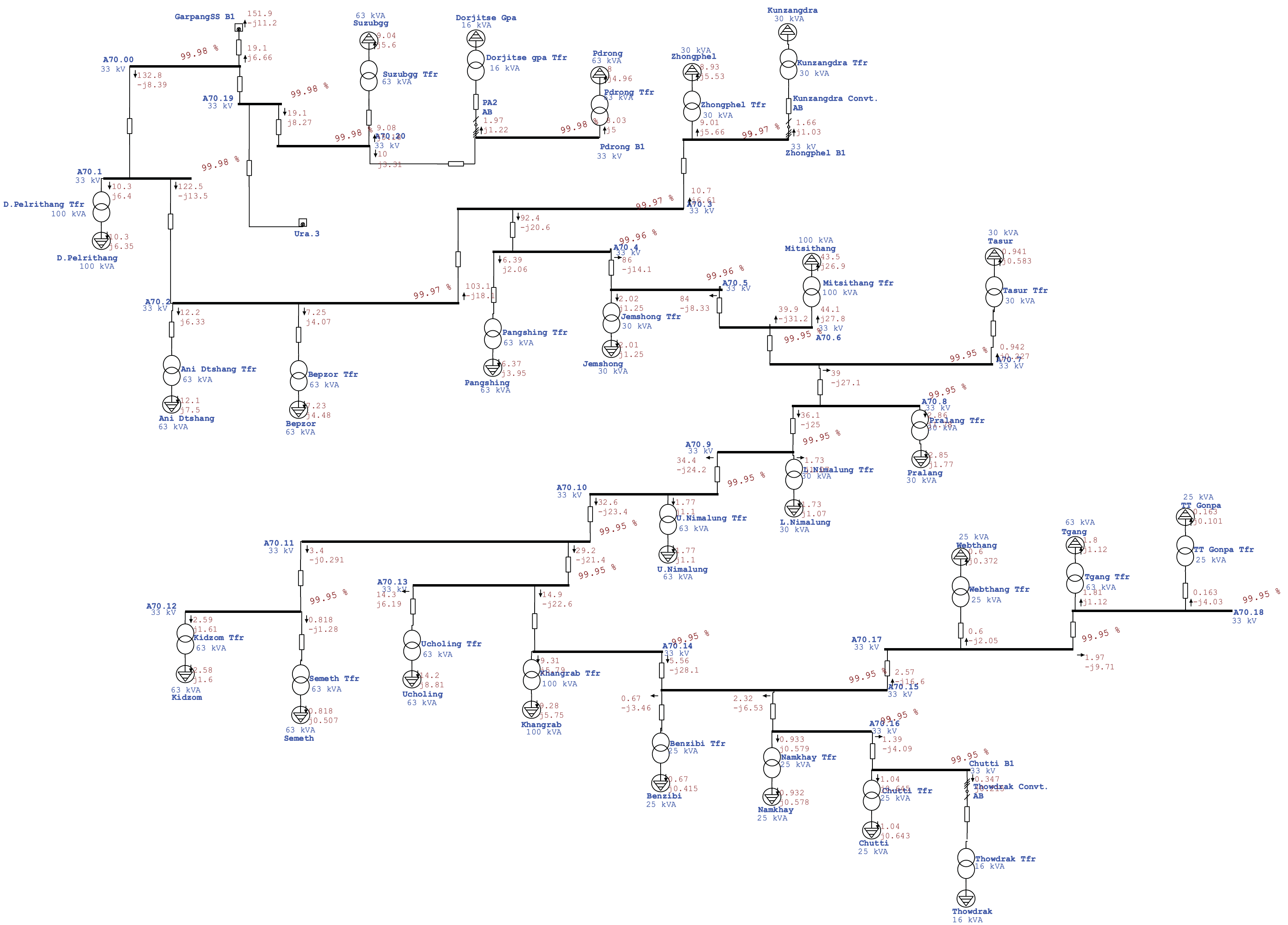
One-Line Diagram - OLV1=>Ura Feeder (Load Flow Analysis)

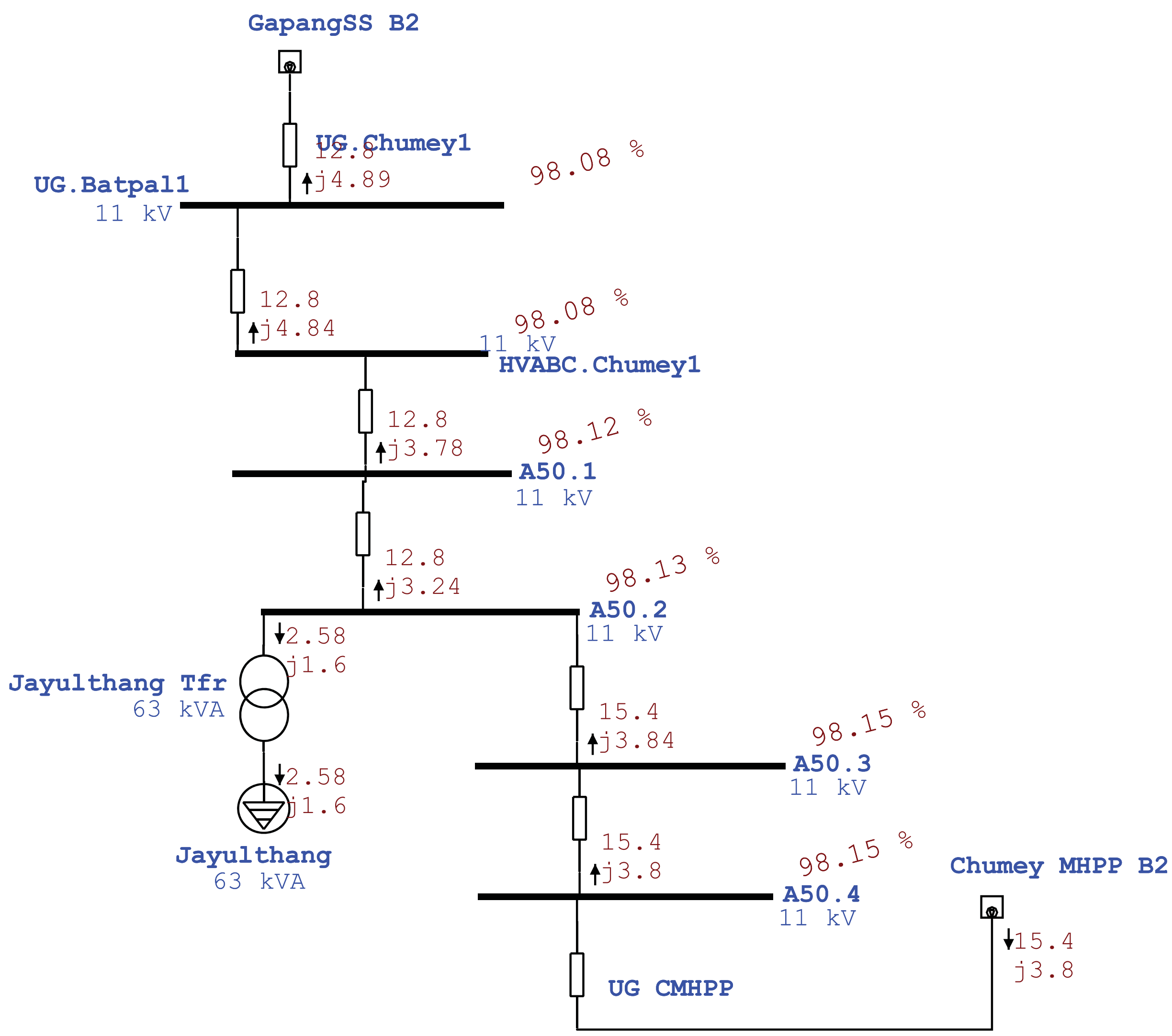


One-Line Diagram - OLV1=>Shurikertshok Feeder (Load Flow Analysis)

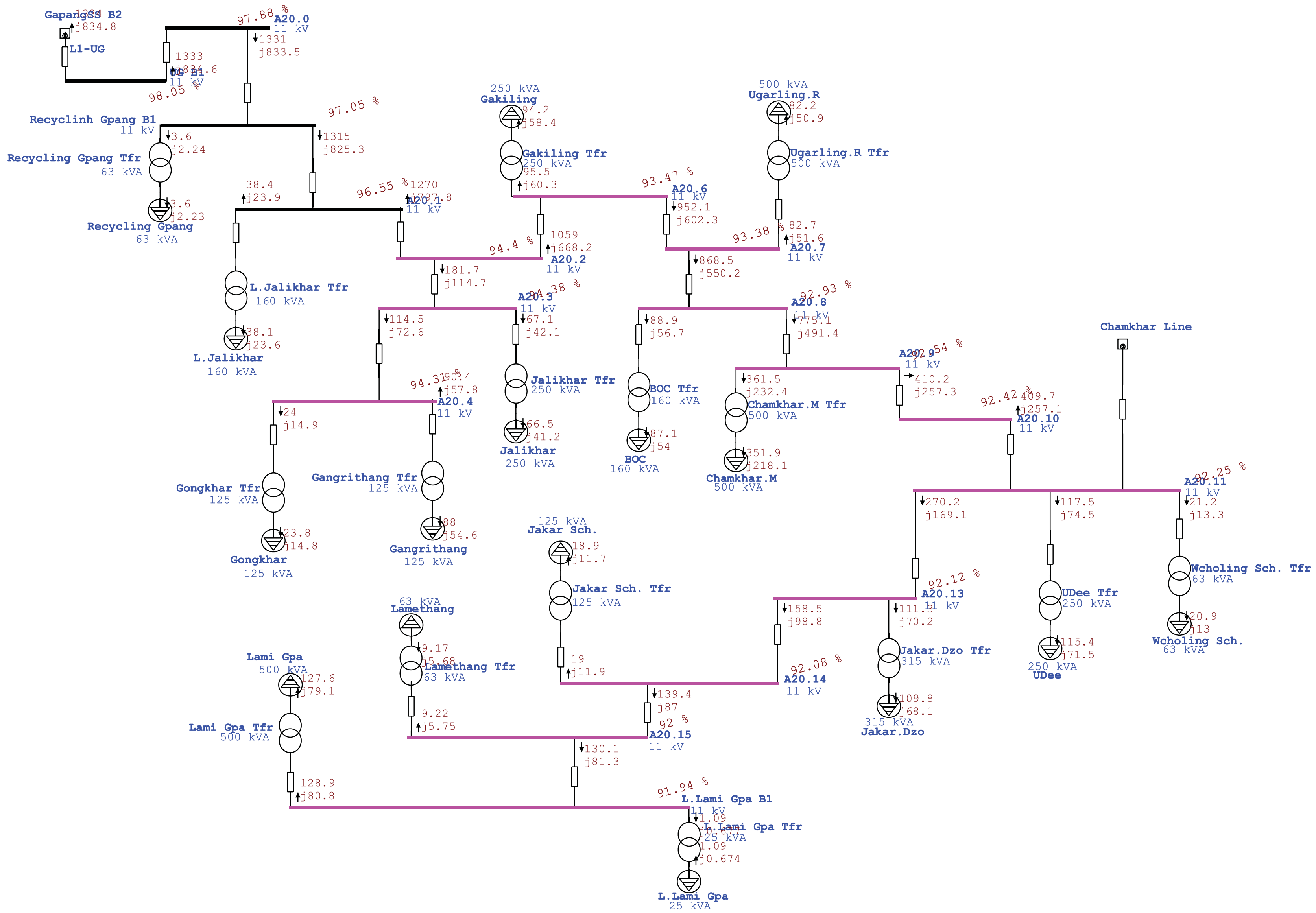


One-Line Diagram - OLV1=>Tang Feeder (Load Flow Analysis)

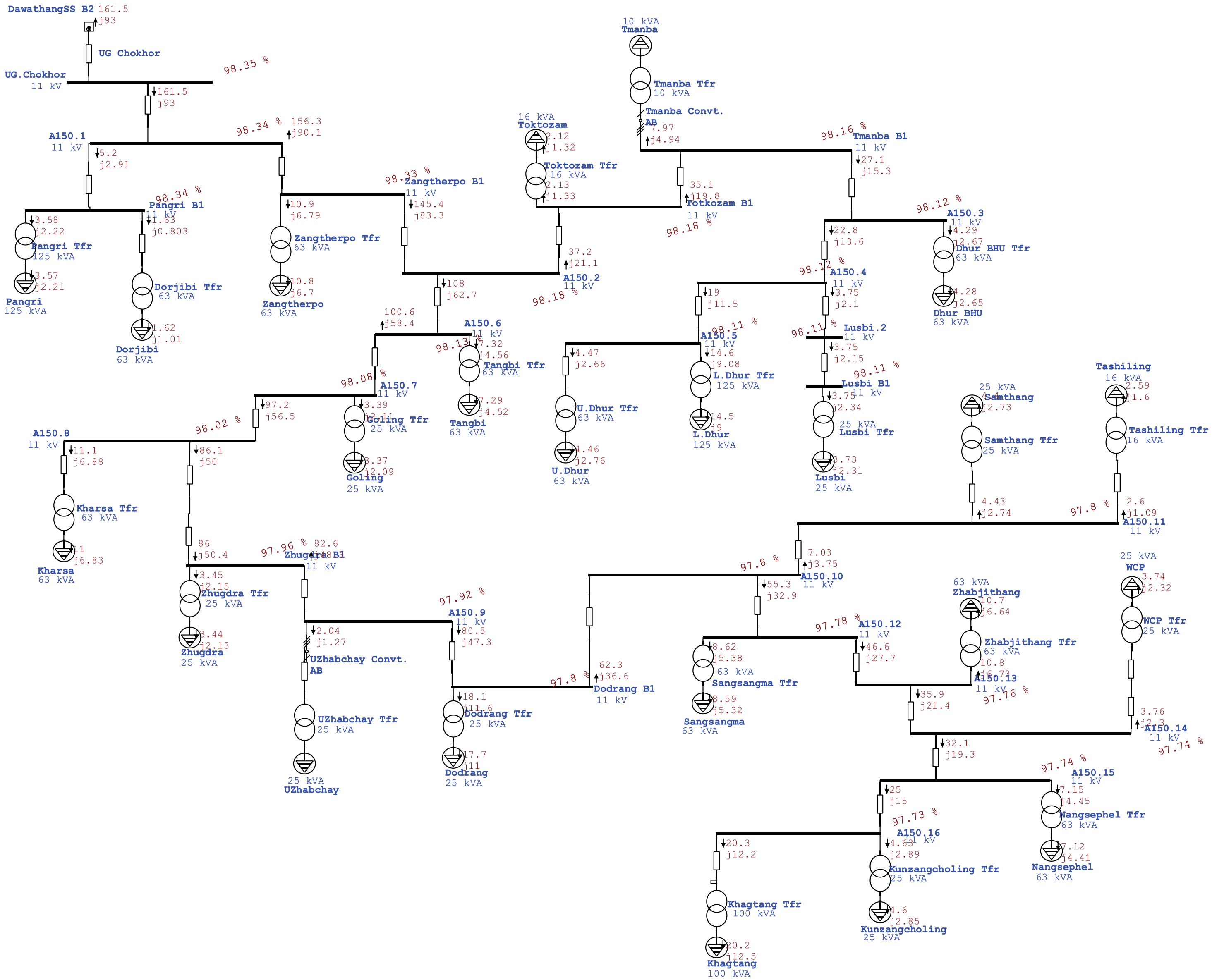



GapangSS B2
UG.Chumey1
12.8
j4.89
UG.Batpal1
11 kV
98.08 %
12.8
j4.84
98.08 %
11 kV
HVABC.Chumey1
12.8
j3.78
98.12 %
A50.1
11 kV
12.8
j3.24
98.13 %
A50.2
11 kV
2.58
j1.6
Jayulthang Tfr
63 kVA
2.58
j1.6
Jayulthang
63 kVA
15.4
j3.84
98.15 %
A50.3
11 kV
15.4
j3.8
98.15 %
A50.4
11 kV
Chumey MHPP B2
15.4
j3.8
UG CMHPP

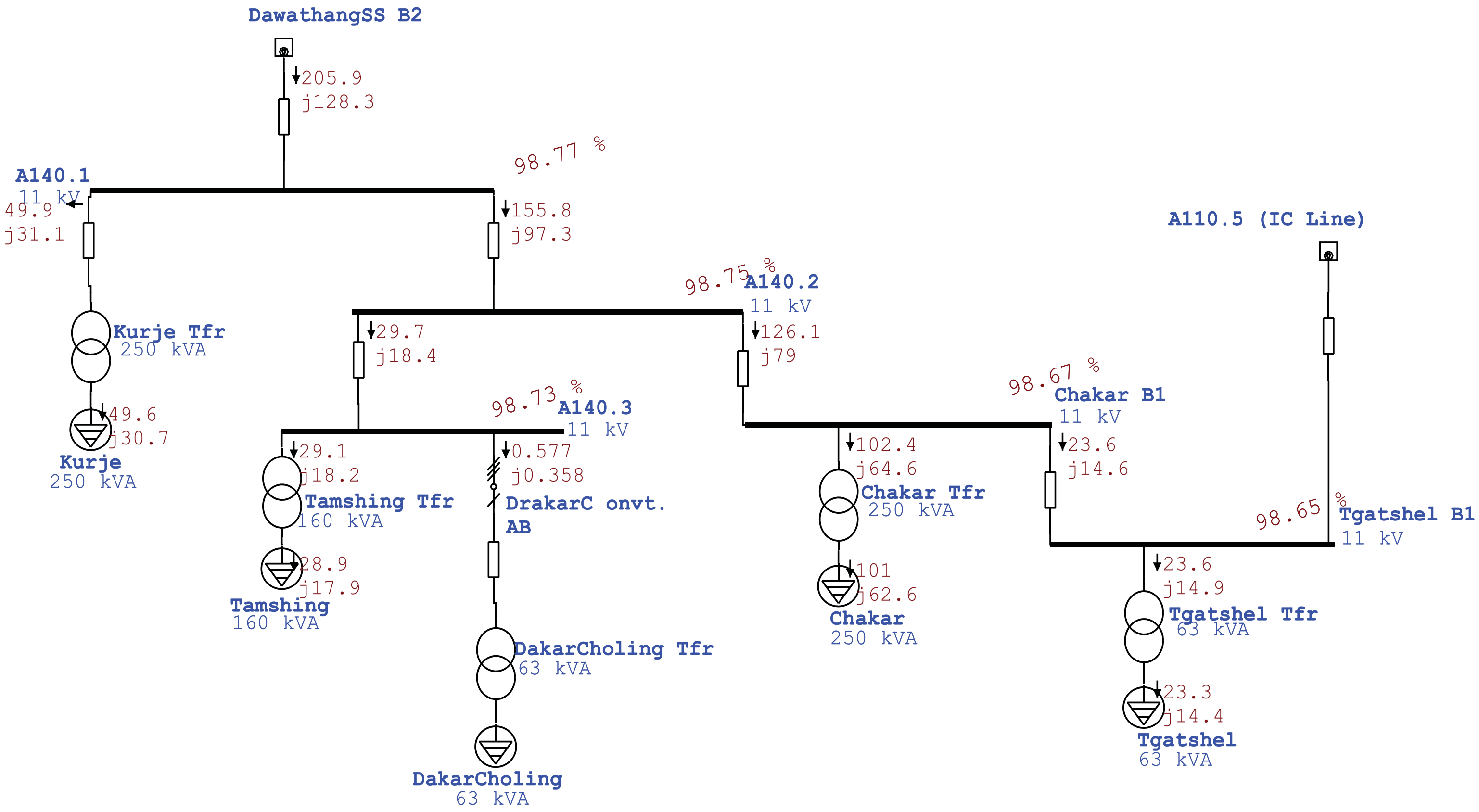
One-Line Diagram - OLV1=>Chamkhar Feeder (Load Flow Analysis)

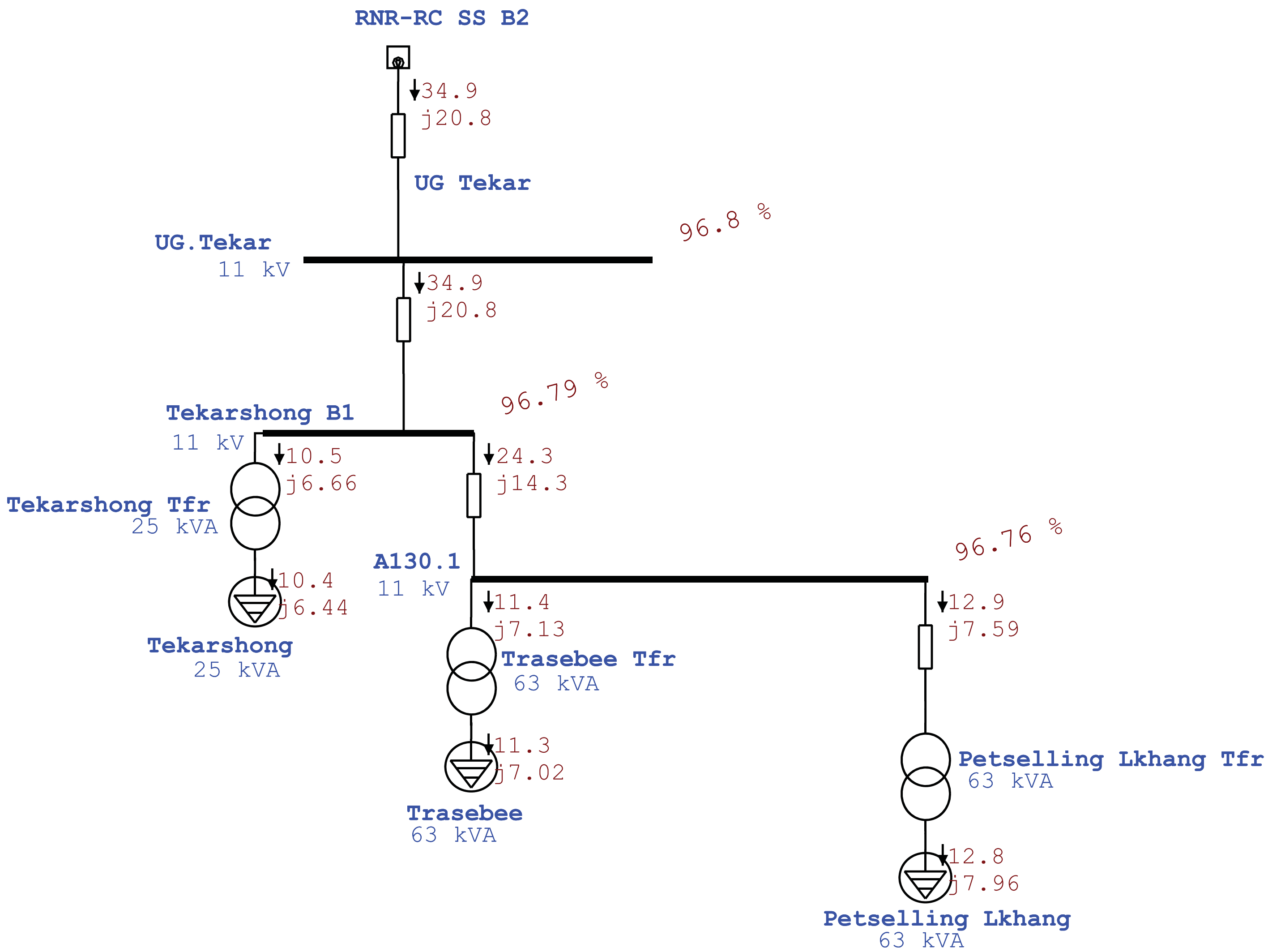


One-Line Diagram - OLV1=>Chokhor Feeder (Load Flow Analysis)

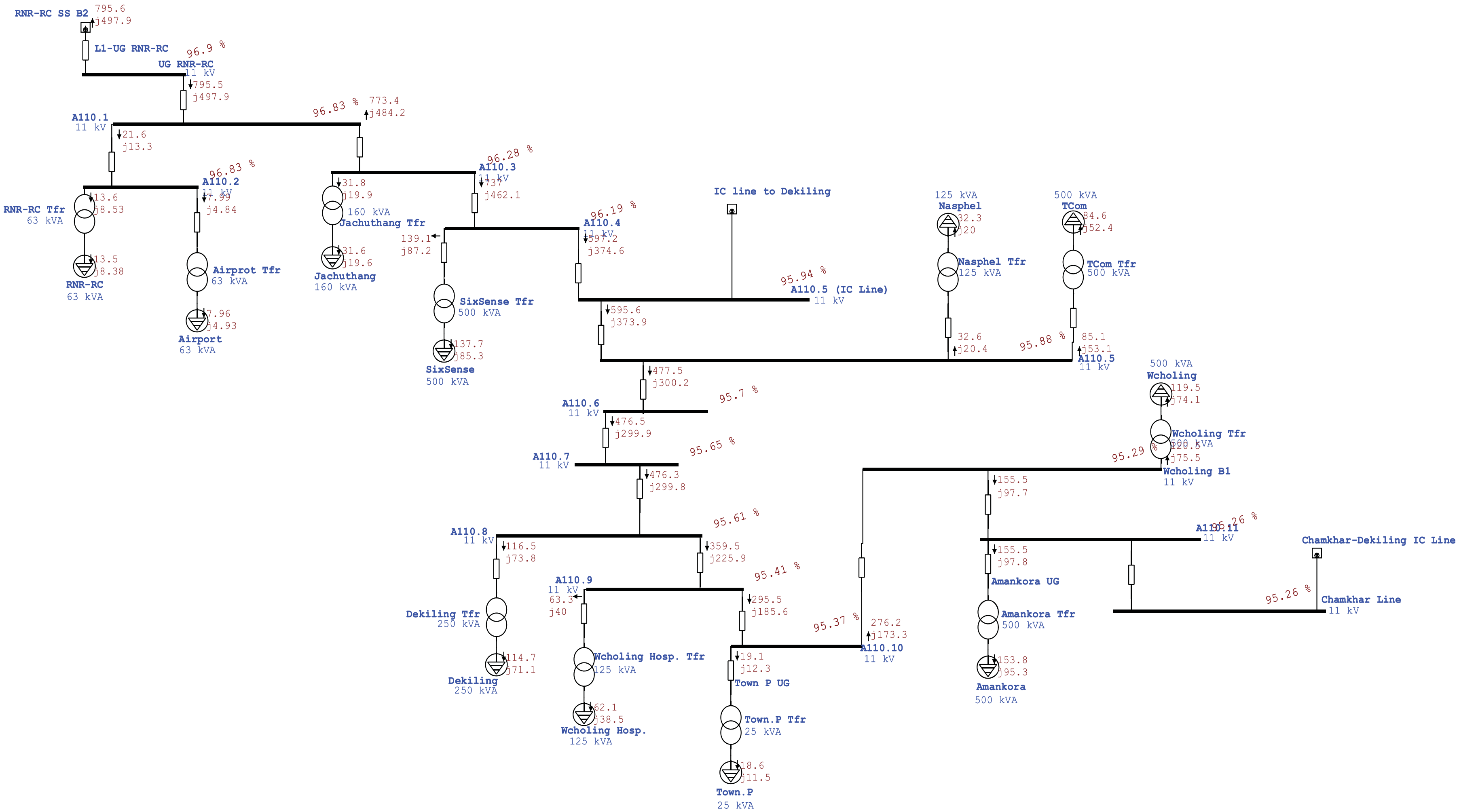


One-Line Diagram - OLV1=>Chakhar Feeder (Load Flow Analysis)

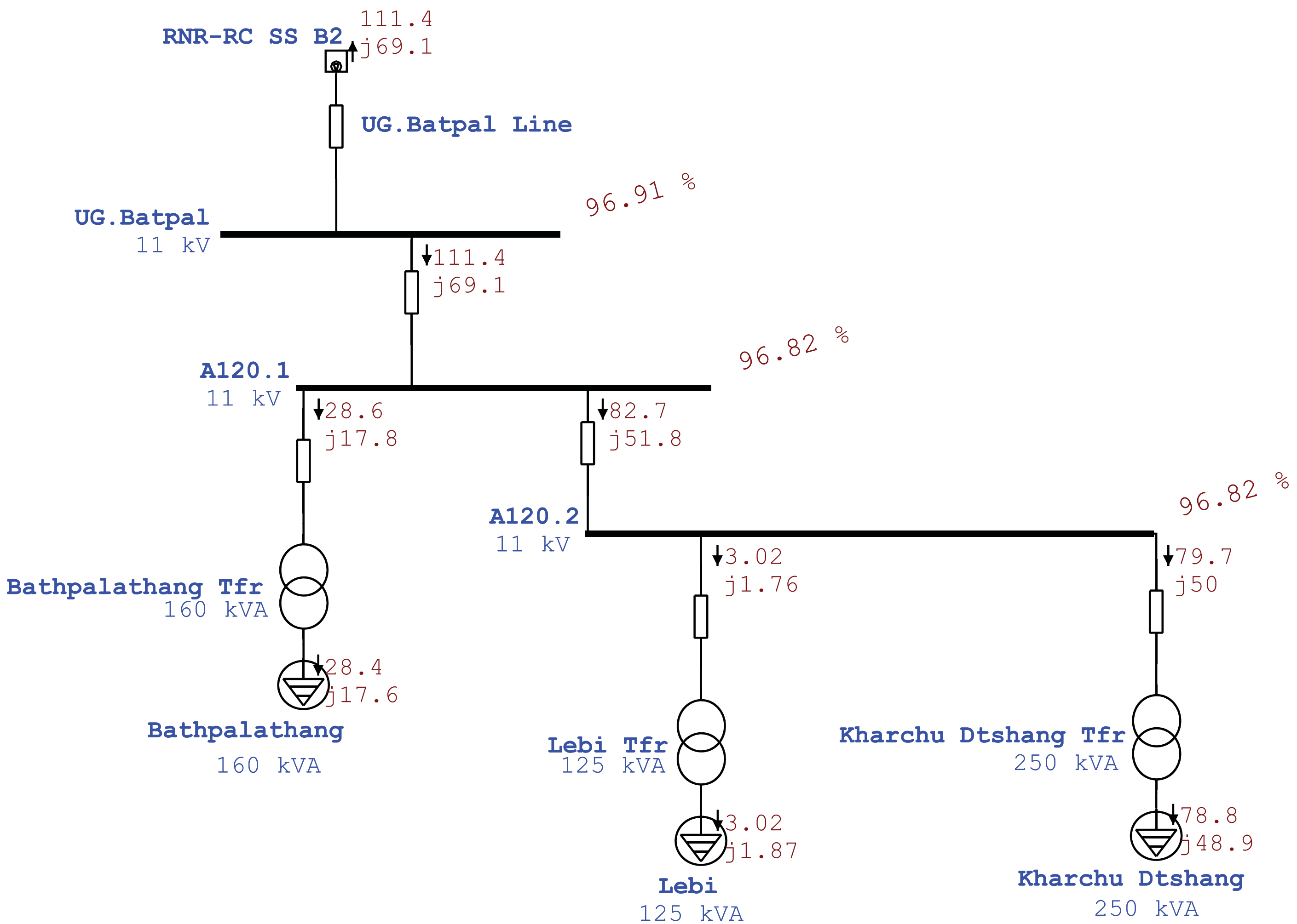


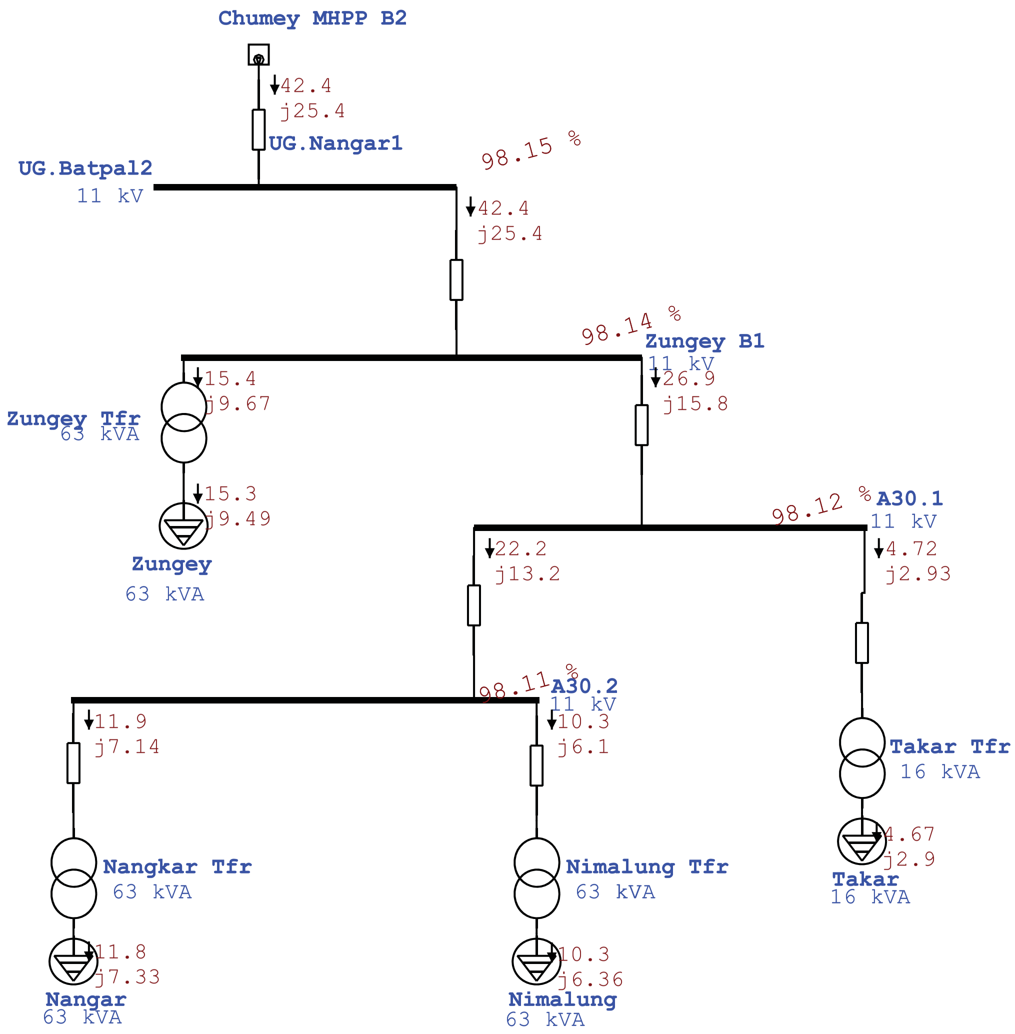

RNR-RC SS B2
34.9
j20.8
UG Tekar
UG.Tekar
11 kV
96.8 %
34.9
j20.8
96.79 %
Tekarshong B1
11 kV
10.5
j6.66
24.3
j14.3
Tekarshong Tfr
25 kVA
96.76 %
A130.1
11 kV
10.4
j6.44
Tekarshong
25 kVA
11.4
j7.13
12.9
j7.59
Trasebee Tfr
63 kVA
11.3
j7.02
Trasebee
63 kVA
Petselling Lkhang Tfr
63 kVA
12.8
j7.96
Petselling Lkhang
63 kVA

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

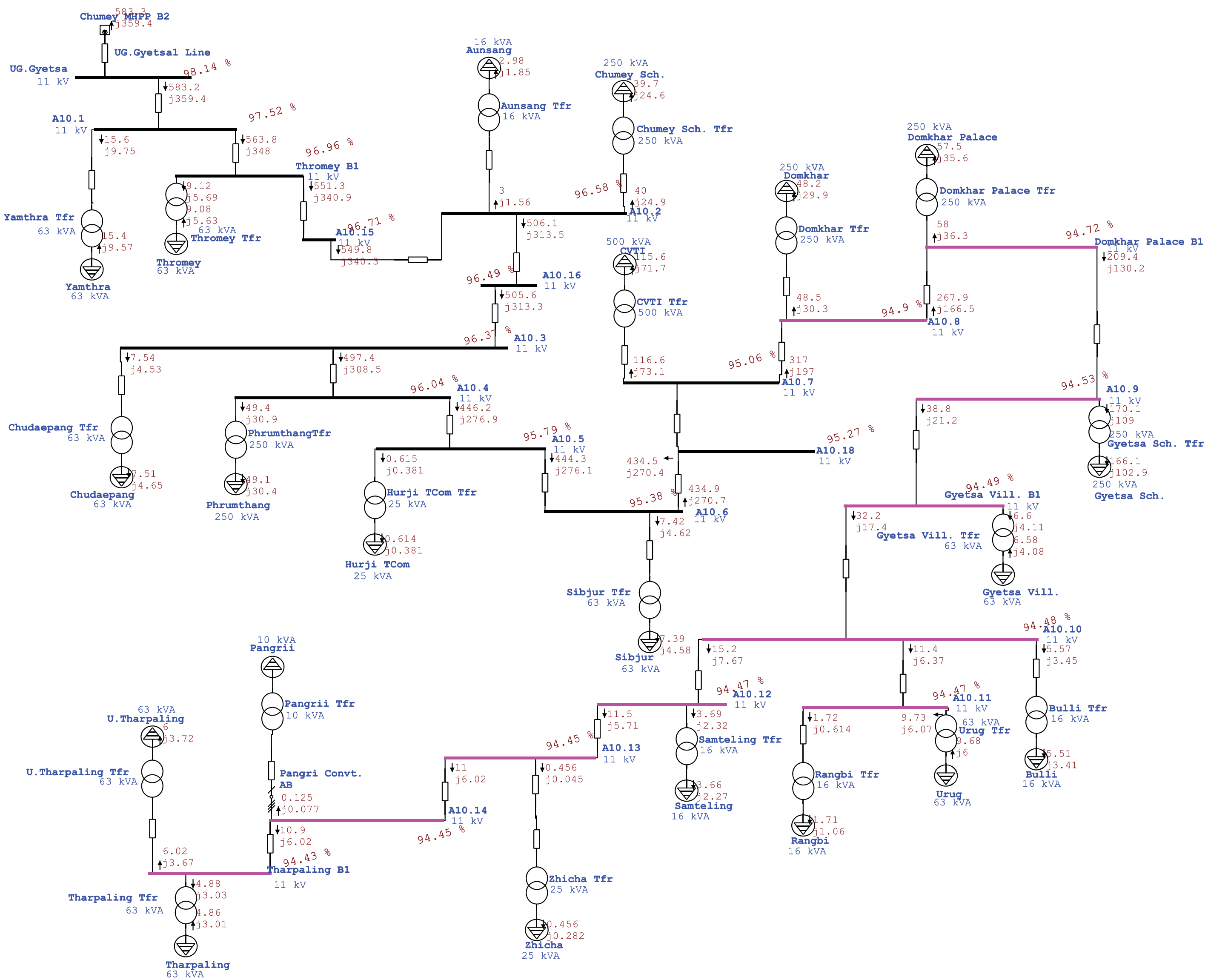


One-Line Diagram - OLV1=>Bathpalathang Feeder (Load Flow Analysis)

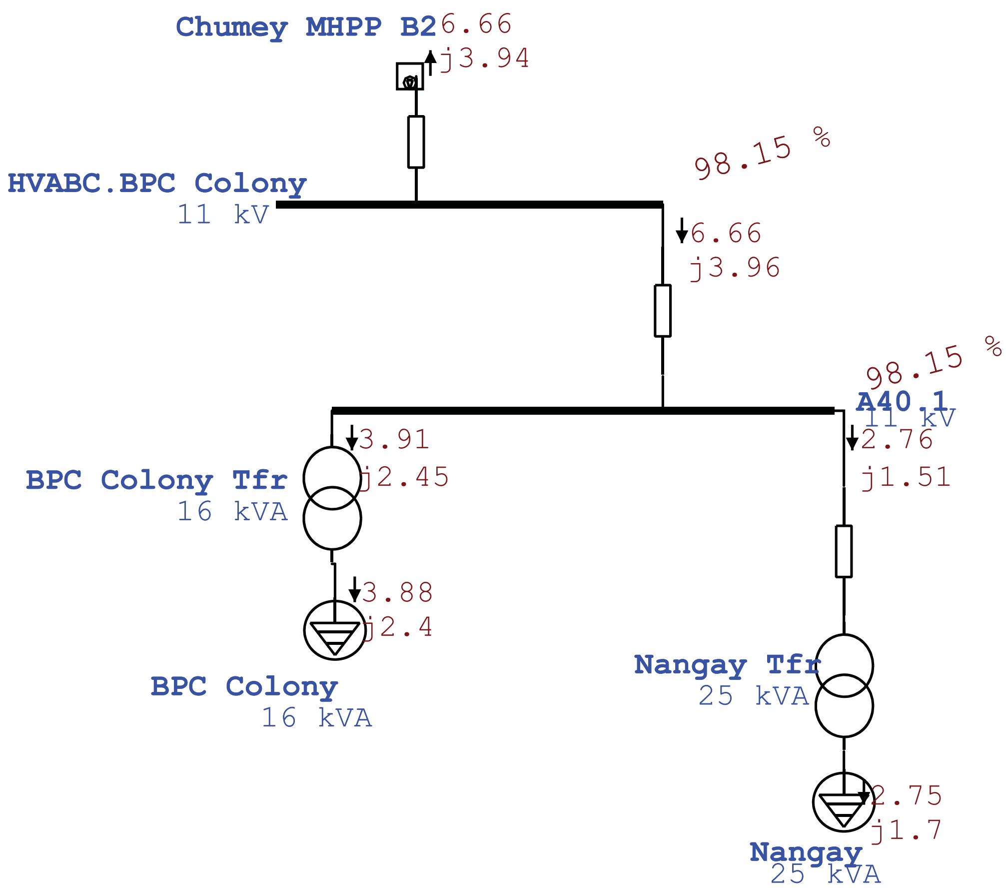



Chumey MHPP B2
42.4
j25.4
UG.Nangar1
UG.Batpal2
11 kV
98.15 %
42.4
j25.4
98.14 %
Zungey B1
11 kV
26.9
j15.8
15.4
j9.67
Zungey Tfr
63 kVA
15.3
j9.49
Zungey
63 kVA
98.12 %
A30.1
11 kV
4.72
j2.93
22.2
j13.2
98.11 %
A30.2
11 kV
10.3
j6.1
11.9
j7.14
Takar Tfr
16 kVA
4.67
j2.9
Takar
16 kVA
Nangkar Tfr
63 kVA
11.8
j7.33
Nangar
63 kVA
Nimalung Tfr
63 kVA
10.3
j6.36
Nimalung
63 kVA

One-Line Diagram - OLV1 (Load Flow Analysis)=>Gyetsa&Tharpaling Feeder



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



Annexure-I: Verified data of Distribution Network of Bumthang Dzongkhag

Feeder		Voltage (kV)	Section		CONDUCTOR	Conductor type & Line Length						Length (km)		
Name	ID					UG	HV ABC	WOLF	DOG	RABBIT	AAAC	Section Length (km)	Cumulative Length (km)	Phase
11 KV Gyatsa-Tharpaling Feeder	A10	11	A10H00	A10H00	Rabbit					9.381		9.381	9.381	3
			A10H021	A10H021	Rabbit					0.017		0.017	9.398	3
			A10H052	A10H052	Rabbit					0.027		0.027	9.425	3
			A10H052	A10H052	Rabbit					1.033		1.033	10.458	3
			A10H064	A10H064	95 SQ.MM HV ABC		0.506					0.506	10.964	3
			A10H098	A10H098	Rabbit					0.01		0.01	10.974	3
			A10H108	A10H108	Rabbit					0.021		0.021	10.995	3
			A10H114	A10H114	Rabbit					0.182		0.182	11.177	3
			A10H148	A10H148	Rabbit					0.221		0.221	11.398	3
			A10H149	A10H149	Rabbit					1.221		1.221	12.619	3
			A10H201	A10H201	Rabbit					3.779		3.779	16.398	3
			A10H98	A10H98	150 SQ.MM AAAC						0.154	0.154	16.552	3
			A10H010	A10H010	95 SQ.MM HV ABC		0.059					0.059	16.611	3
			A10H217	A10H217	96 SQ.MM HV ABC		0.916					0.916	17.527	3
			A10H222	A10H222	50 SQ.MM HV ABC		0.204					0.204	17.731	3
			A10H273	A10H273	Rabbit					0.268		0.268	17.999	3
			A10H142	A10H142	Rabbit					1.087		1.087	19.086	3
			A10H164	A10H164	Rabbit					1.544		1.544	20.63	3
				TOTAL									20.63	
						0	**1.685**	**0**	**0**	**18.791**	**0.154**	**4.232**	**20.63**	
11 KV Chamkhar feeder	A20	11	A20H000	A20H001	150 sq.mm UG Cable	0.062						0.062	0.062	3
			A20H057	A20H062	95 Sq.mm HV ABC		0.144					0.144	0.206	3
			A20H001	A20H005	95 Sq.mm HV ABC		0.15					0.15	0.356	3
			A20H005	A20H134	Rabbit					5.871		5.871	6.227	3
			A20H021	A20H028	Rabbit					0.533		0.533	6.76	3
			A20H048	A20H054	Rabbit					0.3		0.3	7.06	3
			A20H106	A20H108	Rabbit					0.087		0.087	7.147	3
			A20H118	A20H119	Rabbit					0.064		0.064	7.211	3
			A20H129 t	A20H189	Rabbit					3		3	10.211	3
			A20H050	A20H074	Rabbit					1.056		1.056	11.267	3
			A20H068	A20H090	Rabbit					0.775		0.775	12.042	3
			A20H139	A20H142	Rabbit					0.157		0.157	12.199	3
			A20H143	A20H150	Rabbit					0.348		0.348	12.547	3
			A20H160	A20H161	Rabbit					0.008		0.008	12.555	3
			A20H169	A20H170	Rabbit					0.028		0.028	12.583	3
				TOTAL									12.583	
						0.062	**0.294**	**0**	**0**	**12.227**	**0**	**12.583**	**12.583**	
11 KV Nangar feeder	A30	11	A30H000	A30H033	Rabbit					2.633		2.633	2.633	3
			A30H019	A30H021	Rabbit					0.098		0.098	2.829	3
			A30H023	A30H050	Rabbit					1.116		1.116	5.061	3
				TOTAL									5.061	
						0	**0**	**0**	**0**	**3.847**	**0**	**3.847**	**5.061**	

11 KV Nangay	A40	11	A40H000	A40H010	Rabbit					0.79		0.79	0.79	3
				TOTAL									0.79	
						0	**0**	**0**	**0**	**0.79**	**0**	**0.79**	**0.79**	
11 KV Chumey-garpang feeder	A50	11	A50H000	A50H027	Dog				2.231			2.231	2.231	3
			A50H038	A50H064	Rabbit					1.693		1.693	3.924	3
			A50H027	A50H104	Dog				4.132			4.132	8.056	3
				TOTAL									8.056	
						0	**0**	**0**	**6.363**	**1.693**	**0**	**8.056**	**8.056**	
6.6 KV Ura power Plant-Urgang feeder	A60	6.6	A60H000	A60H096	Rabbit					4.648		4.648	4.648	3
			A60H094	A60H099	Rabbit					0.252		0.252	4.9	3
			A60H004	A60H143	Rabbit					3.459		3.459	8.359	3
			A60H023	A60H024	Rabbit					0.006		0.006	8.365	3
			A60H025	A60H031	Rabbit					0.369		0.369	8.734	3
			A60H084	A60H107	Rabbit					0.769		0.769	9.503	3
			A60H104	A60H111	Rabbit					0.381		0.381	9.884	3
			A60H112	A60H114	Rabbit					0.11		0.11	9.994	3
				TOTAL									9.994	
						0	**0**	**0**	**0**	**9.994**	**0**	**9.994**	**9.994**	
33 KV Tang feeder	A70	33	A70H001	A70H006	Dog				0.432			0.432	0.432	3
			A70H006	A70H371	Dog				19.14			19.14	19.572	3
			A70H040	A70H059	Rabbit					1.411		1.411	20.983	3
			A70H129	A70H131	Rabbit					0.142		0.142	21.125	3
			A70H129	A70H136	Rabbit					0.427		0.427	21.552	3
			A70H155	A70H170	Rabbit					1.204		1.204	22.756	3
			A70H204	A70H212	Rabbit					0.645		0.645	23.401	3
			A70H283	A70H286	Rabbit					0.12		0.12	23.521	3
			A70H323	A70H327	Rabbit					0.195		0.195	23.716	3
			A70H359	A70H370	Rabbit					0.931		0.931	24.647	3
			A70H378	A70H390	Rabbit					1.82		1.82	26.467	3
			A70H378	A70H487	Rabbit					1.015		1.015	27.482	3
			A70H378	A70H461	Rabbit					3.902		3.902	31.384	3
			A70H045	A70H048	Rabbit				0.164			0.164	31.548	3
			A70H061	A70H105	Dog					3.614		3.614	35.162	3
			A70H510	A70H554	Rabbit					4.363			39.525	3
			A70H461	A70H471	Rabbit					1.385			40.91	3
				TOTAL									40.91	
						0	**0**	**0**	**19.736**	**21.174**	**0**	**35.162**	**40.91**	
33 KV RNR-RC	A80	33	A80H000	A80H074	Dog				7.045			7.045	7.045	3
				TOTAL									7.045	
						0	**0**	**0**	**7.045**	**0**	**0**	**7.045**	**7.045**	

11 KV Shuri-Kertshok feeder	A90	11	A90H000	A90H117	Rabbit					8.861		8.861	8.861	3
			A90H011	A90H012	95 Sq.mm HV ABC		0.022					0.022	8.883	3
			A90H070	A90H082	95 Sq.mm HV ABC		0.559					0.559	9.442	3
			A90H108	A90H118	Rabbit					0.091		0.091	9.533	3
			A90H112	A90H158	Rabbit					3.321		3.321	12.854	1
			A90H137	A90H139	Rabbit					0.117		0.117	12.971	1
				TOTAL									12.971	
						0	**0.581**	**0**	**0**	**12.39**	**0**	**12.971**	**12.971**	
33 KV Dawathang feeder	A100	33	A100H000	A100H044	Dog				3.857			3.857	3.857	3
			A100H00	A100H00	Dog				0.166			0.166	4.023	3
				TOTAL									4.023	
						0	**0**	**0**	**4.023**	**0**	**0**	**4.023**	**4.023**	
11 KV Dekeling feeder	A110	11	A110H000	A110H007	Rabbit					0.351		0.351	0.351	3
			A110H007	A110H015	Rabbit					0.815		0.815	1.166	3
			A110H003	A110H025	Rabbit					0.786		0.786	1.952	3
			A110H060	A110H063	95 sq.mm HV ABC		0.109					0.109	2.061	3
			A110H003	A110H025						0.786		0.786	2.847	3
					Rabbit							0	2.847	3
			A110H025	A20H134	Rabbit					2.317		2.317	5.164	3
			A110H028	A110H036	Rabbit					0.428		0.428	5.592	3
			A110H043	A110H058	Rabbit					0.744		0.744	6.336	3
			A110H063	A110H064	Rabbit					0.02		0.02	6.356	3
			A110H070	A110H072	Rabbit					0.149		0.149	6.505	3
			A110H082	A110H090	150 sq.mm UG cable	0.291						0.291	6.796	3
			A110H089	A11T8	95 sq.mm HV ABC		0.79					0.79	7.586	3
			A110H071	A110H080	Dog				0.433			0.433	8.019	3
				TOTAL									8.019	
						0.291	**0.899**	**0**	**0.433**	**6.396**	**0**	**8.019**	**8.019**	
11 KV Batpalathang feeder	A120	11	A120H000	A120H017	Dog				1.832			1.832	1.832	3
			A120H018	A120H024	Rabbit					0.384		0.384	2.216	3
			A120H000	A120H029	Rabbit					0.399		0.399	2.615	3
				TOTAL									2.615	
						0	**0**	**0**	**1.832**	**0.783**	**0**	**2.615**	**2.615**	
11 KV Tekarshon	A130	11	A130H000	A130H048	Rabbit					3.351		3.351	3.351	3
				TOTAL									3.351	
						0	**0**	**0**	**0**	**3.351**	**0**	**3.351**	**3.351**	
11 KV Chakar feeder	A140	11	A140H000	A140H012	Dog				0.921			0.921	0.921	3
			A140H012	A140H017	Rabbit					0.356		0.356	1.277	3
			A140H018	A140H053	Rabbit					0.611		0.611	1.888	3
			A140H012	A140H034	Rabbit					0.905		0.905	2.793	3
			A140H034	A110H042	Rabbit					0.898		0.898	3.691	3
			A140H054	A140H065	150 sq.mm AAAC						1.126	1.126	4.817	3
				TOTAL									4.817	
						0	**0**	**0**	**0.921**	**2.77**	**1.126**	**4.817**	**4.817**	

11 KV Chokhor feeder	A150	11	A150H000	A150H047	Rabbit					2.17		2.17	2.17	3
			A150H002	A150H015	Rabbit					0.994		0.994	3.164	3
			A150H047	A150H312	100 Sq.mm AAAC						12.013	12.013	15.177	3
			A150H180	A150H182	Dog				0.116			0.116	15.293	3
			A150H220	A150H224	Rabbit					0.167		0.167	15.46	3
			A150H226	A150H333	100 Sq.mm AAAC						0.33	0.33	15.79	3
			A150H299	A150H302	Rabbit					0.151		0.151	15.941	3
			A150H332	A150H355	Rabbit					1.613		1.613	17.554	3
			A150H312	A150H329	Rabbit					1.476		1.476	19.03	3
			A150H047	A150H131	Dog				5.268			5.268	24.298	3
			A150H110	A150H119	Rabbit					0.735		0.735	25.033	3
				TOTAL									25.033	
						0	**0**	**0**	**5.384**	**7.306**	**12.343**	**25.033**	**25.033**	
11 KV VVIP feeder	A160	11	A160H000	A160H033	50 sq.mm HV ABC		1.829					1.829	1.829	3
			A160H012	A160H016	50 sq.mm HV ABC		0.35					0.35	2.179	3
				TOTAL									2.179	
						0	**2.179**	**0**	**0**	**0**	**0**	**2.179**	**2.179**	
33 KV Yotongla feeder	A170	33	A170H000	A170H104	150 Sq.mm AAAC						8.053	8.053	8.053	3
			A170H004	A170H005	Rabbit					0.125		0.125	8.178	3
			A170H072	A170H073	Rabbit					0.077		0.077	8.255	3
				TOTAL									8.255	
						0	**0**	**0**	**0**	**0.202**	**8.053**	**8.255**	**8.255**	
33 KV Ura feeder	A220	33	A220H001	A220H042	Dog				2.5			2.5	2.5	3
			A70H044, A220H043	A220H291	Dog				21.999			21.999	24.499	3
			A220H113	A220H114	Rabbit					0.031		0.031	24.53	3
			A220H350	A220H366	Rabbit					1.31		1.31	25.84	3
			A220H157	A220H349	Rabbit					0.206		0.206	26.046	3
			A220H292	A220H316	Rabbit					2.125		2.125	28.171	3
			A220H191	A220H197	Rabbit					0.985		0.985	29.156	3
			A220H202	A220H203	Rabbit					0.019		0.019	29.175	3
			A220H256	A220H346	Dog				0.095			0.095	29.27	3
			A220H257	A220H345	Rabbit					2.41743		2.41743	31.687	3
				TOTAL									31.687	
						0	**0**	**0**	**24.594**	**7.09343**	**0**	**31.68743**	**31.687**	
33 KV Yurmung	TRE110	33	TRE110H000	TRE110H017	150 Sq.mm AAAC						1.499	1.499	1.499	3
				TOTAL									1.499	
						0	**0**	**0**	**0**	**0**	**1.499**	**1.499**	**1.499**	
					33 KV	**0**	**0**	**0**	**55.398**	**28.46943**	**9.552**	**93.42**		
					11 KV	**0.353**	**5.638**	**0**	**14.933**	**70.344**	**13.623**	**98.90**		
					6.6 KV	**0**	**0**	**0**	**0**	**9.994**	**0**	**9.99**		

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.**

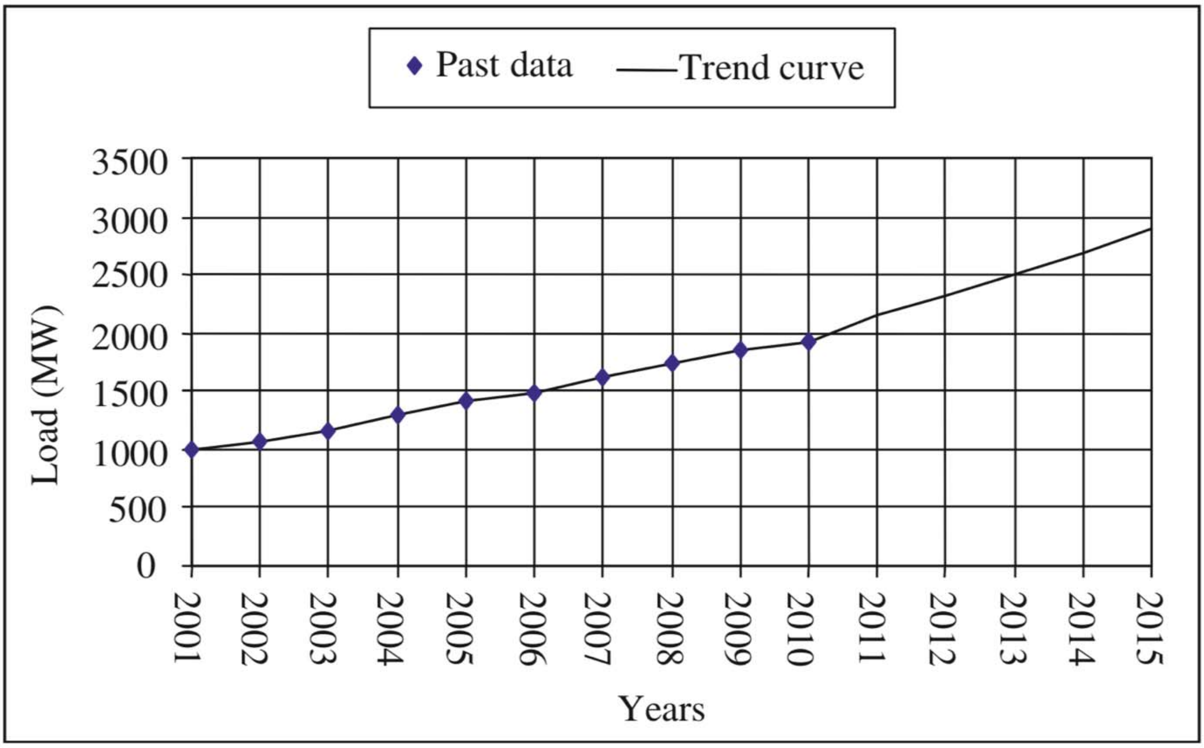


Figure 1: Typical trend curve[1]

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.

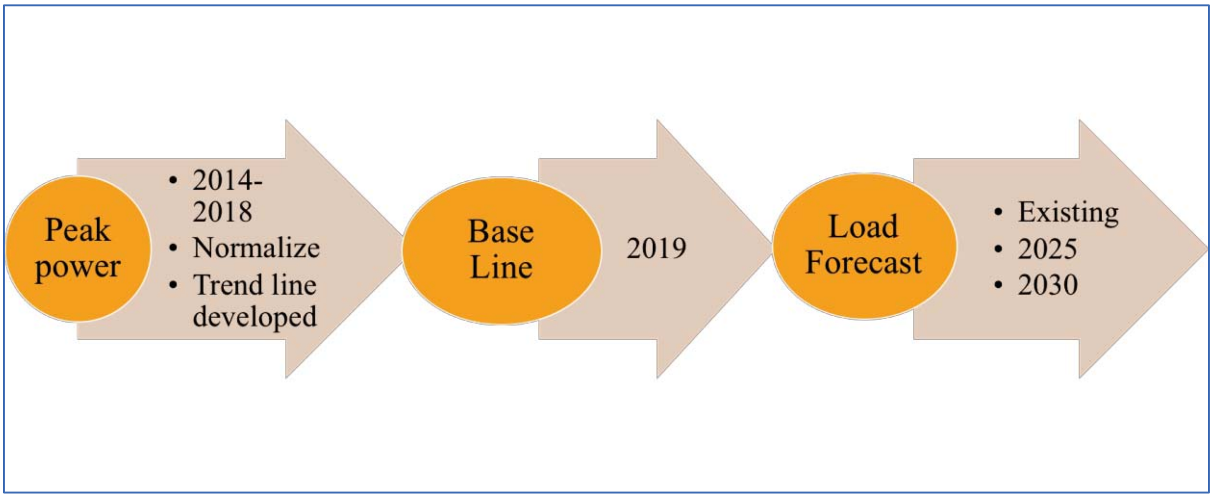


Figure 2: Flow diagram for load forecast

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**

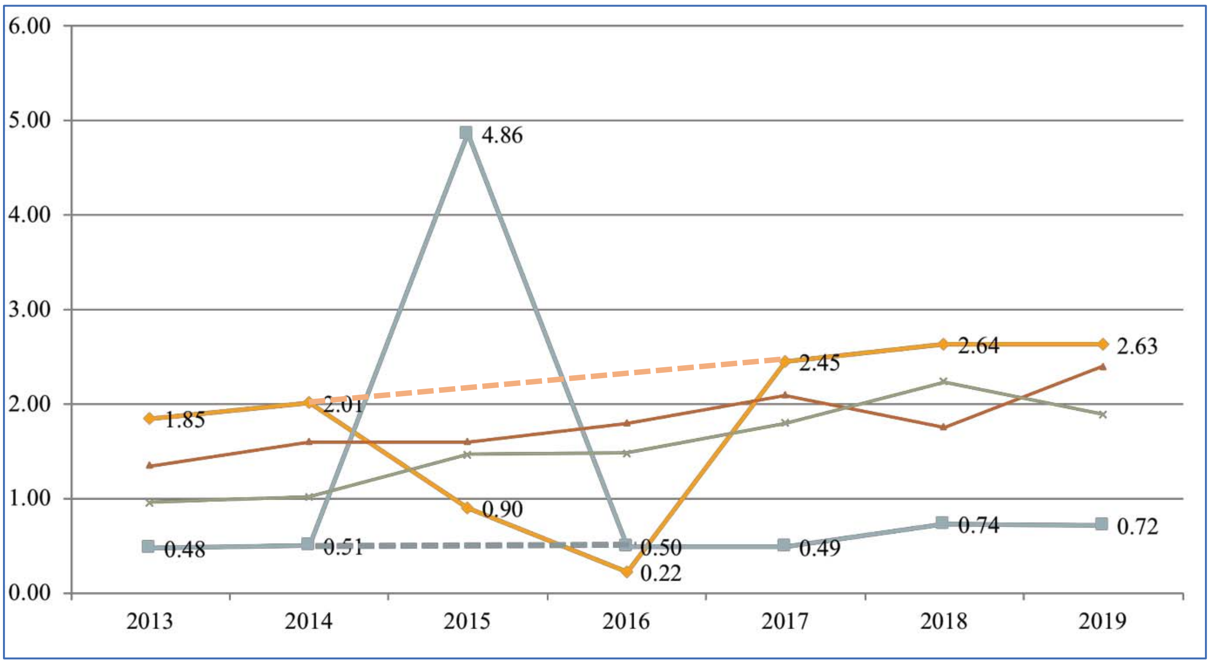


Figure 3: Actual data of Punakha Dzongkhag

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

$Where:$

$x \text{ is the normalized data}$

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

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.**

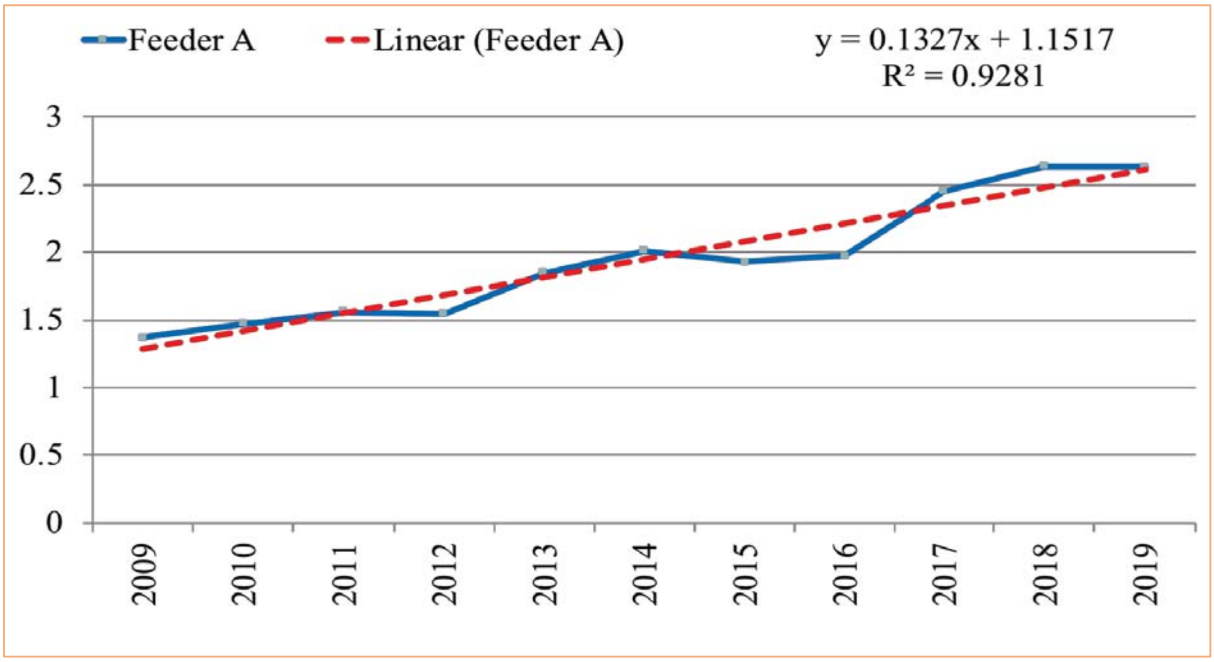


Figure 4: Trend line and load forecast for Punakha Dzongkhag

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.

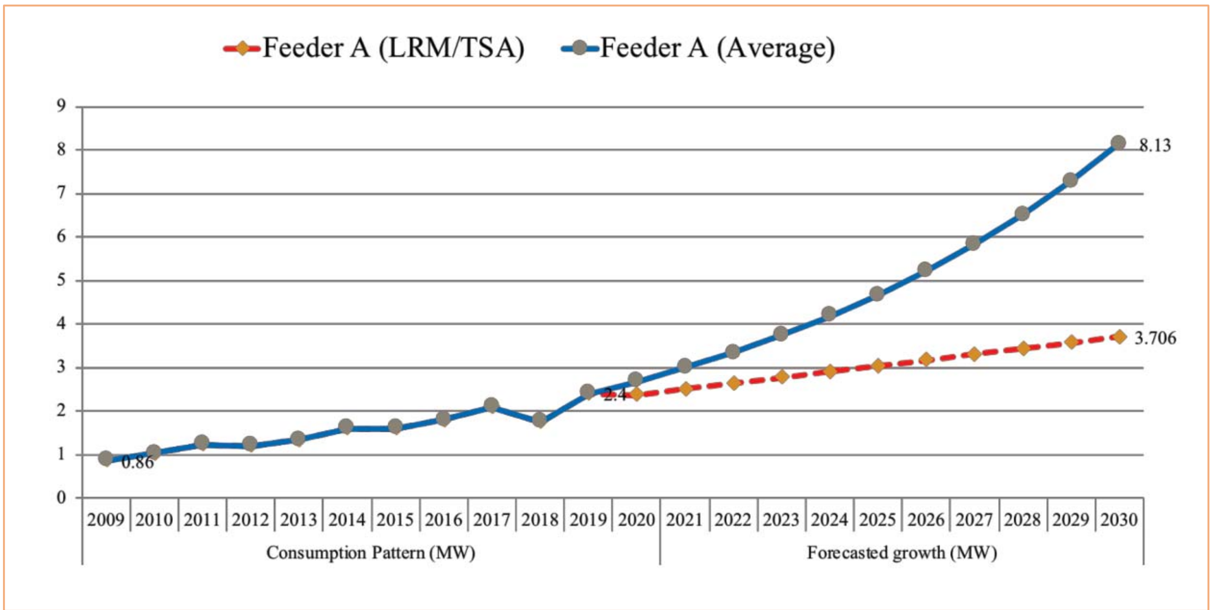


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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.

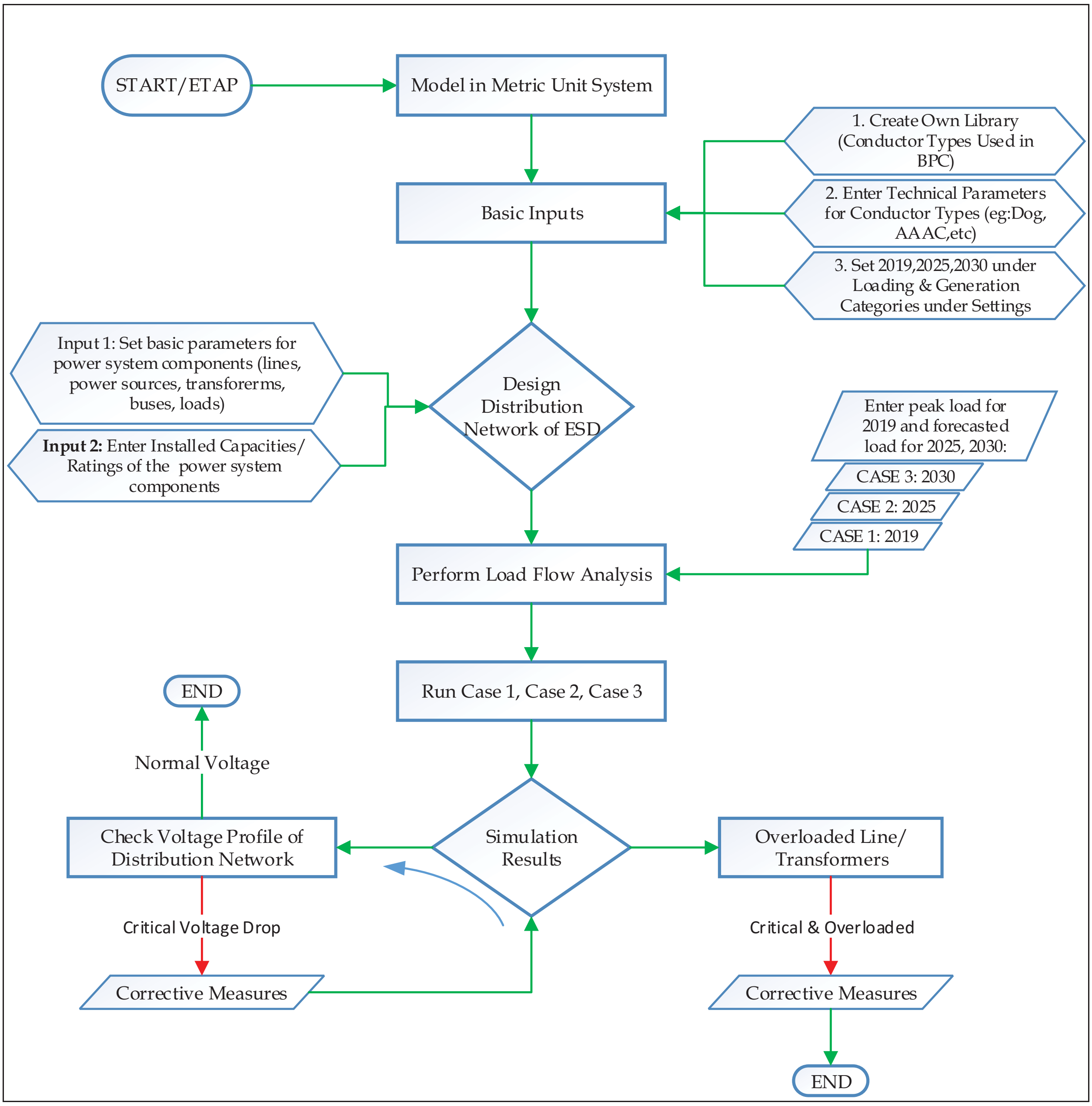


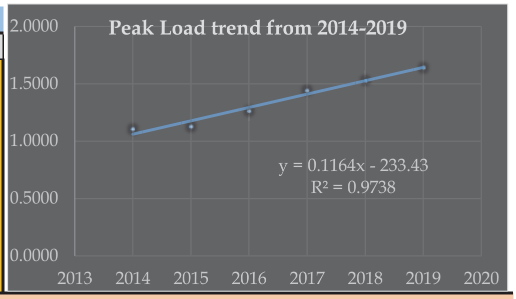
Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

[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

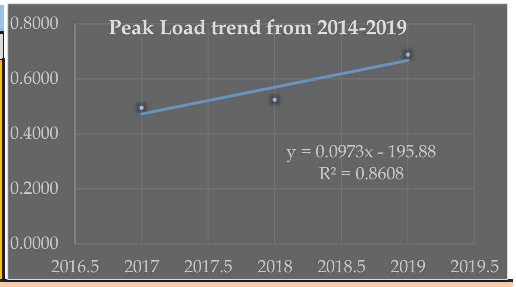
[3]http://www.powerqualityworld.com/2011/05/etap-tutorials-load-flow-analysis.html dated September 30, 2020

Garpang Substation (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	**1.1050**	**1.1270**	**1.2650**	**1.4430**	**1.5292**	**1.6431**



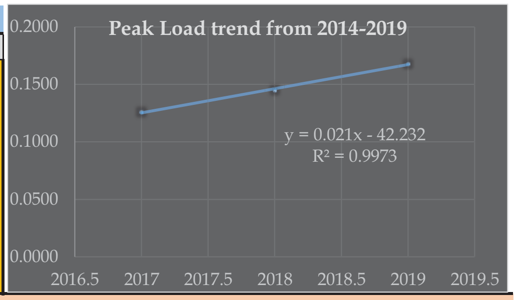
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.698	1.814	1.931	2.047	2.164	2.280	2.396	2.513	2.629	2.746	2.862
	0.1164	0.1164	0.1164	0.1164	0.1164	0.1164	0.1164	0.1164	0.1164	0.1164	

RNR-RC (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load				**0.4952**	**0.5248**	**0.6899**



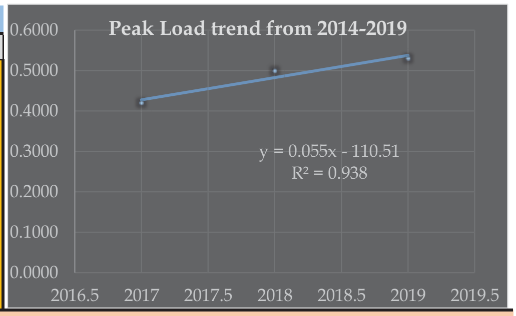
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.596	0.669	0.743	0.816	0.889	0.963	1.036	1.109	1.182	1.256	1.329
	0.0733	0.0733	0.0733	0.0733	0.0733	0.0733	0.0733	0.0733	0.0733	0.0733	

Dawathang Substation (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load				**0.1259**	**0.1450**	**0.1679**



Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.188	0.209	0.230	0.251	0.272	0.293	0.314	0.335	0.356	0.377	0.398
	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	

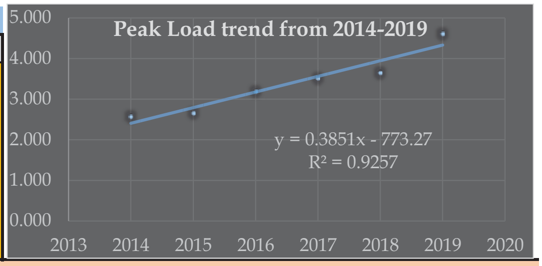
RNR-RC (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load				**0.4195**	**0.4990**	**0.5295**



Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.590	0.645	0.700	0.755	0.810	0.865	0.920	0.975	1.030	1.085	1.140
	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	

33kV Incomer, Garpang (MW)

Year	2014	2015	2016	2017	2018	2019
Peak Load	2.577	2.664	3.186	3.522	3.657	4.610

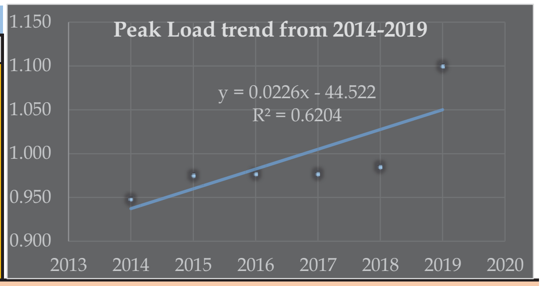


Forecasted Peak Load(MW) from 2020-2030

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	4.632	5.017	5.402	5.787	6.172	6.558	6.943	7.328	7.713	8.098	8.483
	0.3851	0.3851	0.3851	0.3851	0.3851	0.3851	0.3851	0.3851	0.3851	0.3851	

33kV RNR Feeder (MW)

Year	2014	2015	2016	2017	2018	2019
Peak Load	0.948	0.975	0.977	0.977	0.985	1.100

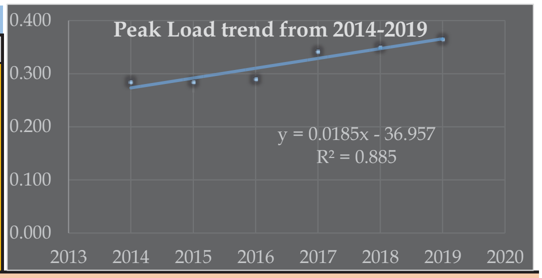


Forecasted Peak Load(MW) from 2020-2030

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.130	1.153	1.175	1.198	1.220	1.243	1.266	1.288	1.311	1.333	1.356
	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226	

33kV Tang Feeder (MW)

Year	2014	2015	2016	2017	2018	2019
Peak Load	0.285	0.285	0.290	0.342	0.350	0.365

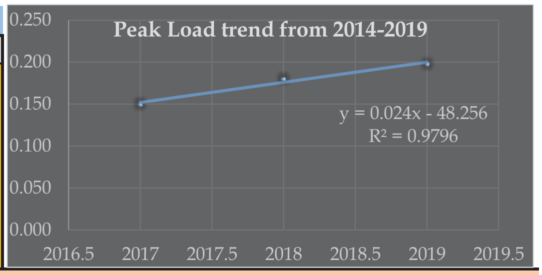


Forecasted Peak Load(MW) from 2020-2030

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.413	0.432	0.450	0.468	0.487	0.505	0.524	0.542	0.561	0.579	0.598
	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	

33kV Ura Feeder (MW)

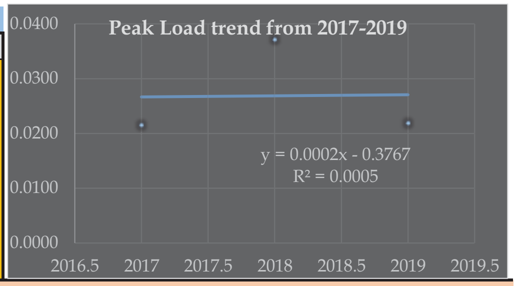
Year	2014	2015	2016	2017	2018	2019
Peak Load				0.150	0.180	0.198



Forecasted Peak Load(MW) from 2020-2030

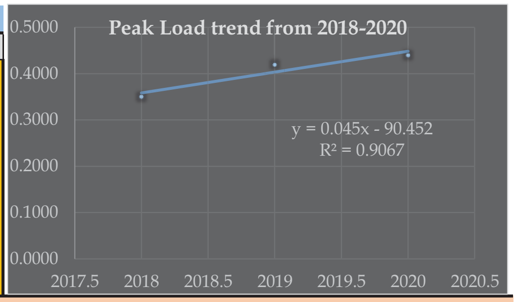
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.224	0.248	0.272	0.296	0.320	0.344	0.368	0.392	0.416	0.440	0.464
	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	0.0240	

6.6 kV Ura Power House feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	**0.0000**	**0.0000**	**0.0000**	**0.0215**	**0.0372**	**0.0219**



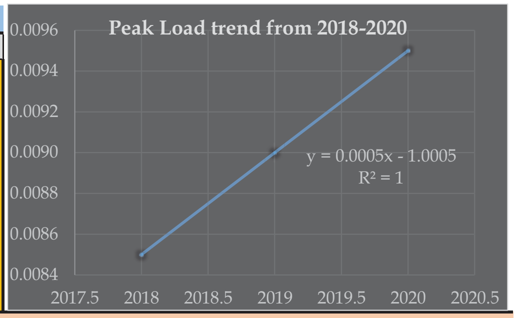
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.027	0.028	0.028	0.028	0.028	0.028	0.029	0.029	0.029	0.029	0.029
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	

11 KV Gyetsa - Tharpaling Feeder (MW)						
Year				2018	2019	2020
Peak Load	**0.0000**	**0.0000**	**0.0000**	**0.3500**	**0.4200**	**0.4400**



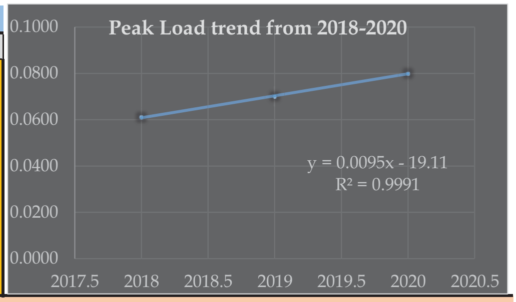
Forecasted Peak Load(MW) from 2021-2030											
Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Peak Load	0.493	0.538	0.583	0.628	0.673	0.718	0.763	0.808	0.853	0.898	0.943
	0.0450	0.0450	0.0450	0.0450	0.0450	0.0450	0.0450	0.0450	0.0450	0.0450	

11 KV Colony-Nangay feeder (MW)						
Year				2018	2019	2020
Peak Load	**0.0000**	**0.0000**	**0.0000**	**0.0085**	**0.0090**	**0.0095**



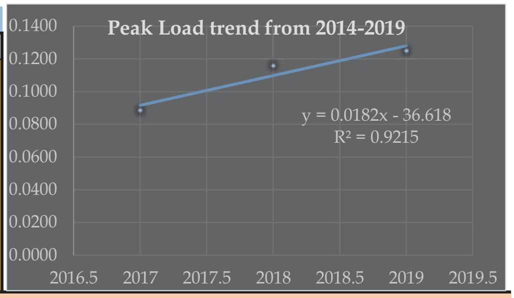
Forecasted Peak Load(MW) from 2021-2030											
Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Peak Load	0.010	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.015
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	

11 KV Nangar (MW)						
Year				2018	2019	2020
Peak Load	**0.0000**	**0.0000**	**0.0000**	**0.0610**	**0.0700**	**0.0800**



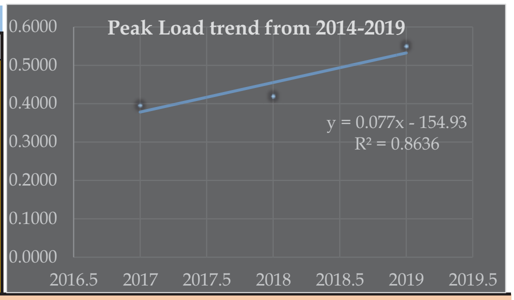
Forecasted Peak Load(MW) from 2021-2030											
Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Peak Load	0.090	0.099	0.108	0.118	0.128	0.137	0.147	0.156	0.166	0.175	0.185
	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	

11 kV Batpalathang Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	0.0000	0.0000	0.0000	0.0886	0.1160	0.1250



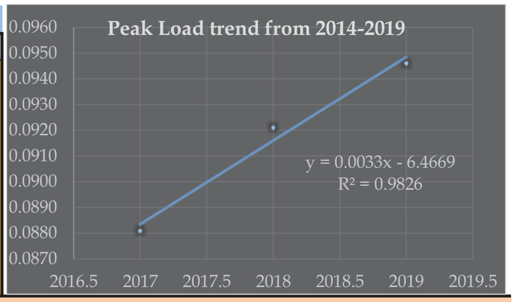
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.146	0.164	0.182	0.201	0.219	0.237	0.255	0.273	0.292	0.310	0.328
	0.0182	0.0182	0.0182	0.0182	0.0182	0.0182	0.0182	0.0182	0.0182	0.0182	

11 kV Dekeling Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	0.0000	0.0000	0.0000	0.3960	0.4200	0.5500



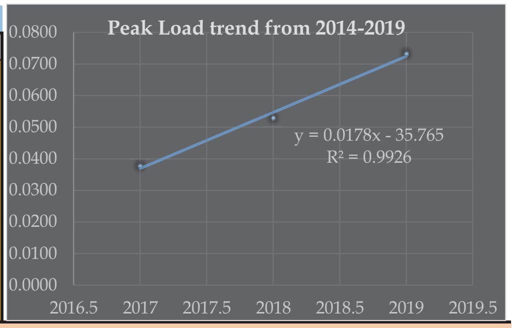
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.610	0.687	0.764	0.841	0.918	0.995	1.072	1.149	1.226	1.303	1.380
	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770	

11 kV Chekhortey Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	0.0000	0.0000	0.0000	0.0881	0.0921	0.0946



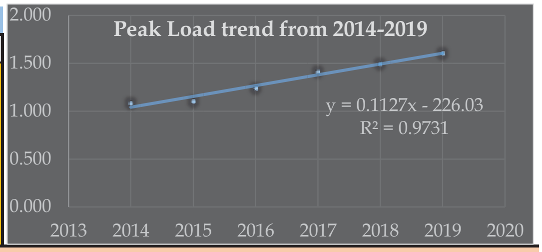
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.199	0.202	0.206	0.209	0.212	0.216	0.219	0.222	0.226	0.229	0.232
	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	0.0033	

11 kV Chakar Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	0.0000	0.0000	0.0000	0.0378	0.0529	0.0733



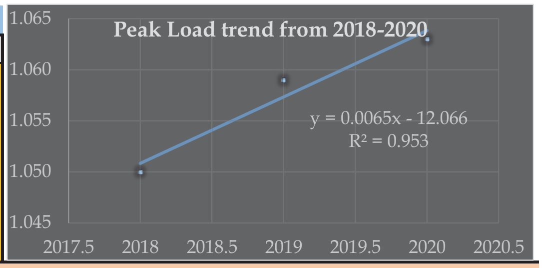
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.191	0.209	0.227	0.244	0.262	0.280	0.298	0.316	0.333	0.351	0.369
	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	0.0178	

11 kV Chamkhar Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	**1.085**	**1.105**	**1.240**	**1.413**	**1.494**	**1.606**



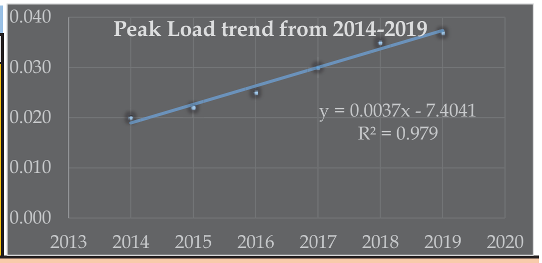
Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.624	1.737	1.849	1.962	2.075	2.188	2.300	2.413	2.526	2.638	2.751
	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	0.1127	

11 kV Chumey Feeder (MW)						
Year				2018	2019	2020
Peak Load				**1.050**	**1.059**	**1.063**



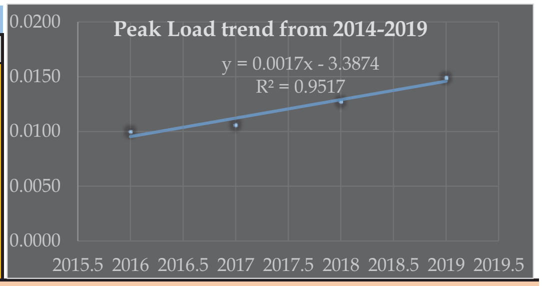
Forecasted Peak Load(MW) from 2020-2030											
Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Peak Load	1.071	1.077	1.084	1.090	1.097	1.103	1.110	1.116	1.123	1.129	1.136
	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	

11 kV Shuri-Kertshok Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	**0.020**	**0.022**	**0.025**	**0.030**	**0.035**	**0.037**



Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.070	0.074	0.077	0.081	0.085	0.088	0.092	0.096	0.100	0.103	0.107
	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	

11 kV Tekarshong Feeder (MW)						
Year	2014	2015	2016	2017	2018	2019
Peak Load	**0.0000**	**0.0000**	**0.0100**	**0.0106**	**0.0128**	**0.0149**



Forecasted Peak Load(MW) from 2020-2030											
Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.047	0.048	0.050	0.052	0.053	0.055	0.057	0.059	0.060	0.062	0.064
	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	

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
A10.1	11.000										0.915	84.9	49.9	
A10.2	11.000										0.864	84.8	47.8	
A10.3	11.000										0.794	84.7	44.1	
A10.4	11.000										0.779	84.7	43.4	
A10.5	11.000										0.698	84.7	39.1	
A10.6	11.000										0.693	84.6	39.0	
A10.7	11.000										0.679	84.6	38.4	
A10.8	11.000										0.495	84.6	28.0	
A10.9	11.000										0.326	84.4	18.6	
A10.10	11.000										0.049	86.9	2.8	
A10.11	11.000										0.018	85.8	1.0	
A10.12	11.000										0.023	87.4	1.3	
A10.13	11.000										0.017	87.4	1.0	
A10.14	11.000		0.000	0.000	0.000	-					0.017	86.7	1.0	
A10.15	11.000										0.866	84.8	47.8	
A10.16	11.000										0.795	84.7	44.1	
A10.18	11.000										0.681	84.6	38.4	
A20.0	11.000										2.790	83.3	152.6	
A20.1	11.000										2.740	83.5	152.2	
A20.2	11.000										2.591	83.7	147.7	
A20.6	11.000										2.187	83.8	126.1	
A20.7	11.000										1.984	83.8	114.5	
A20.8	11.000										1.801	83.8	104.5	
A20.9	11.000			0.000							1.608	83.8	93.8	
A20.10	11.000										0.854	84.2	49.9	
A20.11	11.000										0.852	84.2	49.9	
A20.13	11.000										0.563	84.4	33.0	
A20.14	11.000										0.330	84.5	19.4	
A20.15	11.000										0.290	84.5	17.0	
A20.16	11.000										0.239	83.7	13.6	
A20.17	11.000										0.380	84.0	21.7	
A30.1	11.000										0.104	84.6	5.6	
A30.2	11.000										0.086	84.7	4.6	
A40.1	11.000										0.017	85.1	0.9	
A50.1	11.000										0.129	97.1	7.0	
A50.2	11.000										0.133	97.0	7.2	
A50.3	11.000										0.133	97.1	7.2	
A50.4	11.000										0.133	97.2	7.2	
A50.8.1	11.000										0.136	85.8	7.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
A70.00	33.000										0.639	90.3	11.2	
A70.1	33.000										0.556	90.6	9.7	
A70.2	33.000										0.512	90.7	9.0	
A70.3	33.000										0.427	91.3	7.5	
A70.4	33.000										0.382	91.2	6.7	
A70.5	33.000										0.357	90.8	6.3	
A70.6	33.000										0.350	90.4	6.1	
A70.7	33.000										0.160	95.9	2.8	
A70.8	33.000										0.157	95.3	2.7	
A70.9	33.000										0.145	95.6	2.5	
A70.10	33.000										0.138	95.7	2.4	
A70.11	33.000										0.130	95.8	2.3	
A70.12	33.000										0.015	89.9	0.3	
A70.13	33.000										0.117	95.1	2.1	
A70.14	33.000										0.062	93.1	1.1	
A70.15	33.000										0.027	79.5	0.5	
A70.16	33.000										0.009	97.0	0.2	
A70.17	33.000										0.012	81.5	0.2	
A70.18	33.000										0.009	86.8	0.2	
A70.19	33.000										0.085	86.4	1.5	
A70.20	33.000										0.085	86.3	1.5	
A90.1	11.000										0.115	84.9	6.3	
A90.2	11.000										0.110	84.8	6.0	
A90.3	11.000										0.110	84.3	6.0	
A90.4	11.000										0.035	85.1	1.9	
A90.5	11.000		0.004	0.002	0.015	0.009					0.030	84.9	1.7	
A110.1	11.000										1.440	84.5	80.3	
A110.2	11.000										0.039	84.8	2.2	
A110.3	11.000										1.388	84.5	78.1	
A110.4	11.000										1.328	84.5	74.8	
A110.5	11.000										1.071	84.4	60.7	
A110.5 (IC Line)	11.000										1.072	84.4	60.7	
A110.6	11.000										0.856	84.4	48.7	
A110.7	11.000										0.856	84.3	48.7	
A110.8	11.000										0.855	84.3	48.7	
A110.9	11.000										0.643	84.4	36.7	
A110.10	11.000										0.530	84.4	30.3	
A110.11	11.000										0.279	84.4	16.0	
A120.1	11.000										0.343	84.2	19.1	
A120.2	11.000										0.255	84.1	14.2	
A130.1	11.000										0.047	85.1	2.6	
A140.1	11.000										0.408	84.5	22.0	

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
A140.2	11.000										0.309	84.4	16.7	
A140.3	11.000		0.000	0.000	0.001	-					0.059	84.7	3.2	
A150.1	11.000										0.254	86.0	13.7	
A150.2	11.000										0.229	86.0	12.4	
A150.3	11.000										0.043	85.4	2.3	
A150.4	11.000										0.036	85.5	2.0	
A150.5	11.000										0.030	85.0	1.6	
A150.6	11.000										0.170	85.8	9.2	
A150.7	11.000										0.158	85.8	8.6	
A150.8	11.000										0.153	85.7	8.3	
A150.9	11.000		0.001	0.000	0.002	0.001					0.130	85.6	7.1	
A150.10	11.000										0.098	85.7	5.3	
A150.11	11.000										0.011	86.9	0.6	
A150.12	11.000										0.087	85.4	4.8	
A150.13	11.000										0.074	85.4	4.0	
A150.14	11.000										0.057	85.3	3.1	
A150.15	11.000										0.051	85.2	2.8	
A150.16	11.000										0.040	85.2	2.2	
Airport B1	11.000										0.015	84.8	0.8	
Airport B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	21.5	
Amankora B1	11.000										0.279	84.4	16.0	
Amankora B2	0.415		0.055	0.034	0.176	0.109					0.272	85.0	422.8	
Ani Dtshang B1	33.000										0.055	84.2	1.0	
Ani Dtshang B2	0.415		0.010	0.006	0.036	0.022					0.053	85.0	76.8	
Aunsang B1	11.000										0.005	84.7	0.3	
Aunsang B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.0	
Bathpalathang B1	11.000										0.088	84.4	4.9	
Bathpalathang B2	0.415		0.017	0.010	0.057	0.035					0.086	85.0	130.9	
Benzibi B1	33.000										0.003	84.9	0.1	
Benzibi B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.3	
Bepzor B1	33.000										0.033	84.5	0.6	
Bepzor B2	0.415		0.006	0.004	0.022	0.014					0.032	85.0	46.0	
BOC B1	11.000										0.186	83.7	10.8	
BOC B2	0.415		0.038	0.024	0.112	0.069					0.176	85.0	285.5	
BPC Colony B1	0.415		0.002	0.001	0.006	0.004					0.010	85.0	14.0	
Bulli B1	11.000										0.009	84.4	0.5	
Bulli B2	0.415		0.002	0.001	0.006	0.003					0.009	85.0	13.2	
Chakar B1	11.000										0.250	84.3	13.5	
Chakar B2	0.415		0.037	0.023	0.130	0.081					0.196	85.0	291.1	
Chamkhar Line	11.000												-	
Chamkhar.M B1	0.415		0.156	0.097	0.440	0.273					0.702	85.0	1163.8	
Cherezeth B	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.2	

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
Chudaepang B1	11.000										0.012	84.8	0.7	
Chudaepang B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.5	
Chumey MHPP B1	0.690										1.273	84.3	1064.8	
Chumey MHPP B2	11.000										1.235	86.6	66.8	
Chumey Sch. B1	11.000										0.063	84.8	3.5	
Chumey Sch. B2	0.415		0.012	0.007	0.041	0.026					0.063	85.0	92.8	
Chutti B1	33.000		0.000	0.000	0.001	0.001					0.006	84.9	0.1	
Chutti B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.6	
CMHPP Station B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.9	
CVTI B1	11.000										0.183	84.6	10.3	
CVTI B2	0.415		0.035	0.022	0.118	0.073					0.180	85.0	274.2	
D.Pelrithang B2	0.415		0.008	0.005	0.031	0.019					0.046	85.0	65.2	
Dawathang Station B1	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.6	
DawathangSS B1	33.000										0.680	83.9	12.0	
DawathangSS B2	11.000										0.669	85.1	36.1	
Dekiling B1	11.000										0.210	84.1	11.9	
Dekiling B2	0.415		0.041	0.026	0.130	0.081					0.202	85.0	316.1	
Dhur BHU B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.8	
Dodrang B1	11.000										0.127	85.4	6.9	
Dodrang B2	0.415		0.005	0.003	0.018	0.011					0.028	85.0	41.7	
Domkhar B1	11.000										0.076	84.7	4.3	
Domkhar B2	0.415		0.015	0.009	0.049	0.030					0.075	85.0	114.3	
Domkhar Palace B1	11.000										0.417	84.5	23.7	
Domkhar Palace B2	0.415		0.018	0.011	0.058	0.036					0.089	85.0	136.8	
Dorjibi B1	11.000										0.003	85.0	0.1	
Dorjibi B2	0.415		0.000	0.000	0.002	0.001					0.003	85.0	3.7	
Gakiling B2	0.415		0.040	0.025	0.124	0.077					0.193	85.0	305.3	
Gangrithang B5	0.415		0.038	0.024	0.112	0.069					0.176	85.0	285.8	
Gangrithang B6	11.000										0.189	83.4	10.8	
GapangSS B2	11.000										2.952	83.5	160.8	
GarpangSS B1	33.000										6.644	82.9	116.2	
Goling B2	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.8	
Gongkhar B5	0.415		0.010	0.006	0.032	0.020					0.049	85.0	76.1	
Gongkhar B6	11.000										0.050	84.6	2.9	
Gyetsa Sch. B2	0.415		0.053	0.033	0.163	0.101					0.254	85.0	403.0	
Gyetsa Vill. B1	11.000										0.059	86.7	3.4	
Gyetsa Vill. B2	0.415		0.002	0.001	0.007	0.004					0.010	85.0	15.6	
Hurji TCom B1	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
HVABC.BPC Colony	11.000										0.017	85.1	0.9	
HVABC.Chumey1	11.000										0.129	97.0	7.0	
Jachuthang B1	0.415		0.011	0.007	0.037	0.023					0.057	85.0	85.8	
Jakar Sch. B1	11.000										0.040	84.7	2.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Jakar Sch. B2	0.415		0.008	0.005	0.025	0.016					0.039	85.0	61.8	
Jakar.Dzo B2	0.415		0.048	0.030	0.143	0.089					0.224	85.0	360.7	
Jalikhar B5	0.415		0.028	0.017	0.089	0.055					0.137	85.0	212.8	
Jalikhar B6	11.000										0.141	84.4	8.0	
Jayulthang B1	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.4	
Jemshong B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.8	
Kertshok B2	0.415		0.002	0.001	0.005	0.003					0.008	85.0	11.9	
Khagtang B1	11.000										0.032	84.7	1.8	
Khagtang B2	0.415		0.006	0.004	0.021	0.013					0.032	85.0	46.8	
Khakharte B1	6.600										0.004	84.9	0.3	
Khakharte B2	0.415		0.001	0.000	0.002	0.002					0.004	85.0	5.3	
Khangrab B2	0.415		0.007	0.005	0.028	0.017					0.042	85.0	59.0	
Kharampay B1	33.000										0.202	84.3	3.5	
Kharchu Dtshang B1	11.000										0.245	84.0	13.7	
Kharchu Dtshang B2	0.415		0.047	0.029	0.153	0.095					0.235	85.0	363.0	
Kharmapay B2	0.415		0.035	0.022	0.131	0.081					0.196	85.0	281.5	
Kharsa B1	11.000										0.018	84.7	1.0	
Kharsa B2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	25.4	
Kidzom B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	16.5	
Kikila BBS B1	11.000										0.005	84.8	0.3	
Kikila BBS B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.0	
Kunzangcholing B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.7	
Kurje B1	11.000										0.099	84.6	5.4	
Kurje B2	0.415		0.018	0.011	0.065	0.040					0.098	85.0	142.1	
L.Dhur B2	0.415		0.004	0.003	0.015	0.010					0.023	85.0	33.4	
L.Jalikhar B1	11.000										0.081	84.5	4.5	
L.Jalikhar B2	0.415		0.015	0.009	0.052	0.032					0.079	85.0	119.2	
L.Lami Gpa B1	11.000										0.271	84.4	15.9	
L.Lami Gpa B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	3.5	
L.Nimalung B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.0	
L.Pangkhar B1	6.600										0.005	84.8	0.4	
L.Pangkhar B2	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.1	
Lamethang B1	11.000										0.019	84.7	1.1	
Lamethang B2	0.415		0.004	0.002	0.012	0.008					0.019	85.0	29.9	
Lami Gpa B1	11.000										0.268	84.4	15.8	
Lami Gpa B2	0.415		0.055	0.034	0.167	0.104					0.262	85.0	418.6	
Lebi B1	11.000										0.009	84.9	0.5	
Lebi B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.9	
Lusbi B1	11.000										0.006	84.8	0.3	
Lusbi B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.6	
Lusbi.2	11.000										0.006	86.1	0.3	
Mitsithang B2	0.415		0.035	0.022	0.120	0.074					0.182	85.0	273.9	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Namkhay B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.9	
Nangar B1	11.000										0.046	84.3	2.5	
Nangar B2	0.415		0.008	0.005	0.030	0.018					0.045	85.0	66.2	
Nangay B1	11.000										0.007	84.7	0.4	
Nangay B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
Nangsephel B2	0.415		0.002	0.001	0.008	0.005					0.011	85.0	16.4	
Nasphel B1	11.000										0.059	84.5	3.3	
Nasphel B2	0.415		0.011	0.007	0.038	0.023					0.058	85.0	88.3	
Nimalung B1	11.000										0.040	84.4	2.2	
Nimalung B2	0.415		0.007	0.004	0.026	0.016					0.039	85.0	57.5	
Pangri B1	11.000										0.008	86.0	0.4	
Pangri B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.2	
Pangshing B1	33.000										0.029	84.6	0.5	
Pangshing B2	0.415		0.005	0.003	0.019	0.012					0.029	85.0	40.5	
Park B1	6.600										0.019	84.4	1.7	
Park b2	0.415		0.003	0.002	0.012	0.007					0.018	85.0	26.4	
Pdrong B1	33.000		0.002	0.001	0.006	0.004					0.046	84.6	0.8	
Pdrong B2	0.415		0.006	0.004	0.024	0.015					0.036	85.0	50.8	
Petselling Lkhang B1	11.000										0.025	84.6	1.4	
Petselling Lkhang B2	0.415		0.005	0.003	0.016	0.010					0.025	85.0	37.1	
Phogo B1	11.000										0.076	83.8	4.2	
Phogo B2	0.415		0.014	0.009	0.047	0.029					0.072	85.0	110.4	
Phrumthang B1	0.415		0.015	0.009	0.051	0.031					0.077	85.0	115.3	
Pralang B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.1	
PWD B1	33.000										0.002	84.9	-	
PWD B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.5	
Rangbi B1	11.000										0.003	84.8	0.2	
Rangbi B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.1	
Recycling Gpang B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.1	
Recyclinh Gpang B1	11.000										2.763	83.4	152.6	
RNR-RC B1	0.415		0.005	0.003	0.016	0.010					0.024	85.0	36.6	
RNR-RC SS B1	33.000										2.625	81.9	46.4	
RNR-RC SS B2	11.000										1.858	84.5	103.4	
RNR-RC Station B2	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.9	
Samteling B1	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.7	
Samthang B1	11.000										0.007	84.7	0.4	
Samthang B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.2	
Sangsangma B2	0.415		0.002	0.002	0.009	0.006					0.014	85.0	19.8	
Semeth B1	33.000										0.004	84.9	0.1	
Semeth B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.2	
Shetangla B1	33.000										0.014	84.5	0.3	
Shetangla B2	0.415		0.002	0.002	0.009	0.006					0.014	85.0	20.0	

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
Shingkhar B1	33.000										0.022	84.8	0.4	
Shingkhar B2	0.415		0.004	0.002	0.015	0.009					0.022	85.0	30.3	
Shingneer B1	33.000										0.017	84.9	0.3	
Shingneer B2	0.415		0.003	0.002	0.012	0.007					0.017	85.0	24.4	
Sibjur B1	11.000										0.012	84.8	0.7	
Sibjur B2	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.4	
SixSense B1	11.000										0.251	84.5	14.2	
SixSense B2	0.415		0.048	0.030	0.161	0.100					0.246	85.0	375.7	
Somdrong B1	6.600										0.007	84.7	0.6	
Somdrong B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.0	
Station B1	0.415		0.006	0.003	0.022	0.013					0.032	85.0	46.3	
Station B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.3	
Suzubgg B1	33.000										0.041	84.4	0.7	
Suzugbb B2	0.415		0.007	0.004	0.027	0.017					0.040	85.0	57.4	
Takar B1	11.000										0.018	83.9	1.0	
Takar B2	0.415		0.003	0.002	0.011	0.007					0.017	85.0	26.1	
Tamshing B1	0.415		0.010	0.006	0.038	0.024					0.057	85.0	82.9	
Tangbi B1	0.415		0.002	0.001	0.008	0.005					0.012	85.0	16.8	
Tangsibi B1	33.000										0.059	84.6	1.0	
Tangsibi B2	0.415		0.010	0.006	0.039	0.024					0.058	85.0	82.7	
Tashiling B1	11.000										0.004	84.8	0.2	
Tashiling B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.0	
Tasur B1	33.000										0.004	84.9	0.1	
Tasur B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.0	
TCom B1	11.000										0.154	84.7	8.7	
TCom B2	0.415		0.030	0.018	0.099	0.061					0.152	85.0	230.6	
Tekarshong B1	11.000										0.067	85.1	3.7	
Tekarshong B2	0.415		0.004	0.002	0.013	0.008					0.020	85.0	30.2	
Tgang B2	0.415		0.001	0.001	0.006	0.003					0.008	85.0	11.5	
Tgatshel B1	11.000										0.047	84.3	2.5	
Tgatshel B2	0.415		0.008	0.005	0.030	0.019					0.045	85.0	67.1	
Tharpaling B1	11.000										0.017	85.1	1.0	
Tharpaling B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.5	
Thromey B1	11.000										0.883	84.8	48.6	
Thromey B2	0.415		0.003	0.002	0.010	0.006					0.014	85.0	21.1	
Tmanba B1	11.000		0.002	0.001	0.009	0.005					0.055	86.1	3.0	
Toktozam B2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.9	
Totkozam B1	11.000										0.058	86.3	3.2	
Town.P B1	11.000										0.034	83.5	2.0	
Town.P B2	0.415		0.007	0.004	0.021	0.013					0.032	85.0	51.9	
Trailing B1	6.600										0.004	84.9	0.4	
Trailing B2	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.8	

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
Trasebee B1	0.415		0.004	0.003	0.014	0.009					0.022	85.0	32.7	
TT Gonpa B1	33.000										0.001	85.0	-	
TT Gonpa B2	0.415		0.000	0.000	0.001	-					0.001	85.0	1.0	
U.Dhur B1	11.000										0.007	84.9	0.4	
U.Dhur B2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.2	
U.Nimalung B2	0.415		0.001	0.001	0.005	0.003					0.008	85.0	11.3	
U.Pangkhar B1	6.600										0.002	84.9	0.2	
U.Pangkhar B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.8	
U.Tangsibi B2	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.0	
U.Tangsiib B1	33.000										0.013	84.8	0.2	
U.Tharpaling B1	11.000										0.009	84.8	0.5	
U.Tharpaling B2	0.415		0.002	0.001	0.006	0.004					0.009	85.0	14.2	
Ucholing B1	33.000										0.065	84.1	1.1	
Ucholing B2	0.415		0.011	0.007	0.042	0.026					0.062	85.0	90.1	
UDee B1	11.000										0.245	83.9	14.3	
UDee B2	0.415		0.051	0.031	0.148	0.092					0.234	85.0	379.9	
UG B1	11.000										2.799	83.4	152.6	
UG RNR-RC	11.000										1.441	84.5	80.3	
UG.Batpal	11.000										0.344	84.2	19.1	
UG.Batpal1	11.000										0.129	97.0	7.0	
UG.Batpal2	11.000										0.163	84.5	8.8	
UG.Chokhor	11.000										0.254	86.0	13.7	
UG.Gyetsa	11.000										0.923	84.9	49.9	
UG.Tekar	11.000										0.067	85.2	3.7	
Ugarling.R B1	11.000										0.173	84.6	10.0	
Ugarling.R B2	0.415		0.034	0.021	0.110	0.068					0.171	85.0	264.9	
Ura BHU B1	33.000										0.047	84.7	0.8	
Ura BHU B2	0.415		0.008	0.005	0.031	0.019					0.046	85.0	65.2	
Ura ICT B1	33.000										0.056	86.0	1.0	
Ura ICT B2	6.600										0.055	86.4	4.9	
Ura PP B1	0.415										0.042	82.9	58.4	
Ura PP B2	6.600										0.041	83.4	3.7	
Ura Sch. B2	0.415		0.006	0.003	0.020	0.013					0.030	85.0	44.3	
Ura Sch. B3	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.9	
Ura Village B1	33.000										0.061	84.7	1.1	
Ura Village B2	0.415		0.010	0.006	0.040	0.025					0.060	85.0	84.8	
Ura.1	33.000										0.456	91.8	8.0	
Ura.2	33.000										0.457	91.6	8.0	
Ura.3	33.000													
Ura.4	33.000										0.459	91.0	8.0	
Ura.5	33.000										0.461	90.5	8.1	
Ura.6	33.000										0.462	90.0	8.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Ura.7	33.000										0.253	92.8	4.4	
Ura.8	33.000										0.199	92.8	3.5	
Ura.9	33.000										0.183	92.6	3.2	
Ura.10	33.000		0.000	0.000	0.000	-					0.173	90.9	3.0	
Ura.11	33.000										0.176	89.2	3.1	
Ura.12	33.000										0.121	90.4	2.1	
Ura.13	33.000										0.106	86.1	1.9	
Ura.14	6.600										0.055	86.3	4.9	
Ura.15	6.600										0.048	86.5	4.3	
Ura.16	6.600										0.011	85.2	1.0	
Ura.17	6.600										0.007	85.0	0.6	
Ura.18	6.600										0.037	86.7	3.3	
Ura.19	6.600										0.036	84.5	3.2	
Ura.20	6.600										0.036	82.4	3.2	
Ura.21	6.600										0.040	82.7	3.5	
Ura.22	6.600										0.041	83.4	3.7	
Ura.23	33.000										0.212	85.3	3.7	
Urgang B2	0.415		0.003	0.002	0.012	0.008					0.018	85.0	26.4	
Urug B1	0.415		0.003	0.002	0.010	0.006					0.015	85.0	23.0	
Wangtha Gpa B1	6.600										0.002	84.9	0.2	
Wangtha gpa B2	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.4	
Wcholing B1	11.000										0.495	84.5	28.3	
Wcholing B2	0.415		0.042	0.026	0.138	0.085					0.212	85.0	327.6	
Wcholing Hosp. B1	11.000										0.113	84.0	6.5	
Wcholing Hosp. B2	0.415		0.022	0.014	0.070	0.043					0.109	85.0	171.7	
Wcholing Sch. B2	0.415		0.009	0.006	0.027	0.017					0.043	85.0	68.6	
Wcholing Sch.B1	11.000										0.044	84.2	2.6	
WCP B0	11.000										0.006	85.0	0.3	
WCP B1	11.000										0.006	84.8	0.3	
WCP B2	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.6	
Webthang B1	33.000										0.003	84.9	-	
Webthang B2	0.415		0.000	0.000	0.002	0.001					0.003	85.0	3.8	
Yamthra B1	11.000										0.025	84.6	1.4	
Yamthra B2	0.415		0.005	0.003	0.016	0.010					0.024	85.0	35.9	
Zangtherpo B1	11.000										0.246	86.0	13.3	
Zangtherpo B2	0.415		0.003	0.002	0.012	0.007					0.017	85.0	24.9	
Zhabjithang B1	0.415		0.003	0.002	0.011	0.007					0.017	85.0	24.8	
Zhicha B	11.000										0.001	93.5	-	
Zhicha B1	11.000										0.001	85.0	-	
Zhicha B2	0.415		0.000	0.000	0.000	-					0.001	85.0	1.1	
Zhongphel B1	33.000		0.001	0.001	0.005	0.003					0.048	84.0	0.8	
Zhongphel B2	0.415		0.007	0.004	0.026	0.016					0.039	85.0	56.5	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Zhugdra B1	11.000										0.136	85.7	7.4	
Zhugdra B2	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.9	
Zungey B1	11.000										0.163	84.5	8.8	
Zungey B2	0.415		0.010	0.006	0.038	0.024					0.057	85.0	85.5	

* 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	%
Amankora UG	Cable	229.86	15.95	6.94					
L1-UG	Cable	270.43	152.59	56.43					
L1-UG RNR-RC	Cable	270.43	80.25	29.68					
Town P UG	Cable	229.86	1.96	0.85					
UG Chokhor	Cable	178.41	13.72	7.69					
UG CMHPP	Cable	178.41	7.18	4.03					
UG Tekar	Cable	229.86	3.74	1.63					
UG.Batpal Line	Cable	229.86	19.14	8.32					
UG.Chumey1	Cable	229.86	7.03	3.06					
UG.Gyetsa1 Line	Cable	178.41	49.93	27.99					
UG.Nangar1	Cable	178.41	8.84	4.96					
(33/11kV) DawathangSS Tfr	Transformer				2.500	0.680	27.2	0.669	26.8
(33/11kV) RNR-RC SS Tfr	Transformer				2.500	1.952	78.1	1.858	74.3
Airprot Tfr	Transformer				0.063	0.015	23.1	0.014	22.9
Amankora Tfr	Transformer				0.500	0.279	55.7	0.272	54.4
Ani Dtshang Tfr	Transformer				0.063	0.055	87.4	0.053	84.6
Aunsang Tfr	Transformer				0.016	0.005	29.7	0.005	29.4
Bathpalathang Tfr	Transformer				0.160	0.088	55.3	0.086	54.0
Benzibi Tfr	Transformer				0.025	0.003	12.2	0.003	12.2
Bepzor Tfr	Transformer				0.063	0.033	52.4	0.032	51.4
* BOC Tfr	Transformer				0.160	0.186	116.0	0.176	110.0
BPC Colony Tfr	Transformer				0.016	0.010	60.9	0.010	59.5
Bulli Tfr	Transformer				0.016	0.009	54.5	0.009	53.2
Chakar Tfr	Transformer				0.250	0.203	81.2	0.196	78.6
* Chamkhar.M Tfr	Transformer				0.500	0.753	150.6	0.702	140.3
Chenrezith Tfr	Transformer				0.016	0.004	26.5	0.004	26.2
Chudaepang Tfr	Transformer				0.063	0.012	18.9	0.012	18.8
Chumey Sch. Tfr	Transformer				0.250	0.063	25.3	0.063	25.1
Chutti Tfr	Transformer				0.025	0.005	18.9	0.005	18.8
CMHPP Tfr1	Transformer				0.800	0.424	53.0	0.412	51.4
CMHPP Tfr2	Transformer				0.800	0.424	53.0	0.412	51.4
CMHPP Tfr3	Transformer				0.800	0.424	53.0	0.412	51.4
CVTI Tfr	Transformer				0.500	0.183	36.6	0.180	36.0

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
D.Pelrithang Tfr	Transformer				0.100	0.047	46.8	0.046	46.0
Dawathang Station Tfr	Transformer				0.063	0.007	10.7	0.007	10.7
Dekiling Tfr	Transformer				0.250	0.210	83.8	0.202	80.8
Dhur BHU Tfr	Transformer				0.063	0.007	10.9	0.007	10.8
* Dodrang Tfr	Transformer				0.025	0.029	115.9	0.028	110.6
Domkhar Palace Tfr	Transformer				0.250	0.091	36.3	0.089	35.7
Domkhar Tfr	Transformer				0.250	0.076	30.4	0.075	30.0
Dorjibi Tfr	Transformer				0.063	0.003	4.1	0.003	4.1
Gakiling Tfr	Transformer				0.250	0.200	79.9	0.193	77.1
* Gangrithang Tfr2	Transformer				0.125	0.189	151.0	0.176	141.1
GarpangSS Tfr1	Transformer				2.500	1.469	58.8	1.415	56.6
GarpangSS Tfr2	Transformer				2.500	1.469	58.8	1.415	56.6
Goling Tfr	Transformer				0.025	0.005	21.7	0.005	21.5
Gongkhar Tfr2	Transformer				0.125	0.050	40.2	0.049	39.6
* Gyetsa Sch. Tfr	Transformer				0.250	0.267	106.7	0.254	101.8
Gyetsa Vill. Tfr	Transformer				0.063	0.010	16.4	0.010	16.3
Hurji TCom Tfr	Transformer				0.025	0.001	3.9	0.001	3.9
Jachuthang Tfr	Transformer				0.160	0.058	35.9	0.057	35.4
Jakar Sch. Tfr	Transformer				0.125	0.040	31.8	0.039	31.3
Jakar.Dzo Tfr	Transformer				0.315	0.232	73.7	0.224	71.2
Jalikhar Tfr2	Transformer				0.250	0.141	56.3	0.137	54.9
Jayulthang Tfr	Transformer				0.063	0.004	5.9	0.004	5.9
Jemshong Tfr	Transformer				0.030	0.009	30.6	0.009	30.3
Kertshok Tfr	Transformer				0.025	0.008	32.9	0.008	32.4
Khagtang Tfr	Transformer				0.100	0.032	32.4	0.032	32.0
Khakharte Tfr	Transformer				0.050	0.004	7.4	0.004	7.4
Khangrab Tfr	Transformer				0.100	0.042	42.3	0.042	41.6
Kharampay Tfr	Transformer				0.250	0.202	80.7	0.196	78.3
Kharchu Dtshang Tfr	Transformer				0.250	0.245	98.1	0.235	94.1
Kharsa Tfr	Transformer				0.063	0.018	28.1	0.018	27.8
Kidzom Tfr	Transformer				0.063	0.012	18.7	0.012	18.6
Kikila BBS Tfr	Transformer				0.025	0.005	19.5	0.005	19.3
Kunzangcholing Tfr	Transformer				0.025	0.007	29.5	0.007	29.2
Kurje Tfr	Transformer				0.250	0.099	39.7	0.098	39.1
L.Dhur Tfr	Transformer				0.125	0.023	18.6	0.023	18.5

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
L.Jalikhar Tfr	Transformer				0.160	0.081	50.6	0.079	49.5
L.Lami Gpa Tfr	Transformer				0.025	0.002	9.1	0.002	9.1
L.Nimalung Tfr	Transformer				0.030	0.008	26.3	0.008	26.0
L.Pangkhar Tfr	Transformer				0.030	0.005	16.6	0.005	16.5
Lamethang Tfr	Transformer				0.063	0.019	30.5	0.019	30.1
Lami Gpa Tfr	Transformer				0.500	0.268	53.7	0.262	52.4
Lebi Tfr	Transformer				0.125	0.009	7.5	0.009	7.5
Lusbi Tfr	Transformer				0.025	0.006	24.0	0.006	23.7
* Mitsithang Tfr	Transformer				0.100	0.196	196.3	0.182	182.1
Namkhay Tfr	Transformer				0.025	0.004	17.0	0.004	16.9
Nangay Tfr	Transformer				0.025	0.007	27.6	0.007	27.3
Nangkar Tfr	Transformer				0.063	0.046	73.1	0.045	71.0
Nangsephel Tfr	Transformer				0.063	0.011	18.1	0.011	18.0
Nasphel Tfr	Transformer				0.125	0.059	47.0	0.058	46.1
Nimalung Tfr	Transformer				0.063	0.040	63.5	0.039	61.9
Pangri Tfr	Transformer				0.125	0.006	4.6	0.006	4.6
Pangshing Tfr	Transformer				0.063	0.029	46.1	0.029	45.3
Park Tfr	Transformer				0.030	0.019	61.9	0.018	60.4
Pdrong Tfr	Transformer				0.063	0.037	58.0	0.036	56.7
Petselling Lkhang Tfr	Transformer				0.063	0.025	39.9	0.025	39.2
* Phogo Tfr	Transformer				0.063	0.076	120.8	0.072	115.0
PhrumthangTfr	Transformer				0.250	0.078	31.2	0.077	30.8
Pralang Tfr	Transformer				0.030	0.013	43.3	0.013	42.6
PWD Tfr	Transformer				0.025	0.002	7.1	0.002	7.1
Rangbi Tfr	Transformer				0.016	0.003	16.8	0.003	16.7
Recycling Gpang Tfr	Transformer				0.063	0.008	12.1	0.008	12.0
RNR-RC Station Tfr	Transformer				0.063	0.005	8.5	0.005	8.5
RNR-RC Tfr	Transformer				0.063	0.025	39.4	0.024	38.7
Samteling Tfr	Transformer				0.016	0.006	36.1	0.006	35.5
Samthang Tfr	Transformer				0.025	0.007	28.2	0.007	27.9
Sangsangma Tfr	Transformer				0.063	0.014	21.8	0.014	21.6
Semeth Tfr	Transformer				0.063	0.004	5.9	0.004	5.9
Shetangla Tfr	Transformer				0.025	0.014	57.2	0.014	56.0
Shingkhar Tfr	Transformer				0.125	0.022	17.3	0.022	17.2
Shingneer Tfr	Transformer				0.125	0.017	14.0	0.017	13.9

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
Sibjur Tfr	Transformer				0.063	0.012	18.5	0.012	18.4
SixSense Tfr	Transformer				0.500	0.251	50.3	0.246	49.2
Somdrong Tfr	Transformer				0.025	0.007	28.0	0.007	27.7
Station T2	Transformer				0.250	0.032	12.8	0.032	12.8
Station Tfr	Transformer				0.050	0.005	9.6	0.005	9.6
StationI T1	Transformer				0.250	0.004	1.7	0.004	1.7
Suzubgg Tfr	Transformer				0.063	0.041	65.5	0.040	63.9
* Takar Tfr	Transformer				0.016	0.018	113.6	0.017	108.6
Tamshing Tfr	Transformer				0.160	0.058	36.1	0.057	35.6
Tangbi Tfr	Transformer				0.063	0.012	18.6	0.012	18.4
Tangsibi Tfr	Transformer				0.125	0.059	47.4	0.058	46.6
Tashiling Tfr	Transformer				0.016	0.004	26.0	0.004	25.7
Tasur Tfr	Transformer				0.030	0.004	14.3	0.004	14.2
TCom Tfr	Transformer				0.500	0.154	30.7	0.152	30.3
Tekarshong Tfr	Transformer				0.025	0.020	81.8	0.020	79.1
Tgang Tfr	Transformer				0.063	0.008	13.1	0.008	13.0
Tgatshel Tfr	Transformer				0.063	0.047	74.2	0.045	72.1
Tharpaling Tfr	Transformer				0.063	0.008	12.1	0.008	12.0
Thromey Tfr	Transformer				0.063	0.014	23.0	0.014	22.8
Toktozam Tfr	Transformer				0.016	0.003	21.3	0.003	21.1
* Town.P Tfr	Transformer				0.025	0.034	137.1	0.032	128.9
Trailing Tfr	Transformer				0.050	0.004	8.1	0.004	8.1
Trasebee Tfr	Transformer				0.063	0.022	35.2	0.022	34.7
TT Gonpa Tfr	Transformer				0.025	0.001	3.0	0.001	3.0
U.Dhur Tfr	Transformer				0.063	0.007	11.3	0.007	11.3
U.Nimalung Tfr	Transformer				0.063	0.008	12.8	0.008	12.8
U.Pangkhar Tfr	Transformer				0.030	0.002	6.6	0.002	6.6
U.Tangsibi Tfr	Transformer				0.063	0.013	20.5	0.013	20.3
U.Tharpaling Tfr	Transformer				0.063	0.009	14.9	0.009	14.8
* Ucholing Tfr	Transformer				0.063	0.065	102.4	0.062	98.6
UDee Tfr	Transformer				0.250	0.245	97.9	0.234	93.5
Ugarling.R Tfr	Transformer				0.500	0.173	34.6	0.171	34.1
Ura BHU Tfr	Transformer				0.125	0.047	37.3	0.046	36.8
Ura CS Tfr	Transformer				0.016	0.005	30.2	0.005	29.9
Ura ICT	Transformer				0.125	0.056	44.7	0.055	44.0

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
Ura PP Tfr	Transformer				0.075	0.042	55.9	0.041	54.8
Ura Sch. Tfr	Transformer				0.050	0.031	62.2	0.030	60.8
Ura Village Tfr	Transformer				0.160	0.061	37.9	0.060	37.4
Urgang Tfr	Transformer				0.050	0.019	37.1	0.018	36.6
Urug Tfr	Transformer				0.063	0.015	24.1	0.015	23.9
Wangtha Gpa Tfr	Transformer				0.030	0.002	5.7	0.002	5.7
Wcholing Hosp. Tfr	Transformer				0.125	0.113	90.7	0.109	87.1
Wcholing Sch. Tfr	Transformer				0.063	0.044	70.2	0.043	68.0
Wcholing Tfr	Transformer				0.500	0.216	43.2	0.212	42.4
WCP Tfr	Transformer				0.025	0.006	24.0	0.006	23.8
Webthang Tfr	Transformer				0.025	0.003	10.9	0.003	10.9
Yamthra Tfr	Transformer				0.063	0.025	39.4	0.024	38.7
Zangtherpo Tfr	Transformer				0.063	0.017	27.6	0.017	27.3
Zhabjithang Tfr	Transformer				0.063	0.017	27.3	0.017	27.0
Zhicha Tfr	Transformer				0.025	0.001	2.8	0.001	2.8
* Zhongphel Tfr	Transformer				0.030	0.041	135.1	0.039	128.4
Zhugdra Tfr	Transformer				0.025	0.006	22.1	0.005	21.9
Zungey Tfr	Transformer				0.063	0.060	94.7	0.057	91.2

* 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
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
A10.1-Thromey	0.755	0.471	-0.749	-0.468	6.2	2.9	96.2	95.4	0.75
A10.1-Yamthra	0.021	0.013	-0.021	-0.013	0.0	0.0	96.2	96.2	0.00
L1-A10.1	-0.776	-0.484	0.784	0.488	7.2	3.4	96.2	97.0	0.85
A10(2-3)	0.675	0.423	-0.674	-0.422	0.9	0.4	94.9	94.8	0.12
A10.2-Aunsang	0.004	0.002	-0.004	-0.003	0.0	-0.3	94.9	94.9	0.00
A10.2-Chumey Sch.	0.054	0.034	-0.054	-0.034	0.0	0.0	94.9	94.9	0.00
A10(15-2)	-0.733	-0.458	0.734	0.459	1.4	0.6	94.9	95.1	0.17
A10(3-4)	0.663	0.416	-0.659	-0.414	3.3	1.5	94.6	94.1	0.45
A10.3-Chudaepang	0.010	0.006	-0.010	-0.006	0.0	-0.2	94.6	94.6	0.00
A10(16-3)	-0.673	-0.422	0.674	0.422	1.2	0.6	94.6	94.8	0.17
A10(4-5)	0.593	0.373	-0.591	-0.372	2.3	1.0	94.1	93.8	0.34
PhrumthangTfr	0.066	0.042	-0.065	-0.041	0.6	0.9	94.1	92.9	1.21
A10(5-6)	0.590	0.371	-0.587	-0.369	3.7	1.6	93.8	93.2	0.56
Hurji TCom Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	93.8	93.6	0.15
A10(6-)	0.577	0.363	-0.576	-0.362	0.7	0.7	93.2	93.1	0.14
A10.6-Sibjur	0.010	0.006	-0.010	-0.006	0.0	0.0	93.2	93.2	0.00
A10(7-8)	0.419	0.264	-0.418	-0.264	1.0	0.4	92.8	92.6	0.22
A10.7-CVTI	0.155	0.097	-0.155	-0.097	0.0	0.0	92.8	92.8	0.00
A10(18-7)	-0.574	-0.362	0.576	0.362	1.8	0.8	92.8	93.1	0.28
A10.8-Domkhar	0.064	0.040	-0.064	-0.040	0.0	0.0	92.6	92.6	0.01
A10.8-Domkhar Palace	0.354	0.223	-0.353	-0.223	1.0	0.3	92.6	92.3	0.25
A10.9-Gyetsa Vill.	0.051	0.029	-0.051	-0.030	0.0	-0.3	92.1	92.0	0.05
Domkhar Palace-A10.9	-0.275	-0.175	0.276	0.175	0.8	0.1	92.1	92.3	0.25
Gyetsa Sch. Tfr	0.224	0.145	-0.216	-0.134	7.4	11.2	92.1	87.9	4.24
A10(10-11)	0.015	0.009	-0.015	-0.009	0.0	-0.3	92.0	92.0	0.02
A10(10-12)	0.020	0.011	-0.020	-0.011	0.0	-0.3	92.0	92.0	0.02
A10.10-Bulli	0.007	0.005	-0.007	-0.005	0.0	-0.1	92.0	92.0	0.00
Gyetsa Vill.-A10.10	-0.043	-0.024	0.043	0.024	0.0	-0.1	92.0	92.0	0.01
A10.11-Rangbi	0.002	0.001	-0.002	-0.001	0.0	-0.4	92.0	92.0	0.00
Urug Tfr	0.013	0.008	-0.013	-0.008	0.1	0.1	92.0	91.1	0.96
A10(12-13)	0.015	0.008	-0.015	-0.008	0.0	-0.3	92.0	92.0	0.02
Samteling Tfr	0.005	0.003	-0.005	-0.003	0.1	0.1	92.0	90.6	1.43
A10(13-14)	0.015	0.008	-0.015	-0.008	0.0	-0.1	92.0	92.0	0.00
A10.13-Zhicha	0.001	0.000	-0.001	0.000	0.0	-0.1	92.0	92.0	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
A10.14-Tharpaling	0.014	0.008	-0.014	-0.009	0.0	-0.6	92.0	92.0	0.03
Thromey-A10.15	-0.734	-0.459	0.737	0.460	2.8	1.3	95.1	95.4	0.35
L1-Recycling Gpang	2.325	1.542	-2.306	-1.523	19.5	19.0	96.0	95.1	0.92
UG-A20.0	-2.325	-1.542	2.334	1.546	8.3	3.9	96.0	96.3	0.31
A20(1-2)	2.219	1.465	-2.170	-1.417	49.1	47.7	94.5	92.1	2.40
A20.1-L.Jalikhar	0.068	0.043	-0.068	-0.043	0.0	-0.1	94.5	94.5	0.03
Recycling Gpang-A20.1	-2.287	-1.508	2.299	1.519	11.9	11.6	94.5	95.1	0.56
A20(2-3)2	0.319	0.206	-0.319	-0.206	0.1	0.0	92.1	92.1	0.03
A20(2-6)	1.851	1.211	-1.832	-1.193	18.2	17.6	92.1	91.0	1.04
A20(6-7)	1.664	1.085	-1.663	-1.083	1.7	1.6	91.0	90.9	0.11
Gakiling Tfr	0.168	0.108	-0.164	-0.102	4.3	6.4	91.0	87.8	3.21
A20(7-8)	1.516	0.991	-1.509	-0.984	7.4	7.1	90.9	90.4	0.51
A20.7-Ugarling.R	0.147	0.092	-0.147	-0.092	0.0	0.0	90.9	90.9	0.01
A20(8-9)	1.353	0.883	-1.348	-0.877	5.6	5.4	90.4	90.0	0.43
A20.8-BOC	0.155	0.101	-0.155	-0.101	0.0	0.0	90.4	90.4	0.01
A20(9-10)	0.720	0.461	-0.719	-0.460	0.9	0.8	90.0	89.9	0.13
Chamkhar.M Tfr	0.627	0.416	-0.596	-0.370	31.1	46.6	90.0	83.9	6.13
A20(10-11)	0.719	0.460	-0.718	-0.459	1.4	1.2	89.9	89.7	0.20
A20(11-13)	0.475	0.302	-0.475	-0.302	0.7	0.5	89.7	89.5	0.14
A20.11-UDee	0.206	0.133	-0.205	-0.133	0.2	0.0	89.7	89.6	0.08
A20.11-Wcholing Sch.	0.037	0.024	-0.037	-0.024	0.0	0.0	89.7	89.7	0.01
Chamkhar-Dekiling IC Line	0.000	0.000	0.000	0.000	0.0	-0.1	89.7	89.7	0.00
A20(13-14)	0.279	0.177	-0.279	-0.177	0.1	0.0	89.5	89.5	0.05
Jakar.Dzo Tfr	0.195	0.125	-0.191	-0.118	4.7	7.1	89.5	86.5	3.01
A20(14-15)	0.245	0.155	-0.245	-0.155	0.2	0.0	89.5	89.4	0.08
A20.14-Jakar Sch.	0.034	0.021	-0.034	-0.021	0.0	0.0	89.5	89.5	0.00
A20.15-L.Lami Gpa	0.229	0.145	-0.229	-0.145	0.1	0.0	89.4	89.3	0.07
A20.15-Lamethamg	0.016	0.010	-0.016	-0.010	0.0	0.0	89.4	89.4	0.00
A20(3-4)2	-0.200	-0.131	0.200	0.131	0.2	-0.1	92.0	92.1	0.08
A20.4-Gangrithang2	0.158	0.104	-0.157	-0.104	0.2	-0.1	92.0	91.9	0.12
A20.4-Gongkhar2	0.043	0.027	-0.043	-0.027	0.0	-0.1	92.0	92.0	0.01
A20.3-Jalikhar2	0.119	0.075	-0.119	-0.075	0.0	0.0	92.1	92.0	0.02
A30(1-2)	0.073	0.046	-0.073	-0.046	0.0	-0.1	96.9	96.9	0.02
A30.1-Takar	0.015	0.010	-0.015	-0.010	0.0	0.0	96.9	96.9	0.00
Zungey-A30.1	-0.088	-0.055	0.088	0.055	0.1	-0.3	96.9	97.0	0.08
A30.20-Nangar	0.039	0.024	-0.039	-0.025	0.0	-0.3	96.9	96.8	0.03
A30.20-Nimalung	0.034	0.021	-0.034	-0.021	0.0	-0.3	96.9	96.8	0.03

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
A40.1-Nangay	0.006	0.003	-0.006	-0.004	0.0	-0.2	97.0	97.0	0.00
L1-A40.1	-0.014	-0.009	0.014	0.009	0.0	0.0	97.0	97.0	0.00
BPC Colony Tfr	0.008	0.005	-0.008	-0.005	0.1	0.2	97.0	94.7	2.29
A50(1-2)	-0.125	-0.031	0.126	0.030	0.2	-0.4	96.7	96.8	0.16
L1-A50.1	0.125	0.031	-0.125	-0.032	0.4	-0.8	96.7	96.4	0.32
A50(2-3)	-0.129	-0.032	0.129	0.031	0.2	-0.8	96.8	97.0	0.17
Jayulthang Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	96.8	96.6	0.22
A50(3-4)	-0.129	-0.031	0.129	0.031	0.0	0.0	97.0	97.0	0.01
UG CMHPP	-0.129	-0.031	0.129	0.031	0.0	0.0	97.0	97.0	0.00
A150(8-8.1)	-0.116	-0.070	0.116	0.069	0.0	-0.2	96.8	96.9	0.05
A150.8.1-Zhugdra	0.116	0.070	-0.116	-0.070	0.0	-0.2	96.8	96.8	0.04
A70.00-A70.19	0.073	0.041	-0.073	-0.042	0.0	-1.3	99.9	99.9	0.00
A70(19-1)	0.504	0.234	-0.504	-0.235	0.0	-1.2	99.9	99.9	0.01
L1-A70.1	-0.577	-0.275	0.578	0.266	0.5	-9.1	99.9	100.0	0.10
A70(1-2)	0.464	0.210	-0.464	-0.216	0.2	-5.7	99.9	99.8	0.05
D.Pelrithang Tfr	0.040	0.025	-0.039	-0.024	0.5	0.7	99.9	98.2	1.71
A70(2-3)	0.390	0.170	-0.390	-0.174	0.1	-4.0	99.8	99.8	0.03
A70.2-Ani Dtshang	0.046	0.028	-0.046	-0.030	0.0	-1.3	99.8	99.8	0.00
A70.2-Bepzor	0.028	0.017	-0.028	-0.018	0.0	-0.4	99.8	99.8	0.00
A70(3-4)	0.349	0.148	-0.349	-0.157	0.1	-8.4	99.8	99.8	0.05
A70.3-Zhongphel	0.040	0.026	-0.040	-0.026	0.0	-0.1	99.8	99.8	0.00
A70(4-5)	0.324	0.143	-0.324	-0.150	0.1	-6.9	99.8	99.7	0.04
A70.4-Pangshing	0.025	0.014	-0.025	-0.015	0.0	-1.9	99.8	99.8	0.00
A70(5-6)	0.316	0.145	-0.316	-0.150	0.1	-4.9	99.7	99.7	0.03
Jemshong Tfr	0.008	0.005	-0.008	-0.005	0.1	0.1	99.7	98.6	1.12
A70(6-7)	0.153	0.041	-0.153	-0.045	0.0	-4.3	99.7	99.7	0.01
Mitsithang Tfr	0.163	0.109	-0.155	-0.096	8.6	12.9	99.7	92.5	7.22
A70(7-8)	0.149	0.043	-0.149	-0.047	0.0	-3.8	99.7	99.7	0.01
A70.7-Tasur	0.004	0.002	-0.004	-0.002	0.0	-0.4	99.7	99.7	0.00
A70(8-9)	0.138	0.040	-0.138	-0.042	0.0	-1.9	99.7	99.7	0.00
Pralang Tfr	0.011	0.007	-0.011	-0.007	0.1	0.2	99.7	98.1	1.58
A70(9-10)	0.132	0.038	-0.132	-0.040	0.0	-1.8	99.7	99.7	0.00
L.Nimalung Tfr	0.007	0.004	-0.007	-0.004	0.0	0.1	99.7	98.7	0.96
A70(10-11)	0.125	0.036	-0.125	-0.037	0.0	-1.7	99.7	99.7	0.00
U.Nimalung Tfr	0.007	0.004	-0.007	-0.004	0.0	0.0	99.7	99.2	0.47
A70(11-12)	0.013	0.006	-0.013	-0.006	0.0	-0.6	99.7	99.7	0.00
A70(11-13)	0.112	0.032	-0.112	-0.036	0.0	-4.9	99.7	99.7	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
A70.12-Semeth	0.003	0.000	-0.003	-0.002	0.0	-1.8	99.7	99.7	0.00
Kidzom Tfr	0.010	0.006	-0.010	-0.006	0.0	0.1	99.7	99.0	0.68
A70.11-Ucholing	0.054	0.032	-0.054	-0.035	0.0	-2.8	99.7	99.7	0.00
A70(13-14)	0.057	0.004	-0.057	-0.005	0.0	-0.3	99.7	99.7	0.00
A70(14-15)	0.022	-0.018	-0.022	0.016	0.0	-1.5	99.7	99.7	0.00
Khangrab Tfr	0.036	0.023	-0.035	-0.022	0.4	0.6	99.7	98.1	1.55
A70(15-17)	0.010	-0.012	-0.010	0.007	0.0	-4.8	99.7	99.7	0.00
A70.15-Benzibi	0.003	-0.002	-0.003	-0.002	0.0	-3.9	99.7	99.7	0.00
A70(15-Namkhay)	0.009	-0.002	-0.009	-0.001	0.0	-3.0	99.7	99.7	0.00
A70.16-Chutti	0.005	-0.002	-0.005	-0.003	0.0	-4.9	99.7	99.7	0.00
Namkhay Tfr	0.004	0.002	-0.004	-0.002	0.0	0.0	99.7	99.0	0.62
A70(17-18)	0.008	-0.006	-0.008	-0.001	0.0	-6.8	99.7	99.7	0.00
A70.17-Webthang	0.002	-0.001	-0.002	-0.001	0.0	-2.4	99.7	99.7	0.00
A70.18-TT Gonpa	0.001	-0.004	-0.001	0.000	0.0	-4.1	99.7	99.7	0.00
Tgang Tfr	0.007	0.004	-0.007	-0.004	0.0	0.0	99.7	99.2	0.48
A70(19-20)	0.073	0.043	-0.073	-0.043	0.0	-0.2	99.9	99.9	0.00
Line to Ura from Tang	0.000	0.000	0.000	0.000	0.0	-0.3	99.9	99.9	0.00
A70.20-Pdrong	0.039	0.021	-0.039	-0.024	0.0	-2.9	99.9	99.9	0.00
A70.20-Suzubgg	0.035	0.022	-0.035	-0.022	0.0	-0.5	99.9	99.9	0.00
A90(1-2)	0.094	0.058	-0.093	-0.058	0.1	-0.2	96.3	96.2	0.08
A90.1-Kikila BBS	0.004	0.003	-0.004	-0.003	0.0	0.0	96.3	96.3	0.00
L1-A90.1	-0.098	-0.061	0.098	0.061	0.1	-0.2	96.3	96.3	0.07
A90(2-3)	0.093	0.058	-0.093	-0.059	0.3	-0.9	96.2	95.9	0.30
A90(3-4)	0.029	0.018	-0.029	-0.018	0.0	-0.1	95.9	95.9	0.01
A90.3-Phogo	0.064	0.041	-0.064	-0.041	0.0	-0.2	95.9	95.9	0.03
A90(4-5)	0.026	0.016	-0.026	-0.016	0.0	-0.1	95.9	95.9	0.01
Chenrezith Tfr	0.004	0.002	-0.004	-0.002	0.0	0.0	95.9	94.9	1.01
Kertshok Tfr	0.007	0.004	-0.007	-0.004	0.1	0.1	95.9	94.6	1.25
A110(1-2)	0.033	0.021	-0.033	-0.021	0.0	-0.1	94.2	94.2	0.01
A110(1-3)	1.184	0.748	-1.172	-0.742	11.5	5.8	94.2	93.3	0.87
L1-A110.1	-1.217	-0.769	1.218	0.770	1.2	1.2	94.2	94.3	0.11
A110.2-Airport	0.012	0.008	-0.012	-0.008	0.0	-0.1	94.2	94.1	0.01
RNR-RC Tfr	0.021	0.013	-0.021	-0.013	0.2	0.4	94.2	92.6	1.52
A110(3-4)	1.124	0.712	-1.122	-0.711	1.8	0.9	93.3	93.1	0.14
Jachuthang Tfr	0.049	0.031	-0.048	-0.030	0.5	0.8	93.3	91.9	1.40
A110(4-5)	0.909	0.576	-0.905	-0.574	4.1	2.0	93.1	92.7	0.40
A110.4-Six Sense	0.213	0.134	-0.212	-0.134	0.2	0.0	93.1	93.1	0.09

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
A110(5-6)	0.725	0.461	-0.722	-0.460	2.3	1.1	92.7	92.4	0.28
A110.5-Nasphel	0.050	0.031	-0.050	-0.031	0.0	-0.1	92.7	92.6	0.02
A110.5-TCom	0.130	0.082	-0.130	-0.082	0.0	0.0	92.7	92.6	0.03
A110(5IC-5)	-0.904	-0.574	0.905	0.574	0.9	0.5	92.7	92.7	0.09
A110(6-7)	0.722	0.460	-0.722	-0.460	0.6	0.3	92.4	92.3	0.07
A110(7-8)	0.722	0.460	-0.721	-0.459	0.6	0.3	92.3	92.2	0.08
A20.20-Dekiling	0.176	0.113	-0.176	-0.113	0.0	0.0	92.2	92.2	0.00
A110(8-9)	0.545	0.346	-0.543	-0.345	1.9	0.8	92.2	91.9	0.30
A20.(9-10)	0.448	0.284	-0.447	-0.284	0.3	0.1	91.9	91.9	0.07
A20.19-Wcholing Hosp.	0.095	0.061	-0.095	-0.061	0.1	-0.1	91.9	91.9	0.05
Town P UG	0.029	0.019	-0.029	-0.019	0.0	0.0	91.9	91.8	0.00
A20.10-Wcholing	0.419	0.265	-0.418	-0.265	0.6	0.2	91.9	91.7	0.13
Amankora UG	0.235	0.149	-0.235	-0.149	0.0	0.0	91.7	91.7	0.00
A20.16-Wcholing	-0.235	-0.149	0.235	0.149	0.1	0.0	91.7	91.7	0.03
A110.11-Chamkhar line	0.000	0.000	0.000	0.000	0.0	0.0	91.7	91.7	0.00
A120(1-2)	0.214	0.138	-0.214	-0.138	0.0	0.0	94.0	94.0	0.01
A120.1-Bathpalathang	0.075	0.047	-0.075	-0.047	0.0	-0.1	94.0	94.0	0.02
UG Batpal-A120.1	-0.289	-0.185	0.290	0.185	0.7	0.2	94.0	94.3	0.25
A120.2-Kharchu Dtshang	0.206	0.133	-0.206	-0.133	0.2	0.0	94.0	93.9	0.08
A120.2-Lebi	0.008	0.005	-0.008	-0.005	0.0	-0.1	94.0	94.0	0.00
A130.1-Petselling Lkhang	0.021	0.013	-0.021	-0.013	0.0	-0.5	94.2	94.2	0.03
Tekarshong-A130.1	-0.040	-0.025	0.040	0.024	0.0	-0.4	94.2	94.3	0.05
Trasebee Tfr	0.019	0.012	-0.019	-0.012	0.2	0.3	94.2	92.9	1.36
A140(1-2)	0.261	0.165	-0.261	-0.165	0.1	0.0	97.1	97.1	0.04
A140.1-Kurje	0.084	0.053	-0.084	-0.053	0.0	-0.1	97.1	97.1	0.03
L1-A140.1	-0.345	-0.218	0.345	0.218	0.5	0.2	97.1	97.3	0.18
A140(2-3)	0.050	0.031	-0.050	-0.031	0.0	-0.2	97.1	97.1	0.03
A140.3-Chakar	0.211	0.134	-0.210	-0.134	0.3	-0.1	97.1	97.0	0.14
Tamshing Tfr	0.049	0.031	-0.048	-0.030	0.5	0.7	97.1	95.7	1.36
A150.1-Pangri	0.007	0.004	-0.007	-0.004	0.0	-0.1	97.3	97.3	0.00
A150.1-Zangtherpo	0.212	0.126	-0.212	-0.126	0.0	0.0	97.3	97.3	0.02
UG Chokhor-A150.1	-0.219	-0.130	0.219	0.130	0.0	0.0	97.3	97.3	0.01
A150(2-6)	0.146	0.087	-0.146	-0.087	0.1	-0.2	97.1	97.0	0.07
A150.2-Toktozam	0.050	0.029	-0.050	-0.030	0.0	0.0	97.1	97.1	0.00
Zangtherpo-A150.2	-0.197	-0.117	0.197	0.116	0.4	-0.3	97.1	97.3	0.20
A150(3-4)	0.031	0.019	-0.031	-0.019	0.0	0.0	97.0	97.0	0.00
\	-0.037	-0.022	0.037	0.021	0.0	-0.9	97.0	97.0	0.06

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
Dhur BHU Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	97.0	96.6	0.41
A150(4-5)	0.026	0.016	-0.026	-0.016	0.0	-0.2	97.0	97.0	0.01
A150.4-Lusbi.1	0.005	0.003	-0.005	-0.003	0.0	0.0	97.0	97.0	0.00
A150.50-U.Dhur	0.006	0.004	-0.006	-0.004	0.0	-0.1	97.0	97.0	0.00
L.Dhur Tfr	0.020	0.012	-0.020	-0.012	0.1	0.2	97.0	96.3	0.70
A150(6-7)	0.136	0.081	-0.136	-0.081	0.1	-0.2	97.0	96.9	0.08
Tangbi Tfr	0.010	0.006	-0.010	-0.006	0.1	0.1	97.0	96.3	0.70
A150(7-8)	0.131	0.079	-0.131	-0.079	0.1	-0.3	96.9	96.9	0.08
Goling Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.9	96.1	0.81
A150.8-Kharsa	0.015	0.009	-0.015	-0.009	0.0	0.0	96.9	96.8	0.00
A150.9-Dodrang	0.109	0.065	-0.109	-0.066	0.1	-0.8	96.7	96.6	0.16
Zhugdra-A150.9	-0.111	-0.067	0.112	0.067	0.0	-0.2	96.7	96.8	0.05
A150(10-11)	0.010	0.005	-0.010	-0.005	0.0	-0.1	96.5	96.5	0.00
A150(10-12)	0.075	0.045	-0.075	-0.045	0.0	-0.2	96.5	96.5	0.03
Dodrang-A150.10	-0.084	-0.051	0.084	0.051	0.0	0.0	96.5	96.6	0.01
A150.11-Samthang	0.006	0.004	-0.006	-0.004	0.0	0.0	96.5	96.5	0.00
A150.11-Tashiling	0.004	0.002	-0.004	-0.002	0.0	-0.5	96.5	96.5	0.00
A150(12-13)	0.063	0.038	-0.063	-0.038	0.0	-0.3	96.5	96.5	0.03
Sangsangma Tfr	0.012	0.007	-0.012	-0.007	0.1	0.1	96.5	95.7	0.82
A150(13-14)	0.048	0.029	-0.048	-0.030	0.0	-0.3	96.5	96.5	0.02
Zhabjithang Tfr	0.015	0.009	-0.014	-0.009	0.1	0.2	96.5	95.5	1.03
A150(14-15)	0.043	0.026	-0.043	-0.027	0.0	-0.1	96.5	96.5	0.01
A150.14-WCP.1	0.005	0.003	-0.005	-0.003	0.0	0.0	96.5	96.5	0.00
A150(15-16)	0.034	0.021	-0.034	-0.021	0.0	-0.1	96.5	96.4	0.01
Nangsephel Tfr	0.010	0.006	-0.010	-0.006	0.0	0.1	96.5	95.8	0.68
A150.16-Khagtang	0.027	0.017	-0.027	-0.017	0.0	-0.4	96.4	96.4	0.04
Kunzangcholing Tfr	0.006	0.004	-0.006	-0.004	0.1	0.1	96.4	95.3	1.12
Airprot Tfr	0.012	0.008	-0.012	-0.008	0.1	0.1	94.1	93.3	0.89
Amankora Tfr	0.235	0.149	-0.231	-0.143	4.1	6.1	91.7	89.5	2.22
Ani Dtshang Tfr	0.046	0.030	-0.045	-0.028	1.1	1.6	99.8	96.6	3.20
Aunsang Tfr	0.004	0.003	-0.004	-0.002	0.0	0.1	94.9	93.7	1.14
Bathpalathang Tfr	0.075	0.047	-0.073	-0.046	1.2	1.8	94.0	91.9	2.15
Benzibi Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	99.7	99.2	0.45
Bepzor Tfr	0.028	0.018	-0.028	-0.017	0.4	0.6	99.8	97.9	1.91
BOC Tfr	0.155	0.101	-0.150	-0.093	5.8	8.8	90.4	85.7	4.69
Bulli Tfr	0.007	0.005	-0.007	-0.004	0.1	0.2	92.0	89.9	2.16
Chakar-Tgatshel	0.039	0.025	-0.039	-0.025	0.0	-0.2	97.0	96.9	0.03

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Chakar Tfr	0.171	0.109	-0.167	-0.104	3.9	5.8	97.0	93.9	3.06
Chudaepang Tfr	0.010	0.006	-0.010	-0.006	0.1	0.1	94.6	93.9	0.73
CMHPP Tfr1	0.357	0.228	-0.356	-0.206	1.1	22.5	100.0	97.0	2.98
CMHPP Tfr2	0.357	0.228	-0.356	-0.206	1.1	22.5	100.0	97.0	2.98
CMHPP Tfr3	0.357	0.228	-0.356	-0.206	1.1	22.5	100.0	97.0	2.98
UG.Gyetsa1 Line	0.784	0.488	-0.784	-0.488	0.2	0.0	97.0	97.0	0.02
UG.Nangar1	0.138	0.087	-0.138	-0.087	0.0	0.0	97.0	97.0	0.00
HVABC BPC Colony Line	0.014	0.009	-0.014	-0.009	0.0	0.0	97.0	97.0	0.00
Station Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	97.0	96.7	0.36
Chumey Sch. Tfr	0.054	0.034	-0.053	-0.033	0.4	0.6	94.9	93.9	0.97
Chutti Tfr	0.004	0.003	-0.004	-0.002	0.0	0.0	99.7	99.0	0.69
CVTI Tfr	0.155	0.097	-0.153	-0.095	1.7	2.6	92.8	91.4	1.44
Dawathang Station Tfr	-0.006	-0.004	0.006	0.004	0.0	0.0	96.9	97.3	0.40
33kV Line to Dawathang	-0.571	-0.370	0.571	0.359	0.7	-11.2	98.9	99.0	0.13
(33/11kV) DawathangSS Tfr	0.571	0.370	-0.570	-0.352	0.9	18.9	98.9	97.3	1.59
UG Chokhor	0.219	0.130	-0.219	-0.130	0.0	0.0	97.3	97.3	0.00
Dekiling Tfr	0.176	0.113	-0.172	-0.106	4.6	6.9	92.2	88.9	3.32
Dodrang Tfr	0.024	0.016	-0.024	-0.015	0.8	1.2	96.6	92.2	4.39
Domkhar Tfr	0.064	0.040	-0.064	-0.040	0.6	0.9	92.6	91.4	1.20
Domkhar Palace Tfr	0.077	0.048	-0.076	-0.047	0.9	1.3	92.3	90.9	1.43
Pangri-Dorjibi	-0.002	-0.001	0.002	0.001	0.0	-0.2	97.3	97.3	0.00
Dorjibi Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.3	97.1	0.15
Gangrithang Tfr2	-0.150	-0.093	0.157	0.104	7.5	11.2	85.8	91.9	6.02
L1-UG	2.335	1.547	-2.334	-1.546	1.4	0.7	96.3	96.3	0.05
UG.Chumey1	-0.125	-0.032	0.125	0.032	0.0	0.0	96.3	96.3	0.00
GarpangSS Tfr1	-1.169	-0.797	1.174	0.884	4.3	86.2	96.3	100.0	3.66
GarpangSS Tfr2	-1.169	-0.797	1.174	0.884	4.3	86.2	96.3	100.0	3.66
Station T2	0.027	0.017	-0.027	-0.017	0.1	0.1	96.3	95.9	0.48
StationI T1	0.004	0.002	-0.004	-0.002	0.0	0.0	96.3	96.3	0.07
33kV line to RNR-RC SS	2.168	1.504	-2.149	-1.508	18.5	-4.0	100.0	99.0	0.97
L1-Ura.1	0.418	0.174	-0.418	-0.181	0.2	-7.6	100.0	99.9	0.05
Gongkhar Tfr2	-0.042	-0.026	0.043	0.027	0.5	0.8	90.4	92.0	1.60
Gyetsa Vill. Tfr	0.009	0.005	-0.009	-0.005	0.0	0.1	92.0	91.4	0.65
HVABC ChumeyLine1	0.125	0.032	-0.125	-0.032	0.0	0.0	96.4	96.3	0.01
Jakar Sch. Tfr	0.034	0.021	-0.033	-0.021	0.3	0.5	89.5	88.2	1.29
Jalikhar Tfr2	-0.117	-0.072	0.119	0.075	2.1	3.1	89.8	92.0	2.23
Khagtang Tfr	0.027	0.017	-0.027	-0.017	0.3	0.4	96.4	95.2	1.22

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
Ura.16-Khakharte	-0.003	-0.002	0.003	0.002	0.0	0.0	97.8	97.8	0.00
Khakharte Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	97.8	97.6	0.28
Ura.23-Kharampay	-0.170	-0.109	0.170	0.105	0.0	-3.7	99.7	99.7	0.02
Kharampay Tfr	0.170	0.109	-0.166	-0.103	3.6	5.5	99.7	96.7	2.95
Kharchu Dtshang Tfr	0.206	0.133	-0.200	-0.124	6.0	9.1	93.9	90.1	3.81
Kharsa Tfr	0.015	0.009	-0.015	-0.009	0.1	0.2	96.8	95.8	1.06
Kikila BBS Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	96.3	95.5	0.74
Kurje Tfr	0.084	0.053	-0.083	-0.051	0.9	1.4	97.1	95.6	1.49
L.Jalikhar Tfr	0.068	0.043	-0.067	-0.042	1.0	1.5	94.5	92.5	1.95
L.Lami Gpa-Lami Gpa	0.227	0.144	-0.227	-0.144	0.4	0.0	89.3	89.2	0.14
L.Lami Gpa Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	89.3	89.0	0.37
Ura.17-L.Pangkhar	-0.004	-0.003	0.004	0.003	0.0	0.0	97.8	97.8	0.00
L.Pangkhar Tfr	0.004	0.003	-0.004	-0.003	0.0	0.0	97.8	97.2	0.62
Lamethang Tfr	0.016	0.010	-0.016	-0.010	0.2	0.2	89.4	88.1	1.24
Lami Gpa Tfr	0.227	0.144	-0.222	-0.138	4.0	6.0	89.2	87.0	2.20
Lebi Tfr	0.008	0.005	-0.008	-0.005	0.0	0.0	94.0	93.7	0.29
Lusbi.2-Lusbi B1	-0.005	-0.003	0.005	0.003	0.0	-0.2	97.0	97.0	0.00
Lusbi Tfr	0.005	0.003	-0.005	-0.003	0.0	0.1	97.0	96.1	0.90
Nangkar Tfr	0.039	0.025	-0.038	-0.024	0.8	1.2	96.8	94.1	2.76
Nangay Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	97.0	96.0	1.03
Nasphel Tfr	0.050	0.031	-0.049	-0.030	0.7	1.1	92.6	90.8	1.85
Nimalung Tfr	0.034	0.021	-0.033	-0.021	0.6	0.9	96.8	94.5	2.39
Pangri Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	97.3	97.1	0.17
Pangshing Tfr	0.025	0.015	-0.024	-0.015	0.3	0.4	99.8	98.1	1.69
Ura.20-Park	-0.016	-0.010	0.016	0.010	0.0	0.0	97.8	97.8	0.01
Park Tfr	0.016	0.010	-0.015	-0.010	0.3	0.4	97.8	95.5	2.31
Pdrong Tfr	0.031	0.020	-0.030	-0.019	0.5	0.7	99.9	97.8	2.12
Petselling Lkhang Tfr	0.021	0.013	-0.021	-0.013	0.3	0.4	94.2	92.6	1.54
Phogo Tfr	0.064	0.041	-0.062	-0.038	2.2	3.3	95.9	91.3	4.61
Ura.5-PWD	-0.002	-0.001	0.002	0.001	0.0	-0.1	99.8	99.8	0.00
PWD Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	99.8	99.5	0.26
Rangbi Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	92.0	91.3	0.66
Recycling Gpang Tfr	-0.006	-0.004	0.006	0.004	0.0	0.0	94.6	95.1	0.46
(33/11kV) RNR-RC SS Tfr	1.578	1.149	-1.570	-0.993	7.8	155.1	99.0	94.3	4.75
L1-UG RNR-RC	1.219	0.770	-1.218	-0.770	0.2	0.1	94.3	94.3	0.01
UG Tekar	0.057	0.035	-0.057	-0.035	0.0	0.0	94.3	94.3	0.00
UG.Batpal Line	0.290	0.185	-0.290	-0.185	0.0	0.0	94.3	94.3	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
RNR-RC Station Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	94.3	94.0	0.33
Samthang Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	96.5	95.5	1.07
Semeth Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	99.7	99.5	0.22
Ura.9-Shetangla	-0.012	-0.008	0.012	0.008	0.0	-0.1	99.7	99.7	0.00
Shetangla Tfr	0.012	0.008	-0.012	-0.007	0.2	0.3	99.7	97.6	2.09
Ura.12-Shingkhar	-0.018	-0.011	0.018	0.002	0.0	-9.3	99.6	99.6	0.01
Shingkhar Tfr	0.018	0.011	-0.018	-0.011	0.1	0.1	99.6	98.9	0.63
Ura.8-Shingneer	-0.015	-0.009	0.015	0.006	0.0	-2.9	99.7	99.7	0.00
Shingneer Tfr	0.015	0.009	-0.015	-0.009	0.1	0.1	99.7	99.2	0.51
Sibjur Tfr	0.010	0.006	-0.010	-0.006	0.1	0.1	93.2	92.5	0.72
SixSense Tfr	0.212	0.134	-0.209	-0.130	3.2	4.9	93.1	91.1	1.97
Ura.14-Sondrong	-0.006	-0.004	0.006	0.004	0.0	0.0	97.9	97.9	0.00
Somdrong Tfr	0.006	0.004	-0.006	-0.004	0.0	0.1	97.9	96.9	1.04
Suzubgg Tfr	0.035	0.022	-0.034	-0.021	0.6	0.9	99.9	97.5	2.39
Takar Tfr	0.015	0.010	-0.015	-0.009	0.5	0.7	96.9	92.6	4.29
Ura.7-Tangsibi	-0.050	-0.032	0.050	0.031	0.0	-0.6	99.7	99.7	0.00
Tangsibi Tfr	0.050	0.032	-0.050	-0.031	0.6	0.9	99.7	98.0	1.73
Tashiling Tfr	0.004	0.002	-0.003	-0.002	0.0	0.0	96.5	95.6	0.98
Tasur Tfr	0.004	0.002	-0.004	-0.002	0.0	0.0	99.7	99.2	0.52
TCom Tfr	0.130	0.082	-0.129	-0.080	1.2	1.8	92.6	91.4	1.21
UG Tekar-Tekarshong	-0.057	-0.035	0.057	0.035	0.0	-0.1	94.3	94.3	0.02
Tekarshong Tfr	0.017	0.011	-0.017	-0.010	0.4	0.6	94.3	91.1	3.17
IC line to Dekiling	0.000	0.000	0.000	0.000	0.0	-0.1	96.9	96.9	0.00
Tgatshel Tfr	0.039	0.025	-0.039	-0.024	0.8	1.2	96.9	94.1	2.79
Tharpaling-U.Tharpaling	0.008	0.005	-0.008	-0.005	0.0	-0.1	92.0	91.9	0.00
Tharpaling Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	92.0	91.5	0.48
Thromey Tfr	0.012	0.008	-0.012	-0.008	0.1	0.1	95.4	94.5	0.88
Toktozam-Tmanba	-0.048	-0.028	0.048	0.028	0.0	-0.4	97.0	97.1	0.03
Toktozam Tfr	-0.003	-0.002	0.003	0.002	0.0	0.0	96.3	97.1	0.80
Town.P Tfr	0.029	0.019	-0.027	-0.017	1.2	1.9	91.8	86.4	5.47
Ura.21-Trailing	-0.003	-0.002	0.003	0.002	0.0	0.0	97.8	97.8	0.00
Trailing Tfr	0.003	0.002	-0.003	-0.002	0.0	0.0	97.8	97.5	0.30
TT Gonpa Tfr	0.001	0.000	-0.001	0.000	0.0	0.0	99.7	99.6	0.11
U.Dhur Tfr	0.006	0.004	-0.006	-0.004	0.0	0.0	97.0	96.5	0.43
Ura.17-U.Pangkhar	-0.002	-0.001	0.002	0.001	0.0	0.0	97.8	97.8	0.00
U.Pangkhar Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	97.8	97.6	0.25
U.Tangsibi Tfr	-0.011	-0.007	0.011	0.007	0.1	0.1	99.0	99.7	0.75

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	
Ura.23-U.Tangsibi	-0.011	-0.007	0.011	0.006	0.0	-0.9	99.7	99.7	0.00
U.Tharpaling Tfr	0.008	0.005	-0.008	-0.005	0.0	0.1	91.9	91.4	0.59
Ucholing Tfr	0.054	0.035	-0.053	-0.033	1.5	2.2	99.7	95.9	3.76
UDee Tfr	0.205	0.133	-0.199	-0.123	6.6	9.9	89.6	85.6	3.99
L1-Zungey	0.138	0.087	-0.138	-0.087	0.1	-0.1	97.0	97.0	0.04
Ugarling.R Tfr	0.147	0.092	-0.145	-0.090	1.6	2.4	90.9	89.5	1.39
Ura.13-Ura BHU	-0.039	-0.025	0.039	0.024	0.0	-0.5	99.6	99.6	0.00
Ura BHU Tfr	0.039	0.025	-0.039	-0.024	0.4	0.6	99.6	98.2	1.37
Ura.11-ICT	-0.048	-0.029	0.048	0.028	0.0	-0.3	99.6	99.6	0.00
Ura ICT	0.048	0.029	-0.048	-0.028	0.6	0.8	99.6	98.0	1.62
Ura ICT-Ura.14	0.048	0.028	-0.047	-0.028	0.0	0.0	98.0	97.9	0.05
Ura PP Tfr	0.035	0.023	-0.034	-0.023	0.5	0.8	100.0	97.9	2.07
Ura PP-Ura.22	0.034	0.023	-0.034	-0.023	0.0	0.0	97.9	97.9	0.01
Ura Sch. Tfr	-0.026	-0.016	0.026	0.017	0.4	0.7	95.5	97.8	2.32
Ura CS Tfr	-0.004	-0.003	0.004	0.003	0.0	0.1	96.7	97.8	1.13
Ura.13-Ura Village	-0.051	-0.032	0.051	0.029	0.0	-3.0	99.6	99.6	0.00
Ura Village Tfr	0.051	0.032	-0.051	-0.032	0.5	0.8	99.6	98.2	1.39
Ura(1-2)	0.418	0.181	-0.418	-0.181	0.0	-0.1	99.9	99.9	0.00
Ura(2-3)	0.000	-0.002	0.000	0.000	0.0	-2.2	99.9	99.9	0.00
Ura(2-4)	0.418	0.184	-0.418	-0.190	0.3	-6.3	99.9	99.9	0.08
Ura(4-5)	0.418	0.190	-0.417	-0.196	0.4	-6.6	99.9	99.8	0.09
Ura(5-6)	0.416	0.195	-0.416	-0.201	0.1	-5.3	99.8	99.7	0.04
Ura(6-7)	0.235	0.093	-0.235	-0.094	0.0	-1.5	99.7	99.7	0.01
Ura(6-23)	0.181	0.108	-0.181	-0.111	0.0	-2.9	99.7	99.7	0.02
Ura(7-8)	0.185	0.063	-0.184	-0.074	0.1	-10.7	99.7	99.7	0.06
Ura(8-9)	0.170	0.068	-0.170	-0.069	0.0	-1.6	99.7	99.7	0.00
Ura(9-10)	0.158	0.062	-0.157	-0.072	0.1	-10.6	99.7	99.6	0.05
Ura(10-11)	0.157	0.072	-0.157	-0.080	0.1	-7.2	99.6	99.6	0.04
Ura(11-12)	0.109	0.051	-0.109	-0.052	0.0	-0.4	99.6	99.6	0.00
Ura(12-13)	0.091	0.049	-0.091	-0.054	0.0	-4.2	99.6	99.6	0.01
Ura (14-15)	0.042	0.024	-0.042	-0.024	0.0	-0.1	97.9	97.8	0.07
Ura (15-16)	0.009	0.006	-0.009	-0.006	0.0	-0.1	97.8	97.8	0.01
Ura (15-18)	0.032	0.019	-0.032	-0.019	0.0	0.0	97.8	97.8	0.01
Ura (16-17)	0.006	0.004	-0.006	-0.004	0.0	0.0	97.8	97.8	0.00
Ura (18-19)	0.017	0.009	-0.017	-0.009	0.0	-0.1	97.8	97.8	0.05
Urgang Tfr	0.016	0.010	-0.016	-0.010	0.2	0.2	97.8	96.5	1.38
Ura (19-20)	-0.014	-0.010	0.014	0.010	0.0	-0.1	97.8	97.8	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
Ura (20-21)	-0.029	-0.020	0.029	0.020	0.0	0.0	97.8	97.8	0.00
Ura (21-22)	-0.033	-0.022	0.033	0.022	0.0	-0.1	97.8	97.9	0.08
Ura.22-Wangtha Gpa	0.001	0.001	-0.001	-0.001	0.0	-0.4	97.9	97.9	0.01
Wangtha Gpa Tfr	0.001	0.001	-0.001	-0.001	0.0	0.0	97.9	97.7	0.21
Wcholing Tfr	0.183	0.115	-0.180	-0.112	2.5	3.7	91.7	90.0	1.72
Wcholing Hosp. Tfr	0.095	0.061	-0.093	-0.057	2.7	4.1	91.9	88.3	3.61
Wcholing Sch. Tfr	-0.036	-0.023	0.037	0.024	0.9	1.3	86.8	89.7	2.86
WCP.1-WCP B1	0.005	0.003	-0.005	-0.003	0.0	0.0	96.5	96.5	0.00
WCP Tfr	0.005	0.003	-0.005	-0.003	0.0	0.1	96.5	95.6	0.91
Webthang Tfr	0.002	0.001	-0.002	-0.001	0.0	0.0	99.7	99.3	0.40
Yamthra Tfr	0.021	0.013	-0.021	-0.013	0.2	0.4	96.2	94.7	1.49
Zangtherpo Tfr	0.015	0.009	-0.015	-0.009	0.1	0.2	97.3	96.2	1.03
A10.13-Zhicha1	0.001	0.000	-0.001	0.000	0.0	-0.1	92.0	92.0	0.00
Zhicha Tfr	0.001	0.000	-0.001	0.000	0.0	0.0	92.0	91.9	0.11
Zhongphel Tfr	0.034	0.022	-0.033	-0.020	1.2	1.8	99.8	94.9	4.95
Zhugdra Tfr	0.005	0.003	-0.005	-0.003	0.0	0.0	96.8	95.9	0.83
Zungey Tfr	0.050	0.032	-0.049	-0.030	1.3	2.0	97.0	93.4	3.57
					385.3	556.8			

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	98.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	110.0	105.0
UnderVoltage	90.0	95.0
Generator Excitation		
OverExcited (Q Max.)	100.0	95.0
UnderExcited (Q Min.)	100.0	

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
A20.10	Bus	Under Voltage	11.000	kV	9.886	89.9	3-Phase
A20.11	Bus	Under Voltage	11.000	kV	9.86	89.7	3-Phase
A20.13	Bus	Under Voltage	11.000	kV	9.85	89.5	3-Phase
A20.14	Bus	Under Voltage	11.000	kV	9.84	89.5	3-Phase
A20.15	Bus	Under Voltage	11.000	kV	9.83	89.4	3-Phase
A20.9	Bus	Under Voltage	11.000	kV	9.90	90.0	3-Phase
Amankora B2	Bus	Under Voltage	0.415	kV	0.37	89.5	3-Phase
BOC B2	Bus	Under Voltage	0.415	kV	0.36	85.7	3-Phase
BOC Tfr	Transformer	Overload	0.160	MVA	0.19	116.0	3-Phase
Bulli B2	Bus	Under Voltage	0.415	kV	0.37	89.9	3-Phase
Chamkhar.M B1	Bus	Under Voltage	0.415	kV	0.35	83.9	3-Phase
Chamkhar.M Tfr	Transformer	Overload	0.500	MVA	0.75	150.6	3-Phase
Dekiling B2	Bus	Under Voltage	0.415	kV	0.37	88.9	3-Phase
Dodrang Tfr	Transformer	Overload	0.025	MVA	0.03	115.9	3-Phase
Gakiling B2	Bus	Under Voltage	0.415	kV	0.36	87.8	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Gangrithang B5	Bus	Under Voltage	0.415	kV	0.356	85.8	3-Phase
Gangrithang Tfr2	Transformer	Overload	0.125	MVA	0.19	151.0	3-Phase
Gyetsa Sch. B2	Bus	Under Voltage	0.415	kV	0.36	87.9	3-Phase
Gyetsa Sch. Tfr	Transformer	Overload	0.250	MVA	0.27	106.7	3-Phase
Jakar Sch. B1	Bus	Under Voltage	11.000	kV	9.84	89.5	3-Phase
Jakar Sch. B2	Bus	Under Voltage	0.415	kV	0.37	88.2	3-Phase
Jakar.Dzo B2	Bus	Under Voltage	0.415	kV	0.36	86.5	3-Phase
Jalikhar B5	Bus	Under Voltage	0.415	kV	0.37	89.8	3-Phase
L.Lami Gpa B1	Bus	Under Voltage	11.000	kV	9.83	89.3	3-Phase
L.Lami Gpa B2	Bus	Under Voltage	0.415	kV	0.37	89.0	3-Phase
Lamethang B1	Bus	Under Voltage	11.000	kV	9.83	89.4	3-Phase
Lamethang B2	Bus	Under Voltage	0.415	kV	0.37	88.1	3-Phase
Lami Gpa B1	Bus	Under Voltage	11.000	kV	9.81	89.2	3-Phase
Lami Gpa B2	Bus	Under Voltage	0.415	kV	0.36	87.0	3-Phase
Mitsithang Tfr	Transformer	Overload	0.100	MVA	0.20	196.3	3-Phase
Phogo Tfr	Transformer	Overload	0.063	MVA	0.08	120.8	3-Phase
Takar Tfr	Transformer	Overload	0.016	MVA	0.02	113.6	3-Phase
Town.P B2	Bus	Under Voltage	0.415	kV	0.36	86.4	3-Phase
Town.P Tfr	Transformer	Overload	0.025	MVA	0.03	137.1	3-Phase
Ucholing Tfr	Transformer	Overload	0.063	MVA	0.06	102.4	3-Phase
UDee B1	Bus	Under Voltage	11.000	kV	9.86	89.6	3-Phase
UDee B2	Bus	Under Voltage	0.415	kV	0.36	85.6	3-Phase
Ugarling.R B2	Bus	Under Voltage	0.415	kV	0.37	89.5	3-Phase
Wcholing Hosp. B2	Bus	Under Voltage	0.415	kV	0.37	88.3	3-Phase
Wcholing Sch. B2	Bus	Under Voltage	0.415	kV	0.36	86.8	3-Phase
Wcholing Sch.B1	Bus	Under Voltage	11.000	kV	9.86	89.7	3-Phase
Zhongphel Tfr	Transformer	Overload	0.030	MVA	0.04	135.1	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
A10.10	Bus	Under Voltage	11.000	kV	10.123	92.0	3-Phase
A10.11	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
A10.12	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
A10.13	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
A10.14	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
A10.16	Bus	Under Voltage	11.000	kV	10.42	94.8	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
A10.18	Bus	Under Voltage	11.000	kV	10.241	93.1	3-Phase
A10.2	Bus	Under Voltage	11.000	kV	10.44	94.9	3-Phase
A10.3	Bus	Under Voltage	11.000	kV	10.41	94.6	3-Phase
A10.4	Bus	Under Voltage	11.000	kV	10.36	94.1	3-Phase
A10.5	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
A10.6	Bus	Under Voltage	11.000	kV	10.26	93.2	3-Phase
A10.7	Bus	Under Voltage	11.000	kV	10.21	92.8	3-Phase
A10.8	Bus	Under Voltage	11.000	kV	10.19	92.6	3-Phase
A10.9	Bus	Under Voltage	11.000	kV	10.13	92.1	3-Phase
A110.1	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase
A110.10	Bus	Under Voltage	11.000	kV	10.10	91.9	3-Phase
A110.11	Bus	Under Voltage	11.000	kV	10.09	91.7	3-Phase
A110.2	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase
A110.3	Bus	Under Voltage	11.000	kV	10.26	93.3	3-Phase
A110.4	Bus	Under Voltage	11.000	kV	10.25	93.1	3-Phase
A110.5	Bus	Under Voltage	11.000	kV	10.19	92.7	3-Phase
A110.5 (IC Line)	Bus	Under Voltage	11.000	kV	10.20	92.7	3-Phase
A110.6	Bus	Under Voltage	11.000	kV	10.16	92.4	3-Phase
A110.7	Bus	Under Voltage	11.000	kV	10.15	92.3	3-Phase
A110.8	Bus	Under Voltage	11.000	kV	10.14	92.2	3-Phase
A110.9	Bus	Under Voltage	11.000	kV	10.11	91.9	3-Phase
A120.1	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
A120.2	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
A130.1	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase
A20.1	Bus	Under Voltage	11.000	kV	10.39	94.5	3-Phase
A20.16	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
A20.17	Bus	Under Voltage	11.000	kV	10.13	92.1	3-Phase
A20.2	Bus	Under Voltage	11.000	kV	10.13	92.1	3-Phase
A20.6	Bus	Under Voltage	11.000	kV	10.01	91.0	3-Phase
A20.7	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
A20.8	Bus	Under Voltage	11.000	kV	9.95	90.4	3-Phase
Airport B1	Bus	Under Voltage	11.000	kV	10.36	94.1	3-Phase
Airport B2	Bus	Under Voltage	0.415	kV	0.39	93.3	3-Phase
Amankora B1	Bus	Under Voltage	11.000	kV	10.09	91.7	3-Phase
Aunsang B1	Bus	Under Voltage	11.000	kV	10.44	94.9	3-Phase
Aunsang B2	Bus	Under Voltage	0.415	kV	0.39	93.7	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bathpalathang B1	Bus	Under Voltage	11.000	kV	10.342	94.0	3-Phase
Bathpalathang B2	Bus	Under Voltage	0.415	kV	0.38	91.9	3-Phase
BOC B1	Bus	Under Voltage	11.000	kV	9.95	90.4	3-Phase
BPC Colony B1	Bus	Under Voltage	0.415	kV	0.39	94.7	3-Phase
Bulli B1	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Chakar B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
Chamkhar Line	Bus	Under Voltage	11.000	kV	10.09	91.7	3-Phase
Cherezeth B	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
Chudaepang B1	Bus	Under Voltage	11.000	kV	10.40	94.6	3-Phase
Chudaepang B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
Chumey Sch. B1	Bus	Under Voltage	11.000	kV	10.44	94.9	3-Phase
Chumey Sch. B2	Bus	Under Voltage	0.415	kV	0.39	93.9	3-Phase
CVTI B1	Bus	Under Voltage	11.000	kV	10.21	92.8	3-Phase
CVTI B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Dekiling B1	Bus	Under Voltage	11.000	kV	10.14	92.2	3-Phase
Dodrang B2	Bus	Under Voltage	0.415	kV	0.38	92.2	3-Phase
Domkhar B1	Bus	Under Voltage	11.000	kV	10.18	92.6	3-Phase
Domkhar B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Domkhar Palace B1	Bus	Under Voltage	11.000	kV	10.16	92.3	3-Phase
Domkhar Palace B2	Bus	Under Voltage	0.415	kV	0.38	90.9	3-Phase
Gangrithang B6	Bus	Under Voltage	11.000	kV	10.10	91.9	3-Phase
Gongkhar B5	Bus	Under Voltage	0.415	kV	0.38	90.4	3-Phase
Gongkhar B6	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Gyetsa Vill. B1	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Gyetsa Vill. B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Hurji TCom B1	Bus	Under Voltage	0.415	kV	0.39	93.6	3-Phase
Jachuthang B1	Bus	Under Voltage	0.415	kV	0.38	91.9	3-Phase
Jalikhar B6	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Kertshok B2	Bus	Under Voltage	0.415	kV	0.39	94.6	3-Phase
Kharchu Dtshang B1	Bus	Under Voltage	11.000	kV	10.33	93.9	3-Phase
Kharchu Dtshang B2	Bus	Under Voltage	0.415	kV	0.37	90.1	3-Phase
Kharchu Dtshang Tfr	Transformer	Overload	0.250	MVA	0.25	98.1	3-Phase
L.Jalikhar B1	Bus	Under Voltage	11.000	kV	10.39	94.5	3-Phase
L.Jalikhar B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
Lebi B1	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
Lebi B2	Bus	Under Voltage	0.415	kV	0.39	93.7	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Mitsithang B2	Bus	Under Voltage	0.415	kV	0.384	92.5	3-Phase
Nangar B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
Nasphel B1	Bus	Under Voltage	11.000	kV	10.19	92.6	3-Phase
Nasphel B2	Bus	Under Voltage	0.415	kV	0.38	90.8	3-Phase
Nimalung B2	Bus	Under Voltage	0.415	kV	0.39	94.5	3-Phase
Petselling Lkhang B1	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase
Petselling Lkhang B2	Bus	Under Voltage	0.415	kV	0.38	92.6	3-Phase
Phogo B2	Bus	Under Voltage	0.415	kV	0.38	91.3	3-Phase
Phrumthang B1	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
Rangbi B1	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Rangbi B2	Bus	Under Voltage	0.415	kV	0.38	91.3	3-Phase
Recycling Gpang B2	Bus	Under Voltage	0.415	kV	0.39	94.6	3-Phase
RNR-RC B1	Bus	Under Voltage	0.415	kV	0.38	92.6	3-Phase
RNR-RC SS B2	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
RNR-RC Station B2	Bus	Under Voltage	0.415	kV	0.39	94.0	3-Phase
Samteling B1	Bus	Under Voltage	0.415	kV	0.38	90.6	3-Phase
Sibjur B1	Bus	Under Voltage	11.000	kV	10.26	93.2	3-Phase
Sibjur B2	Bus	Under Voltage	0.415	kV	0.38	92.5	3-Phase
SixSense B1	Bus	Under Voltage	11.000	kV	10.24	93.1	3-Phase
SixSense B2	Bus	Under Voltage	0.415	kV	0.38	91.1	3-Phase
Takar B2	Bus	Under Voltage	0.415	kV	0.38	92.6	3-Phase
TCom B1	Bus	Under Voltage	11.000	kV	10.19	92.6	3-Phase
TCom B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
Tekarshong B1	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Tekarshong B2	Bus	Under Voltage	0.415	kV	0.38	91.1	3-Phase
Tgatshel B2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
Tharpaling B1	Bus	Under Voltage	11.000	kV	10.11	92.0	3-Phase
Tharpaling B2	Bus	Under Voltage	0.415	kV	0.38	91.5	3-Phase
Thromey B2	Bus	Under Voltage	0.415	kV	0.39	94.5	3-Phase
Town.P B1	Bus	Under Voltage	11.000	kV	10.10	91.8	3-Phase
Trasebee B1	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
U.Tharpaling B1	Bus	Under Voltage	11.000	kV	10.11	91.9	3-Phase
U.Tharpaling B2	Bus	Under Voltage	0.415	kV	0.38	91.4	3-Phase
UDee Tfr	Transformer	Overload	0.250	MVA	0.24	97.9	3-Phase
UG RNR-RC	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
UG.Batpal	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
UG.Tekar	Bus	Under Voltage	11.000	kV	10.371	94.3	3-Phase
Ugarling.R B1	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Urug B1	Bus	Under Voltage	0.415	kV	0.38	91.1	3-Phase
Wcholing B1	Bus	Under Voltage	11.000	kV	10.09	91.7	3-Phase
Wcholing B2	Bus	Under Voltage	0.415	kV	0.37	90.0	3-Phase
Wcholing Hosp. B1	Bus	Under Voltage	11.000	kV	10.11	91.9	3-Phase
Yamthra B2	Bus	Under Voltage	0.415	kV	0.39	94.7	3-Phase
Zhicha B	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Zhicha B1	Bus	Under Voltage	11.000	kV	10.12	92.0	3-Phase
Zhicha B2	Bus	Under Voltage	0.415	kV	0.38	91.9	3-Phase
Zhongphel B2	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
Zungey B2	Bus	Under Voltage	0.415	kV	0.39	93.4	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	6.618	4.419	7.958	83.16 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	6.618	4.419	7.958	83.16 Lagging
Total Motor Load:	1.458	0.904	1.715	85.00 Lagging
Total Static Load:	4.775	2.959	5.617	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.385	0.557		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure-5: Feeder Wise Reliability Indices

Sl.No.	Year	Reliability Indices	33 kV RNR Feeder	33 kV Tang Feeder	33 kV Ura Feeder	11 kV Chamkhar Feeder	11 kV Shuri - Kertshok Feeder	11 kV Batpalathang Feeder	11 kV Tekarshong Feeder	11 kV Dekeling Feeder	11 kV Chakar Feeder	11 kV Chekhor Feeder	11 kV Chumey Feeder	11 kV Gyetsa-Tharpaling Feeder	11 kV Colony-Nangay Feeder	11 kV Nangar Feeder
1	2017	SAIFI	0	0.8123	0	0.3	0.0226	0	0	0	0	0	0.18	0	0	0
		SAIDI	0	0.02243	0	0.0003	0.0442	0	0	0	0	0	0.0008	0	0	0
2	2018	SAIFI	0.442	0.668	1.381	1.898	2.452	0	0	0	0	0	0.184	0	0	0
		SAIDI	0.715	0.624	1.685	3.062	0.16	0	0	0	0	0	0.064	0	0	0
3	2019	SAIFI	0	0.83	0.27	1.75	0.03	0	0	0	0	0	0.19	0.45	0	0.09
		SAIDI	0	0.374	0.4	0.59	0.004	0	0	0	0	0	0.015	1.228	0	0.438
	Total *	**SAIFI**	**0.442**	**2.3103**	**1.651**	**3.948**	**2.5046**	**0**	**0**	**0**	**0**	**0**	**0.554**	**0.45**	**0**	**0.09**
		SAIDI	**0.715**	**1.02043**	**2.085**	**3.6523**	**0.2082**	**0**	**0**	**0**	**0**	**0**	**0.0798**	**1.228**	**0**	**0.438**
Average Reliability I			**SAIFI**	**0.854**	**SAIDI**	**0.673**										

Feeder Name: 33kV Tang Feeder

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				2		1							1	1		1	4
2	Line Jumpering														0													0
3	Collaps of Pole-Breakdown														0													0
4	Snap of Conductor														0													0
5	Puncture of insulator/Leakage				1										1													0
6	Puncture of LA/LA Maintenance					1									1													0
7	Ligtining & Strom/Rain														0													0
8	Tree/branch fall on line														0	1			1									2
9	RoW Clearing														0													0
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													0
13	Preventive Maintenance of substation/Switchyard														0													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB														0							1						1
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							1							1													0
21	Close and Open of GO/LBS		1				1								2						1		1					2
	SAIFI	**-**	**0.116**	**-**	**0.115**	**0.115**	**-**	**0.202**	**-**	**-**	**0.120**	**-**	**-**		**0.668**	**0.120**	**0.120**	**-**	**0.120**	**-**	**-**	**0.120**	**-**	**0.120**	**0.120**	**-**	**0.110**	**0.830**
	SAIDI	**-**	**0.012**	**-**	**0.186**	**0.130**	**-**	**0.016**	**-**	**-**	**0.280**	**-**	**-**		**0.624**	**0.230**	**0.030**	**-**	**0.160**	**-**	**-**	**0.110**	**-**	**0.050**	**0.010**	**-**	**0.010**	**0.600**

Feeder Name: 33kV RNR Feeder

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													0
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				2													0
9	RoW Clearing														0													0
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													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														0													0
20	Because of Bird/Animals														0													0
21	Close and Open of GO/LBS							1			1				2					1					1			2
	SAIFI	**-**	**-**	**-**	**-**	**-**	**-**	**0.143**	**-**	**-**	**0.229**	**-**	**-**		**0.372**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	SAIDI	**-**	**-**	**-**	**-**	**-**	**-**	**0.715**	**-**	**-**	**0.000**	**-**	**-**		**0.715**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Feeder Name: 33kV Ura Feeder

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		2						1		1					2
2	Line Jumpering								1			1			2													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								1					1
7	Ligtining & Strom/Rain														0													0
8	Tree/branch fall on line														0													0
9	RoW Clearing												1		1													0
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													0
13	Preventive Maintenance of substation/Switchyard														0			1										1
14	Breakdown Maintenance of Line/LBS/GO/ARCB									1					1													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										1				1													0
21	Close and Open of GO/LBS											1			1					1								1
	SAIFI	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.910**	**0.091**	**0.200**	**0.090**	**0.090**		**1.381**	**-**	**-**	**0.090**	**-**	**-**	**0.090**	**-**	**0.090**	**-**	**-**	**-**	**-**	**0.270**
	SAIDI	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.980**	**0.064**	**0.101**	**0.510**	**0.030**		**1.685**	**-**	**-**	**0.230**	**-**	**-**	**0.030**	**-**	**0.140**	**-**	**-**	**-**	**-**	**0.400**

Feeder Name: 11kV Chamkhar Feeder																												
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				1	1		1			5
2	Line Jumpering							1							1													0
3	Collaps of Pole-Breakdown														0													0
4	Snap of Conductor														0													0
5	Puncture of insulator/Leakage			1											1													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					1								1
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0			1										1
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)					1									1													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					1				1		1			3		1				1				1			3
	SAIFI	**-**	**-**	**0.510**	**-**	**0.508**	**-**	**0.370**	**-**	**0.510**	**-**	**-**	**-**		**1.898**	**-**	**0.300**	**0.290**	**-**	**0.290**	**-**	**0.290**	**0.290**	**-**	**0.290**	**-**	**-**	**1.750**
	SAIDI	**-**	**-**	**2.600**	**-**	**0.422**	**-**	**0.020**	**-**	**0.020**	**-**	**-**	**-**		**3.062**	**-**	**0.170**	**0.110**	**-**	**0.110**	**-**	**0.080**	**0.010**	**-**	**0.040**	**-**	**-**	**0.520**

Feeder Name: 11kV Shuri-Kertshok Feeder

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
2	Line Jumpering														0													0
3	Collaps of Pole-Breakdown									1					1													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														0													0
9	RoW Clearing					1	1								2				1									1
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													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														0													0
20	Because of Bird/Animals		1												1													0
21	Close and Open of GO/LBS										1				1					1								1
	SAIFI	**-**	**0.012**	**-**	**-**	**1.220**	**1.220**	**-**	**-**	**0.010**	**-**	**-**	**-**	**-**	**2.462**	**-**	**-**	**-**	**0.010**	**-**	**-**	**0.010**	**-**	**-**	**0.010**	**-**	**-**	**0.030**
	SAIDI	**-**	**0.016**	**-**	**-**	**0.074**	**0.070**	**-**	**-**	**0.003**	**-**	**-**	**-**	**-**	**0.163**	**-**	**-**	**-**	**0.001**	**-**	**-**	**0.002**	**-**	**-**	**0.001**	**-**	**-**	**0.004**

Feeder Name: 11kV chumey Feeder

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													0
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														0													0
9	RoW Clearing														0													0
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													0
13	Preventive Maintenance of substation/Switchyard														0				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)					1									1													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								1						1								1					1
	SAIFI	-	-	-	-	**0.184**	-	-	-	-	-	-	-	-	**0.184**	-	-	-	**0.190**	-	-	-	-	-	-	-	-	**0.190**
	SAIDI	-	-	-	-	**0.064**	-	-	-	-	-	-	-	-	**0.064**	-	-	-	**0.015**	-	-	-	-	-	-	-	-	**0.015**

Feeder Name: 11kV Gyetsa-Tharpaling Feeder

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														0													0
9	RoW Clearing														0													0
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0								1					1
13	Preventive Maintenance of substation/Switchyard														0													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB														0				1									1
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
	SAIFI	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.150**	**-**	**-**	**-**	**0.150**	**-**	**0.150**	**-**	**-**	**0.450**
	SAIDI	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.100**	**-**	**-**	**-**	**0.258**	**-**	**0.870**	**-**	**-**	**1.228**

Feeder Name: 11kV Nangar Feeder

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													0
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														0													0
9	RoW Clearing														0						1	1						2
10	Land Slide														0													0
11	Forest fire														0													0
12	Preventive Maintenance of Line/LBS/GO/ARCB														0													0
13	Preventive Maintenance of substation/Switchyard														0										1			1
14	Breakdown Maintenance of Line/LBS/GO/ARCB														0							1						1
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
	SAIFI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.030**	**0.030**	-	-	**0.030**	-	-	**0.090**
	SAIDI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.030**	**0.004**	-	-	**0.404**	-	-	**0.438**

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

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

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

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

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

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

Annexure-7: Distribution Transformer Loading

Sl.No.	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**	Peak Load (I)	Peak Load (kVA)**					
				2019-2020	2019-2020	2019-2020	% Loading	2025	% Loading	2030(kVA)	% Loading
								2576.47		3235.29	
								0.48		0.86	
11 kV Chamkhar Feeder								1.48		1.86	
1	Garpang Waste Management, Bumthang	11/0.415kV	63	4.456	6.200	4.456	7.07%	6.59	10.46%	8.3	13.14%
2	Yugarling, Chamkhar, Bumthang	11/0.415kV	500	109.113	151.803	109.113	21.82%	161.37	32.27%	202.6	40.53%
3	BOD, Chamkhar, Bumthang	11/0.415kV	160	120.220	79.533	120.220	75.14%	177.79	111.12%	223.3	139.54%
4	Chamkhar Town, Bumthang	11/0.415kV	500	495.340	387.933	495.340	99.07%	732.56	146.51%	919.9	183.98%
5	Wangdicholing School, Bumthang	11/0.415kV	160	72.932	101.467	72.932	45.58%	107.86	67.41%	135.4	84.65%
6	Udee, Chamkhar, Bumthang	11/0.415kV	250	160.120	155.617	160.120	64.05%	236.80	94.72%	297.4	118.94%
7	Gakiling,Bumthang	11/0.415kV	250	127.000	129.507	127.000	50.80%	187.82	75.13%	235.8	94.34%
8	Lower Jalikhar	11/0.415kV	160	48.254	67.133	48.254	30.16%	71.36	44.60%	89.6	56.01%
9	Jalikhar	11/0.415kV	250	87.500	53.967	87.500	35.00%	129.40	51.76%	162.5	65.00%
10	Gongkhar	11/0.415kV	125	31.200	43.407	31.200	24.96%	46.14	36.91%	57.9	46.35%
11	Gangrithang	11/0.415kV	125	120.276	167.333	120.276	96.22%	177.88	142.30%	223.4	178.69%
12	Jakar Dzong	11/0.415kV	315	151.200	149.000	151.200	48.00%	223.61	70.99%	280.8	89.14%
13	Jakar HSS	11/0.415kV	125	25.636	35.667	25.636	20.51%	37.91	30.33%	47.6	38.09%
14	Lamaythang	11/0.415kV	63	12.435	17.300	12.435	19.74%	18.39	29.19%	23.1	36.65%
15	Lower Lamay Goenpa	11/0.415kV	25	1.466	2.040	1.466	5.86%	2.17	8.67%	2.7	10.89%
16	Lamay Goenpa	11/0.415kV	500	175.000	103.467	175.000	35.00%	258.81	51.76%	325.0	65.00%
			3571	**1742.149**							
								64.71		75.29	
11 kV Tekarshong Feeder				**2347.696**				0.48		0.72	
								1.48		1.72	
1	Tekarshong, Bumthang	11/0.415kV	25	13.273	18.467	13.273	53.09%	19.67	78.67%	22.89	91.54%
2	Tashibethang, Bumthang	11/0.415kV	63	14.237	19.807	14.237	22.60%	21.09	33.48%	24.55	38.96%
3	Padseling, Bumthang	11/0.415kV	63	16.161	22.483	16.161	25.65%	23.94	38.01%	27.86	44.23%
			151	**43.671**							
								1170.59		1623.53	
								0.17		0.62	
11 kV Dekeling Feeder								1.17		1.62	
1	Nasphel, Bumthang	11/0.415kV	125	41.435	57.647	41.435	33.15%	48.33	38.67%	67.03	53.63%
2	Dekiling, Bumthang	11/0.415kV	250	150.000	169.433	150.000	60.00%	174.97	69.99%	242.67	97.07%
3	Wangdicholling Hospital	11/0.415kV	125	81.845	113.867	81.845	65.48%	95.47	76.37%	132.41	105.93%
4	Wangdicholling	11/0.415kV	500	154.490	214.933	154.490	30.90%	180.21	36.04%	249.93	49.99%
5	Aumankora substation.	11/0.415kV	500	200.000	118.733	200.000	40.00%	233.29	46.66%	323.56	64.71%
6	Jachungthang	11/0.415kV	160	40.000	18.573	40.000	25.00%	46.66	29.16%	64.71	40.44%
7	Telecom	11/0.415kV	500	107.817	150.000	107.817	21.56%	125.76	25.15%	174.43	34.89%
8	Dekeling Town	11/0.415kV	25	25.000		25.000	100.00%	29.16	116.65%	40.44	161.78%
9	RNR	11/0.415kV	63	17.010	13.100	17.010	27.00%	19.84	31.49%	27.52	43.68%
10	Airport	11/0.415kV	63	9.946	13.837	9.946	15.79%	11.60	18.41%	16.09	25.54%
11	Six Sense	11/0.415kV	500	176.000		176.000	35.20%	205.30	41.06%	284.73	56.95%
			2811	**1003.543**							
								329.41		434.12	
				1186.663				0.32		0.74	
11 kV Chakar Feeder								1.32		1.74	
1	Kurjee	11/0.415kV	250	60.378	84.000	60.378	24.15%	79.54	31.82%	104.83	41.93%
2	Chakar	11/0.415kV	250	125.000	60.393	125.000	50.00%	164.68	65.87%	217.02	86.81%
3	Tashigatshel	11/0.415kV	63	28.770	40.027	28.770	45.67%	37.90	60.16%	49.95	79.29%
4	Tamzhing	11/0.415kV	160	35.200	7.713	35.200	22.00%	46.37	28.98%	61.11	38.20%
5	Drakar choling	11/0.240kV	**63**	0.696	2.900	0.696	1.10%	0.92	1.46%	1.21	1.92%
			786	**250.044**							
								594.12		703.53	
				447.302				2.30		2.90	

Sl.No.	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**	Peak Load (I)	Peak Load (kVA)**					
				2019-2020	2019-2020	2019-2020	% Loading	2025	% Loading	2030(kVA)	% Loading
33 kV Tang Feeder								3.30		3.90	
1	Suzubigang	33/0.415kV	63	10.741	14.943	10.741	17.05%	35.39	56.18%	41.91	66.52%
2	Phomrong	33/0.415kV	63	9.493	13.207	9.493	15.07%	31.28	49.65%	37.04	58.79%
3	Dorjitse gonpa	33/0.240kV	16	2.322	3.230	2.322	14.51%	7.65	47.81%	9.06	56.62%
4	Dechenpelrithang	33/0.415kV	100	12.150	16.903	12.150	12.15%	40.03	40.03%	47.41	47.41%
5	Bebzur	33/0.415kV	63	8.573	11.927	8.573	13.61%	28.25	44.84%	33.45	53.10%
6	Ane DrasangTang	33/0.415kV	63	14.428	20.073	14.428	22.90%	47.54	75.47%	56.30	89.36%
7	Zhongphel	33/0.415kV	30	10.729	14.927	10.729	35.76%	35.35	117.84%	41.86	139.55%
8	Kuenzangdra	33/0.415kV	30	1.959	2.725	1.959	6.53%	6.45	21.51%	7.64	25.48%
9	Pangshing	33/0.415kV	63	7.552	10.507	7.552	11.99%	24.88	39.50%	29.47	46.77%
10	Jamshong	33/0.415kV	30	2.379	3.310	2.379	7.93%	7.84	26.13%	9.28	30.94%
11	Mesithang	33/0.415kV	100	52.782	73.433	52.782	52.78%	173.92	173.92%	205.95	205.95%
12	Tasur	33/0.415kV	30	1.109	1.543	1.109	3.70%	3.66	12.18%	4.33	14.43%
13	Pralang	33/0.415kV	30	3.378	4.700	3.378	11.26%	11.13	37.11%	13.18	43.94%
14	Lower Nimalung	33/0.415kV	30	2.041	2.840	2.041	6.80%	6.73	22.42%	7.97	26.55%
15	Upper Nimalung	33/0.415kV	63	2.089	2.907	2.089	3.32%	6.88	10.93%	8.15	12.94%
16	Kizom	33/0.415kV	63	3.050	4.243	3.050	4.84%	10.05	15.95%	11.90	18.89%
17	Sermith	33/0.415kV	63	0.963	1.340	0.963	1.53%	3.17	5.04%	3.76	5.97%
18	Ugyencholing	33/0.415kV	63	17.010	16.100	17.010	27.00%	56.05	88.97%	66.37	105.35%
19	Khangrab	33/0.415kV	100	11.000	5.533	11.000	11.00%	36.25	36.25%	42.92	42.92%
20	Benzibi	33/0.415kV	25	0.791	1.100	0.791	3.16%	2.61	10.42%	3.09	12.34%
21	Wabthang	33/0.415kV	25	0.707	0.983	0.707	2.83%	2.33	9.32%	2.76	11.03%
22	Tandinggang	33/0.415kV	63	2.132	2.967	2.132	3.38%	7.03	11.15%	8.32	13.21%
23	Thangna goenpa	33/0.415kV	25	0.192	0.267	0.192	0.77%	0.63	2.53%	0.75	2.99%
24	Namkey	33/0.415kV	25	1.100	1.530	1.100	4.40%	3.62	14.50%	4.29	17.16%
25	Chutey	33/0.415kV	25	1.224	1.703	1.224	4.90%	4.03	16.14%	4.78	19.11%
26	Thowadra	33/0.240kV	16	0.408	1.700	0.408	2.55%	1.34	8.40%	1.59	9.95%
			1267	**180.302**							
								278.82		385.88	
								1.00		1.77	
11 kV Batpala Feeder								2.00		2.77	
1	Bathpalathang	11/0.415kV	160	35.699	49.667	35.699	22.31%	71.38	44.61%	98.79	61.74%
2	Lebi	11/0.415kV	125	3.750	0.610	3.750	3.00%	7.50	6.00%	10.38	8.30%
3	Kharchu	11/0.415kV	250	100.000	53.500	100.000	40.00%	199.95	79.98%	276.72	110.69%
			8078	**139.449**							
								254.12		272.94	
								0.29		0.38	
11 KV Chokor Feeder								1.29		1.38	
1	Pangri	11/0.415kV	125	4.325	6.017	4.325	3.46%	5.57	4.46%	5.98	4.79%
2	Dorjibee	11/0.415kV	63	1.965	2.733	1.965	3.12%	2.53	4.02%	2.72	4.32%
3	Zangtherpo	11/0.415kV	63	13.226	18.400	13.226	20.99%	17.04	27.04%	18.30	29.05%
4	Tokto Zampa	11/0.415kV	16	2.595	3.610	2.595	16.22%	3.34	20.89%	3.59	22.44%
5	Trongmanba	11/0.240kV	10	9.653	13.430	9.653	96.53%	12.44	124.36%	13.36	133.57%
6	Menchugang BHU	11/0.415kV	63	5.218	7.260	5.218	8.28%	6.72	10.67%	7.22	11.46%
7	Lusbee	11/0.415kV	25	4.571	6.360	4.571	18.29%	5.89	23.56%	6.33	25.30%
8	Lower Dhur	11/0.415kV	125	17.754	24.700	17.754	14.20%	22.87	18.30%	24.57	19.65%
9	Upper Dhur	11/0.415kV	63	5.434	7.560	5.434	8.63%	7.00	11.11%	7.52	11.93%
10	Thangbi	11/0.415kV	63	8.915	12.403	8.915	14.15%	11.49	18.23%	12.34	19.58%
11	Goling	11/0.415kV	25	4.135	5.753	4.135	16.54%	5.33	21.31%	5.72	22.89%
12	Kharsa	11/0.415kV	63	13.549	18.850	13.549	21.51%	17.45	27.71%	18.75	29.76%
13	Lower Zhukdrag	11/0.415kV	25	4.222	5.873	4.222	16.89%	5.44	21.75%	5.84	23.37%
14	Ugyen Zhabjeyhang	11/0.240kV	25	2.487	3.460	2.487	9.95%	3.20	12.82%	3.44	13.76%
15	Dogrong	11/0.415kV	25	22.725	31.617	22.725	90.90%	29.28	117.10%	31.44	125.78%
16	Sangsangma	11/0.415kV	63	10.568	14.703	10.568	16.78%	13.61	21.61%	14.62	23.21%
17	Zhabjithang	11/0.415kV	63	13.230	10.123	13.230	21.00%	17.04	27.05%	18.31	29.06%
18	WCP	11/0.415kV	25	4.615	6.420	4.615	18.46%	5.94	23.78%	6.39	25.54%
19	Nasiphel	11/0.415kV	63	8.755	12.180	8.755	13.90%	11.28	17.90%	12.11	19.23%
20	Kuenzangcholing	11/0.415kV	25	5.690	7.917	5.690	22.76%	7.33	29.32%	7.87	31.49%
21	Khag thang	11/0.415kV	100	25.000	9.533	25.000	25.00%	32.21	32.21%	34.59	34.59%
22	Samthang	11/0.415kV	25	5.432	7.557	5.432	21.73%	7.00	27.99%	7.52	30.06%
23	Tashiling	11/0.415kV	16	3.194	4.443	3.194	19.96%	4.11	25.71%	4.42	27.62%
			17315	**197.258**							
								791.76		1109.41	
								0.08		0.51	
11 kV Gyetsa-Tharpaling Feeder								1.08		1.51	
1	Gyetsa Lower Secondary School	11/0.415kV	250	225.000	17.563	225.000	90.00%	243.06	97.23%	311.33	124.53%
2	Samteling	11/0.415kV	16	4.800	0.760	4.800	30.00%	5.19	32.41%	6.64	41.51%
3	Chukdark	11/0.415kV	63	7.784	10.830	7.784	12.36%	8.41	13.35%	10.77	17.10%
4	Tharpaling	11/0.415kV	63	6.300	2.137	6.300	10.00%	6.81	10.80%	8.72	13.84%
5	Rangbi	11/0.415kV	16	2.221	3.090	2.221	13.88%	2.40	15.00%	3.07	19.21%
6	Urug	11/0.415kV	63	12.600	1.427	12.600	20.00%	13.61	21.61%	17.43	27.67%
7	Bulli	11/0.415kV	16	7.276	10.123	7.276	45.48%	7.86	49.13%	10.07	62.93%
8	Gyetsa Village	11/0.415kV	63	8.530	11.867	8.530	13.54%	9.21	14.63%	11.80	18.73%
9	Pangri	11/0.240kV	10	0.161	0.670	0.161	1.61%	0.17	1.74%	0.22	2.22%
10	Zhicha	11/0.415kV	25	0.587	0.817	0.587	2.35%	0.63	2.54%	0.81	3.25%
11	Domkhar Palace	11/0.415kV	250	75.000	13.230	75.000	30.00%	81.02	32.41%	103.78	41.51%
12	Domkhar Village	11/0.415kV	250	62.500	17.797	62.500	25.00%	67.52	27.01%	86.48	34.59%
13	Yotola	33/0.415kV	16	3.659	5.090	3.659	22.87%	3.95	24.70%	5.06	31.64%
14	TTI	11/0.415kV	500	150.000	6.570	150.000	30.00%	162.04	32.41%	207.55	41.51%
15	Sibjur	11/0.415kV	63	9.450	1.707	9.450	15.00%	10.21	16.20%	13.08	20.76%
16	Hurchi Telecom	11/0.415kV	25	0.774	1.077	0.774	3.10%	0.84	3.34%	1.07	4.28%
17	Phrumthang	11/0.415kV	250	62.500	33.900	62.500	25.00%	67.52	27.01%	86.48	34.59%
18	Yamthra	11/0.415kV	63	19.239	26.767	19.239	30.54%	20.78	32.99%	26.62	42.26%
19	Thromey	11/0.415kV	63	11.333	15.767	11.333	17.99%	12.24	19.43%	15.68	24.89%
20	Aungsang	11/0.415kV	16	3.762	5.233	3.762	23.51%	4.06	25.40%	5.20	32.53%
21	Chudaypang	11/0.415kV	63	9.450	5.633	9.450	15.00%	10.21	16.20%	13.08	20.76%
22	Chumey High School	11/0.415kV	250	50.000	14.833	50.000	20.00%	54.01	21.61%	69.18	27.67%
			2394	**732.925**							
								150.59		217.65	
								1.34		2.39	

Sl.No.	DT Location Name	Transformer Ratio	kVA Rating	Peak Load (kVA)**	Peak Load (I)	Peak Load (kVA)**					
				2019-2020	2019-2020	2019-2020	% Loading	2025	% Loading	2030(kVA)	% Loading
11 kV Nangar Feeder								2.34		3.39	
1	Nangar	11/0.415kV	63	14.543	20.233	14.543	23.08%	34.10	54.12%	49.28	78.22%
2	Takar	11/0.415kV	16	5.786	8.050	5.786	36.16%	13.57	84.79%	19.61	122.54%
3	Zungay	11/0.415kV	63	18.900	11.240	18.900	30.00%	44.31	70.34%	64.04	101.66%
4	Nimalung	11/0.415kV	125	25.000	10.400	25.000	20.00%	58.61	46.89%	84.71	67.77%
			267	**64.229**							
								14.12		17.65	
								0.73		1.17	
11 kV BPC Colony Feeder								1.73		2.17	
1	Bpc Colony	11/0.415kV	16	4.785	6.657	4.785	29.90%	8.30	51.87%	10.37	64.84%
2	Nangay	11/0.415kV	25	3.354	4.667	3.354	13.42%	5.82	23.27%	7.27	29.09%
			41	**8.139**		8.139					
								103.53		125.88	
								2.64		3.42	
11 kV Shuri-Kertshok Feeder								3.64		4.42	
1	Kikila	11/0.415kV	25	1.174	1.633	1.174	4.70%	4.27	17.09%	5.19	20.78%
2	Bhim	11/0.230kV	25	0.153	0.667	0.153	0.61%	0.56	2.23%	0.68	2.71%
3	Yerangbi	11/0.230kV	25	1.104	4.800	1.104	4.42%	4.02	16.07%	4.89	19.54%
4	Shuri	11/0.230kV	25	3.750	1.533	3.750	15.00%	13.65	54.59%	16.59	66.37%
5	Chungphel	11/0.230kV	25	0.337	1.467	0.337	1.35%	1.23	4.91%	1.49	5.97%
6	khertshok	11/0.415kV	25	2.000	1.167	2.000	8.00%	7.28	29.11%	8.85	35.40%
7	Chenrizithang	11/0.415kV	16	1.030	1.433	1.030	6.44%	3.75	23.43%	4.56	28.49%
8	Phogo	11/0.415kV	63	18.900	6.033	18.900	30.00%	68.78	109.17%	83.63	132.75%
			229	**28.449**							
								1290.59		1336.47	
								0.21		0.25	
								1.21		1.25	
9	Jayungthang	11/0.415kV	63	3.136	4.363	3.136	4.98%	3.80	6.03%	3.93	6.24%
			63	**1066.136**		1066.136					
								404.71		545.88	
								0.02		0.38	
33 kV Ura Feeder								1.02		1.38	
1	Shingkhar	33/0.415 KV	125	15.911	22.137	15.911	12.73%	16.23	12.98%	21.89	17.51%
2	Somrong Village	6.6/0.400KV	25	5.300	4.300	5.300	21.20%	5.41	21.62%	7.29	29.17%
3	Tangsibi NWF	33/0.400KV	25	1.294	1.800	1.294	5.18%	1.32	5.28%	1.78	7.12%
4	Thrumsingla N/Park	6.6/0.415KV	30	14.167	19.710	14.167	47.22%	14.45	48.17%	19.49	64.97%
5	Tangsibi Village	33/0.415KV	125	43.750	24.300	43.750	35.00%	44.62	35.70%	60.19	48.15%
6	Tangsibi Upper	33/0.415KV	63	9.450		9.450	15.00%	9.64	15.30%	13.00	20.64%
7	Trashigadhen	33/0.230	10	0.069	0.300	0.069	0.69%	0.07	0.70%	0.09	0.95%
8	Tralingthang	6.6/0.415	50	3.067	4.267	3.067	6.13%	3.13	6.26%	4.22	8.44%
9	Khekharthe	6.6/0.415	50	2.803	3.900	2.803	5.61%	2.86	5.72%	3.86	7.71%
10	Ura Center School 1	6.6/0.415	50	23.768	33.067	23.768	47.54%	24.24	48.48%	32.70	65.40%
11	Ura Center School 2	6.6/0.415	16	3.666	5.100	3.666	22.91%	3.74	23.37%	5.04	31.52%
12	Yurgang	6.6/0.415	50	14.076	19.583	14.076	28.15%	14.36	28.71%	19.36	38.73%
13	Lower Pangkhar	6.6/0.415	30	3.752	5.220	3.752	12.51%	3.83	12.76%	5.16	17.21%
14	Wangthang Gonpa	6.6/0.415	30	1.294	1.800	1.294	4.31%	1.32	4.40%	1.78	5.93%
15	Upper Pangkhar	6.6/0.415	30	1.500	0.727	1.500	5.00%	1.53	5.10%	2.06	6.88%
16	Shamzar	33/0.230	10	0.300	0.100	0.300	3.00%	0.31	3.06%	0.41	4.13%
17	Ura Village	33/0.415	160	44.800	27.967	44.800	28.00%	45.69	28.56%	61.63	38.52%
18	Shetangla	33/0.415	25	10.580	14.720	10.580	42.32%	10.79	43.17%	14.56	58.22%
19	BHU	33/0.415	125	34.430	47.900	34.430	27.54%	35.12	28.09%	47.37	37.89%
20	Shingneer	33/0.415	125	12.818	17.833	12.818	10.25%	13.07	10.46%	17.63	14.11%
21	Kharamphey	33/0.415	250	150.000		150.000	60.00%	152.99	61.20%	206.36	82.54%
			1404	**396.795**							
								7715.29		9980.00	
								1.03		1.62	
33 kV incomer form Kewathang/Yurmong								2.03		2.62	
1	Yotola	33/0.415	**16**	**8.000**		8.000	50.00%	2.07	12.92%	20.97	131.04%
				3808.000				4.00		4.59	
								1.00		1.29	
								2.00		2.29	
	Garpang Station 1	11/0415	**250**	**2.000**		2.000	0.80%	4.00	1.60%	4.59	1.84%
				2.000				30.59		34.12	
								0.18		0.31	
								1.18		1.31	
	Garpang Station 2	11/0415	**250**	**26.000**		26.000	10.40%	30.59	12.24%	34.12	13.65%
			500	**26.000**							
								5.88		7.06	
								0.47		0.76	
								1.47		1.76	
	Dawathang Station	11/0.415	**63**	**4.000**		4.000	6.35%	5.88	9.34%	7.06	11.20%
								4.71		5.88	
								0.07		0.34	
								1.07		1.34	
	RNR-RC Station	11/0.415	**63**	**4.400**		4.400	6.98%	4.71	7.47%	5.88	9.34%
								4.47		5.06	
								0.15		0.30	
								1.15		1.30	
	Power House switch yard(station)	11/0.415	**50**	**3.900**		3.900	7.80%	4.47	8.94%	5.06	10.12%

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**