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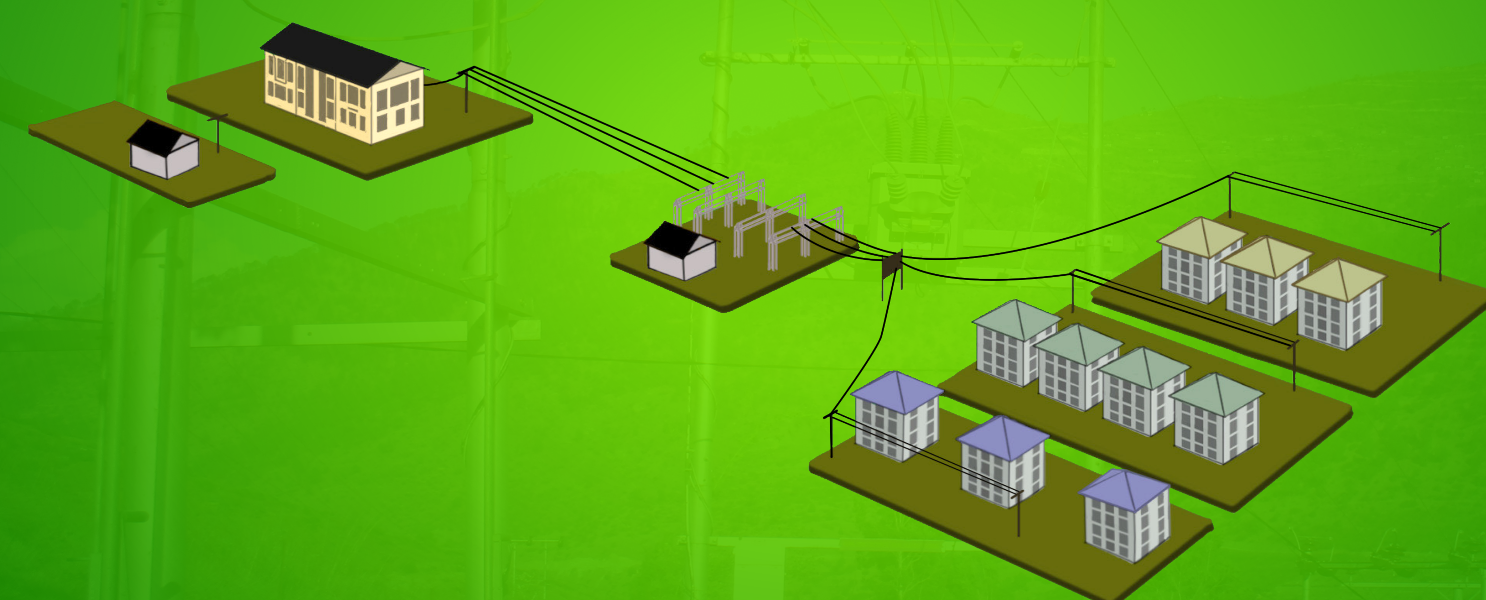
DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

HAA 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Outage - Interruption of service to an electric consumer.

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

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

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

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

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

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

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

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

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

Power supply - Source of current and voltage.

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

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

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

1. Executive Summary

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

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

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

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

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

2. Introduction

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

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

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

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

3. Objectives of the Master Plan

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

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

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

3.3 To come out with annual investment plans.

4. Scope of the Distribution System Master Plan

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

5. Methodology and Approach

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

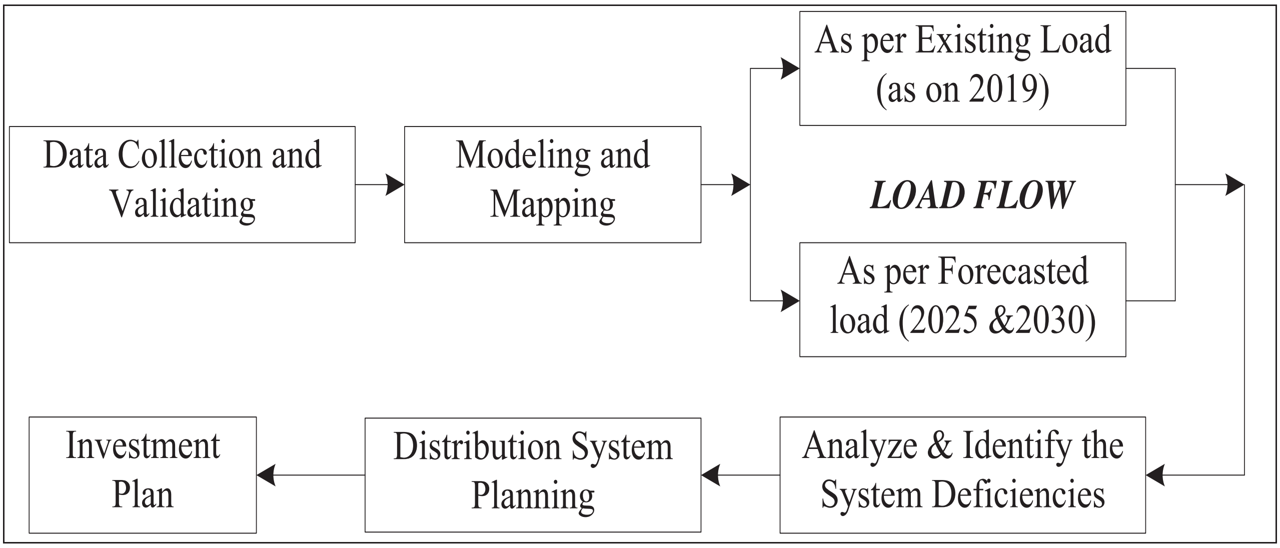


Figure 1: Block Diagram for Distribution System Planning for Thematic Studies

5.1 Data Collection and Validation

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

5.2 Modeling and Mapping

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

5.3 Analysis and Identification of System Deficiencies

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

5.4 Distribution System Planning

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

5.5 Investment Plan

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

6. Existing Electricity Distribution Network

6.1 Overview of the Power Supply Sources of Haa Dzongkhag

Haa Dzongkhag comprises of six (6) Gewogs (Katsho, Uesu, Bji, Samar, Sombaykha, and Gakiling). The power supply to Haa Dzongkhag is met from Wangtsa and Watsa substations. The 2x5 MVA, 66/11 kV Wangtsa substation is connected to the western transmission grid via a 66 kV line from the Chumdo switching station. This substation has five 11 kV feeders. One of the feeders connects with the 33/11kV Jenkana substation at 11 kV voltage level.

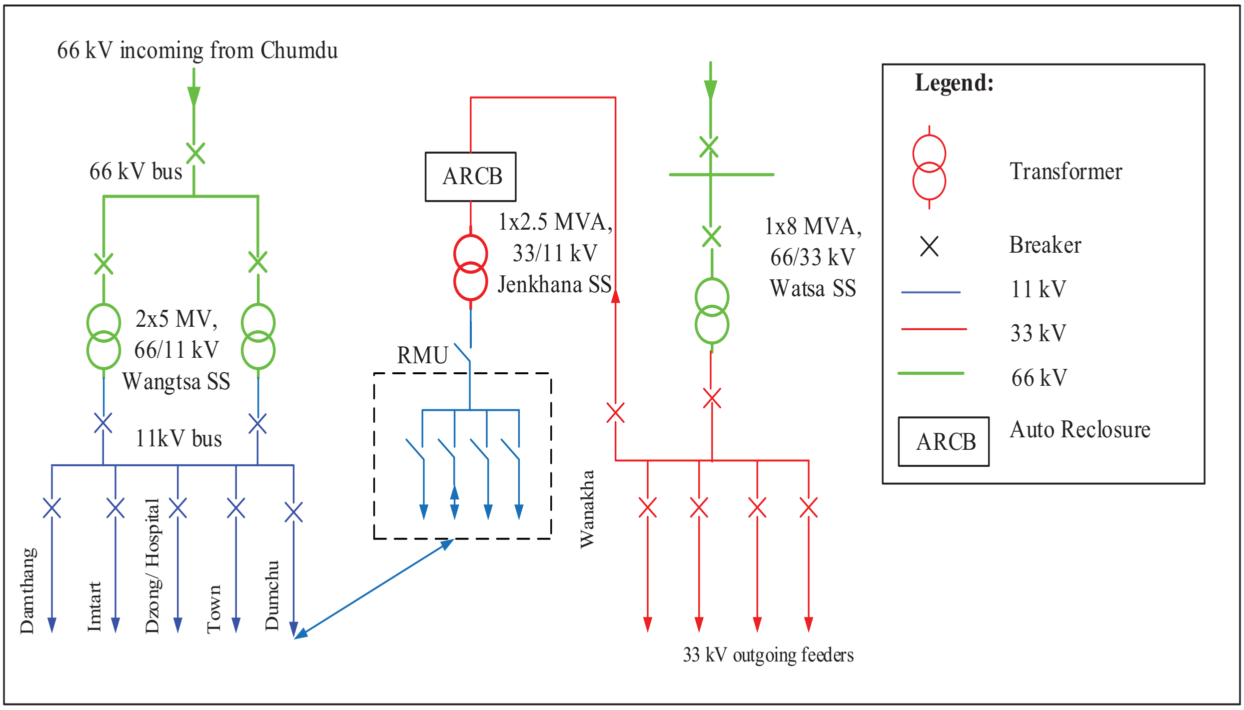


Figure 2: Electricity distribution schematic of Haa dzongkhag

Similarly, the 66/33 kV Watsa substation is fed by a single 66 kV feeder from the Chumdo switching station. It has a capacity of 8 MVA and two 33kV outgoing feeders catering to the load of Chapcha (Chukha) and Wanaka (Paro). The 33 kV Wanaka feeder is also the primary source for 2.5 MVA, 33/11 kV Jenekana substation. The Watsa substation recorded a peak load of 5.629 MW in 2017. However, after the commissioning of the Pangbesa substation, the load of Paro was segregated and was fed from Pangbesa. Currently, the load at the Watsa substation is around 0.79 MW only.

The power supply to the customers of Sombaykha and Gakidling Gewogs is fed from a 33 kV Dorokha feeder which is sourced from 220/66/33 kV, Dhamdum substation. The schematic diagram for the existing electricity distribution network is exhibited in **Figure 2**.

6.2 Electricity Distribution Lines

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

Table 1: MV and LV line details of ESD Haa

Sl. No.	33 kV (km)		11 kV (km)		Total MV Length (km)	LV lines (km)		Total LV Length (km)
	OH	UG	OH	UG		OH	UG	
1	93.414	-	60.94	0.743	**155.16**	218.125	1.642	**219.768**

The total MV line length is 155.16 km and the total LV line length is 219.768 km. The ratio of LV to MV line length is 1.42:1 which reflects a high proportion of power distribution through LV distribution lines. While the ratio of LV to MV line length would vary according to the site conditions, as a general thumb rule, a network ratio of 1.2:1 (LV to MV) should be maintained for optimum initial capex and the running and maintenance costs. The MV distribution network is mainly through 33kV and 11kV overhead lines.

6.3 Distribution Transformers

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

Table 2: Total numbers of transformers and installed capacity

Source	Capacity (MVA)	Name of Feeder	Feeder Length (km)	DTs (Nos.)	Connected (kVA)
66/11kV Wangtsa SS	2x15	11kV Dumchu	34.146	31	1947
		11kV IMTART	3.333	7	1761
		11kV Hospital & Adm	0.650	2	1750
		11 kV Bazar feeder	2.195	4	2315
		11kV Damthang	20.794	23	4379
66/33 kV Dhamdhum	2x5	33 kV Sombyakha	42.452	35	638
66/33 Watsa SS	1x8	33 kV Wanakha	51.081	31	1835
Total			**155.16**	**133**	**14,625**

Till July 2020, there were 133 distribution transformers with a total installed capacity of 14,625kVA. As evidenced from **Table 2,** the installed capacity of the transformer per customer is 3.56 kVA (4,110 customers as of July 2020)

7. Analysis of the Existing System

Based on the model developed in ETAP for the existing 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

The 66/11kV Wangtsa substation is the primary power source for Haa Dzongkhag. The substation has an installed capacity of 2x5 MVA. Additionally, the Haa Dzongkhag has access to 8 MVA, 66/33 kV Watsa substation via Jenkana substation.

Table 3: HV Power Sources

Sl. No	Name of Source SS	Voltage Level	Installed Capacity		Peak Load(MW)	Forecasted Peak Load (MW)	
			MVA	MW*	2019	2025	2030
1	Wangtsa	66/11	2x5	8.50	2.92	3.10	3.23
2	Watsa	66/33	1x8	6.80	0.79	0.85	0.90

* *Power Factor of 0.85 is considered for study purpose*

From the above table, it is conclusive that both the substations have adequate capacity to meet the present and forecasted electricity demand.

7.1.2 MV Substation (33/11 kV)

The 2.5 MVA, 33/11 kV Jenkana substation is an alternate source for Haa Dzongkhag in the event of power interruption in 66 kV incomer from Chumdo to the Wangtsa substation. The peak load recorded for Wangtsa substation in 2019-20 is 2.92 MW. With the forecasted load of 3.10MW & 3.23 MW by 2025 and 2030 respectively, the Wangtsa substation would be adequate. However, it is imperative that the Jenkana substation needs up-gradation should there be power interruption from 66kV incomer from Chumdo or any maintenance to be carried out at the Wangtse substation.

7.2 Assessment of MV Feeders

Feeder wise planning is necessary to ensure that the power delivery capacity, power quality, and reliability requirements of the customers are met. In 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 HV substations at Wangtsa and Watsa 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 **Figure 3.**

Table 4: Feeder wise peak power demand of ESD Haa

Sl. No.	Name of Feeder	Peak Load Consumption Pattern (MW)					
		2014	2015	2016	2017	2018	2019
1	33 kV O/G Feeder I (Shemagangkha/Wanakha/Dawakha)	1.09	3.32	3.13	3.83	4.53	0.49
2	11kV Outgoing-I (Dumchu)	0.55	0.68	0.61	0.62	0.59	0.67
3	11kV Outgoing-II (IMTRAT)	1.00	1.03	1.03	0.93	0.93	0.93
4	11kV Outgoing-III (Hospital/New Adm. Block)					0.28	0.30
5	11kV Outgoing-IV (Bazar)	0.46	0.52	0.57	0.57	0.44	0.47
6	11kV Outgoing-V (Damthang)	0.88	1.00	1.14	1.09	1.17	1.17

Source: Monthly Substation Data of TD, BPC

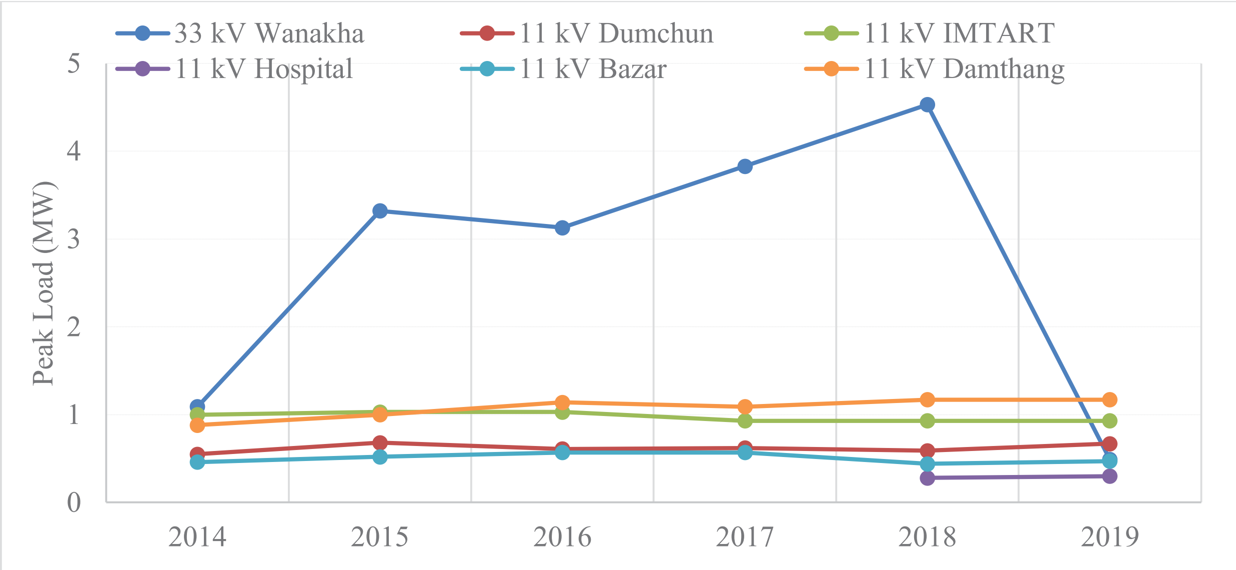


Figure 3: Electricity consumption peak load trend of Haa

As can be inferred from the plot of feeder-wise historical peak load, the peak load growth pattern is irregular which may be due to interconnections and data anomalous to some extent.

The 33kV Feeder I (Shemagangkha/Wanakha/Dawakha) has been catering to the power supply of Dawakha of Paro, Wananakha of Haa, and Shemagangkha of Chukha from 2015-2018. The peak load ranged from 3-4.5 MW throughout the years. However, from 2018 onwards, with the commissioning of 66/33 kV Pangbesa substation, the customers of Dawakha and Shemagangkha are fed from the Pangbesa substation. Therefore, there is a drastic reduction in load in this feeder.

Similarly, the drop in peak load of the Bazar feeder is due to the construction of a dedicated feeder for the customers of the hospital and its administration block. The said feeder is used to cater to an entire load of Bazar, hospital, and the administration block.

Due to inconsistent feeder loads of the said feeders from 2015-2018, peak loads of 2019 and 2020 were considered to forecast the peak power demand for the next ten 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 MV lines under ESD Haa are all operated at 11kV voltage level except for the Wanakha area which is through a 33kV 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
2	DOG	300	17.146
3	WOLF	398	22.748
11 kV Voltage Level			
1	RABBIT	193	3.677
2	DOG	300	5.715
3	WOLF	398	7.582

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

a) System Study with Existing Load
b) System Study with future load: 2025 scenario
c) System Study with future load: 2030 scenario
d) System study with the loss of the 66 kV incomer from Chumdo to Wangtsa substation
e) System study with the connection of Sombeykha and Gakiling load to Wanaka feeder.

a) System Study with Existing Load

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

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: Demand forecast for ESD Haa

Name of Feeder	Forecasted Load Growth (MW)										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
33 kV Wanakha	0.50	0.52	0.53	0.55	0.57	0.58	0.60	0.61	0.63	0.65	0.66
11kV Dumchu	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.71
11kV IMTRAT	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
11kV Hospital/New Adm. Block	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52
11kV Bazar	0.50	0.53	0.56	0.59	0.62	0.65	0.68	0.70	0.73	0.76	0.791
11kV Damthang/ Wangtsa	1.24	1.29	1.35	1.40	1.46	1.51	1.57	1.62	1.66	1.73	1.79

From the power flow analysis of the 2025 and 2030 loading scenarios, it was found that there will be a significant drop in bus voltage and marginal voltage drop alerts in some of the feeders. The voltage profile of the feeders is presented in **Table 7.**

As can be inferred from **Table 7**, there is a marginal voltage drop in the Damthang and Dorokha feeders. While the voltage profile of the 11 kV Damthang feeder can be improved by changing the transformer tap position, the simulation result doesn't show any improvement in the voltage profile of the 33 kV Dorokha feeder which could be due to the long circuit line length.

Table 7: Feeder wise voltage profile (existing, 2025, and 2030 loading)

Source	Feeder Name	End Voltage profile		
		Existing	2025	2030
Watsa SS	33 kV Wanakha Feeder	99.65%	99.32%	99.20%
Wangtsa SS	E10 Dumchu feeder	98.46%	96.95%	96.69%
	E20 Imtrat Feeder	99.20%	98.37%	98.26%
	E30 Adm block & Hospital Feeder	99.72%	98.97%	98.87%
	E40 Bazaar Feeder	99.48%	98.70%	98.45%
	E50 Damthang Feeder	95.93%	93.72%	92.50%
Dhamdum SS	E70 Dorokha Feeder (Sombeykha)	97.8%	93.06%	90.76%

The Dorokha feeder which originates from the 66/33 kV Dhamdum substation has 157 DTs connected and caters to around 3224 customers under the jurisdiction of ESD Samtse. Additionally, there are 35 DTs catering to the power requirement of Sombaykha and Gakaling Gewogs under Haa Dzongkhag. The feeder has a total line length of 178 km (132.63 under Samtse and 42.452 under Haa). Because of the above, reconfiguration of the source either from the 33 kV Wanakha or 33/11kV Jenkana substation is recommended.

However, 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.

c) System study with Sombeykha and Gakiling loads catered from Wanaka feeder

A system study was carried out to check the behavior of the distribution network when the Sombeykha and Gakiling load is connected to a 33 kV Wanakha feeder. From the power flow study, it is found that Wanakha feeder would experience no voltage drop issues. Therefore, it is recommended to reconfigure the source to the Wanakha feeder. **Table 8** shows the voltage profile of the Wanakha and Sombeykha feeder with a new arrangement.

Table 8: End voltage profile with a new arrangement

Source	Name of Feeder	End Voltage profile		Remarks
		2025	2030	
Watsa SS	33 kV Wanakha Feeder	99.02%	98.75%	
	E70 Sombeykha Feeder	98.17%	97.59%	Alternate sources

d) System study with the loss of the 66 kV incomer from Chumdo to Wangtsa substation

Whenever there is a power interruption 66 kV incomer from Chumdo, power is catered by 2.5 MVA, 33/11 kV Jyenkana substation which has its 33 kV incomer from the Watsa substation. In this scenario, the Jyenkana substation will get overloaded. Hence, it is recommended to upgrade the 2.5MVA transformer at Jyenkana with a 5 MVA transformer as an immediate solution.
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 Haa**.**

Table 9: Summary of energy requirement trend of ESD, Haa

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
1	**Energy Requirement in kWh**						
i)	Purchase from GenCos as per TD bill	11.93	12.12	12.50	13.40	14.06	
ii)	Import	-	-	-	0.16	0.29	
	Total	**11.93**	**12.12**	**12.50**	**13.56**	**14.34**	

Sl. No.	Particulars	2015	2016	2017	2018	2019	Average
	% growth over previous year	9.73%	1.63%	3.14%	8.43%	5.78%	5.74%
2	**Energy Sales in kWh (Category Wise)**						
i)	LV*	11.05	10.59	11.48	12.31	12.91	
ii)	Medium Voltage	-	-	-	-	-	
iii)	High Voltage	-	-	-	-	-	
	Total Energy Sales	**11.05**	**10.59**	**11.48**	**12.31**	**12.91**	
	% growth over previous year	8.43%	-4.21%	8.43%	7.24%	4.82%	4.94%
	Total Energy Loss (1-2)	0.88	1.53	1.02	1.25	1.44	
	Total Energy Loss (%)	7.34%	12.66%	8.18%	9.19%	10.01%	9.48%
3	**Number of Customers (Category wise)**						
i)	LV*	3,515	3,669	3,824	3,586	4,055	
ii)	Medium Voltage	-	-	-	-	-	
iii)	High Voltage	-	-	-	-	-	
	Total Customers	**3,515**	**3,669**	**3,824**	**3,586**	**4,055**	
	% growth over previous year	11.13%	4.38%	4.22%	-6.22%	13.08%	5.32%

Source: Adapted from Power Data Book 2019, BPC

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

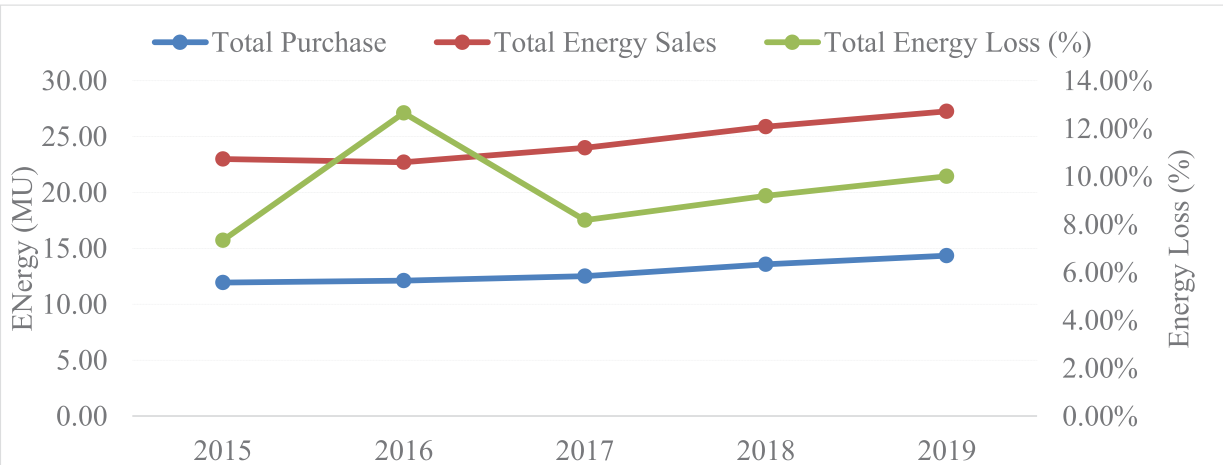


Figure 4: Summary of energy requirement trend of ESD, Haa

The plot of the energy requirement data presented in **Table 9** yields the trend graphs shown in **Figure 4.** The energy requirement and energy consumption growth between 2015-2019 indicates a steady increase @ 5.74% and 4.94% respectively.

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 Haa (2015-2019) is 9.48% (1.224 million units).

The ETAP software was used to compute the technical loss of the system, however, as the system study is till DT, the technical loss obtained through the ETAP does not account for the loss due to the LV network and transmission system. The simulation result shows that only 1.76% constitute MV technical loss (including the loss DT). The remaining (7.72%) is due to LV and commercial loss. Therefore, Haa needs to strategize and focus more on commercial loss to reduce the overall loss of the Dzongkhag. The feeder wise MV and DT technical loss is as shown in **Table 10.**

Table 10: Feeder wise energy losses (technical)

Feeder Name	Total Demand (MW)	Apparent loss (MW)	Feeder Loss (%)
Transformer no load loss	0.004	0.004	
11kV Dumchu Feeder	0.388	0.003	0.77%
11kV Imtrat Feeder	0.753	0.006	0.80%
11kV Adm Block & Hospital Feeder	0.356	0.001	0.28%
11kV Bazaar Feeder	0.251	0.001	0.40%
11kV Damthanng Feeder	1.032	0.029	2.81%
33kV Wanakha Betikha	0.441	0.001	0.23%
Overall System loss	**3.235**	**0.057**	**1.76%**

7.2.3 Reliability Assessment of 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 is summarized in **Table 11.** The individual feeder reliability details used to derive the summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered to compute the actual representation of the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2018-2019 are 221.36 & 458.23 respectively which is exceptionally high.

Table 11: Feeder wise reliability indices of ESD Haa

Sl.No.	Year	Reliability Indices	11 kV Dumchu	11 kV IMTART	11 kV Hospital	11 kV Town	11 kV Damthang	33 kV Wanakha	33 kV Dorokha-Sombeykha
1	2017	SAIFI	7.82	0.17	-	1.76	4.99	9.53	
		SAIDI	15.86	0.21	-	1.05	5.50	5.07	
2	2018	SAIFI	9.07	0.39	0.01	4.61	7.60	7.41	82.92
		SAIDI	26.55	3.66	0.01	14.07	15.55	16.84	103.93
3	2019	SAIFI	6.42	0.32	0.02	2.22	5.63	5.23	311.00
		SAIDI	38.91	1.60	0.18	1.00	15.57	43.31	675.91

Sl.No.	Year	Reliability Indices	11 kV Dumchu	11 kV IMTART	11 kV Hospital	11 kV Town	11 kV Damthang	33 kV Wanakha	33 kV Dorokha-Sombeykha
Individual Average (2018-19)		**SAIFI**	**7.77**	**0.29**	**0.01**	**2.86**	**6.07**	**7.39**	**196.96**
		SAIDI	**27.11**	**1.82**	**0.06**	**5.37**	**12.21**	**21.74**	**389.92**
Overall Average (2018-19)		**SAIFI**	**221.36**						
		SAIDI	**458.23**						

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 excluded.

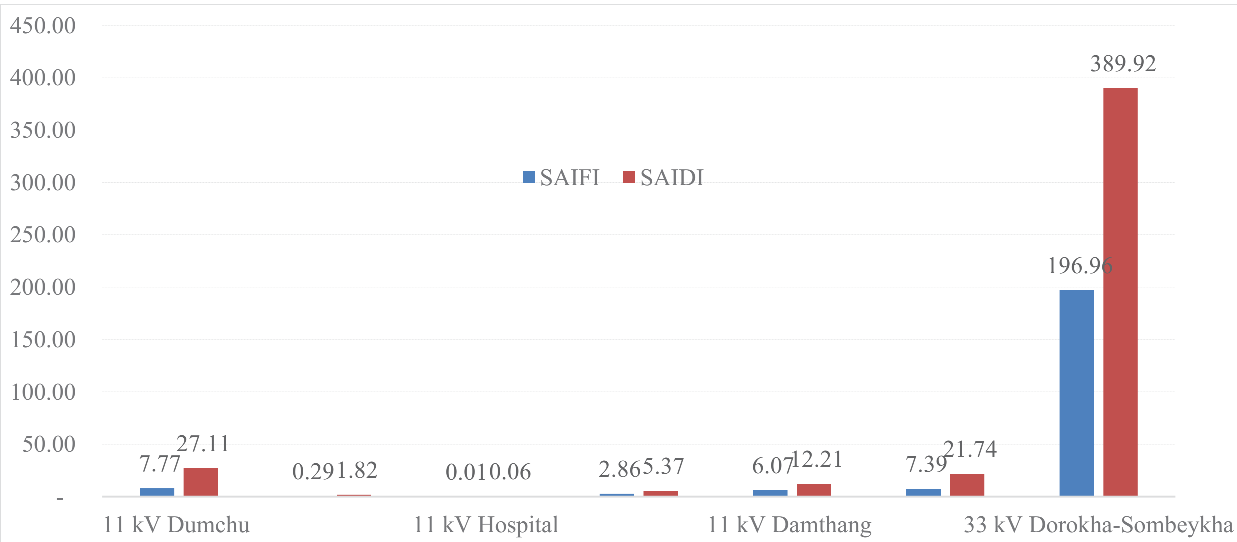


Figure 5: Feeder wise average SAIFI and SAIDI

The summary **Table 11** and **Figure 5**, indicate that the 33 kV Dorokha-Sombeykha feeder has the highest value of both the indices and is more susceptible to interruptions compared to the other feeders. The feeder passes through dense forests, tough terrains, and even river crossings. The feeder also comprises multiple tapped spur lines. To get a better understanding of the reliability index of this particular feeder, the past tripping records of 2018 and 2019 have been tabulated below.

Table 12: Tripping Data of Dorokha-Sombeykha Feeder

Trip Record	**2018**												**Total**
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Outage Duration (hours)	-	-	-	3.6	-	13.2	59.4	2.2	19.2	0.6	4.4	2.3	104.9
Frequency (numbers)	-	-	-	1.0	-	14.0	11.0	9.0	26.0	10.0	6.0	6.0	83.0
2019													
Outage Duration (hours)	10.6	18.7	163.3	167.0	26.4	24.2	27.2	25.0	17.1	68.1	6.7	8.7	563.5
Frequency (numbers)	17.0	15.0	26.0	21.0	36.0	50.0	50.0	20.0	39.0	22.0	7.0	15.0	318.0

Table 12 shows the duration of outage along with frequency in a particular month of the year. The outage duration and the frequency shown above are sums of both planned and tripping due to faults (unplanned). In 2018, July month saw the longest outage duration with 59.4 hours. Out of the two years, 2019 was hit the hardest with 163.3 hours and 167.0 hours in March and April respectively. The frequency of tripping varied from a minimum of no tripping to a maximum of 50 times from 2018 to 2019. The main reason which accounted for such a high value of outage time was lightning and heavy rainfall (from April to July), RoW clearing works (in October), replacement of HT fuses, pin insulators, and lightning arresters.

Figure 6 exhibits the line faults and line tripping. The faults recorded are categorized into faults due to lightning and rainfall, planned outages, RoW, and transient faults. All electrical line and equipment maintenance works were categorized under planned outages.

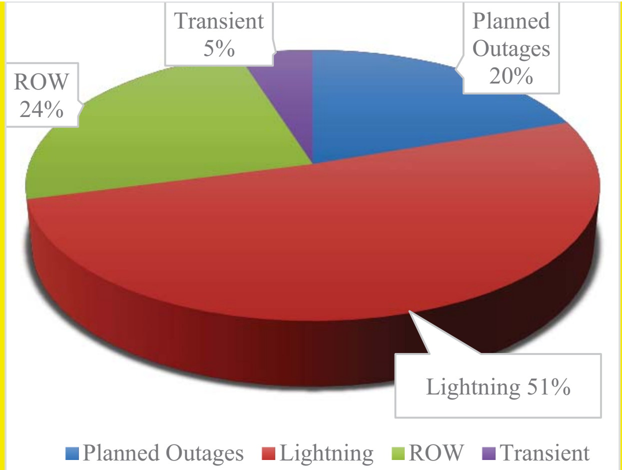


Figure 6: Root Causes of Outages

A detailed study was carried out by the Engineering and Research Department, BPC for the improvement of power supply to Sombeykha. The study explored the following long term solutions;

a) To improve the supply reliability of the Dorokha feeder, the stretch of line between Dhamdum and Yabala could be re-routed via Thulungaon village. The new line route is approximately 8km to Sebichang (before Yabala) and can be aligned along the old footpath trail towards Dorokha. If this portion of the line is realigned, multiple crossings over the Dhamdum river would be avoided during monsoon for faster operation and maintenance and fewer faults due to thick vegetation.

b) The construction of a new 33kV line on specially designed towers and telescopic poles from Balamna to Dorithasa could be one of the definite solutions to improve the reliability of customers in Sombeykha and Gakidling. The line would be approximately 25 km passing through Tergola Pass. In the lower belt of the line towards the Sombeykha area, the 33 kV line on towers could be utilized due to rainfall, thick vegetation, and at the critical locations. The use of towers in such areas would mean the line will have better right of way clearances. The line beyond Tergola Pass towards Haa could be constructed on telescopic poles as the vegetation gets sparse with rigid ground stability.

Until any of the aforementioned plans are approved and implemented, ESD Haa in coordination with ESD Samtse is recommended to increase the frequency of RoW clearing, non-working ARCBs should be made functional, installation of communicable FPI to identify the fault and early restoration. Additional line lightning arrestors (LA) could also be installed at critical locations where maximum faults occur due to lightning.

Although it is not possible to quantify the reliability indices that can be achieved with preventive and corrective measures in place, the proposed plans would significantly improve the power quality to the customers.

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 a three-phase power supply where there are single-phase power supplies. It was reported that while all the alternatives required the third conductor of the MV system to be extended on the existing poles following three proposals along with the financial impact were proposed:

i. **Alternative -I**

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

ii. **Alternative -II**

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

iii. Alternative -III

Option 3 is found to be a techno-commercially viable alternative as the lines can be easily upgraded to three phases by constructing the third conductor on existing pole structures. The transformer can be upgraded from single-phase to three-phases as and when the demand for 3-phase supply comes. The line up-gradation across the country would amount to 97.00 million (Detail in **Annexure-6**) excluding the cost of three-phase transformers that have to be procured on need-basis, rather than one-time conversion in general.

The total single phase line length in the Dzongkhag is 4.39 km (33 kV). The estimated cost for the conversion of such is Nu. 0.53 million.

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

7.3 Assessment of the Existing Distribution Transformers

7.3.1 Distribution Transformer Loading

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

Some of the existing transformer capacities would not be adequate to cater to the forecasted load growth for the next ten (10) years. Accordingly, the capacities of the transformers need to be up-graded and such a proposal is tabulated **in Table 13.** The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Table 13: List of Overloaded Distribution Transformers

Sl. No.	Name	Capacity (kVA)	Existing Load		% loading		Remarks
			KVA	%	2025	2030	
11kV Damthang Feeder							
1	Yatom	63	36.11	57.31%	89%	106%	Can be replaced by 315kVA Lhayulkha which will be idle once the 1000kVA USS is charged.
33kV Wanakha Feeder							
1	Betikha	125	83.14	66.51%	108%	123%	New

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 one transformer.

7.3.2 Asset life of Distribution Transformers

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 14**, 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 to use.

Table 14: List of outlived Distribution Transformers

Substation Name/Transformer location	Transformer Details		Manufacturer Detail			Age (2020)
	Voltage level	Capacity	Sl. No	Year	Make	
MH substation / Imtrat	11/.415 kV	163	S/3441	1988	Stanelec	32
Dumchu substation / Dumchu village	11/.415 kV	250	94FD-103/01	1994	Kirloskar	26
Jawang Gompa Substation / Jawang gompa	11/.415 kV	16	1994-12	1994	Begana	26
Neechu Substation / Tsilungkha	11/.415 kV	125	15223	1995	Uttam	25
Betsho substation / Betsho	11/.415 kV	63	1996-06	1995	Begana	25
Damtikha / Damtikha	11/.415 kV	16	1994-23	1993	Begana	27
Balamna-3 S/S / Balamna	11/.415 kV	16	1996-7	1994	ABB	26
Bangayna / Bangayna	11/.415 kV	160	94DD-083/02	1994	Kirloskar	26
Imtrat Engg.Cell / Imtrat	11/.415 kV	500	75127	1982	Marson	38
Lower Market / Ha Town	11/.415 kV	500	KT-500/175	1994	Kanohar	26
Lhayulkha / Haa Market	11/.415 kV	315	KT-315/291	1994	Kanohar	26
Yangto / Yangto	11/.415 kV	250	94FD-103/03	1994	Kirloskar	26
Tokey / Tokey	11/.415 kV	160	94DD-083/04	1994	Kirloskar	26
Upper Wangtsa / Wangtsa village	11/.415 kV	63	S/3300	1988	Stanelec	32

7.3.3 Replacement of Single Phase Transformers

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 23 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu. 4.9 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

Haa town basically is the only urban center of the Dzongkhag. On one side, Haa town seems to have good potential to grow judging from the good road infrastructure, good space, scenic views, and proximity to larger economic hubs such as Thimphu, Paro, and Phuentsholing. However, on the flip side, the Dzongkhag apparently neither have much development potential in terms of industries, commercial centers nor is its cold climate conducive for service industries. The latter perspective of the two is likely to be the dominant one as evident from the relatively low growth of power demand. The total peak load of Haa is still under 2.92 MW and the growth has not been constrained by feeder or source capacity limitations. For this small magnitude of power demand and given the close proximity of the load center to the 66 kV sub-station, the issue is more about the reliability of supply rather than about the source or feeder capacity. ESD Haa is therefore recommended to interconnect the 11 kV Bazar and Hospital Feeders for better reliability and provision two 500 kVA, 11/0.415 kV transformers to cater to the load of the town. Haa town has 384 plots, of that 100 plots have been already developed. **Figure 7** depicts the structural plan of the Haa LAP.

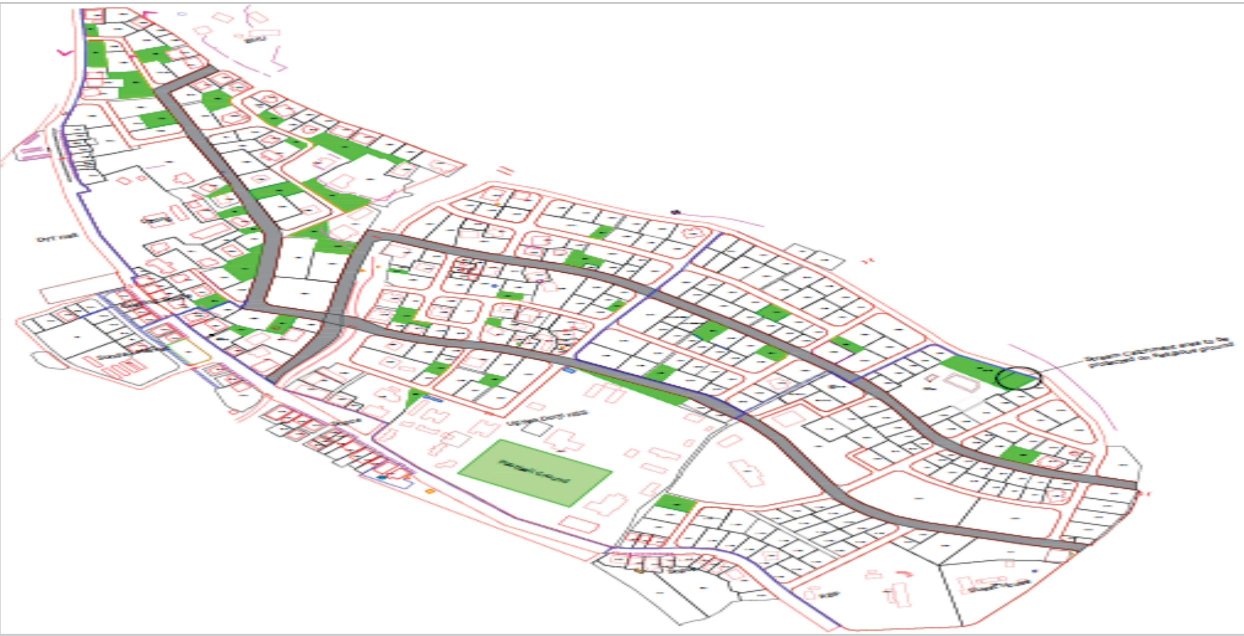


Figure 7: Haa local area plan

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

8. Distribution System Panning till 2030

The distribution network of Haa 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 are detailed from **Section 8.1** through **Section 8.4.**

8.1 Power Supply Source

8.1.1 HV Substation

As per the power source assessment made in section 7.1.1, a load of 3.23MW is forecasted for Wangtsa substation against the installed capacity of 10MVA. Similarly, a load of around 1.00 MW is projected at the Watsa substation against its installed capacity of 8 MVA. Therefore, both the substations would be adequate to cater to the present and the forecasted power demand.

8.1.2 MV Substations

As detailed in **Section 7.1.2,** to address the issue of overloading and power supply arrangement for future load growth, it is proposed to either:

a) Up-grade 2.5 MVA to 5MVA, 33/11 kV Jenkana substation to cater the entire load of Haa even in the event of power interruption from Chumdo substation or 66 kV incomer.

OR

b) Install 5 MVA, 33/11kV ICT at Jenkana, which can be utilised as a source in case of power interruptions from either source. Additionally, installing ICT at Jenkana would mean that the customers of Sombaykha and Gakidling Gewogs can be fed from the substation instead of Dhamdum. This arrangement would not only improve the reliability and quality of the power, the administration of the customers, and energy accounting will be crystal clear.

8.2 MV Lines

As detailed in **Section 7.2,** in order the meet the future power demand, improve the voltage profile, reliability, loss, and other associated issues, it is proposed to construct or arrange the followings:

a) The construction of a new 33kV line on specially designed towers and telescopic poles from Balamna to improve the reliability of customers in Sombaykha and Gakidling.
b) Interconnection of 11 kV Hospital and Bazar feeder
c) Construction of cable trench and laying of UG HV cables in and around Haa town

8.3 Distribution Transformers

The list of overloaded distribution transformers has been presented in **section 7.3.1** of this report. Two DTs are expected to be overloaded by the year 2030 (33/0.415 kV, 125 kVA Betikha substation, and 11/0.415 kV, 63 kVA Yatom substation). However, it is pertinent to mention that the 63 kVA Yatom DT can be replaced by a 315 kVA transformer at Lhayulkha. The customer of Lhayulkha can cater from the new 1000 kVA USS.
The up-gradation of overloaded DTs and construction of new substations for the LAPs are recommended as follows:

- Up-gradation of 33/0.415 kV, 125 kVA Betikha substation to 315 kVA substation.
- Construction of 2 Nos. of 11/0.415 kV, 500 kVA substation in and around Haa to cater to the future power demand of LPs.

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 reflected in **Section 7.2.3,** the 33 kV Dorokha-Sombeykha feeder sustained more interruptions compared to other feeders. 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 15 shows the list of proposed switching devices for easing operation and maintenance and to improve the power supply reliability.

Table 15: Existing and Proposed switching equipment

Sl. No.	Name of Feeder	ARCBs	FPIs		LBS	
		Existing	Existing	Prop	Existing	Prop
1	33kV Wanakha feeder	2	0	2	9	0
2	11kV Dumchu Feeder	1	0	3	7	0

Sl. No.	Name of Feeder	ARCBs	FPIs		LBS	
		Existing	Existing	Prop	Existing	Prop
3	11kV IMTART Feeder	0	0	0	0	0
4	11kV Hospita/Adm block	0	0	0	0	0
5	11kV Bazaar Feeder	0	0	0	1	0
6	11kV Damthang Feeder	0	0	0	1	0
	Total	**3**	**0**	**5**	**18**	**0**

8.4.2 Distribution System Smart Grid

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

9. Investment Plan

Following the above-mentioned contingency plans targeted to improve the power quality, reduce losses, and improve reliability indices of the Dzongkhag, an investment proposal is developed. The investment plan has been confined to power supply sources, MV lines, DTs, switching and control equipment, and RoW. The proposed/approved (2019-2023) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 8.**

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

How urgent is the task?

Figure 8: Priority Matrix

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

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

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 16** 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 Haa Dzongkhag is Nu. 138.28 million.

Table 16: Investment Plan until 2030

Sl. No	Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1	**Power Supply Sources**	-	-	-	-	-	-	-	-	-	-	-	**-**
1.1	Upgrade 2.5 MVA, 33/11 kV Jenkana SS to 5 MVA. (or) installation of 33/11 kV, 5 MVA ICT.	-	5.00	15.00	-	-	-	-	-	-	-	-	**20.00**
2	**MV Lines**	-	-	-	-	-	-	-	-	-	-	-	**-**
2.1	Power supply arrangement to town planning	-	-	-	-	-	-	-	-	-	-	-	**-**
2.1.1	UG Cable trenching and laying	-	-	-	-	2.00	-	-	-	-	-	-	**2.00**
2.1.2	Interconnection of 11 kV Hospital and Bazar feeder	-	-	-	-	3.22	-	-	-	-	-	-	**3.22**
2.2	The construction of a new 33kV line on specially designed towers and telescopic poles from Balamna to improve the reliability of customers in Sombaykha and Gakidling.	-	-	-	98.00	-	-	-	-	-	-	-	**98.00**
3	**Distribution Transformers**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.1	Up-gradation of 33/0.415 kV, 125 kVA Betikha substation to 315 kVA substation.	-	-	-	-	0.63	-	-	-	-	-	-	**0.63**
3.2	Construction of 2 Nos. of 11/0.415 kV, 500 kVA substation in and around Haa to cater to the future power demand of LPAs.	-	-	-	-	-	4.50	-	-	-	-	4.50	-
5	**Conversion Works**												**-**
5.1	Single Phase to Three Phase Line conversion	-	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	**0.53**
5.2	Single Phase Transformer to Three Phase conversion	-	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	**4.90**
	Total	**-**	**5.54**	**15.54**	**98.54**	**6.39**	**5.04**	**0.54**	**0.54**	**0.54**	**0.54**	**5.04**	**138.28**

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		
1	HV Substations	The Wangtsa and Watsa substations would be adequate to cater to the load requirement.
2	MV Substations	Up-gradation of 1x2.5 MVA, 33/11 kV Jyenkana substation to 5 MVA to supply the Haa load in the event of loss of the 66 kV incomer from Chumdo to the Wangtsa substation
B. MV and LV Lines		
	Overhead and UG system	a) The construction of a new 33kV line on specially designed towers and telescopic poles from Balamna to improve the reliability of customers in Sombaykha and Gakidling b) Interconnection of 11 kV Hospital and Bazar feeder c) Construction of cable trench and laying of UG HV cables in and around Haa town
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.

Sl. No.	Parameters	Recommendations
		1) Install FPI, Sectionalizes, and ARCBs at various identified locations. 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.
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	The power carrying capacity of the 33kV system is almost 3-fold compared to

Sl. No.	Parameters	Recommendations
	through 33kV network	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: 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.

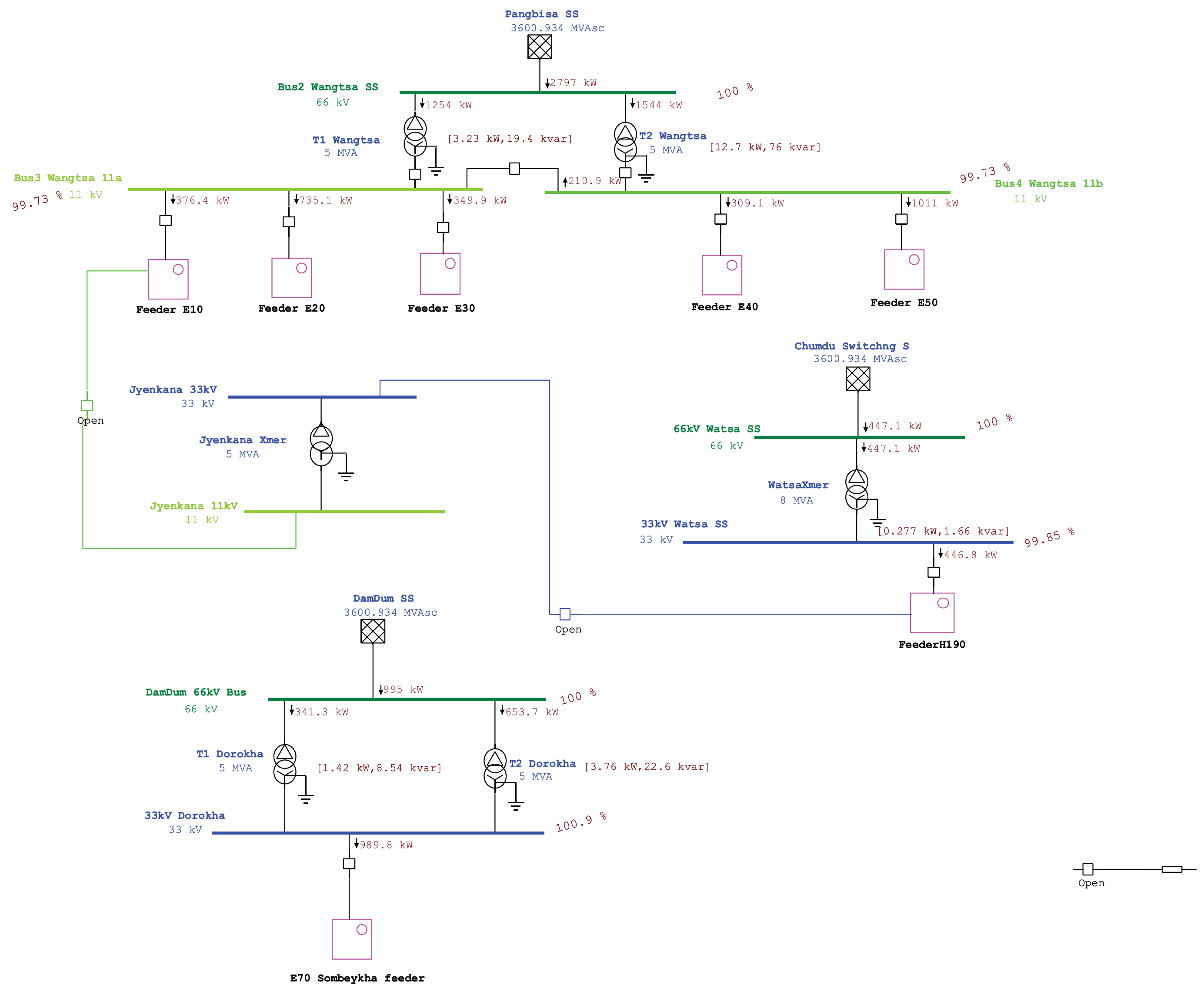
15. Challenges

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
		b) Balanced Load	

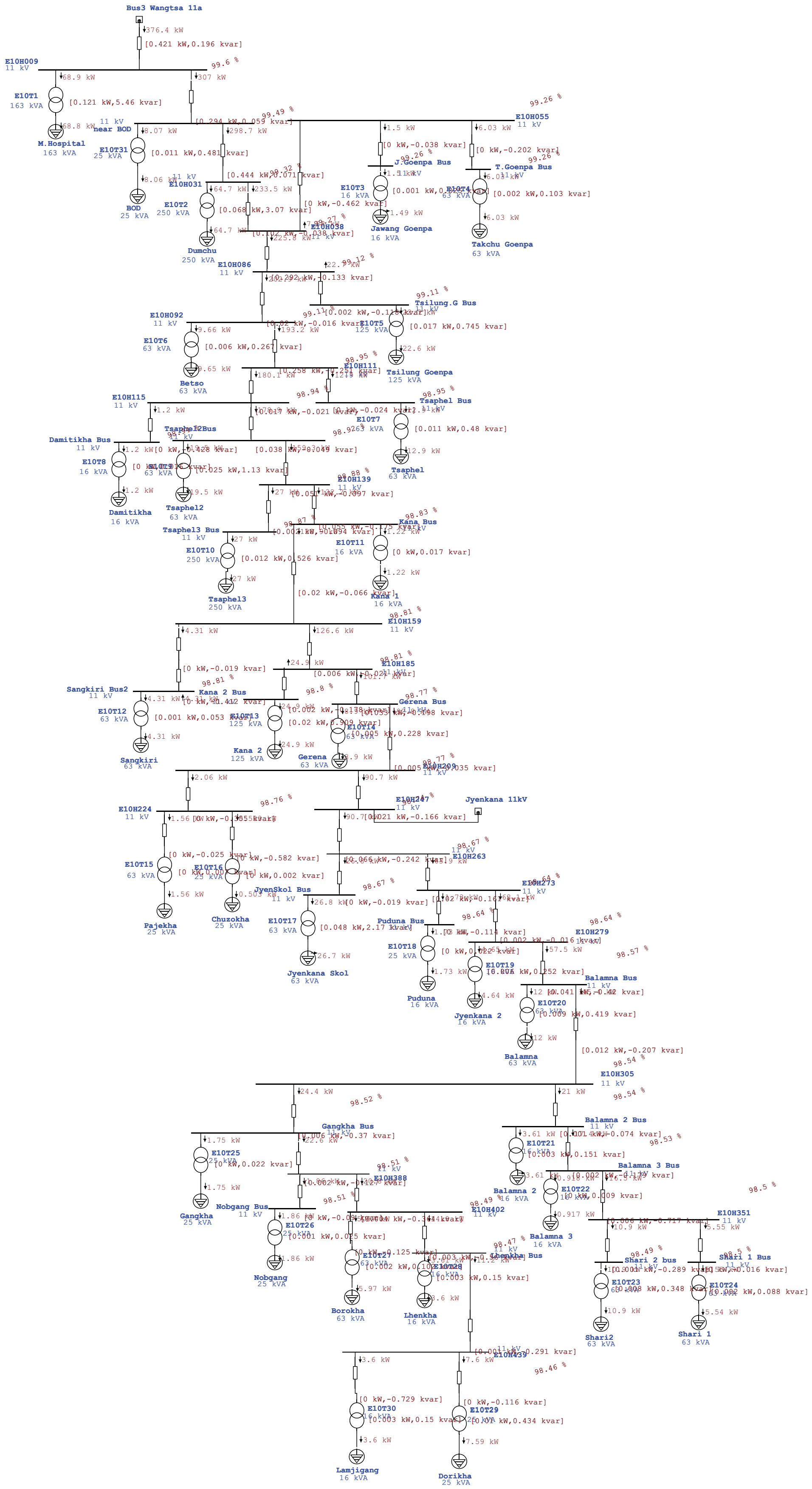
Sl. No.	Parameters	Challenges	Opportunities/Proposals
		Flow c) Limitations of No. of buses (1000)	flow system. This would be more applicable and accrue good results for LV networks.
2	Data	a) No recorded data (reliability & energy) on the out-going feeders of MV SS	a) Feeder Meters could be installed for outgoing feeders of MV substations to record actual data (reliability & energy)
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to timing and number of DTs.	b) To get the accurate Transformer Load Management (TLM)/loading, it is proposed to install DT meters which could also have additional features to capture other required information.
		c) No proper feeder and DT wise Customer Mapping recorded	c) Customer Information System (CIS) of the feeder/DT would enable us to have a proper TLM and replacement framework.
3	Manpower	a) Resource gap in terms of trained (ETAP) and adequate engineers (numbers)	a) Due to the lesser number of trained engineers in the relevant fields (software), engineers from other areas were involved.

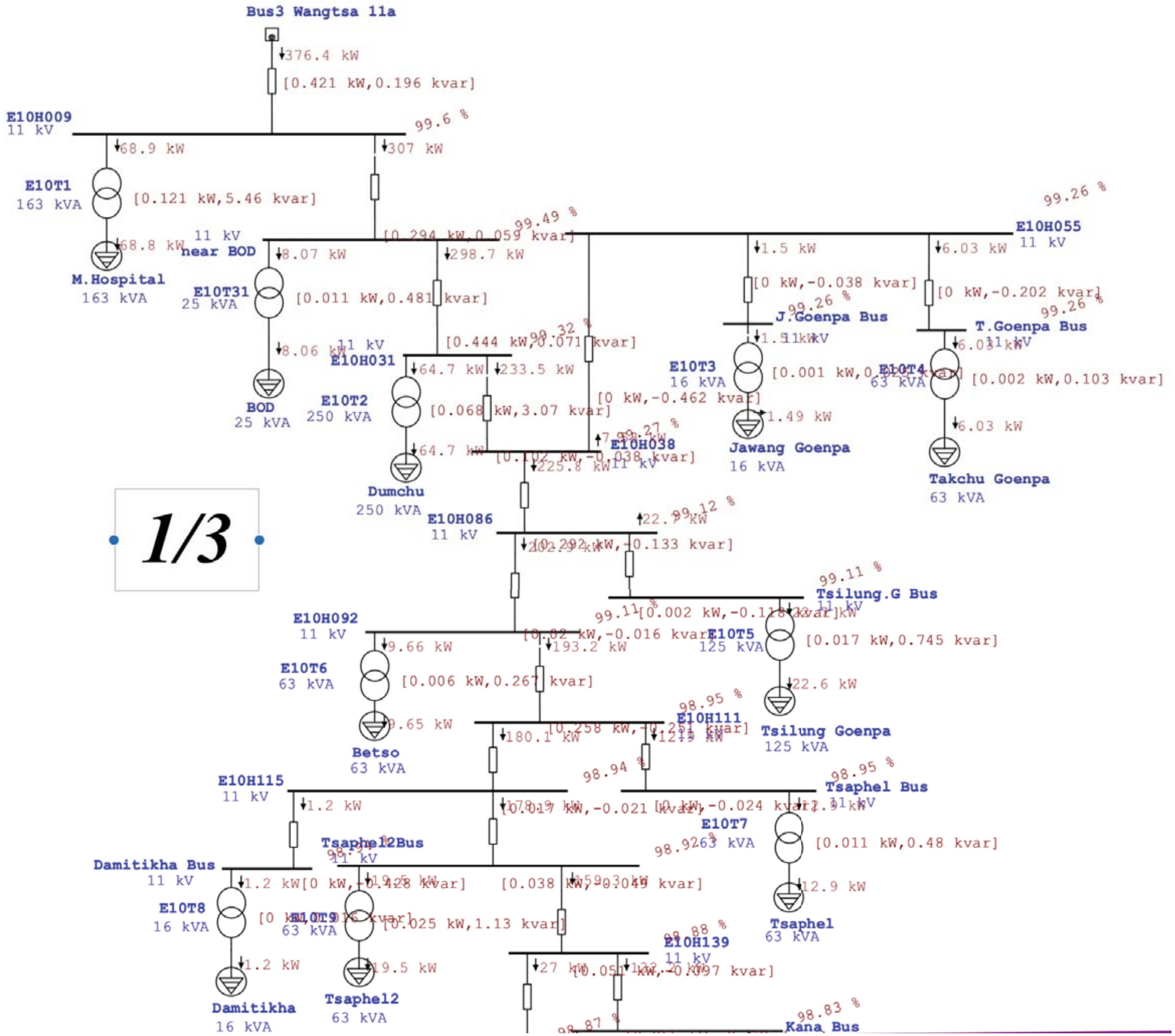
Annexure-1: MV Line Details and Single Line Diagram

One-Line Diagram - ESD Haa (Load Flow Analysis)

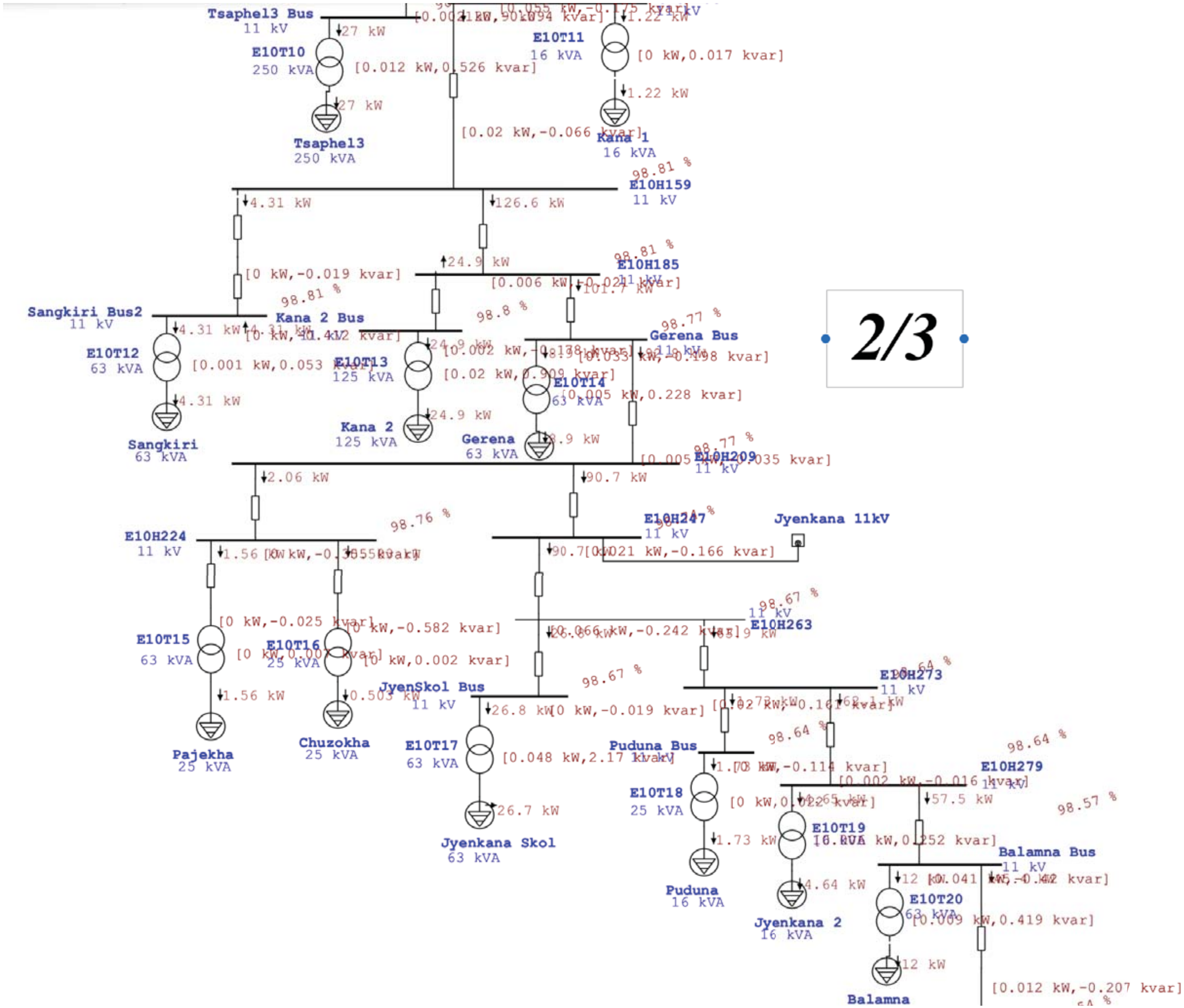


One-Line Diagram - ESD Haa=>Feeder E10 (Load Flow Analysis)

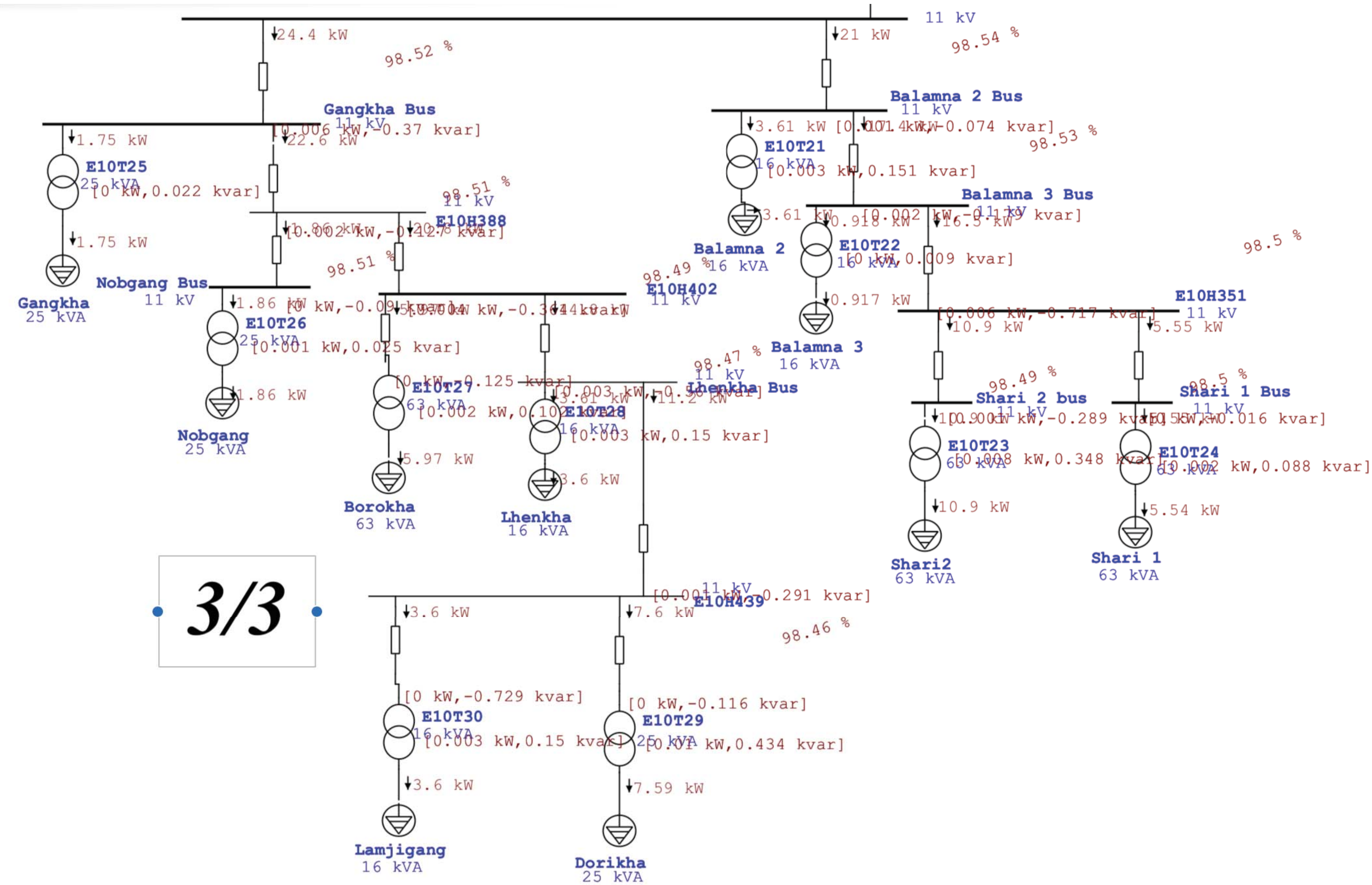




Bus3 Wangtsa 11a
376.4 kW
[0.421 kW,0.196 kvar]
E10H009
11 kV
99.6 %
68.9 kW
307 kW
E10T1
163 kVA
[0.121 kW,5.46 kvar]
68.8 kW
M.Hospital
163 kVA
11 kV
near BOD
99.49 %
8.07 kW
298.7 kW
E10T31
25 kVA
[0.011 kW,0.481 kvar]
8.06 kW
BOD
25 kVA
11 kV
E10H031
99.32 %
[0.444 kW,0.071 kvar]
64.7 kW
233.5 kW
E10T2
250 kVA
[0.068 kW,3.07 kvar]
64.7 kW
Dumchu
250 kVA
[0 kW,-0.462 kvar]
99.27 %
E10H038
11 kV
225.8 kW
E10H055
11 kV
99.26 %
1.5 kW
6.03 kW
[0 kW,-0.038 kvar]
[0 kW,-0.202 kvar]
J.Goenpa Bus
T.Goenpa Bus
E10T3
16 kVA
1.49 kW
Jawang Goenpa
16 kVA
E10T4
63 kVA
[0.002 kW,0.103 kvar]
6.03 kW
Takchu Goenpa
63 kVA
1/3
E10H086
11 kV
99.12 %
22.7 kW
[0.292 kW,-0.133 kvar]
99.11 %
Tsilung.G Bus
11 kV
E10T5
125 kVA
[0.017 kW,0.745 kvar]
22.6 kW
Tsilung Goenpa
125 kVA
E10H092
11 kV
9.66 kW
193.2 kW
E10T6
63 kVA
[0.006 kW,0.267 kvar]
9.65 kW
Betso
63 kVA
98.95 %
E10H111
180.1 kW
98.94 %
E10H115
11 kV
1.2 kW
98.95 %
Tsaphel Bus
11 kV
E10T7
63 kVA
[0.011 kW,0.48 kvar]
12.9 kW
Tsaphel
63 kVA
Tsaphel2Bus
11 kV
Damitikha Bus
11 kV
E10T8
16 kVA
1.2 kW
Damitikha
16 kVA
E10T9
63 kVA
[0.025 kW,1.13 kvar]
19.5 kW
Tsaphel2
63 kVA
[0.038 kW,-0.049 kvar]
98.88 %
E10H139
11 kV
27 kW
98.87 %
98.83 %
Kana Bus

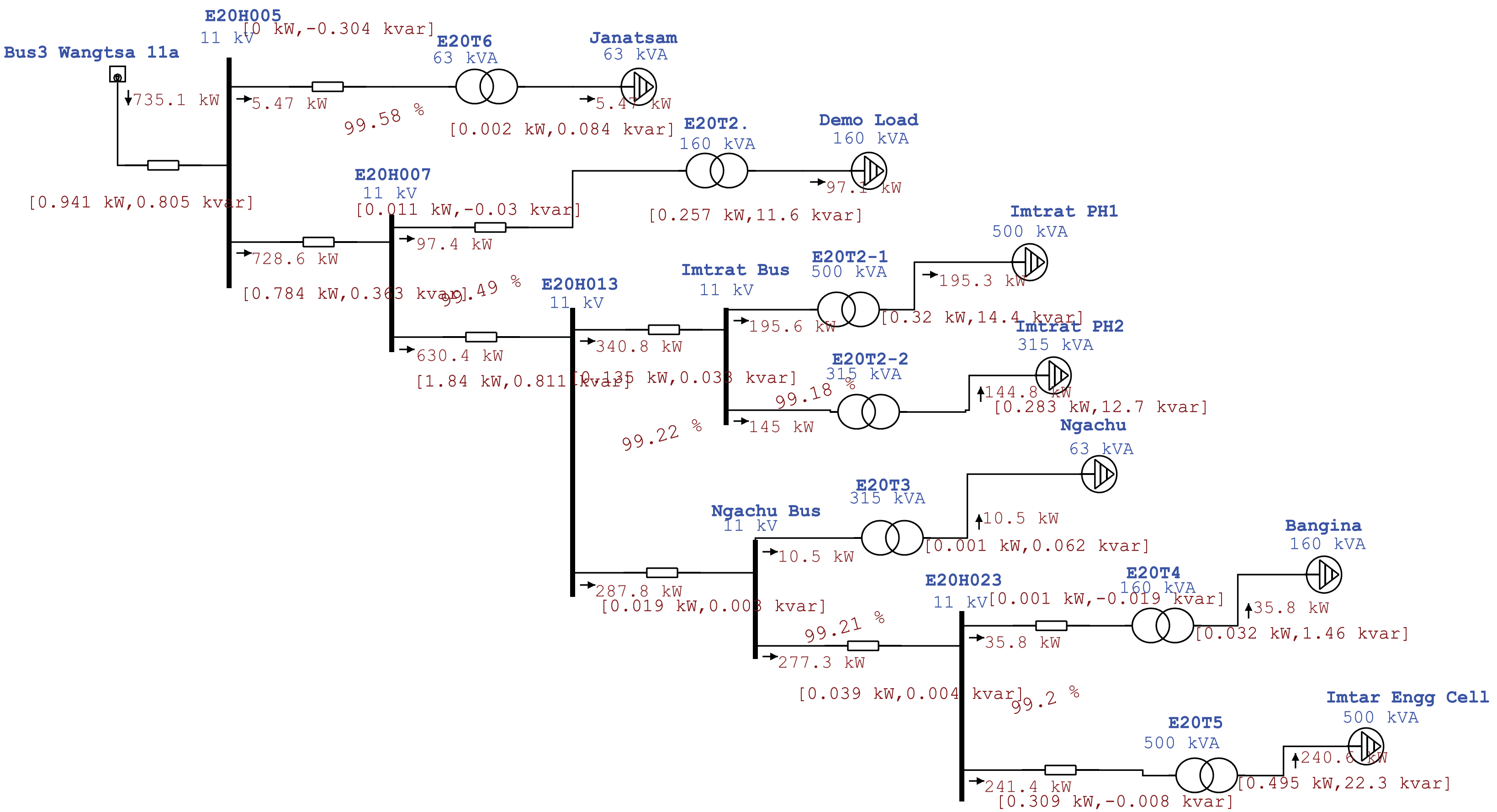

Tsaphel3 Bus
11 kV
E10T10
250 kVA
Tsaphel3
250 kVA
E10T11
16 kVA
Kana 1
16 kVA
E10H159
11 kV
E10H185
Sangkiri Bus2
11 kV
Kana 2 Bus
E10T12
63 kVA
E10T13
125 kVA
Sangkiri
63 kVA
Kana 2
125 kVA
Gerena Bus
E10T14
63 kVA
Gerena
63 kVA
E10H209
11 kV
E10H224
11 kV
E10H247
11 kV
Jyenkana 11kV
E10T15
63 kVA
E10T16
25 kVA
Pajekha
25 kVA
Chuzokha
25 kVA
JyenSkol Bus
11 kV
E10T17
63 kVA
Jyenkana Skol
63 kVA
E10H263
E10H273
11 kV
Puduna Bus
E10T18
25 kVA
Puduna
16 kVA
E10H279
E10T19
Jyenkana 2
16 kVA
Balamna Bus
11 kV
E10T20
Balamna

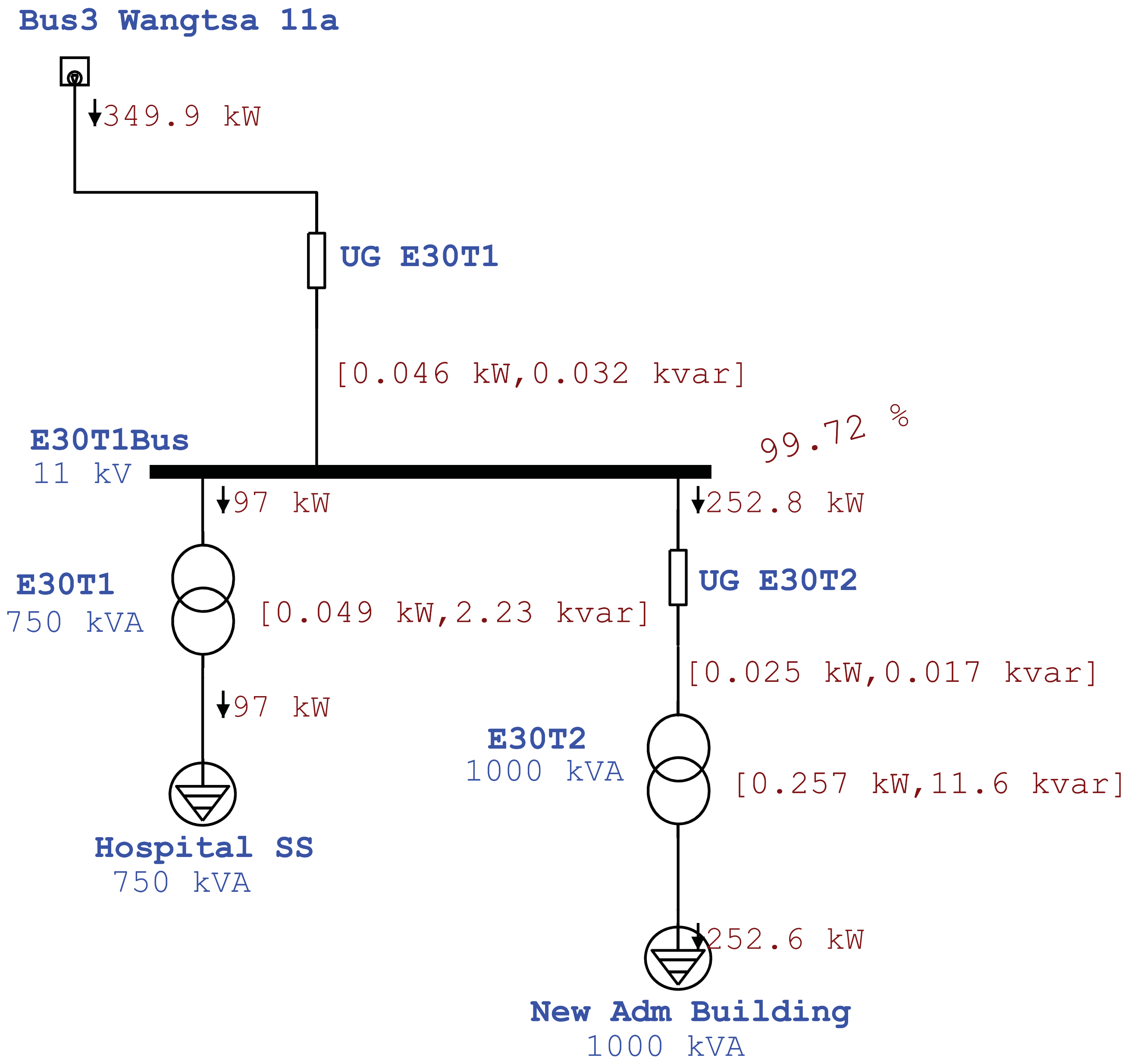
2/3


11 kV
24.4 kW
98.52 %
21 kW
98.54 %
Gangkha Bus
Balamna 2 Bus
1.75 kW
E10T25
[0 kW,0.022 kvar]
1.75 kW
Gangkha
25 kVA
22.6 kW
E10T21
[0.003 kW,0.151 kvar]
98.53 %
Balamna 3 Bus
E10H388
98.51 %
Balamna 2
16 kVA
E10T22
[0 kW,0.009 kvar]
0.917 kW
Balamna 3
16 kVA
98.5 %
Nobgang Bus
11 kV
E10T26
[0.001 kW,0.025 kvar]
1.86 kW
Nobgang
25 kVA
E10H402
E10H351
11 kV
10.9 kW
5.55 kW
E10T27
63 kVA
5.97 kW
Borokha
63 kVA
Lhenkha Bus
[0.003 kW,0.15 kvar]
3.6 kW
Lhenkha
16 kVA
Shari 2 bus
Shari 1 Bus
E10T23
E10T24
[0.002 kW,0.088 kvar]
10.9 kW
5.54 kW
Shari2
63 kVA
Shari 1
63 kVA
E10H439
98.46 %
3.6 kW
7.6 kW
[0 kW,-0.729 kvar]
E10T30
[0 kW,-0.116 kvar]
E10T29
[0.01 kW,0.434 kvar]
3.6 kW
7.59 kW
Lamjigang
16 kVA
Dorikha
25 kVA

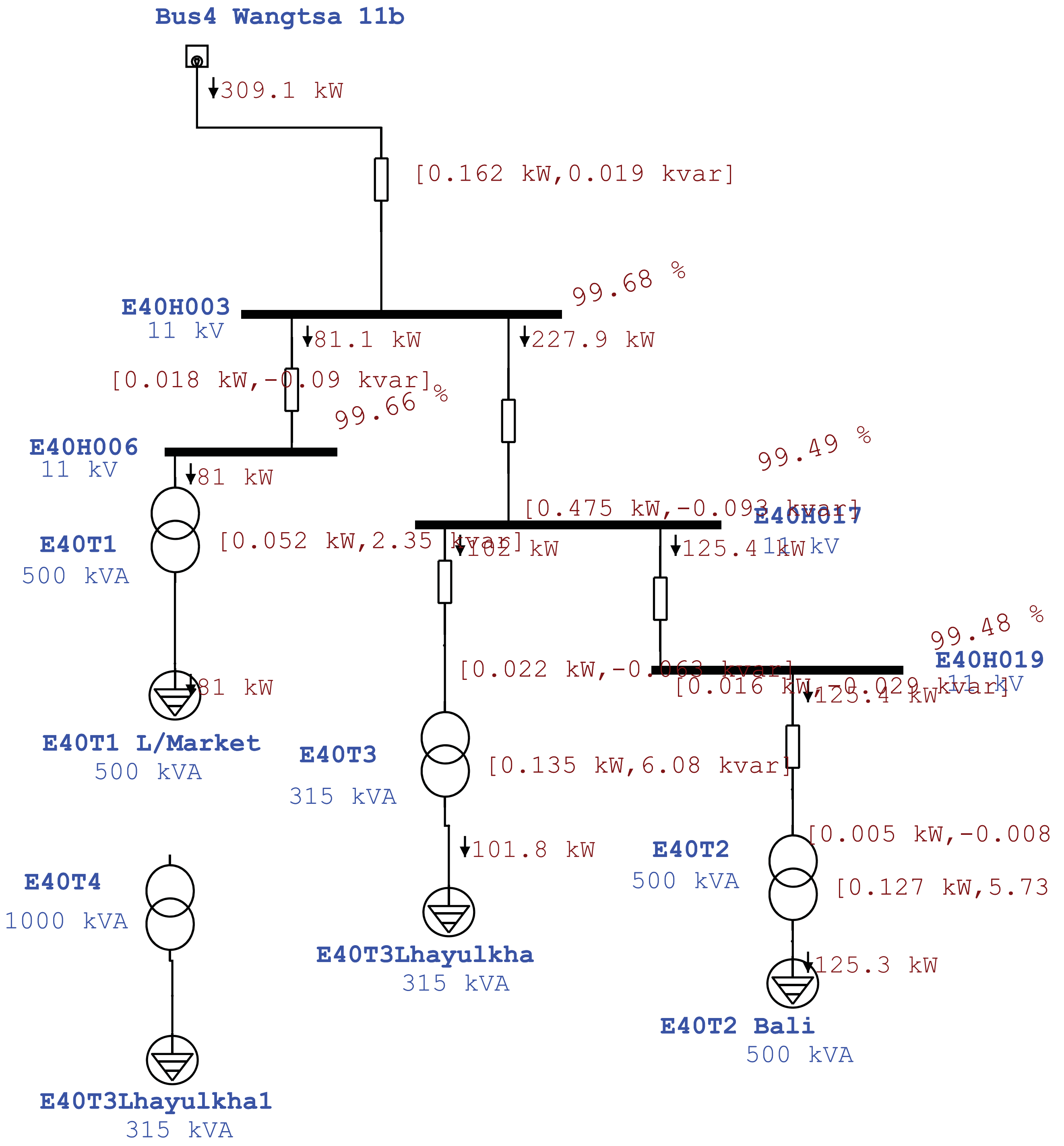
3/3

One-Line Diagram - ESD Haa=>Feeder E20 (Load Flow Analysis)

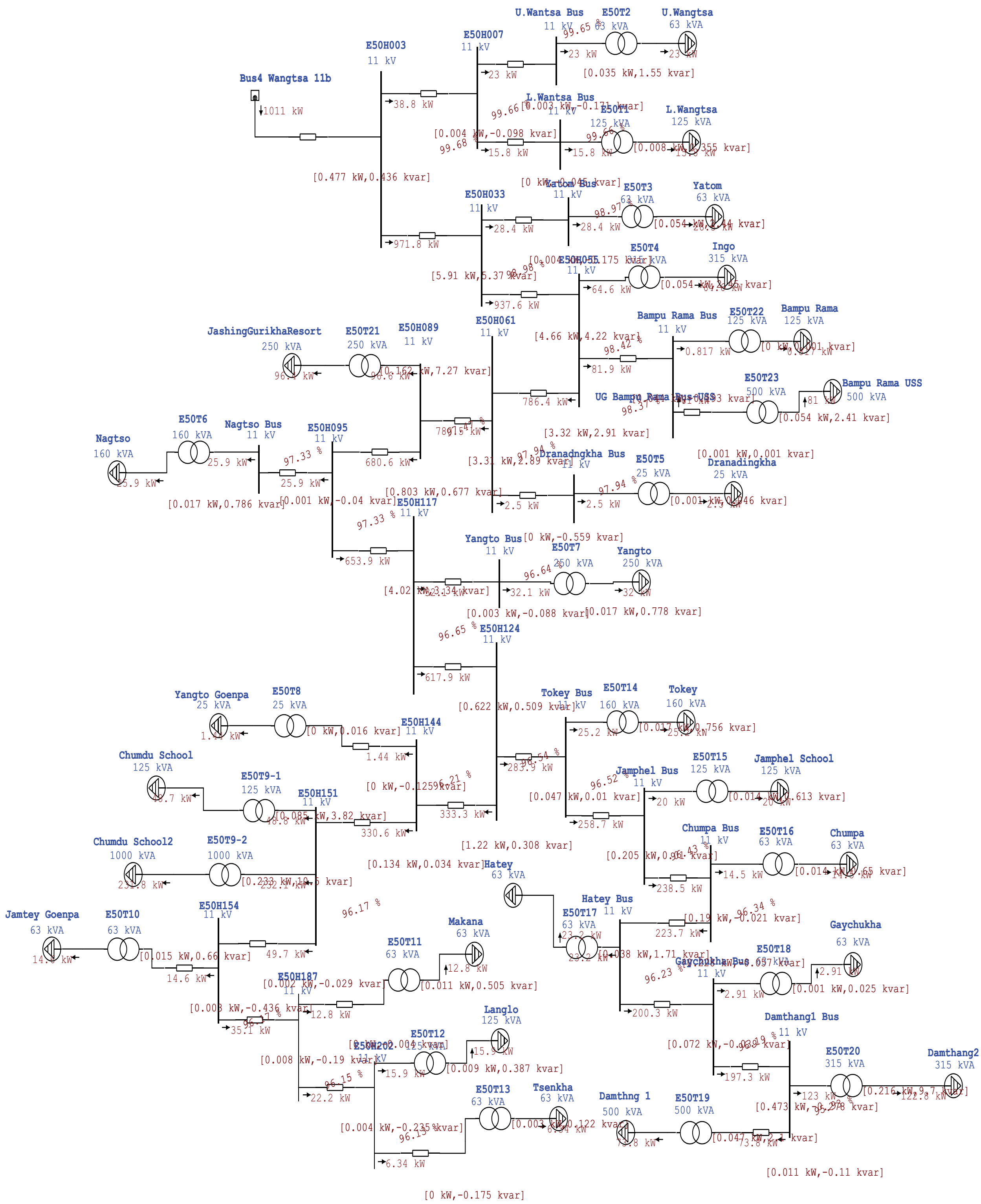


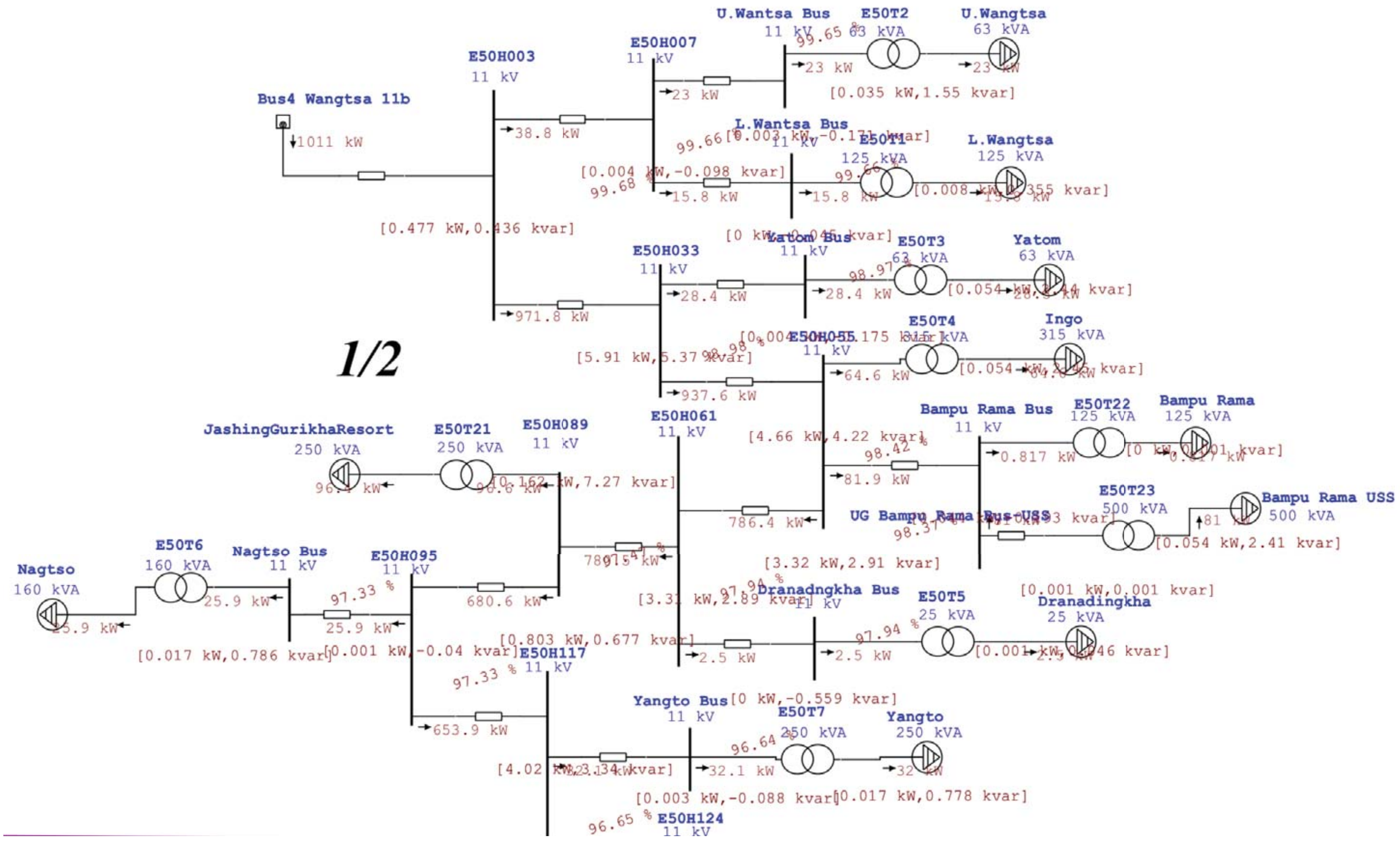

Bus3 Wangtsa 11a
349.9 kW
UG E30T1
[0.046 kW,0.032 kvar]
E30T1Bus
11 kV
99.72 %
97 kW
252.8 kW
E30T1
750 kVA
[0.049 kW,2.23 kvar]
UG E30T2
[0.025 kW,0.017 kvar]
97 kW
E30T2
1000 kVA
[0.257 kW,11.6 kvar]
Hospital SS
750 kVA
252.6 kW
New Adm Building
1000 kVA

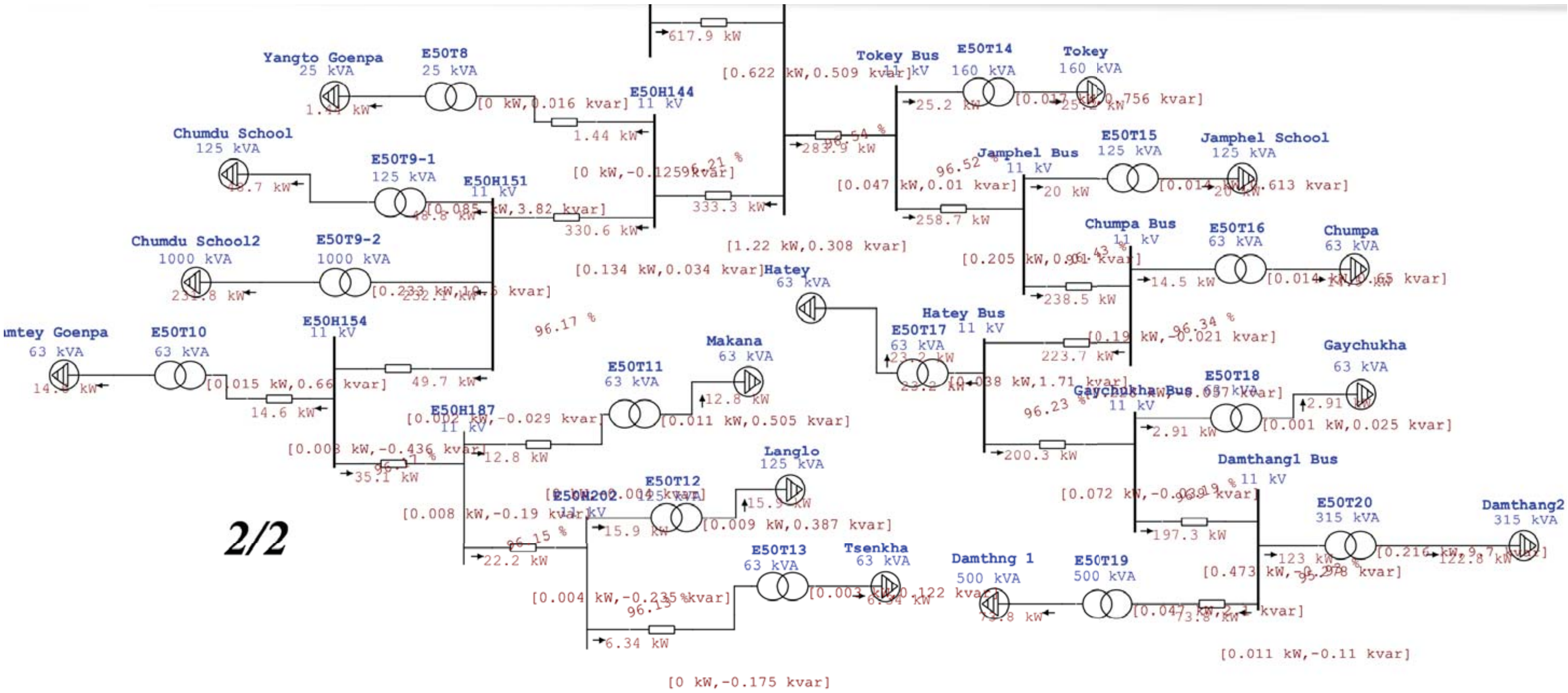
One-Line Diagram - ESD Haa=>Feeder E40 (Load Flow Analysis)



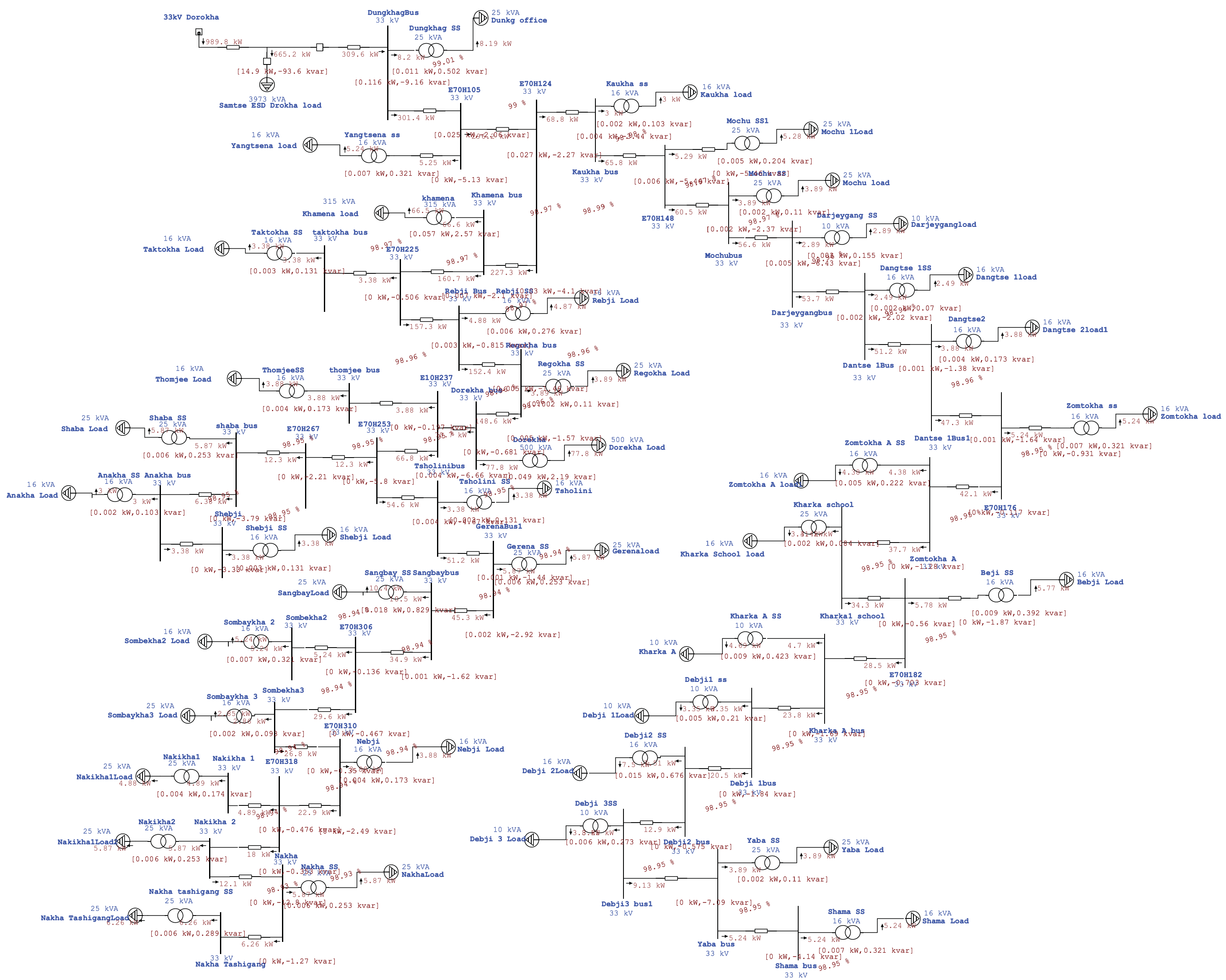
One-Line Diagram - ESD Haa=>Feeder E50 (Load Flow Analysis)

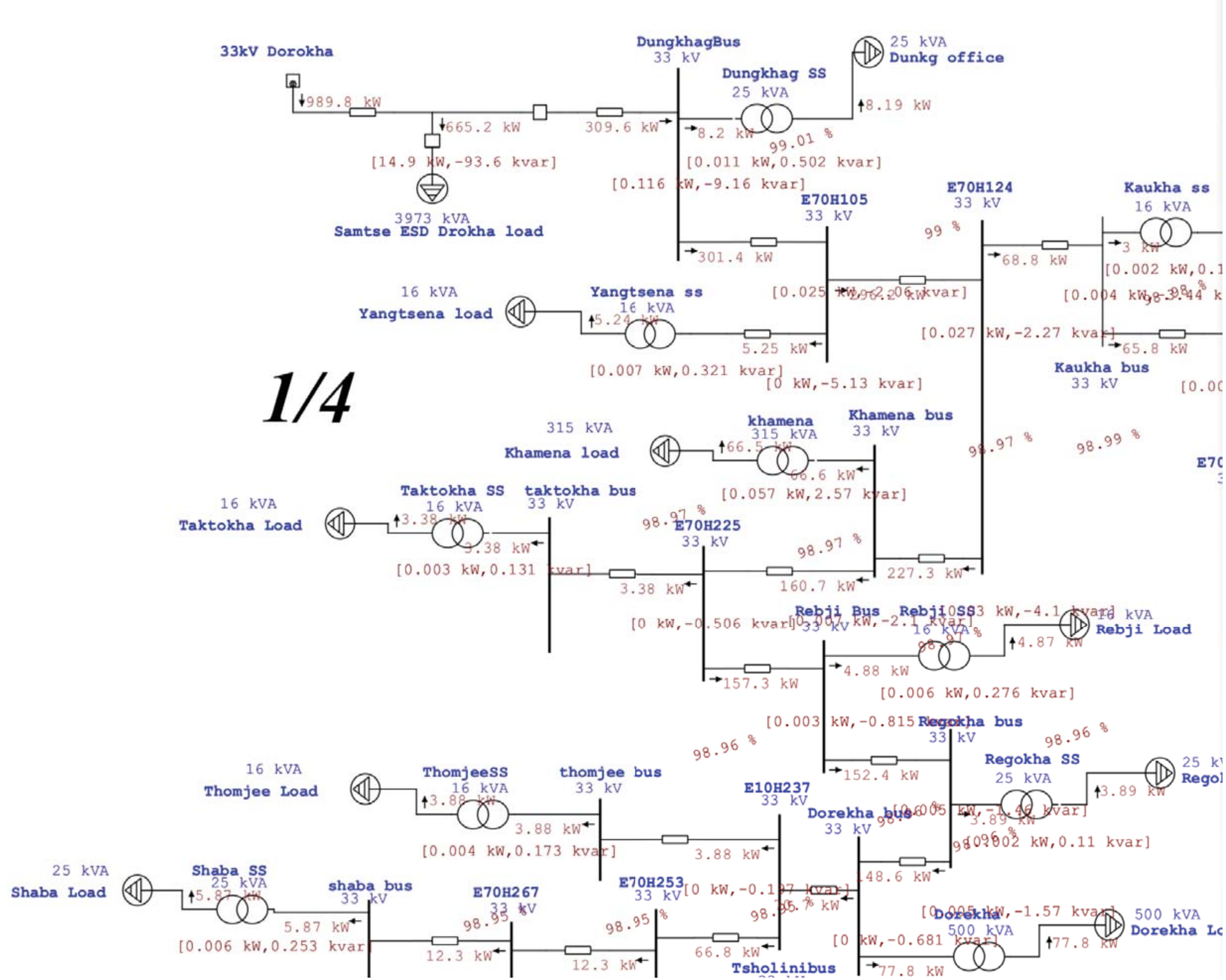



1/2
Bus4 Wangtsa 11b
1011 kW
E50H003
11 kV
[0.477 kW,0.436 kvar]
38.8 kW
971.8 kW
E50H007
11 kV
23 kW
15.8 kW
U.Wantsa Bus
11 kV
E50T2
63 kVA
U.Wangtsa
63 kVA
[0.035 kW,1.55 kvar]
L.Wantsa Bus
11 kV
E50T1
125 kVA
L.Wangtsa
125 kVA
[0.004 kW,-0.098 kvar]
99.68 %
E50H033
11 kV
28.4 kW
[5.91 kW,5.37 kvar]
937.6 kW
Yatom Bus
11 kV
E50T3
63 kVA
Yatom
63 kVA
E50H055
11 kV
64.6 kW
E50T4
315 kVA
Ingo
315 kVA
E50H061
11 kV
[4.66 kW,4.22 kvar]
81.9 kW
786.4 kW
Bampu Rama Bus
11 kV
0.817 kW
E50T22
125 kVA
Bampu Rama
125 kVA
UG Bampu Rama Bus-USS
E50T23
500 kVA
Bampu Rama USS
500 kVA
[0.054 kW,2.41 kvar]
[3.32 kW,2.91 kvar]
[0.001 kW,0.001 kvar]
Dranadngkha Bus
11 kV
E50T5
25 kVA
97.94 %
Dranadingkha
25 kVA
2.5 kW
JashingGurikhaResort
250 kVA
E50T21
250 kVA
E50H089
11 kV
680.6 kW
E50H095
11 kV
97.33 %
Nagtso Bus
11 kV
25.9 kW
E50T6
160 kVA
Nagtso
160 kVA
[0.017 kW,0.786 kvar]
E50H117
11 kV
653.9 kW
Yangto Bus
11 kV
[0 kW,-0.559 kvar]
E50T7
250 kVA
96.64 %
32.1 kW
Yangto
250 kVA
[0.003 kW,-0.088 kvar]
[0.017 kW,0.778 kvar]
E50H124
11 kV
96.65 %

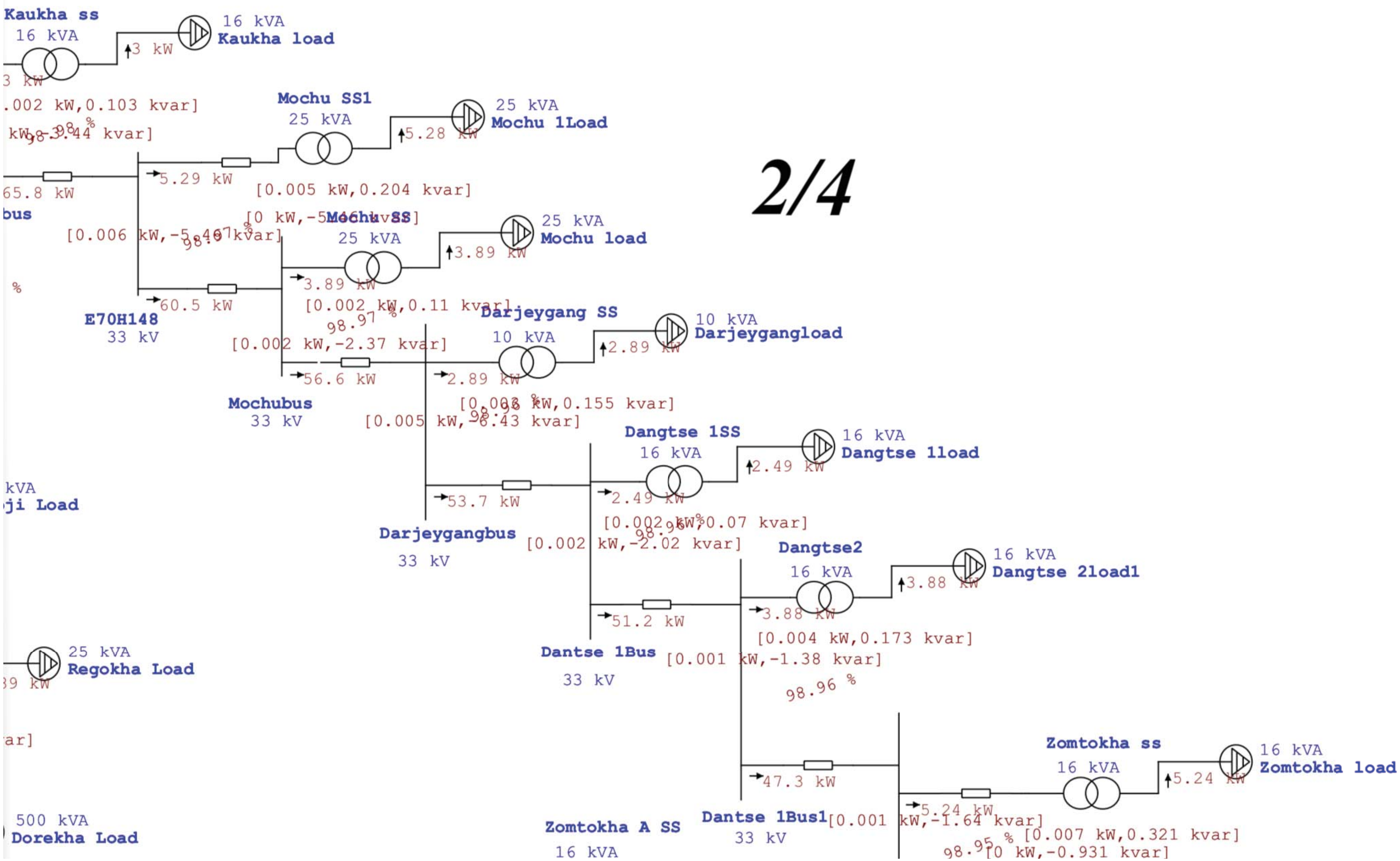

Yangto Goenpa
25 kVA
E50T8
25 kVA
E50H144
11 kV
617.9 kW
[0.622 kW,0.509 kvar]
Tokey Bus
11 kV
E50T14
160 kVA
Tokey
160 kVA
25.2 kW
283.9 kW
Chumdu School
125 kVA
E50T9-1
125 kVA
E50H151
11 kV
[0 kW,-0.1259 kvar]
1.44 kW
333.3 kW
330.6 kW
E50T15
125 kVA
Jamphel School
125 kVA
Jamphel Bus
11 kV
20 kW
[0.047 kW,0.01 kvar]
258.7 kW
Chumdu School2
1000 kVA
E50T9-2
1000 kVA
[1.22 kW,0.308 kvar]
[0.134 kW,0.034 kvar]
Hatey
63 kVA
Chumpa Bus
11 kV
E50T16
63 kVA
Chumpa
63 kVA
14.5 kW
238.5 kW
E50H154
11 kV
E50T10
63 kVA
49.7 kW
14.6 kW
Hatey Bus
11 kV
E50T17
63 kVA
223.7 kW
Makana
63 kVA
E50T11
63 kVA
12.8 kW
[0.011 kW,0.505 kvar]
E50H187
11 kV
Gaychukha
63 kVA
E50T18
Gaychukha Bus
11 kV
2.91 kW
[0.001 kW,0.025 kvar]
200.3 kW
35.1 kW
Langlo
125 kVA
E50T12
125 kVA
E50H202
11 kV
15.9 kW
[0.009 kW,0.387 kvar]
[0.008 kW,-0.19 kvar]
22.2 kW
Damthang1 Bus
11 kV
197.3 kW
E50T20
315 kVA
Damthang2
315 kVA
123 kW
122.8 kW
E50T13
63 kVA
Tsenkha
63 kVA
Damthng 1
500 kVA
E50T19
500 kVA
73.8 kW
6.34 kW
[0.004 kW,-0.235 kvar]
[0 kW,-0.175 kvar]
[0.011 kW,-0.11 kvar]
96.17 %
2/2

One-Line Diagram - ESD Haa=>E70 Sombeykha feeder (Load Flow Analysis)

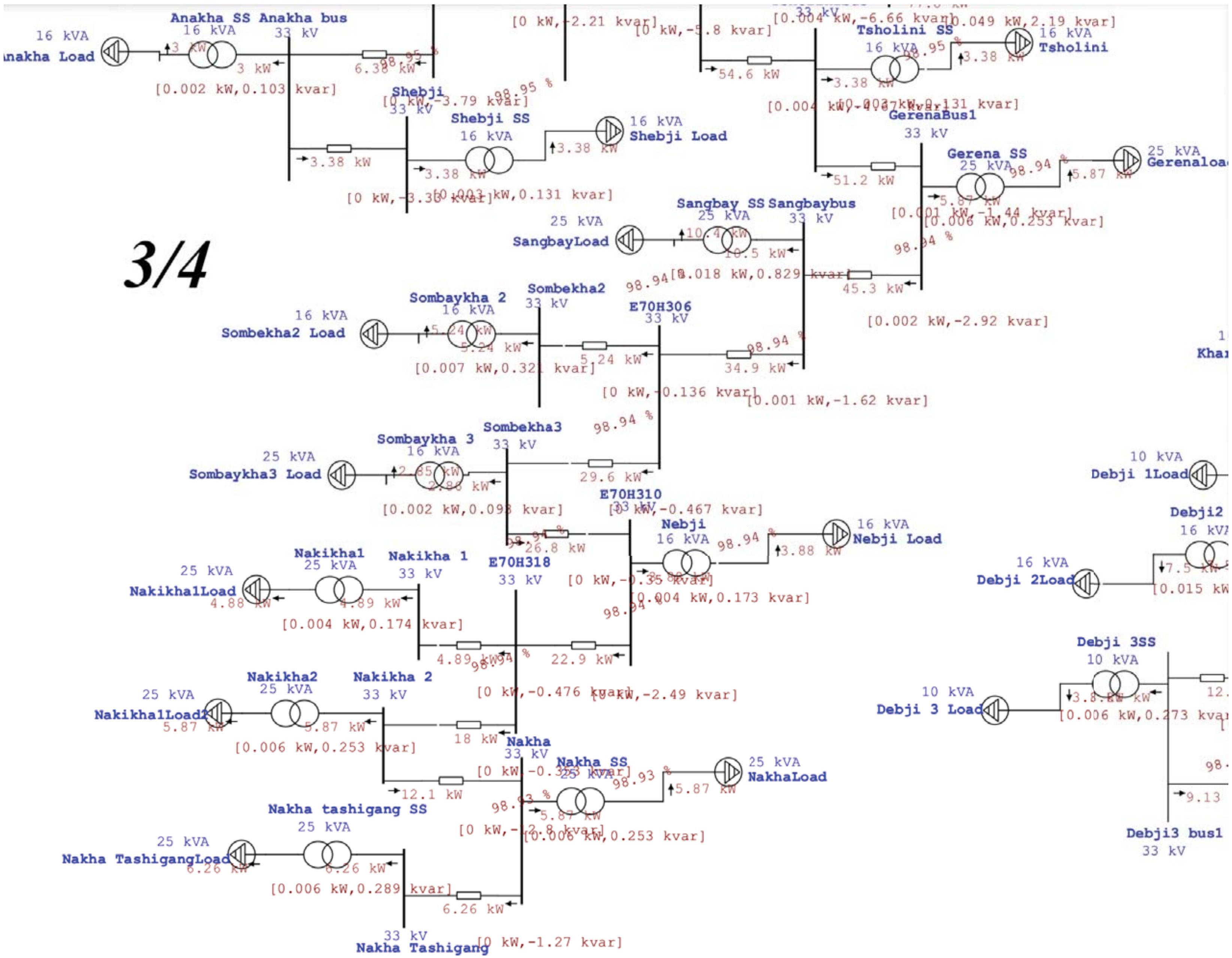



1/4
33kV Dorokha
989.8 kW
665.2 kW
[14.9 kW,-93.6 kvar]
3973 kVA
Samtse ESD Drokha load
309.6 kW
DungkhagBus
33 kV
Dungkhag SS
25 kVA
8.2 kW
99.01 %
[0.011 kW,0.502 kvar]
[0.116 kW,-9.16 kvar]
25 kVA
Dunkg office
8.19 kW
E70H105
33 kV
301.4 kW
E70H124
33 kV
99 %
68.8 kW
[0.027 kW,-2.27 kvar]
Kaukha ss
16 kVA
3 kW
Kaukha bus
33 kV
65.8 kW
16 kVA
Yangtsena load
Yangtsena ss
16 kVA
5.24 kW
5.25 kW
[0.007 kW,0.321 kvar]
[0 kW,-5.13 kvar]
315 kVA
Khamena load
khamena
315 kVA
66.6 kW
[0.057 kW,2.57 kvar]
Khamena bus
33 kV
98.97 %
98.99 %
227.3 kW
16 kVA
Taktokha Load
Taktokha SS
16 kVA
3.38 kW
taktokha bus
33 kV
[0.003 kW,0.131 kvar]
E70H225
33 kV
3.38 kW
160.7 kW
[0 kW,-0.506 kvar]
157.3 kW
Rebji Bus
33 kV
Rebji SS
16 kVA
Rebji Load
4.87 kW
4.88 kW
[0.006 kW,0.276 kvar]
Regokha bus
33 kV
98.96 %
152.4 kW
Regokha SS
25 kVA
3.89 kW
[0.002 kW,0.11 kvar]
16 kVA
Thomjee Load
ThomjeeSS
16 kVA
3.88 kW
thomjee bus
33 kV
[0.004 kW,0.173 kvar]
E10H237
33 kV
Dorekha bus
33 kV
148.6 kW
Dorekha
500 kVA
500 kVA
Dorekha Lo
77.8 kW
[0 kW,-0.681 kvar]
25 kVA
Shaba Load
Shaba SS
25 kVA
5.87 kW
shaba bus
33 kV
[0.006 kW,0.253 kvar]
E70H267
33 kV
98.95 %
12.3 kW
E70H253
33 kV
66.8 kW
Tsholinibus

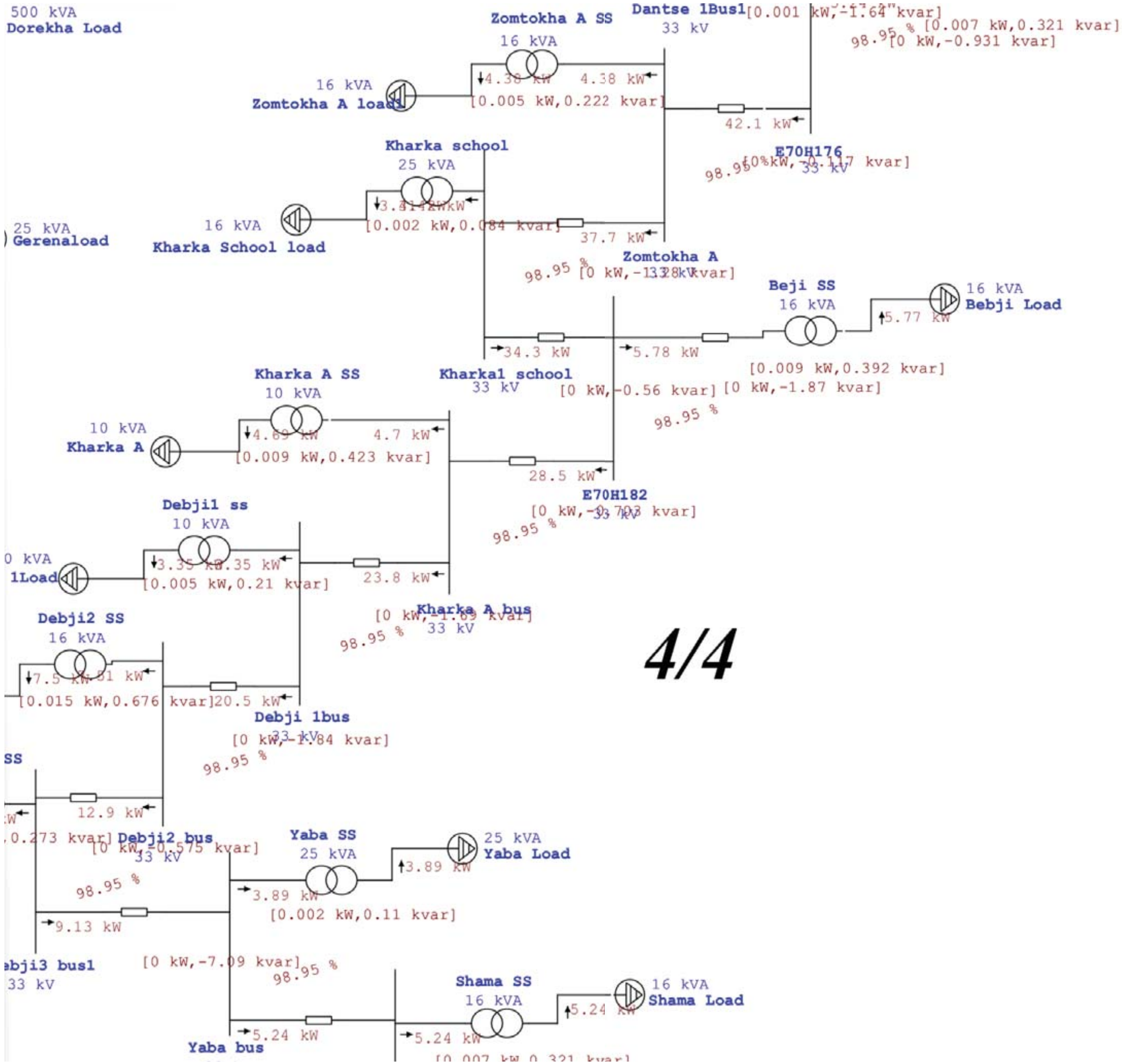
2/4



Kaukha ss
16 kVA
3 kW
16 kVA
Kaukha load
.002 kW,0.103 kvar]
65.8 kW
bus
Mochu SS1
25 kVA
5.28 kW
25 kVA
Mochu 1Load
5.29 kW
[0.005 kW,0.204 kvar]
[0.006 kW,-5.46 kvar]
Mochu SS
25 kVA
3.89 kW
25 kVA
Mochu load
3.89 kW
[0.002 kW,0.11 kvar]
98.97 %
60.5 kW
E70H148
33 kV
[0.002 kW,-2.37 kvar]
56.6 kW
Mochubus
33 kV
Darjeygang SS
10 kVA
2.89 kW
10 kVA
Darjeygangload
2.89 kW
[0.005 kW,-6.43 kvar]
0.155 kvar]
53.7 kW
Darjeygangbus
33 kV
Dangtse 1SS
16 kVA
2.49 kW
16 kVA
Dangtse 1load
2.49 kW
0.07 kvar]
kW,-2.02 kvar]
51.2 kW
Dantse 1Bus
33 kV
Dangtse2
16 kVA
3.88 kW
16 kVA
Dangtse 2load1
3.88 kW
[0.004 kW,0.173 kvar]
[0.001 kW,-1.38 kvar]
98.96 %
47.3 kW
Dantse 1Bus1
33 kV
[0.001 kW,-1.64 kvar]
5.24 kW
Zomtokha ss
16 kVA
5.24 kW
16 kVA
Zomtokha load
[0.007 kW,0.321 kvar]
[0 kW,-0.931 kvar]
98.95 %
Zomtokha A SS
16 kVA
kVA
ji Load
25 kVA
Regokha Load
500 kVA
Dorekha Load



3/4
16 kVA
Anakha SS
Anakha bus
33 kV
[0.002 kW,0.103 kvar]
Shebji
33 kV
Shebji SS
16 kVA
16 kVA
Shebji Load
[0 kW,-2.21 kvar]
Tsholini SS
16 kVA
Tsholini
GerenaBus1
33 kV
Gerena SS
25 kVA
25 kVA
54.6 kW
51.2 kW
Sangbay SS
Sangbaybus
25 kVA
SangbayLoad
[0.018 kW,0.829 kvar]
45.3 kW
[0.002 kW,-2.92 kvar]
16 kVA
Sombekha2 Load
Sombaykha 2
Sombekha2
E70H306
33 kV
[0.007 kW,0.321 kvar]
[0 kW,-0.136 kvar]
[0.001 kW,-1.62 kvar]
34.9 kW
25 kVA
Sombaykha3 Load
Sombaykha 3
Sombekha3
29.6 kW
[0.002 kW,0.098 kvar]
E70H310
[0 kW,-0.467 kvar]
Nebji
16 kVA
Nebji Load
[0.004 kW,0.173 kvar]
Nakikha1
Nakikha 1
E70H318
25 kVA
Nakikha1Load
[0.004 kW,0.174 kvar]
22.9 kW
Nakikha2
Nakikha 2
Nakikha1Load2
[0.006 kW,0.253 kvar]
18 kW
Nakha
Nakha SS
NakhaLoad
12.1 kW
Nakha tashigang SS
Nakha TashigangLoad
[0.006 kW,0.289 kvar]
6.26 kW
Nakha Tashigang
[0 kW,-1.27 kvar]
10 kVA
Debji 1Load
Debji2
Debji 2Load
Debji 3SS
Debji 3 Load
Debji3 bus1


500 kVA
Dorekha Load
Zomtokha A SS
16 kVA
Dantse 1Bus1
33 kV
16 kVA
Zomtokha A load
4.38 kW
[0.005 kW,0.222 kvar]
42.1 kW
E70H176
33 kV
Kharka school
25 kVA
[0.002 kW,0.084 kvar]
25 kVA
Gerenaload
16 kVA
Kharka School load
37.7 kW
Zomtokha A
98.95 %
Beji SS
16 kVA
16 kVA
Bebji Load
5.77 kW
34.3 kW
5.78 kW
Kharka1 school
33 kV
[0.009 kW,0.392 kvar]
[0 kW,-1.87 kvar]
[0 kW,-0.56 kvar]
Kharka A SS
10 kVA
10 kVA
Kharka A
4.7 kW
[0.009 kW,0.423 kvar]
28.5 kW
E70H182
Debji1 ss
10 kVA
[0.005 kW,0.21 kvar]
23.8 kW
Kharka A bus
33 kV
Debji2 SS
16 kVA
[0.015 kW,0.676 kvar]
20.5 kW
Debji 1bus
12.9 kW
Debji2 bus
33 kV
Yaba SS
25 kVA
25 kVA
Yaba Load
3.89 kW
[0.002 kW,0.11 kvar]
9.13 kW
[0 kW,-7.09 kvar]
Shama SS
16 kVA
16 kVA
Shama Load
5.24 kW
Yaba bus

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Feeder details		Voltage (kV)	Section	Conductor type & Line Length						Distribution Transformer			Remarks
Name	ID			UG(300sq. mm)	DOG	RABBIT	Section Length (km)	Cumulative Length (km)	3-Phase/1-Phase	Capacity (kVA)	3-Phase/1-Phase	ID	
Watsa SS to Haa Feeder	B180,H190,E60	33	Watsa SS to B180H007		635.000		0.635	0.635	3				
			B180H007 to Lower Wanakha SS		1270.000		1.270	1.270	3	63	3	H190T1	
			H190H013 to H190H020		622.000		0.622	0.622	3				
			H190H020 to Stone Crasher S/S			164.670	0.165	0.165	3	250	3	H190T31	BPC
			H190H022 to Wanakha School S/S			842.390	0.842	0.842	3			H190T2	BPC
			H190H029 to H190H032			258.000	0.258	0.258	3				
			H190H031 to Susuna S/S			2290.000	2.290	2.290	3	63		H190T3	BPC
			H190H032 to Neymo S/S			591.000	0.591	0.591	3	63		H190T4	BPC
			H190H020 to H190H073		466.000		0.466	0.466	3				
			H190H073 to Gangney S/s			465.000	0.465	0.465	3	63		H190T5	BPC
			H190H079 to H190H091		1390.000		1.390	1.390	3				
			H190H091 to Labana S/S		53.100		0.053	0.053	3	63		H190T6	BPC
			H190H092 to H190H097		633.000		0.633	0.633	3				
			H190H097 to Domzaygang		39.100		0.039	0.039	3	63		H190T7	BPC
			H190H098 to Pawgang S/S		1700.000		1.700	1.700	3	63		H190T8	BPC
			H190H113 to Jazhina S/S		841.000		0.841	0.841	3	63		H190T9	BPC
			Jazhina S/S to H190H128		647.000		0.647	0.647	3				
			H190H128 to H190H142		1330.000		1.330	1.330	3				
			H190H142 to Gurugang			16.900	0.017	0.017	3	63		H190T10	BPC
			H190H142 to Rashigang S/S		1060.000		1.060	1.060	3	25		H190T11	BPC
			H190H153 to H190H155		227.000		0.227	0.227	3				
			H190H155 to Tsepji S/S		402.000		0.402	0.402	3	63		H190T12	BPC
			H190H155 to Chamthangkha S/S		16.200		0.016	0.016	3	63		H190T13	BPC
			H190H174 to H190H186		1000.000		1.000	1.000	3				
			H190H186 to Sagu S/S		210.000		0.210	0.210	3	63		H190T14	BPC
			H190H186 to H190H193		357.000		0.357	0.357	3				
			H190H193 to Jangkha S/S		338.000		0.338	0.338	3	63		H190T15	BPC
			H190H193 to H190H204		733.000		0.733	0.733	3				
			H190H204 to Betikha S/S		159.000		0.159	0.159	3	125		H190T16	BPC
			H190H204 to H190H215		1140.000		1.140	1.140	3				
			H190H215 to Jelikha S/S			315.000	0.315	0.315	3	315		H190T17	BPC
			H190H215 to Lhazukha S/S		217.000		0.217	0.217	3	63		H190T18	BPC
			Lhazukha S/S to H190H227		1000.000		1.000	1.000	3				
			H190H227 to H190H233			678.000	0.678	0.678	3				
			H190H233 to Nagu S/S			217.000	0.217	0.217	3	63		H190T19	BPC
			H190H233 to H190H245			1510.000	1.510	1.510	3				
			H190H245 to Lingzhi 2			16.400	0.016	0.016	3	63		H190T20	BPC
			H190H245 to H190H256			1160.000	1.160	1.160	3				
			H190H256 to Lingzhi 1			110.000	0.110	0.110	3	63		H190T21	BPC
			H190H256 to Jatakha s/s			2700.000	2.700	2.700	3	63		H190T22	BPC
			H190H228 to Bampo S/S			2360.000	2.360	2.360	3	25		H190T23	BPC
			H190H276 to H190H320		1700.000		1.700	1.700	3				
			H190H320 to E60H080		8450.000		8.450	8.450	3				
			H190H321 to H190H330			1600.000	1.600	1.600	1				
			H190H330 to Aringkha S/S			194.000	0.194	0.194	1	10		H190T24	BPC
			Aringkha S/S to Reringkha S/S			848.000	0.848	0.848	1	25		H190T25	BPC
			H190H330 to Babana S/S			1130.000	1.130	1.130	1	10		H190T26	BPC
			Babana S/S to Kumri S/S			623.000	0.623	0.623	1	25		H190T27	BPC
			H190H208 to Chazhi S/S			3950.000	3.950	3.950	3	25		H190T28	BPC
			Chazhi S/S to H190H371			1200.000	1.200	1.200	3				
			H190H371 to papali S/S			322.000	0.322	0.322	3	25		H190T29	BPC
			H190H371 to Sacho Goenpa S/S			884.000	0.884	0.884	3	16		H190T30	BPC
					26635.400	**24445.360**	**51.081**	**51.081**		**30**			

Wangtsa SS to Dumchu	E10	11	Wangtsa SS to Imtrat Hospital SS		627		0.627	0.627	3	163	3	E10T1	BPC
			M.Hospital SS to BOB S/S		662.88		0.663	0.663	3	25	3	E10T31	BPC
			BOB S/S to Dumcho S/S		1057.12		1.057	1.057	3	250	3	E10T2	BPC
			Dumcho S/S to E10H038		402		0.402	0.402	3				
			E10H038 to E10H055			1340	1.340	1.340	3				
			E10H055 to Jawang Goenpa			115	0.115	0.115	3	16	3	E10T3	BPC
			Jawang Goenpa to Takchu Goenpa			620	0.620	0.620	3	63	3	E10T4	BPC
			E10H038 to E10H086		1220		1.220	1.220	3				
			E10H086 to Tshilungpa Goenpa			365	0.365	0.365	3	125	3	E10T5	BPC
			E10H086 to Betsho Goenpa			103	0.103	0.103	3	63	3	E10T6	BPC
			Betsho Goenpa to E10H111		1470		1.470	1.470	3				
			E10H111 to Tsaphel 1 S/S			73.2	0.073	0.073	3	63	3	E10T7	BPC
			E10H111 to E10H115		109		0.109	0.109	3				
			E10H115 to Damtika S/S			1320	1.320	1.320	3	16	3	E10T8	BPC
			E10H115 to Tsaphel 2 S/S		252		0.252	0.252	3	63	3	E10T9	BPC
			Tsaphel 2 S/S to E10H139		430		0.430	0.430	3				
			E10H139 to Tsaphel 3 S/S			294	0.294	0.294	3	250	3	E10T10	BPC
			E10H139 to Kana 1 S/S		668		0.668	0.668	3	16	3	E10T11	BPC
			Kana 1 S/S to E10H159		250		0.250	0.250	3				
			E10H159 to E10H160		56.18		0.056	0.056	3				
			E10H160 to Sangkire S/S			1273.82	1.274	1.274	3	63	3	E10T12	BPC
			E10H159 to E10H185		77.8		0.078	0.078	3				
			E10H185 to Kana 2 S/S			525.62	0.526	0.526	3	125	3	E10T13	BPC
			E10H185 to Gerena S/S		674		0.674	0.674	3	63	3	E10T14	BPC
			Gerena S/S to E10H209		116		0.116	0.116	3				
			E10H209 to E10H224			1100	1.100	1.100	3				
			E10H224 to Pajaykha			76.6	0.077	0.077	3	25	3	E10T15	BPC
			E10H224 to Sacho Gempa			1800	1.800	1.800	3	25	3	E10T16	BPC
			E10H209 to E10H247		548		0.548	0.548	3				
			E10H247 to E10H263			858	0.858	0.858	3				
			E10H263 to Jyenkana School S/S			58.8	0.059	0.059	3	63	3	E10T17	BPC
			E10H263 to E10H273			533	0.533	0.533	3				
			E10H273 to Pudhuna S/S			353	0.353	0.353	3	25	3	E10T18	BPC
			E10H273 to Jyenkana 2 S/S			52.7	0.053	0.053	3	16	3	E10T19	BPC
			Jyenkana 2 S/S to Balamna 1 S/S			1370	1.370	1.370	3	63	3	E10T20	BPC
			Balamna 1 S/S to E10H305			662	0.662	0.662	3				
			E10H305 to Balamna 2			223	0.223	0.223	3	16	3	E10T21	BPC
			Balamna 2 to Balamna 3			560	0.560	0.560	3	16	3	E10T22	BPC
			Balamna 3 S/S to E10H351			2240	2.240	2.240	3				
			E10H351 to Shari 1 S/S			49.2	0.049	0.049	3	63	3	E10T23	BPC
			E10H351 to Shari 2 S/S			900	0.900	0.900	3	63	3	E10T24	BPC
			E10H305 to Gangkha S/S			1160	1.160	1.160	3	25	3	E10T25	BPC
			Gangkha S/S to E10H388			398	0.398	0.398	3				
			E10H388 to Nobgang S/S			281	0.281	0.281	3	25	3	E10T26	BPC
			Nobgang S/S to E10H402			1140	1.140	1.140	3				
			E10H402 to Borakha S/S			390	0.390	0.390	3	63	3	E10T27	BPC
			E10H402 to Lhenkha S/S			1750	1.750	1.750	3	16	3	E10T28	BPC
			Lhenkha S/S to E10H439			908	0.908	0.908	3				
			E10H439 to Dorikha S/S			363	0.363	0.363	3	25	3	E10T29	BPC
			E10H439 to Lamjeygang			2270	2.270	2.270	3	16	3	E10T30	BPC
					8619.980	**25525.940**	**34.146**	**34.146**		**31.000**			

Wangtsa S/S to Imtrat S/S	E20	11	Wangtsa SS to E20H005			346	0.346	0.346	3				
			E20H005 to E20H007			148	0.148	0.148	3				
			E20H007 to Demo S/S			110	0.11	0.11	3	160	3	E20T1	BPC
			E20H007 to E20H015			464	0.464	0.464	3				
			E20H015 to Imtrat Power House S/S			116	0.116	0.116	3	500&315	3	E20T2-1&2	BPC
			E20H015 to Ngachu S/S			23	0.023	0.023	3	63	3	E20T3	BPC
			Ngachu S/S to E20H025			508	0.508	0.508	3				
			E20H025 to Bangina S/S			58.7	0.0587	0.0587	3	160	3	E20T4	BPC
			E20H025 to Imtrat S/S			524	0.524	0.524	3	500	3	E20T5	BPC
			E20H005 to Janatsam S/S			925	0.925	0.925	3	63	3	E20T6	BPC
					0.000	**3222.700**	**3.223**	**3.223**		**7.000**			
Wangtsa S/S to Adm Block	E30	11	Wangtsa S/S to Hospital S/S	136			0.136	0.136	3	750	3		Pvt
			Hospital S/S to New adm Building S/S	514			0.514	0.514	3	1000	3		BPC
				650	**0.000**	**0.000**	**0.650**	**0.650**		**2**			
Wangtsa S/S toTown Feeder	E40	11	Wangtsa SS to E40H003			177	0.177	0.177	3				
			E40H003 to L/Market S/S			284	0.284	0.284	3	125	3	E40T1	BPC
			E40H003 to E40H017			947.75	0.94775	0.94775	3				
			E40H017 to E40H019			107	0.107	0.107	3				
			E40H019 to Bali S/S			31	0.031	0.031	3	500	3	E40T2	BPC
			E40H019 to E40H024(connect with E10)			304	0.304	0.304	3				
			E40H017 to Lhayulkha			212	0.212	0.212	3	315	3	E40T3	BPC
			Lhayulkha to USS below Jamyang Store			132	0.132	0.132	3	1000	3	E40T4	BPC
					0.000	**2194.750**	**2.195**	**2.195**		**4**			
Wangtsa S/S to Damthang	E50	11	Wangtsa S/S to E50H003			95.7	0.0957	0.0957	3				
			E50H003 to E50H007			304	0.304	0.304	3				
			E50H007 to L/Wangtsa S/S			137	0.137	0.137	3	125	3	E50T1	BPC
			E50H007 to U/Wangtsa S/S			523	0.523	0.523	3	63	3	E50T2	BPC
			E50H003 to E50H033		1280		1.28	1.28	3				
			E50H033 to Yatom S/S			545	0.545	0.545	3	63	3	E50T3	BPC
			E50H033 to E50H044		353.05		0.35305	0.35305	3				
			E50H044 to E50H054		676.95								
			E50H054 to Ingo S/S			53.4	0.0534	0.0534	3	315	3	E50T4	BPC
			Ingo S/S to E50H061		409		0.409	0.409	3				
			E50H061 to Dranadingkha S/S			1760	1.76	1.76	3	25	3	E50T5	BPC
			E50H061 to Jangshng gurikha Resort S/S		307.1		0.3071	0.3071	3				
			Jangshng gurikha Resort S/S to E50H095		340.9		0.3409	0.3409	3	250	3	E50T21	BPC
			E50H095 to Nagtso S/S			128	0.128	0.128	3	160	3	E50T6	BPC
			E50H095 to E50H117		1840		1.84	1.84	3				
			E50H117 to Yangto S/S			290	0.29	0.29	3	250	3	E50T7	BPC
			E50H117 to E50H124		315		0.315	0.315	3				
			E50H117 to E50H144			1070	1.07	1.07	3				
			E50H144 to Yangto Goenpa			409	0.409	0.409	3	25	3	E50T8	BPC
			E50H144 to Chundu School S/S			119	0.119	0.119	3	125&1000	3	E50T9	BPC
			Chundu S/S to E50H154			100	0.1	0.1	3				
			E50H154 to Jamtey Goenpa			1430	1.43	1.43	3	63	3	E50T10	BPC
			E50H154 to E50H187			633	0.633	0.633	3				
			E50H187 to Makana S/S			14.1	0.0141	0.0141	3	63	3	E50T11	BPC
			E50H187 to Langlo S/S			773	0.773	0.773	3	125	3	E50T12	BPC
			Langlo S/S to Tsenkha S/S			572	0.572	0.572	3	63	3	E50T13	BPC
			E50H124 to Tokey S/S		1120		1.12	1.12	3	160	3	E50T14	BPC
			Tokey S/S to Jamphel HSS		586		0.586	0.586	3	125	3	E50T15	BPC
			Jamphel HSS to Chumpa S/S		639		0.639	0.639	3	63	3	E50T16	BPC
			Chumpa S/S to Hatey S/S		868		0.868	0.868	3	63	3	E50T17	BPC
			Hatey S/S to Gaychukha		339		0.339	0.339	3	63	3	E50T18	BPC
			Gaychukha to Damthan 1 S/S		2300		2.3	2.3	3	500	3	E50T19	BPC
			Damthang 1 S/S to Damthang 2 S/S		373		0.373	0.373	3	315	3	E50T20	BPC
			E50H055 to Bhempu Rama 1			675	0.675	0.675	3	125	3	E50T22	BPC
			Bhempu Rama 1 to Bhempu Rama 2	93.1			0.0931	0.0931	3	500	3	E50T23	BPC
				93.100	**11747.000**	**9631.200**	**20.794**	**20.794**		**22**			

Damdum S/S to Sombaykha/Gakeling	E70	33	E70H061(Samtse) to Dungkhag SS		3000		3	3	3	25	3		BPC
			Dungkhag SS to E70H105		674		0.674	0.674					
			E70H105 to Yangtsena S/S			1660	1.66	1.66	3	16	1		BPC
			E70H105 to E70H124		744		0.744	0.744	3				
			E70H124 to Kokha S/S			1180	1.18	1.18		16	1		BPC
			Kokha S/S to E70H148			1870	1.87	1.87					
			E70H148 to Mochu 1 S/S			141	0.141	0.141		25	3		BPC
			Mochu 1 S/S to Mochu 2 S/S			812	0.812	0.812		25	3		BPC
			Mochu 2 S/S to E70H166			2110	2.11	2.11					
			E70H166 to Dargaygang S/S			94.34	0.09434	0.09434		10	1		BPC
			Dargaygang S/S to Dangtse 1 S/S			691.64	0.69164	0.69164		16			
			Dongtse 1 S/S to Dongtse 2 S/S			474	0.474	0.474		16			
			Dongtse 2 S/S to E70H176			562	0.562	0.562	3				
			E70H176 to Zomtokha 1			319	0.319	0.319	1	16	1		BPC
			E70H176 to Zomtokha 2			40.1	0.0401	0.0401	3	16	1		BPC
			Zomtokha 2 to Karkha 1			437	0.437	0.437	3	16	1		BPC
			Karkha 1 to E70H182			192	0.192	0.192	3				
			E70H182 to Bepji			642	0.642	0.642	1	16	1		BPC
			E70H182 to karkha 2			241	0.241	0.241	3	10	1		BPC
			karkha 2 to Depji 1			578	0.578	0.578	3	10	1		BPC
			Depji 1 to Depji 2			631	0.631	0.631	3	10	1		BPC
			Depji 2 to Depji 3			197	0.197	0.197	3	10	1		BPC
			Depji 3 to Yaba S/S			2430	2.43	2.43	3	25	3		BPC
			Yaba S/S to Shama S/S			1420	1.42	1.42	3	16	1		BPC
			E70H124 to E70H225			2020	2.02	2.02	3				
			E70H225 to Tatokha S/S		164		0.164	0.164	3	16	1		BPC
			E70H225 to Repji S/S		265		0.265	0.265	3	16	1		BPC
			Repji S/S to Regokha S/S		473		0.473	0.473	3	25	1		BPC
			Regokha S/S to E70H137		733		0.733	0.733	3				BPC
			E70H137 to Thomji S/S			64	0.064	0.064	1	16	1		BPC
			E70H137 to E70H253			2160	2.16	2.16	3				
			E70H253 to E79H267			1880	1.88	1.88	3				
			E79H267 to Shaba S/S			715	0.715	0.715	3	25	3		BPC
			E79H267 to Anakha S/S			1230	1.23	1.23	3	16	3		BPC
			Anakha S/S to Shebji S/S			1080	1.08	1.08	3	16	3		BPC
			E70H253 to Tsholina S/S			1600	1.6	1.6	3	16	1		BPC
			Tsholina S/S to Garakha S/S			492	0.492	0.492	3	25	3		BPC
			Garakha S/S to Sangbay S/S			1000	1	1	3	25	3		BPC
			Sangbay S/S to E70H306			555	0.555	0.555	3				
			E70H306 to Sombeykha 2			46.5	0.0465	0.0465	1	16	1		BPC
			E70H306 to Sombeykha 3			160	0.16	0.16	1	25	1		BPC
			Sombeykha 3 to E70H310			120	0.12	0.12	3				
			E70H310 to Nepji Goenpa			588	0.588	0.588	3	16	1		BPC
			E70H310 to E70H317			855	0.855	0.855	3				
			E70H317 to Nakikha 1 S/S			163	0.163	0.163	1	16	1		BPC
			E70H317 to Nakikha 2 S/S			121	0.121	0.121	3	25	3		BPC
			E70H317 to Nakha 2 S/S			4390	4.39	4.39	3	25	3		BPC
			Nakha 2 S/S to Nakha Tashigang			437	0.437	0.437	3	25	3		BPC
					6053.000	**36398.580**	**42.452**	**42.452**		**35**			

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.**

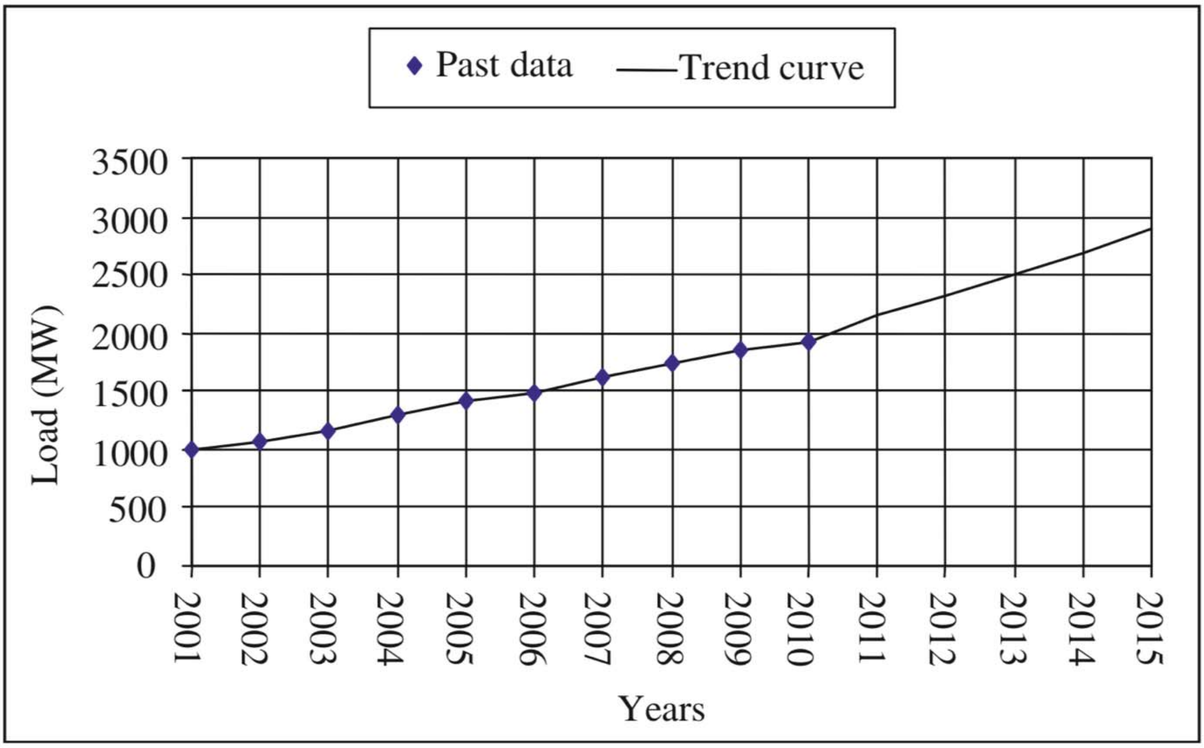


Figure 1: Typical trend curve[1]

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.

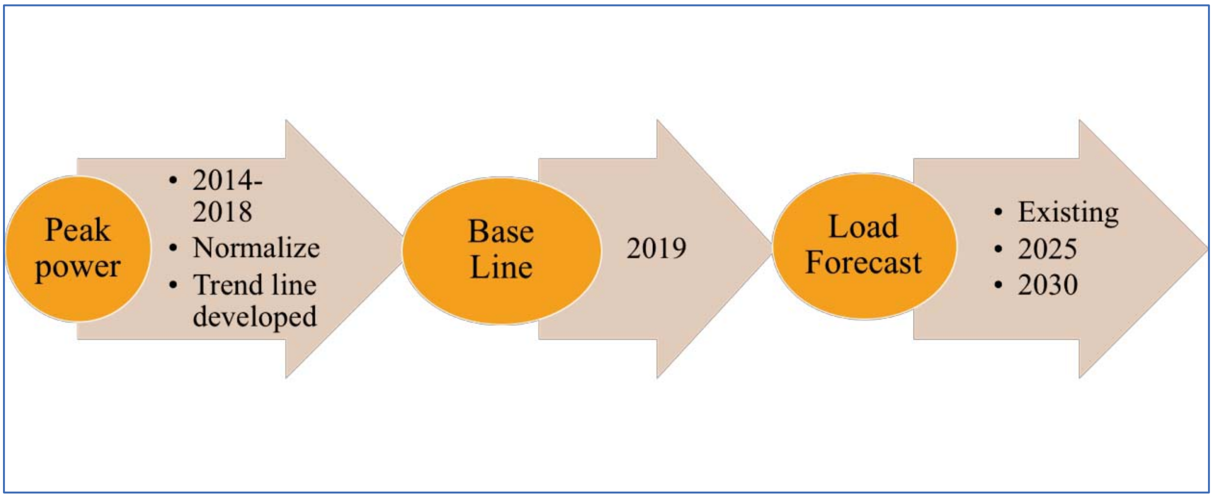


Figure 2: Flow diagram for load forecast

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**

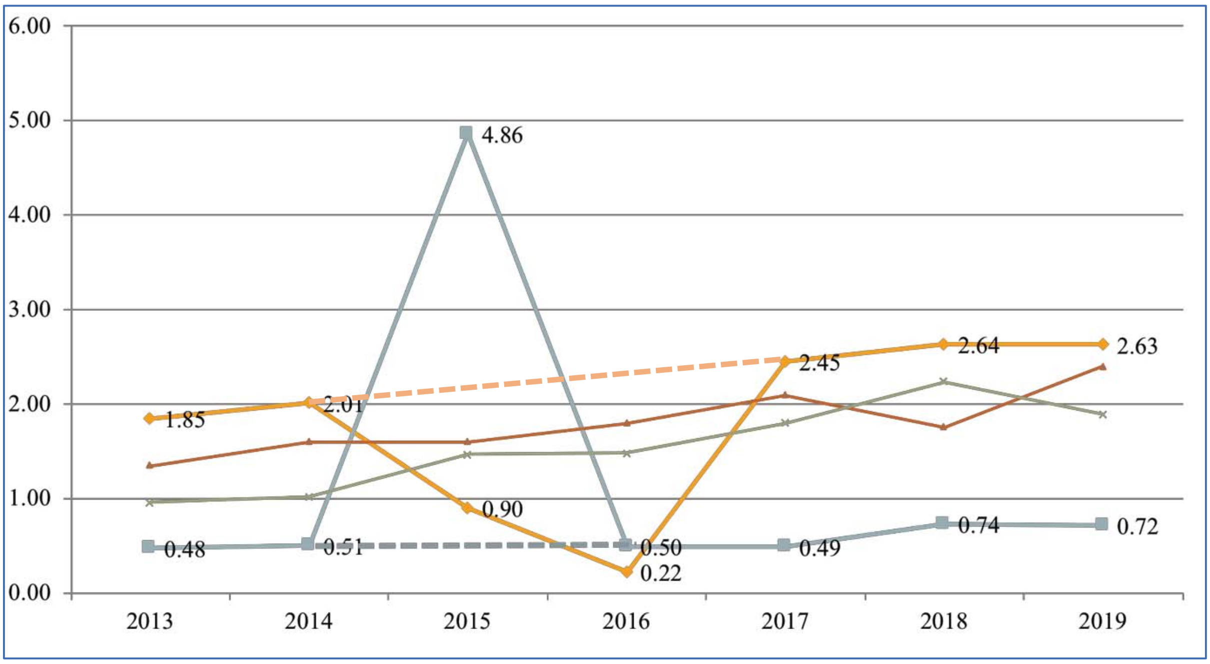


Figure 3: Actual data of Punakha Dzongkhag

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

$Where:$

$x \text{ is the normalized data}$

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.**

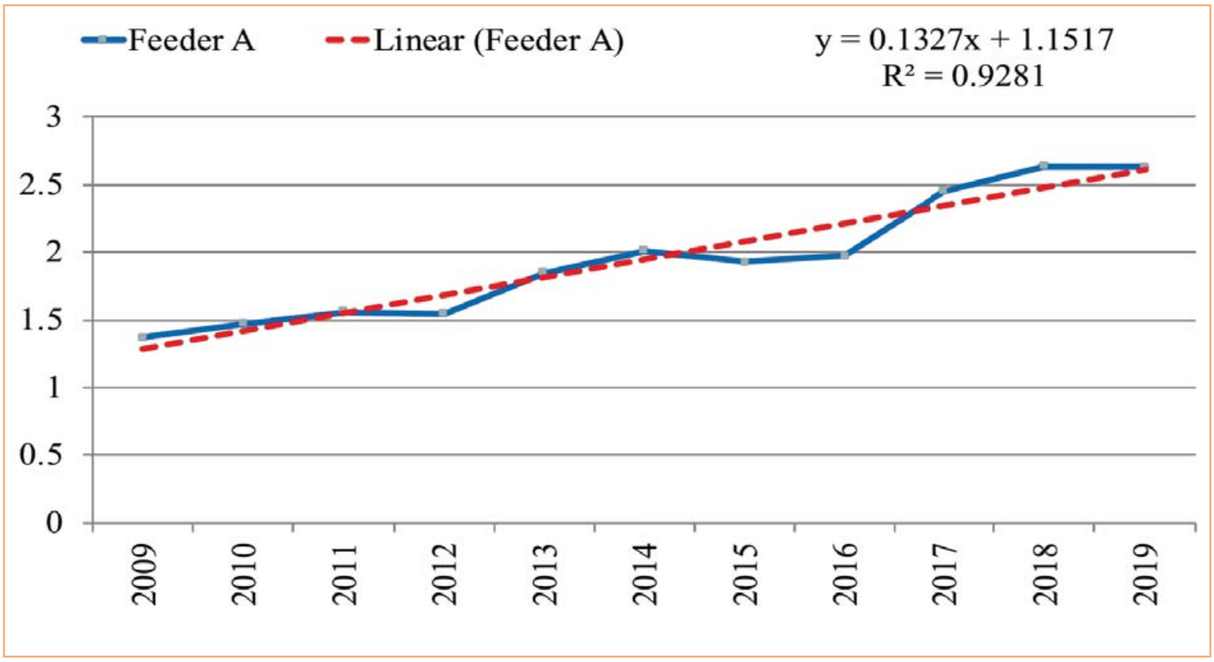


Figure 4: Trend line and load forecast for Punakha Dzongkhag

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.

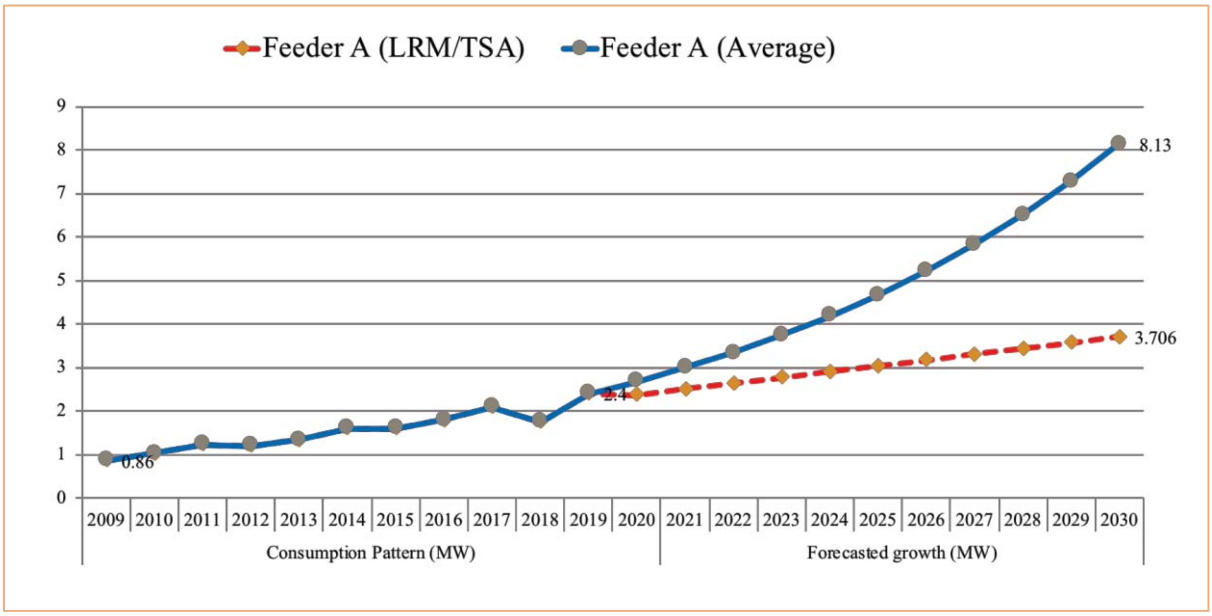


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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.

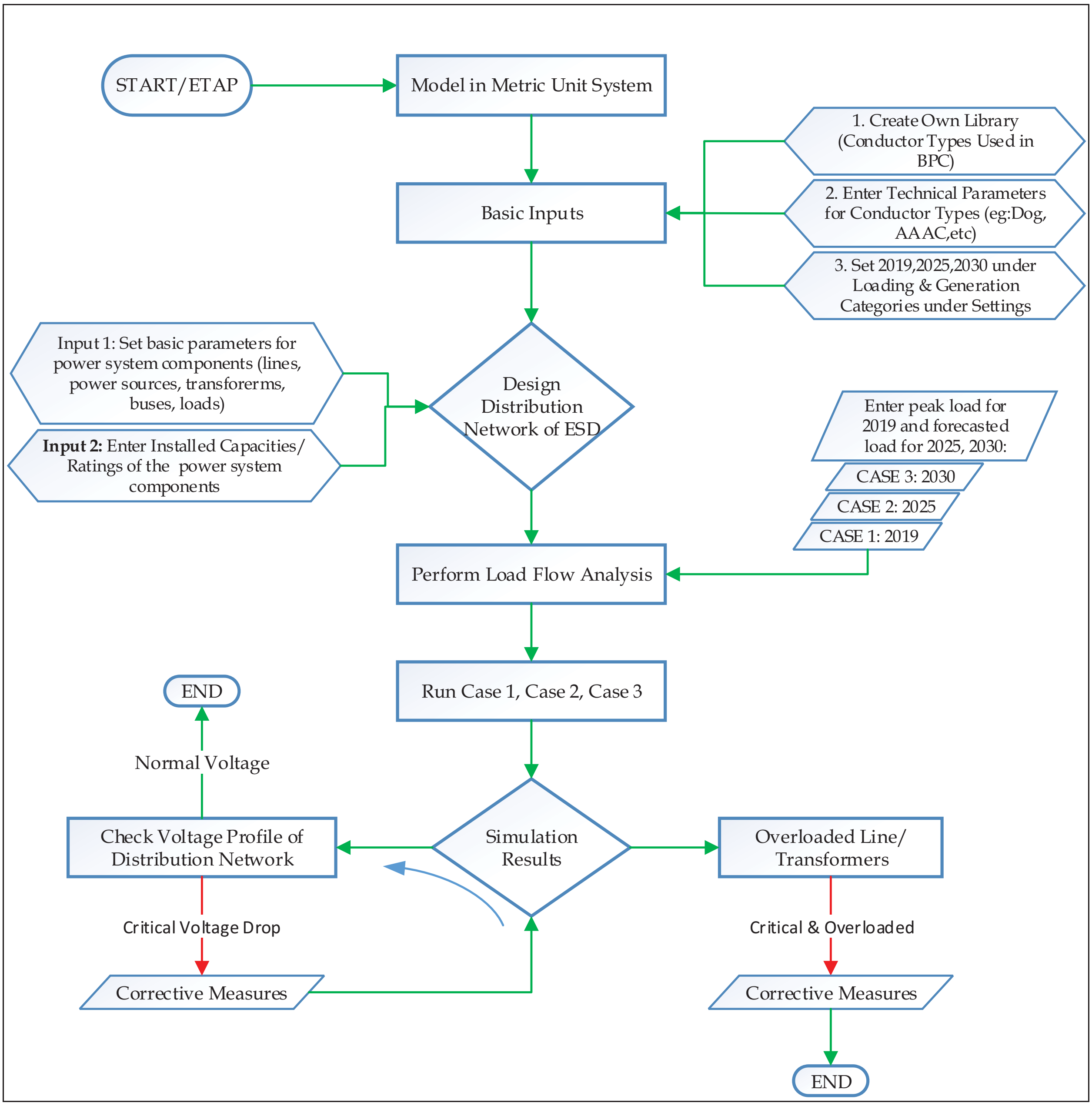


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

[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

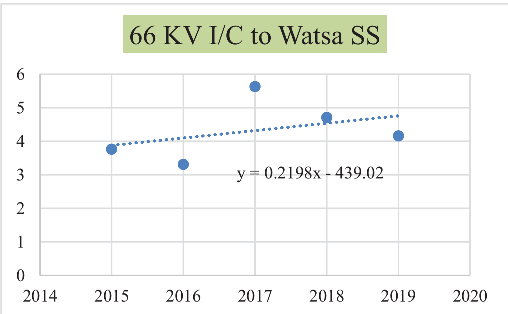
O

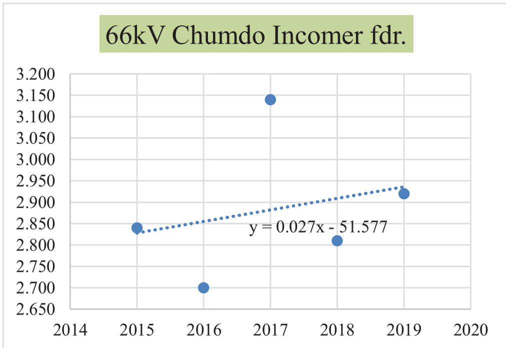
Peak Load (MW)

Incomer		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		2015											
66/33kV Watsa Substation	66 KV I/C	0.592	0.921	0.985	1.034	0.595	0.585	0.968	1.145	1.118	1.039	3.764	3.578
66/11kV Haa Substation	66kV Chumdo Incomer fdr.	2.280	2.490	2.590	2.780	2.430	2.280	2.140	2.460	2.635	2.920	2.840	2.815
		2016											
66/33kV Watsa Substation	66 KV I/C	3.315	3.275	3.315	3.085	0.877	0.645	0.638	1.08	1.104	1.107	1.105	1.06
66/11kV Haa Substation	66kV Chumdo Incomer fdr.	2.390	2.600	2.700	2.630	2.470	2.390	2.070	2.280	2.410	2.590	2.65	2.530
		2017											
66/33kV Watsa Substation	66 KV I/C	0.565	0.873	5.629	3.539	3.166	1.015	2.533	1.149	2.63	4.452	2.1	1.197
66/11kV Haa Substation	66kV Chumdo Incomer fdr.		2.350	2.550	2.520	2.260	2.10	1.97	2.11	2.20	2.62	2.70	3.14
		2018											
66/33kV Watsa Substation	66 KV I/C	1.063	1.155	1.296	1.178	4.713	4.598	0.913	1.357	2.761	1.427	4.248	4.641
66/11kV Haa Substation	66kV Chumdo Incomer fdr.	2.19	2.41	2.60	2.80		2.04	1.85	1.93	2.33	2.67	2.81	2.71
		2019											
66/33kV Watsa Substation	66 KV I/C	4.164	1.144	3.595	1.193	2.759	0.681	0.660	0.71	0.73	0.790	0.780	0.790
66/11kV Haa Substation	66kV Chumdo Incomer fdr.	2.40	2.63	2.82	2.82	2.47	2.55	2.04	2.17	2.69	2.92	2.87	2.88

Incomer		Yearly (Annual PL)				
		2015	**2016**	**2017**	**2018**	**2019**
66/33kV Watsa Substation	66 KV I/C	3.764	3.315	5.629	4.713	4.164
		2015	**2016**	**2017**	**2018**	**2019**
66/11kV Haa Substation	66kV Chumdo Incomer fdr.	2.840	2.700	3.14	2.81	2.92

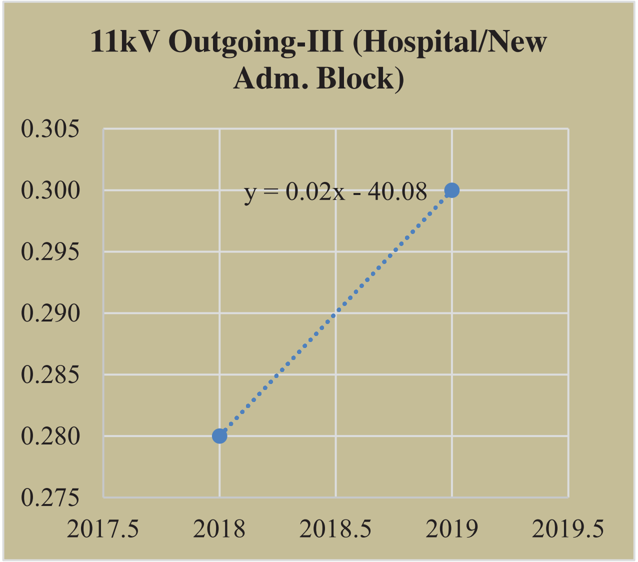
Load Forecast										
2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
4.976	5.196	5.416	5.635	5.855	6.075	6.2948	6.5146	6.7344	6.9542	7.174
2.963	2.99	3.017	3.044	3.071	3.098	3.125	3.152	3.179	3.206	3.233

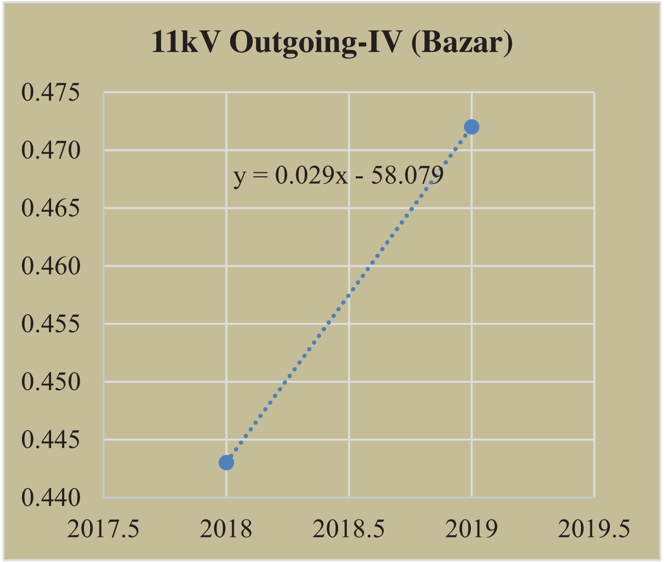


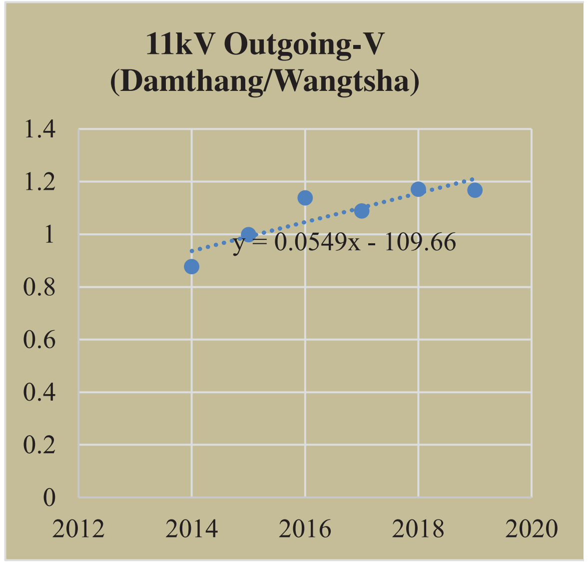


Name of Feeders	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
11kV Outgoing-III (Hospital/New Adm. Block)	0.280	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52

Name of Feeders	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
11kV Outgoing-IV (Bazar)	0.463	0.519	0.565	0.567	0.443	0.472	0.501	0.53	0.559	0.588	0.617	0.646	0.675	0.704	0.733	0.762	0.791
Name of Feeders	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
11kV Outgoing-V (Damthang/Wangtsha)	0.877	0.999	1.138	1.089	1.171	1.168	1.238	1.29	1.348	1.403	1.458	1.513	1.567	1.622	1.677	1.732	1.787

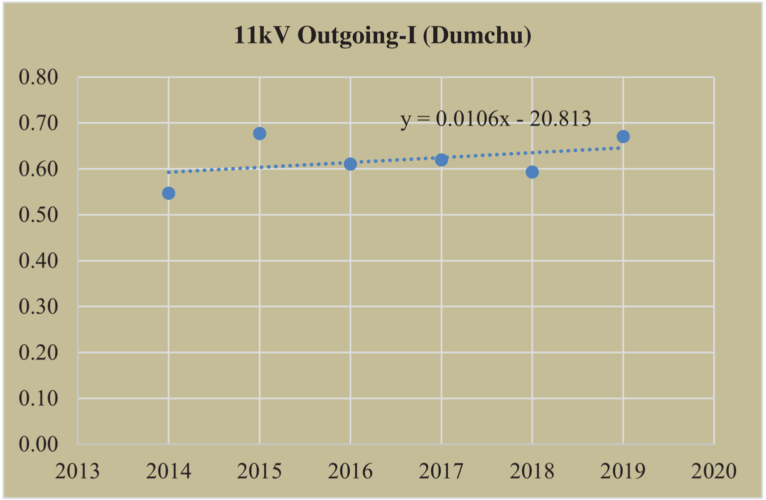


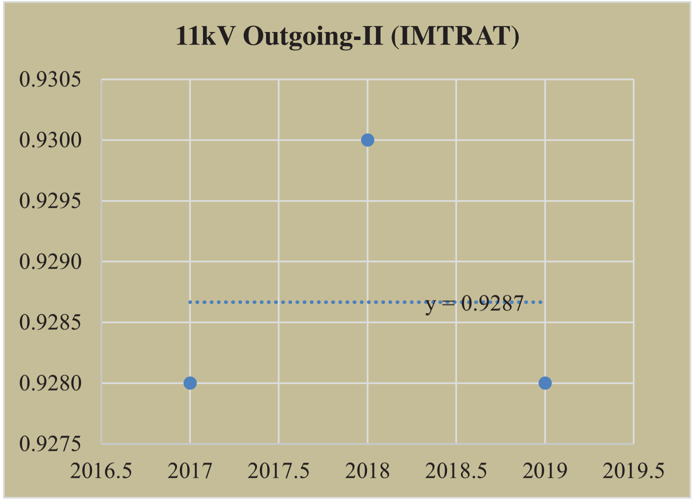




Name of Feeders	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
11kV Outgoing-I (Dumchu)	0.55	0.68	0.61	0.62	0.59	0.67	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.71

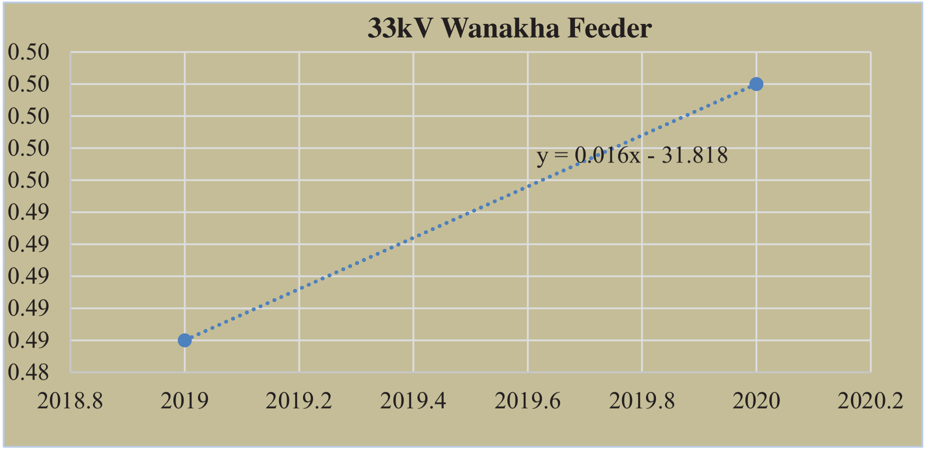
Name of Feeders	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
11kV Outgoing-II (IMTRAT)	1.0010	1.0310	1.0270	0.9280	0.9300	0.9280	0.929	0.929	0.929	0.929	0.929	0.929	0.929	0.929	0.929	0.929	0.929





Note:
The IMTRAT reduced no.of load connected to the feeder and deliberately minimized the power consumption

Name of Feeders	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33 kv O/G Fdr. I(Shemagangkha/Wanakha/Dawakha)						0.49	0.50	0.52	0.53	0.55	0.57	0.58	0.60	0.61	0.63	0.65	0.66



Note:
Previously Feeder connected load of Shemagangkha/Wanakha/Dawakha which is the shared load of ESDs Paro, Chukha & Haa. From 2019 this feeder only bears load of Haa therefore the peak load references are taken from year 2019-20

Annexure-4: Detailed Simulation Results

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
33kV Dorokha	33.000										1.526	64.9	26.5	
33kV Watsa SS	33.000										0.464	96.4	8.1	
66kV Watsa SS	66.000										0.464	96.3	4.1	
Adm Block Bus	11.000										0.304	83.3	16.0	
AdmBlockBus	0.415		0.204	0.126	0.049	0.030					0.297	85.0	423.6	
Anakha bus	33.000										0.007	95.6	0.1	
Anakhabus	0.415		0.001	0.000	0.002	0.001					0.004	85.0	5.0	
Aringkha Bus	33.000										0.000	85.0	-	
Aringkhabus	0.415			0.000	0.000	-					0.000	85.0	-	
B.RAma USS Bus	11.000										0.097	83.9	5.2	
Babana Bus	33.000										0.002	48.0	-	
babanabus	0.415		0.000	0.000	0.000	-					0.000	85.0	0.5	
Balamna 2 Bus	11.000										0.024	86.1	1.3	
Balamna 2Bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.1	
Balamna Bus	11.000										0.066	86.6	3.5	
Balamna3 Bus	0.415		0.000	0.000	0.001	-					0.001	85.0	1.5	
Balamna 3 Bus	11.000										0.020	86.3	1.1	
BaliBus	0.415		0.025	0.015	0.100	0.062					0.147	85.0	210.6	
Bampo Bus	33.000										0.004	84.0	0.1	
Bampu Rama Bus	11.000										0.098	83.9	5.2	
BampuBus	0.415		0.017	0.011	0.064	0.040					0.095	85.0	136.6	
Bampurarma	0.415		0.000	0.000	0.001	-					0.001	85.0	1.4	
Bangina Bus	11.000										0.043	83.5	2.3	
BanginaBus	0.415		0.007	0.005	0.028	0.018					0.042	85.0	60.2	
Bebji Bus	33.000										0.007	82.4	0.1	
Bebji Bus2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.8	
Betikha Bus	33.000										0.080	81.2	1.4	
betikhabus	0.415		0.014	0.009	0.051	0.032					0.077	85.0	112.3	
Betso Bus	0.415		0.002	0.001	0.008	0.005					0.011	85.0	16.1	
BOD Bus	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.6	
Borakha Bus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.0	
Borokha Bus	11.000										0.007	84.4	0.4	
Bus2 Wangtsa SS	66.000										3.418	81.8	29.9	
Bus3 Wangtsa 11a	11.000										1.764	82.9	92.8	
Bus4 Wangtsa 11b	11.000										2.416	63.4	127.1	
Chamthangkhabus	0.415		0.000	0.000	0.001	0.001					0.001	85.0	2.0	
CHangthangkha Bus	33.000										0.001	84.9	-	
Chashi Bus	33.000										0.008	73.0	0.1	
Chashibus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	3.1	

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
ChumduBus	0.415		0.011	0.007	0.038	0.023					0.057	85.0	86.0	
ChumduBus2	0.415		0.051	0.032	0.181	0.112					0.273	85.0	403.0	
Chumpa Bus	11.000										0.287	82.9	15.7	
Chumpabus	0.415		0.003	0.002	0.011	0.007					0.017	85.0	25.2	
Chuzokha Bus	11.000										0.001	84.9	-	
ChuzokhaBus	0.415		0.000	0.000	0.000	-					0.001	85.0	0.8	
DamDum 66kV Bus	66.000										1.547	64.3	13.5	
Damitika Bus	0.415		0.000	0.000	0.001	0.001					0.001	85.0	2.0	
Damitikha Bus	11.000										0.001	84.5	0.1	
DamthagBus	0.415		0.016	0.010	0.058	0.036					0.087	85.0	127.6	
Damthang1 Bus	11.000										0.238	82.8	13.0	
Damthang1bus	11.000										0.088	83.9	4.8	
Damthang2bus	0.415		0.028	0.017	0.095	0.059					0.144	85.0	217.5	
Dangtse2bus1	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.6	
Dangtsebus	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.2	
Dantse 1Bus	33.000										0.055	97.3	1.0	
Dantse 1Bus1	33.000										0.053	97.2	0.9	
Darjeygangbus	33.000										0.058	97.6	1.0	
Darjeygangbus2	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.9	
Debji1bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.7	
Debji 1bus	33.000										0.024	99.4	0.4	
Debji2 bus	33.000										0.021	96.8	0.4	
Debji2bus1	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.9	
Debji3 bus	0.415		0.001	0.001	0.003	0.002					0.004	85.0	6.5	
Debji3 bus1	33.000										0.014	92.9	0.2	
Demo Bus	11.000										0.121	80.5	6.4	
Demobus	0.415		0.021	0.013	0.076	0.047					0.114	85.0	169.2	
Domzegang Bus	33.000										0.005	84.5	0.1	
DomzeygangBus	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.4	
Dorekha bus	33.000										0.157	94.7	2.8	
Dorekhabus	0.415		0.016	0.010	0.062	0.038					0.091	85.0	130.3	
Dorikha Bus	11.000										0.009	82.8	0.5	
Dorithasa	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.0	
DranadingkhaBus	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.2	
Dranadngkha Bus	11.000										0.003	84.3	0.2	
Dumchu Bus	0.415		0.014	0.008	0.051	0.032					0.076	85.0	109.0	
Dungkhagbus	0.415		0.002	0.001	0.006	0.004					0.010	85.0	13.9	
Dungkhagbus1	0.415		0.001	0.000	0.002	0.001					0.004	85.0	5.0	
E10H009	11.000										0.446	84.3	23.5	
E10H031	11.000										0.352	84.8	18.6	
E10H038	11.000										0.274	85.2	14.5	
E10H055	11.000										0.009	85.6	0.5	

Bus			**Directly Connected Load**								**Total Bus Load**			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
E10H086	11.000										0.265	85.1	14.0	
E10H092	11.000										0.238	85.2	12.6	
E10H111	11.000										0.227	85.2	12.0	
E10H115	11.000										0.211	85.3	11.2	
E10H139	11.000										0.186	85.4	9.9	
E10H159	11.000										0.153	85.5	8.1	
E10H185	11.000										0.148	85.4	7.9	
E10H209	11.000										0.108	85.9	5.7	
E10H224	11.000										0.002	90.8	0.1	
E10H237	33.000										0.071	99.6	1.3	
E10H247	11.000										0.106	85.4	5.6	
E10H263	11.000										0.106	85.3	5.6	
E10H273	11.000										0.074	86.6	3.9	
E10H279	11.000										0.072	86.6	3.8	
E10H305	11.000										0.052	87.2	2.8	
E10H351	11.000										0.019	84.7	1.0	
E10H388	11.000										0.026	87.4	1.4	
E10H402	11.000										0.024	86.8	1.3	
E10H439	11.000										0.013	85.9	0.7	
E20H005	11.000										0.897	81.8	47.3	
E20H007	11.000										0.890	81.8	46.9	
E20H013	11.000										0.767	82.0	40.6	
E20H023	11.000										0.339	81.8	17.9	
E30T1Bus	11.000										0.419	83.5	22.1	
E40H003	11.000										0.371	83.3	19.5	
E40H006	11.000										0.097	83.9	5.1	
E40H017	11.000										0.274	83.1	14.4	
E40H019	11.000										0.151	83.3	7.9	
E40H020	11.000										0.151	83.3	7.9	
E40H027	11.000										0.123	82.7	6.5	
E50H003	11.000										1.216	83.1	64.1	
E50H007	11.000										0.047	83.4	2.5	
E50H033	11.000										1.162	83.1	61.6	
E50H055	11.000										1.121	83.2	59.8	
E50H061	11.000										0.942	83.1	50.5	
E50H089	11.000										0.935	83.1	50.3	
E50H095	11.000										0.816	83.3	44.0	
E50H117	11.000										0.780	83.3	42.4	
E50H124	11.000										0.741	83.3	40.3	
E50H144	11.000										0.399	83.3	21.7	
E50H151	11.000										0.397	83.3	21.7	
E50H154	11.000										0.059	84.5	3.2	

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
E50H187	11.000										0.042	84.4	2.3	
E50H202	11.000										0.026	84.4	1.4	
E70H105	33.000										0.312	96.5	5.5	
E70H124	33.000										0.309	95.9	5.5	
E70H148	33.000										0.066	99.5	1.2	
E70H176	33.000										0.049	97.2	0.9	
E70H182	33.000										0.035	98.6	0.6	
E70H225	33.000										0.168	95.5	3.0	
E70H253	33.000										0.067	99.4	1.2	
E70H267	33.000										0.012	99.5	0.2	
E70H306	33.000										0.035	99.1	0.6	
E70H310	33.000										0.027	99.5	0.5	
E70H318	33.000										0.023	99.3	0.4	
Engg cell bus	0.415		0.052	0.032	0.188	0.117					0.283	85.0	415.3	
Ganghe Bus	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.6	
Gangkha bus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.9	
Gaychukha Bus	11.000										0.242	82.9	13.2	
GaychukhaBus	0.415		0.001	0.000	0.002	0.001					0.003	85.0	5.0	
Gerena Bus	11.000										0.119	85.7	6.3	
Gerenabus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
GerenaBus1	33.000										0.052	97.6	0.9	
GurugangBus	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.0	
Gurungang Bus	33.000										0.012	83.9	0.2	
H190H020	33.000										0.452	95.9	7.9	
H190H023	33.000		0.017	0.011	0.068	0.042					0.202	86.5	3.5	
H190H029	33.000										0.104	86.8	1.8	
H190H032	33.000										0.019	98.4	0.3	
H190H073	33.000										0.260	99.4	4.6	
H190H091	33.000										0.249	99.4	4.4	
H190H097	33.000										0.244	99.4	4.3	
H190H128	33.000										0.232	96.1	4.1	
H190H142	33.000										0.196	93.8	3.4	
H190H156	33.000										0.163	94.6	2.9	
H190H174	33.000										0.159	93.8	2.8	
H190H186	33.000										0.158	93.1	2.8	
H190H193	33.000										0.156	92.9	2.7	
H190H204	33.000										0.152	92.3	2.7	
H190H208	33.000										0.080	93.2	1.4	
H190H215	33.000										0.080	87.1	1.4	
H190H228	33.000										0.007	54.5	0.1	
H190H237	33.000										0.005	80.9	0.1	
H190H245	33.000										0.053	43.2	0.9	

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
H190H256	33.000										0.052	30.1	0.9	
H190H283	33.000										0.062	63.6	1.1	
H190H320	33.000										0.039	5.6	0.7	
H190H330	33.000										0.008	28.5	0.1	
Hatey Bus	11.000										0.270	82.8	14.7	
HateyBus	0.415		0.005	0.003	0.018	0.011					0.027	85.0	40.8	
Hospital Bus	0.415		0.078	0.048	0.019	0.012					0.114	85.0	160.9	
Imtart Engg Cell Bus	11.000										0.296	81.5	15.7	
Imtart PH2bus	0.415		0.031	0.019	0.113	0.070					0.170	85.0	249.0	
ImtartBus	0.415		0.042	0.026	0.153	0.095					0.230	85.0	333.7	
Imtrat Bus	11.000										0.415	82.0	22.0	
INGOBus	0.415		0.014	0.008	0.051	0.032					0.076	85.0	109.3	
J.Goenpa Bus	11.000										0.002	84.4	0.1	
J.GoenpaBus	0.415		0.003	0.002	0.011	0.007					0.017	85.0	25.4	
J.School Bus	0.415		0.006	0.004	0.021	0.013					0.031	85.0	46.0	
Jamphel Bus	11.000										0.311	83.0	17.0	
JamphelSchoolbus	0.415		0.004	0.003	0.016	0.010					0.024	85.0	34.5	
Jamtey G.Bus	11.000										0.018	83.3	1.0	
Janatsam Bus	11.000										0.006	84.4	0.3	
JanatsamBus	0.415		0.001	0.001	0.004	0.003					0.006	85.0	9.1	
Jangkha Bus	33.000										0.005	84.5	0.1	
jangkhabus	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.4	
Jashina Bs	33.000										0.237	99.2	4.2	
Jasjinabus	0.415		0.002	0.002	0.009	0.006					0.014	85.0	19.7	
Jatakha Bus	33.000										0.045	17.1	0.8	
Jatakhabus	0.415		0.001	0.001	0.004	0.003					0.006	85.0	9.0	
Jawang G bus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.5	
Jelekha bus	33.000										0.073	83.7	1.3	
JelikhaBus	0.415		0.013	0.008	0.049	0.030					0.072	85.0	102.6	
JGurikhaBus	0.415		0.021	0.013	0.075	0.047					0.113	85.0	167.8	
Jyenkana 2Bus	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.9	
JyenSkol Bus	11.000										0.033	81.9	1.7	
Kana 2 Bus	11.000										0.030	83.6	1.6	
Kana Bus	11.000										0.154	85.6	8.2	
Kana Bus 2	0.415		0.005	0.003	0.020	0.012					0.029	85.0	41.9	
Kana1 bus	0.415		0.000	0.000	0.001	0.001					0.001	85.0	2.0	
Kaukha bus	33.000										0.069	100.0	1.2	
Khamena bus	33.000										0.245	92.8	4.3	
Kharka A bus	33.000										0.029	98.9	0.5	
Kharka school bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.7	
Kharka1 school	33.000										0.038	98.2	0.7	
KharkaA bus	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Kumri Bus	33.000										0.001	84.9	-	
kumribus	0.415		0.000	0.000	0.000	-					0.001	85.0	0.9	
L.Market Bus	0.415		0.017	0.010	0.064	0.040					0.095	85.0	134.8	
L.Wantsa Bus	11.000										0.019	84.2	1.0	
L/Wanakha Bus	33.000										0.465	96.0	8.2	
Labana Bus	33.000										0.006	84.5	0.1	
LabanaBus	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.7	
Lamjaygang Bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.1	
lamjigang Bus	11.000										0.004	83.4	0.2	
langlobus	0.415		0.003	0.002	0.012	0.008					0.019	85.0	27.4	
Lhayulkhabus	0.415		0.021	0.013	0.080	0.050					0.120	85.0	172.3	
Lhazukha Bus	33.000										0.012	67.0	0.2	
Lhazukhabus	0.415		0.001	0.001	0.004	0.002					0.005	85.0	7.3	
Lhenka Bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	6.1	
Lhenkha Bus	11.000										0.017	86.1	0.9	
Lingzhi1 Bus1	33.000										0.009	84.2	0.2	
Lingzhi1bus	0.415		0.002	0.001	0.006	0.004					0.009	85.0	13.0	
Lingzhi2 Bus	33.000										0.009	84.2	0.2	
Lingzhi2bus	0.415		0.002	0.001	0.006	0.004					0.009	85.0	12.5	
LWanakhaBus	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.8	
LWantsa Bus	0.415		0.003	0.002	0.013	0.008					0.019	85.0	26.2	
Makana Bus	11.000										0.015	83.5	0.8	
MakanaBus	0.415		0.003	0.002	0.010	0.006					0.015	85.0	22.2	
MHospital Bus	0.415		0.015	0.009	0.054	0.034					0.081	85.0	117.4	
Mochu1Bus	33.000										0.006	83.5	0.1	
Mochu1bus2	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
Mochubus	33.000										0.061	99.0	1.1	
Mochubus1	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.5	
Nago Bus	33.000										0.020	83.2	0.4	
Nagobus	0.415		0.003	0.002	0.013	0.008					0.020	85.0	27.9	
Nagtso Bus	11.000										0.031	83.9	1.7	
Nagtsobus	0.415		0.006	0.003	0.020	0.013					0.030	85.0	44.1	
Nakha	33.000										0.014	87.3	0.2	
Nakha Tashigang	33.000										0.008	83.3	0.1	
Nakhabus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
Nakikha 1	33.000										0.006	83.7	0.1	
Nakikha1bus	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.2	
Nakikha 2	33.000										0.019	94.8	0.3	
Nakikha2 bus1	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
Nakikha2 bus2	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.6	
near BOD	11.000										0.362	84.8	19.1	
Nebjibus	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.6	

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
Neymo Bus	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.7	
Ngachu Bus	11.000										0.351	81.9	18.6	
NgachuBus	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.4	
Nobgang Bus	11.000										0.002	84.5	0.1	
Nyemo Bus	33.000										0.003	84.7	0.1	
Pajaykha Bus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.6	
Pajekha Bus	11.000										0.002	84.8	0.1	
Papali Bus	33.000										0.004	84.1	0.1	
papalibus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.8	
PawgangBus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.4	
Powgang Bus	33.000										0.240	99.3	4.2	
Puduna Bus	11.000										0.002	84.5	0.1	
PudunaBus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.9	
Raringkha Bus	33.000										0.002	84.5	-	
Rashigang Bus	33.000										0.185	93.6	3.2	
rashigangbus	0.415		0.004	0.002	0.015	0.009					0.022	85.0	32.0	
Rebji Bus	33.000										0.165	95.5	2.9	
RebjiBus	0.415		0.001	0.001	0.004	0.002					0.006	85.0	8.3	
RebjiBus1	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.5	
Regokha bus	33.000										0.159	95.6	2.8	
Reringkhabus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.1	
SachoG Bus	33.000										0.000	84.9	-	
Sagu Bus	33.000										0.003	84.7	0.1	
sagubus	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.5	
Samtse load	33.000		0.135	0.084	0.530	0.329					1.090	89.4	19.3	
SangbayBus	0.415		0.002	0.001	0.008	0.005					0.012	85.0	17.9	
Sangkiri Bus	11.000										0.005	88.1	0.3	
Sangkiri Bus2	11.000										0.005	84.5	0.3	
Sangkirii Bus	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.2	
shaba bus	33.000										0.013	95.3	0.2	
shababus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	9.9	
Shama bus	33.000										0.006	82.7	0.1	
Shari1 Bus	0.415		0.001	0.001	0.004	0.003					0.007	85.0	9.3	
Shari 1 Bus	11.000										0.007	84.4	0.4	
Shari 2 bus	11.000										0.013	83.8	0.7	
Shari 2bus	0.415		0.002	0.001	0.009	0.005					0.013	85.0	18.4	
Shebji	33.000										0.004	83.5	0.1	
Shebji bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.7	
Sombaykha2bus	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
Sombaykha3	0.415		0.001	0.000	0.002	0.001					0.003	85.0	4.8	
Sombekha2	33.000										0.006	82.7	0.1	
Sombekha3	33.000										0.030	99.8	0.5	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Susuna Bus	33.000										0.019	83.3	0.3	
SusunaBus	0.415		0.003	0.002	0.013	0.008					0.019	85.0	26.8	
T.Goenpa Bus	11.000										0.007	84.4	0.4	
Takchu G bus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.0	
taktokha bus	33.000										0.004	83.5	0.1	
Taktokhabus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.7	
Taktokhabus1	0.415		0.014	0.009	0.053	0.033					0.078	85.0	112.0	
thomjee bus	33.000										0.005	83.3	0.1	
Thomjeebus	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.6	
Tokey Bus	11.000										0.342	83.1	18.6	
Tokeybus	0.415		0.005	0.003	0.020	0.012					0.030	85.0	43.3	
Tsapel 3 Bus	0.415		0.006	0.003	0.021	0.013					0.032	85.0	45.1	
Tsaphel Bus	11.000										0.015	83.6	0.8	
Tsaphel bus2	0.415		0.004	0.003	0.015	0.010					0.023	85.0	33.2	
Tsaphel2Bus	11.000										0.210	85.2	11.1	
Tsaphel3 Bus	11.000										0.032	84.3	1.7	
TsaphelBus	0.415		0.003	0.002	0.010	0.006					0.015	85.0	21.6	
Tsenkha Bus	11.000										0.008	84.3	0.4	
tsenkhabus	0.415		0.001	0.001	0.005	0.003					0.007	85.0	10.9	
Tsepji Bus	33.000										0.007	84.4	0.1	
TsepjiBus	0.415		0.001	0.001	0.004	0.003					0.007	85.0	9.2	
Tshilung G Bus	0.415		0.005	0.003	0.018	0.011					0.027	85.0	38.0	
Tsholini Bus	0.415		0.001	0.000	0.003	0.002					0.004	85.0	5.7	
Tsholinibus	33.000										0.056	97.6	1.0	
Tsilung.G Bus	11.000										0.027	83.8	1.4	
U.Wantsa Bus	11.000										0.028	82.4	1.5	
UWantsaBus	0.415		0.005	0.003	0.018	0.011					0.027	85.0	38.9	
Wanakha SchoolBus	0.415		0.010	0.006	0.037	0.023					0.056	85.0	80.0	
WanakhaBus	0.415		0.005	0.003	0.019	0.012					0.028	85.0	40.3	
Yaba bus	33.000										0.009	96.4	0.2	
Yaba bus1	0.415		0.001	0.001	0.003	0.002					0.005	85.0	6.5	
Yangto Bus	11.000										0.038	84.1	2.1	
Yangto Goen Bus	11.000										0.002	84.6	0.1	
YangtoBus	0.415		0.007	0.004	0.025	0.016					0.038	85.0	54.9	
YangtoGBus	0.415		0.000	0.000	0.001	0.001					0.002	85.0	2.5	
Yantsena	33.000										0.006	82.7	0.1	
Yantsena bus	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	
Yatobus	0.415		0.006	0.004	0.022	0.014					0.033	85.0	48.8	
Yatom Bus	11.000										0.035	81.8	1.8	
Zomtokha	33.000										0.006	82.7	0.1	
Zomtokha A	33.000										0.043	97.8	0.8	
Zomtokha Abus1	0.415		0.001	0.001	0.003	0.002					0.005	85.0	7.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Zomtokha bus	0.415		0.001	0.001	0.004	0.003					0.006	85.0	8.9	

* 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 (90.0% 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	%
UG Bampu Rama Bus-USS	Cable	338.03	5.16	1.53					
UG E30T1	Cable	338.03	22.05	6.52					
UG E30T2	Cable	338.03	15.98	4.73					
Anakha SS	Transformer				0.012	0.004	31.0	0.004	30.5
Beji SS	Transformer				0.012	0.007	60.5	0.007	58.6
Dangtse 1SS	Transformer				0.012	0.003	25.6	0.003	25.3
Dangtse2	Transformer				0.012	0.005	40.3	0.005	39.4
Darjeygang SS	Transformer				0.007	0.003	48.2	0.003	47.0
Debji1 ss	Transformer				0.007	0.004	56.1	0.004	54.4
Debji2 SS	Transformer				0.012	0.009	79.5	0.009	76.2
Debji 3SS	Transformer				0.007	0.005	63.9	0.004	61.8
Dorekha	Transformer				0.362	0.093	25.6	0.091	25.3
Dungkhag SS	Transformer				0.018	0.010	54.8	0.010	53.3
E10T1	Transformer				0.163	0.084	51.6	0.081	49.7
E10T2	Transformer				0.250	0.078	31.1	0.076	30.4
E10T3	Transformer				0.016	0.002	11.1	0.002	11.0
E10T4	Transformer				0.063	0.007	11.3	0.007	11.3
E10T5	Transformer				0.090	0.027	29.9	0.027	29.5
E10T6	Transformer				0.046	0.012	25.2	0.011	24.9
E10T7	Transformer				0.046	0.015	33.7	0.015	33.2
E10T8	Transformer				0.012	0.001	12.2	0.001	12.2
E10T9	Transformer				0.046	0.024	51.7	0.023	50.3
E10T10	Transformer				0.181	0.032	17.7	0.032	17.6
E10T11	Transformer				0.012	0.001	12.5	0.001	12.4
E10T12	Transformer				0.046	0.005	11.2	0.005	11.1
E10T13	Transformer				0.090	0.030	32.9	0.029	32.4
E10T14	Transformer				0.046	0.011	23.2	0.010	23.0
E10T15	Transformer				0.046	0.002	4.0	0.002	4.0
E10T16	Transformer				0.018	0.001	3.3	0.001	3.3
E10T17	Transformer				0.046	0.033	71.6	0.031	68.9
E10T18	Transformer				0.018	0.002	11.3	0.002	11.3
E10T19	Transformer				0.012	0.006	48.4	0.005	47.2
E10T20	Transformer				0.046	0.014	31.4	0.014	30.9

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
E10T21	Transformer				0.012	0.004	37.4	0.004	36.6
E10T22	Transformer				0.012	0.001	9.4	0.001	9.3
E10T23	Transformer				0.046	0.013	28.6	0.013	28.2
E10T24	Transformer				0.046	0.007	14.4	0.007	14.3
E10T25	Transformer				0.018	0.002	11.5	0.002	11.4
E10T26	Transformer				0.018	0.002	12.1	0.002	12.1
E10T27	Transformer				0.046	0.007	15.5	0.007	15.4
E10T28	Transformer				0.012	0.004	37.3	0.004	36.6
E10T29	Transformer				0.018	0.009	50.7	0.009	49.3
E10T30	Transformer				0.012	0.004	37.3	0.004	36.6
E10T31	Transformer				0.025	0.010	39.0	0.009	37.9
E20T2-1	Transformer				0.362	0.238	65.7	0.230	63.5
E20T2-2	Transformer				0.228	0.178	77.9	0.170	74.7
E20T2.	Transformer				0.160	0.121	75.6	0.114	71.4
E20T3	Transformer				0.228	0.012	5.4	0.012	5.4
E20T4	Transformer				0.116	0.043	37.1	0.042	36.4
E20T5	Transformer				0.362	0.296	81.7	0.283	78.2
E20T6	Transformer				0.046	0.006	14.2	0.006	14.1
E30T1	Transformer				0.543	0.115	21.2	0.114	21.0
E30T2	Transformer				0.724	0.304	41.9	0.297	41.1
E40T1	Transformer				0.362	0.097	26.7	0.095	26.3
E40T2	Transformer				0.362	0.151	41.6	0.147	40.7
E40T3	Transformer				0.228	0.123	54.0	0.120	52.5
E50T1	Transformer				0.090	0.019	20.8	0.019	20.6
E50T2	Transformer				0.046	0.028	61.2	0.027	59.2
E50T3	Transformer				0.046	0.035	76.1	0.033	73.0
E50T4	Transformer				0.228	0.077	33.9	0.076	33.3
E50T5	Transformer				0.018	0.003	16.4	0.003	16.2
E50T6	Transformer				0.116	0.031	26.7	0.030	26.3
E50T7	Transformer				0.181	0.038	21.1	0.038	20.8
E50T8	Transformer				0.018	0.002	9.4	0.002	9.4
E50T9-1	Transformer				0.090	0.059	65.7	0.057	63.3
E50T9-2	Transformer				0.724	0.279	38.5	0.273	37.7
E50T10	Transformer				0.046	0.018	38.5	0.017	37.7
E50T11	Transformer				0.046	0.015	33.7	0.015	33.0

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
E50T12	Transformer				0.090	0.019	20.9	0.019	20.7
E50T13	Transformer				0.046	0.008	16.5	0.007	16.4
E50T14	Transformer				0.116	0.030	25.9	0.030	25.6
E50T15	Transformer				0.090	0.024	26.4	0.024	26.0
E50T16	Transformer				0.046	0.017	38.3	0.017	37.5
E50T17	Transformer				0.046	0.028	61.9	0.027	59.8
E50T18	Transformer				0.046	0.003	7.5	0.003	7.5
E50T19	Transformer				0.362	0.088	24.3	0.087	24.0
E50T20	Transformer				0.228	0.150	65.8	0.144	63.4
E50T21	Transformer				0.181	0.118	65.0	0.113	62.7
E50T22	Transformer				0.090	0.001	1.1	0.001	1.1
E50T23	Transformer				0.362	0.097	26.7	0.095	26.3
Gerena SS	Transformer				0.018	0.007	38.9	0.007	38.2
H190T1	Transformer				0.063	0.016	24.8	0.015	24.3
H190T2-1	Transformer				0.125	0.057	45.9	0.056	44.4
H190T2-2	Transformer				0.063	0.029	45.9	0.028	44.4
H190T03	Transformer				0.046	0.019	42.2	0.019	41.3
H190T4	Transformer				0.046	0.003	7.3	0.003	7.3
H190T5	Transformer				0.046	0.013	29.2	0.013	28.8
H190T6	Transformer				0.046	0.006	12.1	0.005	12.0
H190T7	Transformer				0.046	0.005	11.6	0.005	11.6
H190T8	Transformer				0.046	0.004	8.5	0.004	8.5
H190T9	Transformer				0.046	0.014	30.9	0.014	30.4
H190T10	Transformer				0.063	0.012	19.3	0.012	19.1
H190T11	Transformer				0.063	0.023	36.4	0.022	35.4
H190T12	Transformer				0.046	0.007	14.4	0.007	14.3
H190T13	Transformer				0.046	0.001	3.2	0.001	3.2
H190T14	Transformer				0.046	0.003	7.1	0.003	7.1
H190T15	Transformer				0.046	0.005	11.6	0.005	11.5
H190T16	Transformer				0.125	0.080	64.3	0.077	61.4
H190T17	Transformer				0.228	0.073	32.2	0.072	31.7
H190T18	Transformer				0.046	0.005	11.4	0.005	11.3
H190T19	Transformer				0.046	0.020	43.8	0.020	42.9
H190T20	Transformer				0.046	0.009	19.6	0.009	19.4
H190T21	Transformer				0.046	0.009	20.5	0.009	20.3

CKT / Branch		Cable & Reactor			Transformer				
					Capability	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	(MVA)	MVA	%	MVA	%
H190T22	Transformer				0.046	0.006	14.2	0.006	14.1
H190T23	Transformer				0.018	0.004	23.7	0.004	23.4
H190T24	Transformer				0.007	0.000	0.4	0.000	0.4
H190T25	Transformer				0.016	0.002	9.5	0.002	9.5
H190T26	Transformer				0.007	0.000	5.2	0.000	5.2
H190T27	Transformer				0.018	0.001	3.6	0.001	3.6
H190T28	Transformer				0.018	0.002	12.2	0.002	12.1
H190T29	Transformer				0.018	0.004	23.0	0.004	22.7
H190T30	Transformer				0.012	0.000	1.7	0.000	1.7
Kaukha ss	Transformer				0.012	0.004	31.0	0.004	30.5
khamena	Transformer				0.228	0.080	35.0	0.078	34.3
Kharka A SS	Transformer				0.007	0.006	79.5	0.006	76.2
Kharka school	Transformer				0.018	0.004	22.5	0.004	22.2
Mochu SS	Transformer				0.018	0.005	25.6	0.005	25.3
Mochu SS1	Transformer				0.018	0.006	35.0	0.006	34.3
Nakha SS	Transformer				0.018	0.007	38.9	0.007	38.1
Nakha tashigang SS	Transformer				0.018	0.008	41.6	0.007	40.7
Nakikha1	Transformer				0.018	0.006	32.3	0.006	31.8
Nakikha2	Transformer				0.018	0.007	38.9	0.007	38.2
Nebji	Transformer				0.012	0.005	40.3	0.005	39.4
Rebji SS	Transformer				0.012	0.006	50.8	0.006	49.5
Regokha SS	Transformer				0.018	0.005	25.6	0.005	25.3
Sangbay SS	Transformer				0.018	0.013	70.5	0.012	67.8
Shaba SS	Transformer				0.018	0.007	38.9	0.007	38.2
Shama SS	Transformer				0.012	0.006	54.8	0.006	53.2
Shebji SS	Transformer				0.012	0.004	35.0	0.004	34.3
Sombaykha 2	Transformer				0.012	0.006	54.8	0.006	53.2
Sombaykha 3	Transformer				0.012	0.003	29.4	0.003	29.0
T1 Dorokha	Transformer				5.000	0.840	16.8	0.832	16.6
T1 Wangtsa	Transformer				5.000	1.254	25.1	1.250	25.0
T2 Dorokha	Transformer				5.000	1.353	27.1	1.331	26.6
T2 Wangtsa	Transformer				5.000	2.483	49.7	2.416	48.3
Taktokha SS	Transformer				0.012	0.004	35.0	0.004	34.3
ThomjeeSS	Transformer				0.012	0.005	40.3	0.005	39.4
Tsholini SS	Transformer				0.012	0.004	34.9	0.004	34.3

CKT / Branch		Cable & Reactor			Transformer				
					Capability (MVA)	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%		MVA	%	MVA	%
WatsaXmer	Transformer				8.000	0.464	5.8	0.464	5.8
Yaba SS	Transformer				0.018	0.005	25.6	0.005	25.3
Yangtsena ss	Transformer				0.012	0.006	54.8	0.006	53.3
Zomtokha A SS	Transformer				0.012	0.005	45.6	0.005	44.5
Zomtokha ss	Transformer				0.012	0.006	54.8	0.006	53.2

* 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
Dorokha-Samtse End Point	0.990	0.394	-0.975	-0.487	14.9	-93.6	100.9	99.1	1.81
T1 Dorokha	-0.340	0.768	0.341	-0.759	1.4	8.5	100.9	100.0	0.87
T2 Dorokha	-0.650	-1.162	0.654	1.184	3.8	22.6	100.9	100.0	0.87
H190G-L.Wanakha	0.447	0.124	-0.447	-0.130	0.2	-6.2	99.8	99.8	0.04
WatsaXmer	-0.447	-0.124	0.447	0.125	0.3	1.7	99.8	100.0	0.15
UG E30T2	-0.253	-0.168	0.253	0.168	0.0	0.0	99.7	99.7	0.01
E30T2	0.253	0.168	-0.253	-0.157	0.3	11.6	99.7	97.6	2.13
Anakha-Shebji	0.003	-0.001	-0.003	-0.002	0.0	-3.3	99.0	99.0	0.00
Shaba-Anakha	-0.006	-0.001	0.006	-0.003	0.0	-3.8	99.0	99.0	0.00
Anakha SS	0.003	0.002	-0.003	-0.002	0.0	0.1	99.0	97.4	1.57
H190H330-Aringkha	0.000	0.000	0.000	-0.001	0.0	-0.6	99.7	99.7	0.00
H190T24	0.000	0.000	0.000	0.000	0.0	0.0	99.7	99.7	0.02
UG Bampu Rama Bus-USS	-0.081	-0.053	0.081	0.053	0.0	0.0	98.4	98.4	0.00
E50T23	0.081	0.053	-0.081	-0.050	0.1	2.4	98.4	97.0	1.36
H190H320-Babana1	0.001	-0.002	-0.001	0.000	0.0	-2.0	99.7	99.7	0.00
H190H330-Babana	-0.001	0.001	0.001	-0.005	0.0	-3.5	99.7	99.7	0.00
H190T26	0.000	0.000	0.000	0.000	0.0	0.0	99.7	99.5	0.26
Balamna2-Balamna 3	0.017	0.010	-0.017	-0.010	0.0	-0.2	98.5	98.5	0.01
E10H305-Balamna2	-0.021	-0.012	0.021	0.012	0.0	-0.1	98.5	98.5	0.00
E10T21	0.004	0.002	-0.004	-0.002	0.0	0.2	98.5	96.6	1.91
Balamna 1-E10H305	0.045	0.025	-0.045	-0.026	0.0	-0.2	98.6	98.5	0.03
E10H279-Balamna	-0.057	-0.033	0.057	0.033	0.0	-0.4	98.6	98.6	0.07
E10T20	0.012	0.008	-0.012	-0.007	0.0	0.4	98.6	97.0	1.60
E10T22	-0.001	-0.001	0.001	0.001	0.0	0.0	98.1	98.5	0.47
Balamna3-E10351	0.016	0.010	-0.016	-0.010	0.0	-0.7	98.5	98.5	0.03
E40T2	-0.125	-0.078	0.125	0.083	0.1	5.7	97.4	99.5	2.12
H190H228-Bampo	-0.004	-0.002	0.004	-0.006	0.0	-7.8	99.7	99.7	0.00
H190T23	0.004	0.002	-0.004	-0.002	0.0	0.1	99.7	98.5	1.19
E50H055-Bampu Rama	-0.082	-0.053	0.082	0.053	0.0	-0.2	98.4	98.4	0.05
E50T22	0.001	0.001	-0.001	-0.001	0.0	0.0	98.4	98.3	0.05
E20H023-Bangina	-0.036	-0.024	0.036	0.024	0.0	0.0	99.2	99.2	0.00
E20T4	0.036	0.024	-0.036	-0.022	0.0	1.5	99.2	97.3	1.88
E70H182-Bebji	-0.006	-0.004	0.006	0.002	0.0	-1.9	99.0	99.0	0.00
Beji SS	0.006	0.004	-0.006	-0.004	0.0	0.4	99.0	95.8	3.13

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
H190H204-Betikha	-0.065	-0.047	0.065	0.046	0.0	-0.5	99.7	99.7	0.00
H190T16	0.065	0.047	-0.065	-0.040	0.1	6.5	99.7	95.0	4.63
E10T6	-0.010	-0.006	0.010	0.006	0.0	0.3	97.8	99.1	1.27
E10T31	-0.008	-0.005	0.008	0.005	0.0	0.5	96.7	99.5	2.76
E10T27	-0.006	-0.004	0.006	0.004	0.0	0.1	97.7	98.5	0.78
E10H402-Borokha	-0.006	-0.004	0.006	0.004	0.0	-0.1	98.5	98.5	0.00
T1 Wangtsa	1.254	0.020	-1.250	-0.001	3.2	19.4	100.0	99.7	0.27
T2 Wangtsa	1.544	1.944	-1.531	-1.868	12.7	76.0	100.0	99.7	0.27
UG E30T1	0.350	0.230	-0.350	-0.230	0.0	0.0	99.7	99.7	0.01
E10-H009	0.376	0.240	-0.376	-0.240	0.4	0.2	99.7	99.6	0.13
E20-E20H005	0.735	0.516	-0.734	-0.516	0.9	0.8	99.7	99.6	0.14
E40 Gantry to H03	0.309	0.205	-0.309	-0.205	0.2	0.0	99.7	99.7	0.05
E550G-E50H003	1.011	0.677	-1.011	-0.677	0.5	0.4	99.7	99.7	0.05
H190T13	-0.001	-0.001	0.001	0.001	0.0	0.0	99.5	99.7	0.16
H190H174-Chamthangkha	-0.001	-0.001	0.001	0.001	0.0	-0.1	99.7	99.7	0.00
Chashi- H190H237	0.004	-0.005	-0.004	0.001	0.0	-3.8	99.7	99.7	0.00
H190H208-Chashi	-0.006	0.004	0.006	-0.016	0.0	-12.4	99.7	99.7	0.00
H190T28	0.002	0.001	-0.002	-0.001	0.0	0.0	99.7	99.1	0.61
E50T9-1	-0.049	-0.030	0.049	0.034	0.1	3.8	92.7	96.2	3.51
E50T9-2	-0.232	-0.144	0.232	0.154	0.2	10.5	94.1	96.2	2.02
Chumpa-Hatey	0.224	0.151	-0.224	-0.151	0.2	-0.1	96.3	96.2	0.11
Jamphel School-Chumpa	-0.238	-0.161	0.238	0.161	0.2	0.0	96.3	96.4	0.09
E50T16	0.015	0.010	-0.015	-0.009	0.0	0.7	96.3	94.3	2.01
E10H224-Chuzokha	-0.001	0.000	0.001	0.000	0.0	-0.6	98.8	98.8	0.00
E10T16	0.001	0.000	-0.001	0.000	0.0	0.0	98.8	98.6	0.16
E10T8	-0.001	-0.001	0.001	0.001	0.0	0.0	98.3	98.9	0.61
E10H115-Damitikha	-0.001	-0.001	0.001	0.000	0.0	-0.4	98.9	98.9	0.00
E50T19	-0.074	-0.046	0.074	0.048	0.0	2.1	94.6	95.9	1.27
Damthang1-D/Thang2	0.074	0.048	-0.074	-0.048	0.0	-0.1	95.9	95.9	0.02
Gaychukh-Damthang1	-0.197	-0.134	0.197	0.133	0.5	-0.3	95.9	96.2	0.26
E50T20	0.123	0.086	-0.123	-0.076	0.2	9.7	95.9	92.4	3.53
Dangtse2	-0.004	-0.002	0.004	0.003	0.0	0.2	96.9	99.0	2.06
Dangtse 1SS	-0.002	-0.002	0.002	0.002	0.0	0.1	97.7	99.0	1.30
Dangtse1-Dangtse2	0.051	0.011	-0.051	-0.012	0.0	-1.4	99.0	99.0	0.00
Darjeygang-Dangtse	-0.054	-0.013	0.054	0.011	0.0	-2.0	99.0	99.0	0.00
Dangtse2-E70H176	0.047	0.010	-0.047	-0.012	0.0	-1.6	99.0	99.0	0.00
Mochu-Darjeygang	-0.057	-0.013	0.057	0.006	0.0	-6.4	99.0	99.0	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
Darjeygang SS	0.003	0.002	-0.003	-0.002	0.0	0.2	99.0	96.5	2.47
Debji1 ss	-0.003	-0.002	0.003	0.002	0.0	0.2	96.1	98.9	2.89
Debji1-Debji 2	0.020	0.000	-0.020	-0.002	0.0	-1.8	98.9	98.9	0.00
Kharka A-Debji	-0.024	-0.003	0.024	0.001	0.0	-1.7	98.9	99.0	0.00
Debji 2-Debji3	0.013	-0.003	-0.013	0.003	0.0	-0.6	98.9	98.9	0.00
Debji2 SS	0.008	0.005	-0.007	-0.005	0.0	0.7	98.9	94.8	4.15
Debji 3SS	-0.004	-0.002	0.004	0.003	0.0	0.3	95.6	98.9	3.31
Debji 3-Yaba	0.009	-0.005	-0.009	-0.002	0.0	-7.1	98.9	98.9	0.00
E20H007-Demo	-0.097	-0.072	0.097	0.072	0.0	0.0	99.5	99.5	0.01
E20T2.	0.097	0.072	-0.097	-0.060	0.3	11.6	99.5	94.0	5.50
H190H097-Domzegang	-0.004	-0.003	0.004	0.003	0.0	-0.1	99.7	99.7	0.00
H190T7	0.004	0.003	-0.004	-0.003	0.0	0.1	99.7	99.2	0.58
Regokha-E10H1	-0.149	-0.046	0.149	0.044	0.0	-1.6	99.0	99.0	0.00
Regokha-E10H237	0.071	-0.004	-0.071	0.004	0.0	-0.7	99.0	99.0	0.00
Dorekha	0.078	0.050	-0.078	-0.048	0.0	2.2	99.0	97.7	1.30
E10H439-Dorikha	-0.008	-0.005	0.008	0.005	0.0	-0.1	98.5	98.5	0.00
E10T29	0.008	0.005	-0.008	-0.005	0.0	0.4	98.5	95.8	2.62
E50T5	-0.002	-0.002	0.002	0.002	0.0	0.0	97.1	97.9	0.83
E50H061-Dranadingkha	-0.002	-0.002	0.002	0.001	0.0	-0.6	97.9	97.9	0.00
E10T2	-0.065	-0.040	0.065	0.043	0.1	3.1	97.1	99.3	2.19
Dungkhag SS	-0.008	-0.005	0.008	0.006	0.0	0.5	96.2	99.0	2.82
Dorokha-Dungkhag1	-0.310	-0.084	0.310	0.075	0.1	-9.2	99.0	99.1	0.04
Dungkhag-E70H105	0.301	0.079	-0.301	-0.081	0.0	-2.1	99.0	99.0	0.01
Kaukha ss	-0.003	-0.002	0.003	0.002	0.0	0.1	97.4	99.0	1.57
E10-MH-BOD	0.307	0.192	-0.307	-0.192	0.3	0.1	99.6	99.5	0.11
E10T1	0.069	0.048	-0.069	-0.043	0.1	5.5	99.6	95.9	3.68
BOD-E10H031	-0.298	-0.186	0.299	0.187	0.4	0.1	99.3	99.5	0.17
E10H031-H038	0.233	0.143	-0.233	-0.143	0.1	0.0	99.3	99.3	0.05
E10H038-H055	0.008	0.004	-0.008	-0.005	0.0	-0.5	99.3	99.3	0.01
E10H038-H086	0.226	0.139	-0.226	-0.139	0.3	-0.1	99.3	99.1	0.15
E10H055-JawangGoenpa	0.001	0.001	-0.001	-0.001	0.0	0.0	99.3	99.3	0.00
E10H055-Takchu Goenpa	0.006	0.004	-0.006	-0.004	0.0	-0.2	99.3	99.3	0.00
E10H055-Tsilung Goenpa1	0.023	0.015	-0.023	-0.015	0.0	-0.1	99.1	99.1	0.01
E10H086-H092	0.203	0.125	-0.203	-0.125	0.0	0.0	99.1	99.1	0.01
E10H092-H111	0.193	0.119	-0.193	-0.119	0.3	-0.3	99.1	99.0	0.15
E10H111-H115	0.180	0.110	-0.180	-0.110	0.0	0.0	99.0	98.9	0.01
E10H111-Tsaphel	0.013	0.008	-0.013	-0.008	0.0	0.0	99.0	99.0	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
E10H115-Tsaphel 2	0.179	0.110	-0.179	-0.110	0.0	0.0	98.9	98.9	0.02
E10H139-Kana Bus	0.132	0.080	-0.132	-0.080	0.1	-0.2	98.9	98.8	0.05
E10H139-Tsaphel3	0.027	0.017	-0.027	-0.017	0.0	-0.1	98.9	98.9	0.01
Tsaphel2-E10H139	-0.159	-0.097	0.159	0.097	0.1	-0.1	98.9	98.9	0.04
E10H159-H160	0.004	0.002	-0.004	-0.002	0.0	0.0	98.8	98.8	0.00
E10H159-H185	0.127	0.077	-0.127	-0.077	0.0	0.0	98.8	98.8	0.01
Kana 1-E10H159	-0.131	-0.079	0.131	0.079	0.0	-0.1	98.8	98.8	0.02
E10H185-Gerena	0.102	0.061	-0.102	-0.061	0.0	-0.2	98.8	98.8	0.04
E10H185-Kana2	0.025	0.016	-0.025	-0.016	0.0	-0.2	98.8	98.8	0.01
E10H209-E10H247	0.091	0.055	-0.091	-0.055	0.0	-0.2	98.8	98.7	0.03
E10H209-H224	0.002	0.000	-0.002	-0.001	0.0	-0.4	98.8	98.8	0.00
Gerena-E10H209	-0.093	-0.055	0.093	0.055	0.0	0.0	98.8	98.8	0.01
E10H224-Pajekha	0.002	0.001	-0.002	-0.001	0.0	0.0	98.8	98.8	0.00
E10H237-E10H253	0.067	-0.006	-0.067	-0.001	0.0	-6.7	99.0	99.0	0.01
E10H237-thomje	0.004	0.002	-0.004	-0.003	0.0	-0.2	99.0	99.0	0.00
E10H247-H263	0.091	0.055	-0.091	-0.055	0.1	-0.2	98.7	98.7	0.07
E10H263-H273	0.064	0.037	-0.064	-0.037	0.0	-0.2	98.7	98.6	0.03
E10H263-Jyenkana Skol	0.027	0.019	-0.027	-0.019	0.0	0.0	98.7	98.7	0.00
E10H273-H279	0.062	0.036	-0.062	-0.036	0.0	0.0	98.6	98.6	0.00
E10H273-Puduna	0.002	0.001	-0.002	-0.001	0.0	-0.1	98.6	98.6	0.00
E10T19	0.005	0.003	-0.005	-0.003	0.0	0.3	98.6	96.1	2.49
E10H305-Gangkha	0.024	0.013	-0.024	-0.014	0.0	-0.4	98.5	98.5	0.02
E10H351-Shari 2	0.011	0.007	-0.011	-0.007	0.0	-0.3	98.5	98.5	0.01
SE10H351-Shar 1	0.006	0.004	-0.006	-0.004	0.0	0.0	98.5	98.5	0.00
E10H388-H402	0.021	0.012	-0.021	-0.012	0.0	-0.4	98.5	98.5	0.02
E10H388-Nobgang	0.002	0.001	-0.002	-0.001	0.0	-0.1	98.5	98.5	0.00
Gangkha1-E10H388	-0.023	-0.013	0.023	0.012	0.0	-0.1	98.5	98.5	0.01
E10H402-Lhenkha	0.015	0.008	-0.015	-0.009	0.0	-0.6	98.5	98.5	0.02
E10H439-Lamjigang	0.004	0.002	-0.004	-0.002	0.0	-0.7	98.5	98.5	0.01
Lhenkha-E10H439	-0.011	-0.007	0.011	0.006	0.0	-0.3	98.5	98.5	0.01
E20H005-H007	0.729	0.512	-0.728	-0.512	0.8	0.4	99.6	99.5	0.10
E20H005-Janatsam	0.005	0.003	-0.005	-0.003	0.0	-0.3	99.6	99.6	0.00
E20H007-H013	0.630	0.440	-0.629	-0.439	1.8	0.8	99.5	99.2	0.27
E20H013-Imtrat	0.341	0.238	-0.341	-0.238	0.1	0.0	99.2	99.2	0.04
E20H013-Ngachu	0.288	0.202	-0.288	-0.202	0.0	0.0	99.2	99.2	0.01
E20H023-Imtrat Engg Cell	0.241	0.171	-0.241	-0.171	0.3	0.0	99.2	99.1	0.12
Ngachu-E20H023	-0.277	-0.195	0.277	0.195	0.0	0.0	99.2	99.2	0.01

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	
E30T1	0.097	0.062	-0.097	-0.060	0.0	2.2	99.7	98.7	1.06
E40 H003-H006T1	0.081	0.052	-0.081	-0.053	0.0	-0.1	99.7	99.7	0.02
E40 H003-H019	0.228	0.152	-0.227	-0.152	0.5	-0.1	99.7	99.5	0.19
E40T1	0.081	0.053	-0.081	-0.050	0.1	2.3	99.7	98.3	1.34
E40 H017-H024	0.125	0.083	-0.125	-0.083	0.0	0.0	99.5	99.5	0.01
E40 H017-H027T2	0.102	0.069	-0.102	-0.069	0.0	-0.1	99.5	99.5	0.02
E40 H019-H020	0.125	0.083	-0.125	-0.083	0.0	0.0	99.5	99.5	0.00
E40T3	0.102	0.069	-0.102	-0.063	0.1	6.1	99.5	96.7	2.77
E50H003-H007	0.039	0.026	-0.039	-0.026	0.0	-0.1	99.7	99.7	0.01
E50H003-H033	0.972	0.651	-0.966	-0.646	5.9	5.4	99.7	99.0	0.69
E50H007-L.Wangtsa	0.016	0.010	-0.016	-0.010	0.0	0.0	99.7	99.7	0.00
E50H007-U.Wangtsa	0.023	0.016	-0.023	-0.016	0.0	-0.2	99.7	99.7	0.01
E50H033-H055	0.938	0.626	-0.933	-0.622	4.7	4.2	99.0	98.4	0.56
E50H033-Yatom	0.028	0.020	-0.028	-0.020	0.0	-0.2	99.0	99.0	0.01
E50H055-E50H061	0.786	0.526	-0.783	-0.524	3.3	2.9	98.4	97.9	0.48
E50T4	0.065	0.042	-0.065	-0.040	0.1	2.5	98.4	96.7	1.74
E50H0061-H089	0.781	0.522	-0.777	-0.520	3.3	2.9	97.9	97.5	0.48
E50H089-H095	0.681	0.453	-0.680	-0.452	0.8	0.7	97.5	97.3	0.13
E50T21	0.097	0.067	-0.096	-0.060	0.2	7.3	97.5	94.0	3.42
E50H089-Nagtsho	0.026	0.017	-0.026	-0.017	0.0	0.0	97.3	97.3	0.00
E50H095-H117	0.654	0.435	-0.650	-0.432	4.0	3.3	97.3	96.6	0.69
E50H117-H124	0.618	0.411	-0.617	-0.411	0.6	0.5	96.6	96.5	0.11
E50H0117-Yangto	0.032	0.021	-0.032	-0.021	0.0	-0.1	96.6	96.6	0.01
E50H0124-H144	0.333	0.221	-0.332	-0.220	1.2	0.3	96.5	96.2	0.33
E50H124-Tokey	0.284	0.190	-0.284	-0.190	0.0	0.0	96.5	96.5	0.02
E50H0144-H151	0.331	0.220	-0.331	-0.220	0.1	0.0	96.2	96.2	0.04
E50H0144-Yangto Goenpa	0.001	0.001	-0.001	-0.001	0.0	-0.1	96.2	96.2	0.00
E50H0151-H154	0.050	0.031	-0.050	-0.031	0.0	0.0	96.2	96.2	0.00
E50H0154-H187	0.035	0.022	-0.035	-0.022	0.0	-0.2	96.2	96.1	0.02
E50H0154-Jamtey G	0.015	0.009	-0.015	-0.010	0.0	-0.4	96.2	96.1	0.02
E50H0154-H1	0.013	0.008	-0.013	-0.008	0.0	0.0	96.1	96.1	0.00
E50H187-H202	0.022	0.014	-0.022	-0.014	0.0	-0.2	96.1	96.1	0.02
E50H0202- Tsenkha	0.006	0.004	-0.006	-0.004	0.0	-0.2	96.1	96.1	0.00
E50T12	0.016	0.010	-0.016	-0.010	0.0	0.4	96.1	95.0	1.09
E70H105-Yantsena	0.005	-0.002	-0.005	-0.004	0.0	-5.1	99.0	99.0	0.00
E70H105-Yantsena1	0.296	0.082	-0.296	-0.085	0.0	-2.3	99.0	99.0	0.01
E70H105-Yantsena5	0.227	0.087	-0.227	-0.091	0.0	-4.1	99.0	99.0	0.02

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
E70H124-Kaukha	0.069	-0.003	-0.069	-0.001	0.0	-3.4	99.0	99.0	0.01
E70H148-Mochu	0.060	0.006	-0.060	-0.009	0.0	-2.4	99.0	99.0	0.00
Kaukha-E70H1	0.005	-0.002	-0.005	-0.003	0.0	-5.5	99.0	99.0	0.00
Kaukha-E70H148	-0.066	-0.004	0.066	-0.001	0.0	-5.5	99.0	99.0	0.01
E70H176-Zomtokha	0.005	0.003	-0.005	-0.004	0.0	-0.9	99.0	99.0	0.00
E70H176-Zomtokha A	0.042	0.009	-0.042	-0.009	0.0	-0.1	99.0	99.0	0.00
E70H182-Kharka A	0.029	0.004	-0.029	-0.004	0.0	-0.7	99.0	99.0	0.00
Kharka school-E70H182	-0.034	-0.006	0.034	0.005	0.0	-0.6	99.0	99.0	0.00
E70H105-Yantsena4	-0.161	-0.050	0.161	0.048	0.0	-2.1	99.0	99.0	0.01
E70H225-Taktokha	0.003	0.002	-0.003	-0.002	0.0	-0.5	99.0	99.0	0.00
Taktokha-rebji	0.157	0.048	-0.157	-0.049	0.0	-0.8	99.0	99.0	0.00
E10H237-Tshloni	0.055	0.008	-0.055	-0.012	0.0	-4.7	99.0	98.9	0.01
E10H253-E10H267	0.012	-0.007	-0.012	0.001	0.0	-5.8	99.0	99.0	0.00
E10H267-Shaba	0.012	-0.001	-0.012	-0.001	0.0	-2.2	99.0	99.0	0.00
E70H306-Sombekha2	0.005	0.003	-0.005	-0.004	0.0	-0.1	98.9	98.9	0.00
E70H306-Sombekha3	0.030	0.001	-0.030	-0.002	0.0	-0.5	98.9	98.9	0.00
Gerena-Sangbay1	-0.035	-0.005	0.035	0.003	0.0	-1.6	98.9	98.9	0.00
E70H306-Sombekha1	-0.027	0.000	0.027	0.000	0.0	-0.4	98.9	98.9	0.00
E70H306-Sombekha4	0.023	-0.002	-0.023	0.000	0.0	-2.5	98.9	98.9	0.00
Nebji	0.004	0.003	-0.004	-0.002	0.0	0.2	98.9	96.9	2.06
E70H318-Nakikha1	0.005	0.003	-0.005	-0.003	0.0	-0.5	98.9	98.9	0.00
E70H318-Nakikha2	0.018	-0.002	-0.018	0.002	0.0	-0.4	98.9	98.9	0.00
E20T5	-0.241	-0.149	0.241	0.171	0.5	22.3	94.8	99.1	4.27
H190T5	-0.011	-0.007	0.011	0.007	0.0	0.4	98.3	99.8	1.47
H190H073-Ganghe	-0.011	-0.007	0.011	0.006	0.0	-1.5	99.8	99.8	0.00
E10T25	-0.002	-0.001	0.002	0.001	0.0	0.0	97.9	98.5	0.58
Hatey-Gaychukha	-0.200	-0.135	0.200	0.135	0.1	0.0	96.2	96.2	0.04
E50T18	0.003	0.002	-0.003	-0.002	0.0	0.0	96.2	95.8	0.39
E10T14	0.009	0.006	-0.009	-0.006	0.0	0.2	98.8	97.6	1.18
Gerena SS	-0.006	-0.004	0.006	0.004	0.0	0.3	97.0	98.9	1.99
Gerena-Sangbay	0.045	0.008	-0.045	-0.010	0.0	-2.9	98.9	98.9	0.00
Tshloni-Gerena	-0.051	-0.011	0.051	0.010	0.0	-1.4	98.9	98.9	0.00
H190T10	-0.010	-0.006	0.010	0.007	0.0	0.3	98.4	99.7	1.34
H190H142-Gurungang	-0.010	-0.007	0.010	0.007	0.0	-0.1	99.7	99.7	0.00
H190H020-H023	0.175	0.101	-0.175	-0.101	0.0	-0.5	99.8	99.8	0.00
H190H020-H073	0.259	0.027	-0.259	-0.028	0.0	-1.5	99.8	99.8	0.00
L.Wanakha-H020	-0.433	-0.127	0.434	0.121	0.1	-6.2	99.8	99.8	0.04

	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
H190H020-H2	0.090	0.049	-0.090	-0.052	0.0	-2.6	99.8	99.8	0.01
H190H029-H032	0.019	0.003	-0.019	-0.003	0.0	-0.8	99.8	99.8	0.00
H190T2-1	0.047	0.033	-0.047	-0.029	0.1	3.3	99.8	96.5	3.26
H190T2-2	0.024	0.016	-0.024	-0.015	0.0	1.7	99.8	96.5	3.26
H190H032-Nyemo	0.003	0.000	-0.003	-0.002	0.0	-1.9	99.8	99.8	0.00
H190H032-Susuna	0.016	0.003	-0.016	-0.011	0.0	-7.2	99.8	99.8	0.00
H190H073-H091	0.248	0.022	-0.248	-0.027	0.0	-4.6	99.8	99.7	0.01
H190H091-H097	0.243	0.024	-0.243	-0.026	0.0	-2.1	99.7	99.7	0.01
H190H091-Labana	0.005	0.003	-0.005	-0.003	0.0	-0.2	99.7	99.7	0.00
H190H097-Powagang	0.238	0.024	-0.238	-0.029	0.0	-5.6	99.7	99.7	0.02
H190H126	0.184	0.064	-0.184	-0.068	0.0	-3.7	99.7	99.7	0.01
H190H128-H283	0.040	-0.040	-0.040	0.038	0.0	-2.1	99.7	99.7	0.00
Jashina-H190H128	-0.223	-0.024	0.223	0.022	0.0	-2.1	99.7	99.7	0.01
H190H142-Rashigang	0.173	0.061	-0.173	-0.065	0.0	-3.5	99.7	99.7	0.01
H190H156-H174	0.149	0.051	-0.149	-0.055	0.0	-4.4	99.7	99.7	0.01
H190H156-Tsepji	0.006	0.002	-0.006	-0.004	0.0	-1.3	99.7	99.7	0.00
Rashigang-H190H156	-0.154	-0.053	0.154	0.052	0.0	-0.8	99.7	99.7	0.00
H190H174-H186	0.148	0.054	-0.148	-0.058	0.0	-3.3	99.7	99.7	0.01
H190H186-H193	0.145	0.057	-0.145	-0.058	0.0	-1.2	99.7	99.7	0.00
H190H245-Lingzhi3	0.003	0.001	-0.003	-0.002	0.0	-0.7	99.7	99.7	0.00
H190H193-H204	0.140	0.056	-0.140	-0.059	0.0	-2.4	99.7	99.7	0.01
H190H193-Jangkha	0.004	0.002	-0.004	-0.003	0.0	-1.1	99.7	99.7	0.00
H190H204-H208	0.075	0.012	-0.075	-0.013	0.0	-0.5	99.7	99.7	0.00
H190H208-H215	0.069	0.029	-0.069	-0.032	0.0	-3.2	99.7	99.7	0.00
H190H215-Jelekha	0.061	0.039	-0.061	-0.040	0.0	-1.0	99.7	99.7	0.00
H190H215-Lhazukha	0.008	-0.007	-0.008	0.006	0.0	-0.7	99.7	99.7	0.00
Lhazukha-H190H228	-0.004	0.006	0.004	-0.009	0.0	-3.3	99.7	99.7	0.00
H190H237-Papali	0.003	0.001	-0.003	-0.002	0.0	-1.0	99.7	99.7	0.00
H190H237-Shacho Gempa	0.000	-0.003	0.000	0.000	0.0	-2.8	99.7	99.7	0.00
H190H245-H256	0.016	-0.048	-0.016	0.045	0.0	-3.6	99.7	99.7	0.00
H190H245-Lingzhi2	0.008	0.005	-0.008	-0.005	0.0	-0.1	99.7	99.7	0.00
Nago-H190H245	-0.023	0.043	0.023	-0.048	0.0	-4.7	99.7	99.7	0.00
H190H245-Lingzhi1	0.008	0.005	-0.008	-0.005	0.0	-0.3	99.7	99.7	0.00
H190H256-Jatakha	0.008	-0.049	-0.008	0.041	0.0	-8.5	99.7	99.7	0.00
H190H283-Nago	0.017	0.010	-0.017	-0.011	0.0	-0.7	99.7	99.7	0.00
H190H320-H330	0.002	-0.012	-0.002	0.007	0.0	-5.0	99.7	99.7	0.00
Jatakha-H190H320	-0.002	0.039	0.002	-0.044	0.0	-5.3	99.7	99.7	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
H190H320-Jyenkana SS	0.000	-0.027	0.000	0.000	0.0	-26.5	99.7	99.7	0.00
H190H330-Raringkha	0.001	-0.002	-0.001	-0.001	0.0	-2.7	99.7	99.7	0.00
E50T17	0.023	0.016	-0.023	-0.014	0.0	1.7	96.2	92.9	3.30
E20T2-2	-0.145	-0.090	0.145	0.102	0.3	12.7	95.1	99.2	4.05
E20T2-1	-0.195	-0.121	0.196	0.135	0.3	14.4	95.8	99.2	3.40
E10T3	0.001	0.001	-0.001	-0.001	0.0	0.0	99.3	98.5	0.77
E50T10	-0.015	-0.009	0.015	0.010	0.0	0.7	94.1	96.1	2.02
E10T17	-0.027	-0.017	0.027	0.019	0.0	2.2	94.9	98.7	3.74
Tokey -Jamphel School	-0.258	-0.174	0.259	0.174	0.2	0.0	96.4	96.5	0.09
E50T15	0.020	0.013	-0.020	-0.012	0.0	0.6	96.4	95.1	1.37
E20T6	0.005	0.003	-0.005	-0.003	0.0	0.1	99.6	98.9	0.71
H190T15	0.004	0.003	-0.004	-0.003	0.0	0.1	99.7	99.1	0.58
Powagang-Jashina	-0.235	-0.030	0.235	0.027	0.0	-2.8	99.7	99.7	0.01
H190T9	0.012	0.008	-0.012	-0.007	0.0	0.4	99.7	98.2	1.56
H190T22	0.005	0.003	-0.005	-0.003	0.0	0.1	99.7	99.0	0.71
H190T17	0.061	0.040	-0.061	-0.038	0.0	2.2	99.7	98.0	1.63
E10T13	0.025	0.016	-0.025	-0.015	0.0	0.9	98.8	97.1	1.68
E10T11	0.001	0.001	-0.001	-0.001	0.0	0.0	98.8	98.2	0.63
khamena	0.067	0.044	-0.067	-0.041	0.1	2.6	99.0	97.2	1.78
Kharka A SS	0.005	0.003	-0.005	-0.003	0.0	0.4	99.0	94.8	4.15
Kharka school	-0.003	-0.002	0.003	0.002	0.0	0.1	97.8	99.0	1.13
Zomtokha A-kharka1 School	-0.038	-0.007	0.038	0.006	0.0	-1.3	99.0	99.0	0.00
H190T27	0.001	0.000	-0.001	0.000	0.0	0.0	99.7	99.5	0.18
E50T1	0.016	0.010	-0.016	-0.010	0.0	0.4	99.7	98.6	1.04
H190T1	0.013	0.009	-0.013	-0.008	0.0	0.5	99.8	98.1	1.73
H190T6	0.005	0.003	-0.005	-0.003	0.0	0.1	99.7	99.1	0.60
E10T30	-0.004	-0.002	0.004	0.002	0.0	0.2	96.5	98.5	1.91
H190T18	0.004	0.003	-0.004	-0.003	0.0	0.1	99.7	99.1	0.57
E10T28	-0.004	-0.002	0.004	0.002	0.0	0.2	96.6	98.5	1.91
H190T21	0.008	0.005	-0.008	-0.005	0.0	0.2	99.7	98.7	1.03
H190T20	0.008	0.005	-0.008	-0.005	0.0	0.2	99.7	98.7	0.98
E50T11	0.013	0.008	-0.013	-0.008	0.0	0.5	96.1	94.4	1.76
Mochu SS1	0.005	0.003	-0.005	-0.003	0.0	0.2	99.0	97.2	1.78
Mochu SS	0.004	0.003	-0.004	-0.002	0.0	0.1	99.0	97.7	1.30
H190T19	0.017	0.011	-0.017	-0.010	0.0	0.8	99.7	97.5	2.23
E50T6	0.026	0.017	-0.026	-0.016	0.0	0.8	97.3	96.0	1.37
Nakha-Nakha tashigang	0.006	0.003	-0.006	-0.004	0.0	-1.3	98.9	98.9	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Nakikha2-Nakikha3	-0.012	-0.007	0.012	-0.006	0.0	-12.8	98.9	98.9	0.00
Nakha SS	0.006	0.004	-0.006	-0.004	0.0	0.3	98.9	96.9	1.99
Nakha tashigang SS	0.006	0.004	-0.006	-0.004	0.0	0.3	98.9	96.8	2.13
Nakikha1	0.005	0.003	-0.005	-0.003	0.0	0.2	98.9	97.3	1.64
Nakikha2	0.006	0.004	-0.006	-0.004	0.0	0.3	98.9	97.0	1.99
H190T4	-0.003	-0.002	0.003	0.002	0.0	0.0	99.4	99.8	0.36
E20T3	0.011	0.007	-0.011	-0.007	0.0	0.1	99.2	98.9	0.27
E10T26	0.002	0.001	-0.002	-0.001	0.0	0.0	98.5	97.9	0.61
E10T15	-0.002	-0.001	0.002	0.001	0.0	0.0	98.6	98.8	0.20
H190T29	0.003	0.002	-0.003	-0.002	0.0	0.1	99.7	98.5	1.15
H190T8	-0.003	-0.002	0.003	0.002	0.0	0.0	99.3	99.7	0.42
E10T18	0.002	0.001	-0.002	-0.001	0.0	0.0	98.6	98.1	0.57
H190T25	0.001	0.001	-0.001	-0.001	0.0	0.0	99.7	99.1	0.66
H190T11	0.019	0.013	-0.019	-0.012	0.0	1.0	99.7	97.1	2.56
-rebji-Regokha	0.152	0.045	-0.152	-0.047	0.0	-1.5	99.0	99.0	0.00
Rebji SS	0.005	0.003	-0.005	-0.003	0.0	0.3	99.0	96.4	2.61
Regokha SS	-0.004	-0.002	0.004	0.003	0.0	0.1	97.7	99.0	1.30
H190T30	0.000	0.000	0.000	0.000	0.0	0.0	99.7	99.6	0.08
H190T14	0.003	0.002	-0.003	-0.002	0.0	0.0	99.7	99.3	0.36
Sangbay SS	-0.010	-0.006	0.010	0.007	0.0	0.8	95.3	98.9	3.66
E10H160-Sangkiri	0.004	0.002	-0.004	-0.003	0.0	-0.4	98.8	98.8	0.00
E10T12	0.004	0.003	-0.004	-0.003	0.0	0.1	98.8	98.2	0.56
Shaba SS	0.006	0.004	-0.006	-0.004	0.0	0.3	99.0	97.0	1.99
Yaba-Shama	-0.005	-0.004	0.005	-0.001	0.0	-4.1	98.9	98.9	0.00
Shama SS	0.005	0.004	-0.005	-0.003	0.0	0.3	98.9	96.1	2.82
E10T24	-0.006	-0.003	0.006	0.004	0.0	0.1	97.8	98.5	0.73
E10T23	0.011	0.007	-0.011	-0.007	0.0	0.3	98.5	97.0	1.46
Shebji SS	0.003	0.002	-0.003	-0.002	0.0	0.1	99.0	97.2	1.78
Sombaykha 2	-0.005	-0.003	0.005	0.004	0.0	0.3	96.1	98.9	2.82
Sombaykha 3	-0.003	-0.002	0.003	0.002	0.0	0.1	97.4	98.9	1.49
H190T03	0.016	0.011	-0.016	-0.010	0.0	0.7	99.8	97.6	2.14
E10T4	0.006	0.004	-0.006	-0.004	0.0	0.1	99.3	98.5	0.79
Taktokha SS	0.003	0.002	-0.003	-0.002	0.0	0.1	99.0	97.2	1.78
ThomjeeSS	0.004	0.003	-0.004	-0.002	0.0	0.2	99.0	96.9	2.06
E50T14	0.025	0.016	-0.025	-0.016	0.0	0.8	96.5	95.2	1.35
E10T10	-0.027	-0.017	0.027	0.017	0.0	0.5	98.0	98.9	0.89
E10T7	0.013	0.008	-0.013	-0.008	0.0	0.5	99.0	97.2	1.72

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
E10T9	-0.020	-0.012	0.020	0.013	0.0	1.1	96.3	98.9	2.66
E50T13	0.006	0.004	-0.006	-0.004	0.0	0.1	96.1	95.3	0.86
H190T12	0.006	0.004	-0.006	-0.003	0.0	0.1	99.7	99.0	0.72
E10T5	-0.023	-0.014	0.023	0.015	0.0	0.7	97.6	99.1	1.52
Tsholini SS	-0.003	-0.002	0.003	0.002	0.0	0.1	97.2	98.9	1.78
E50T2	0.023	0.016	-0.023	-0.014	0.0	1.6	99.7	96.5	3.14
Yaba SS	0.004	0.003	-0.004	-0.002	0.0	0.1	98.9	97.7	1.30
E50T7	0.032	0.021	-0.032	-0.020	0.0	0.8	96.6	95.5	1.09
E50T8	0.001	0.001	-0.001	-0.001	0.0	0.0	96.2	95.7	0.49
Yangtsena ss	0.005	0.004	-0.005	-0.003	0.0	0.3	99.0	96.2	2.82
E50T3	-0.028	-0.018	0.028	0.020	0.1	2.4	95.0	99.0	3.96
Zomtokha ss	0.005	0.004	-0.005	-0.003	0.0	0.3	99.0	96.1	2.82
Zomtokha A SS	0.004	0.003	-0.004	-0.003	0.0	0.2	99.0	96.6	2.33
					74.1	-66.6			

Alert Summary Report

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

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
ChumduBus	Bus	Under Voltage	0.415	kV	0.385	92.7	3-Phase
ChumduBus2	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
Chumpabus	Bus	Under Voltage	0.415	kV	0.39	94.3	3-Phase
DamthagBus	Bus	Under Voltage	0.415	kV	0.39	94.6	3-Phase
Damthang2bus	Bus	Under Voltage	0.415	kV	0.38	92.4	3-Phase
Debji2bus1	Bus	Under Voltage	0.415	kV	0.39	94.8	3-Phase
Demobus	Bus	Under Voltage	0.415	kV	0.39	94.0	3-Phase
Engg cell bus	Bus	Under Voltage	0.415	kV	0.39	94.8	3-Phase
HateyBus	Bus	Under Voltage	0.415	kV	0.39	92.9	3-Phase
J.GoenpaBus	Bus	Under Voltage	0.415	kV	0.39	94.1	3-Phase
J.School Bus	Bus	Under Voltage	0.415	kV	0.39	94.9	3-Phase
JGurikhaBus	Bus	Under Voltage	0.415	kV	0.39	94.0	3-Phase
KharkaA bus	Bus	Under Voltage	0.415	kV	0.39	94.8	3-Phase
MakanaBus	Bus	Under Voltage	0.415	kV	0.39	94.4	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	4.240	2.515	4.929	86.01 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	4.240	2.515	4.929	86.01 Lagging
Total Motor Load:	1.089	0.675	1.281	85.00 Lagging
Total Static Load:	3.077	1.907	3.620	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.074	-0.067		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure-5: Feeder Wise Reliability Indices

2017														
Name of Feeders	Jan		Feb		March		Apr		May		June		July	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI
11kV Dumchu Feeder 1	0.658	2.261	0.439	0.542	1.097	2.788	1.097	1.433	0.658	2.261	0.658	0.367	0.641	0.812
11kV Imtrat Feeder 2	-	-	-	-	0.038	0.122	-	-	-	-	0.038	0.027	-	-
11kV Town Feeder 4	0.179	0.077	-	-	0.179	0.581	-	-	0.179	0.077	0.358	0.200	-	-
11kV Damthang Feeder 5	0.222	1.241	-	-	0.887	1.412	0.443	0.248	0.222	1.241	0.622	0.441	0.216	0.026
33kV Wanakha/BetikhaFeeder	-	-	0.790	0.227	0.263	0.856	-	-	0.263	-	1.581	0.111	2.307	1.361
2018														
11kV Dumchu Feeder 1	0.214	-	-	-	0.780	0.312	0.776	1.320	1.300	22.963	1.296	0.161	3.148	0.971
11kV Imtrat Feeder 2	0.018	-	-	-	0.044	0.022	0.022	0.001	0.092	3.276	0.092	0.280	0.049	0.074
11kV Hospital& New Admin Block Feeder 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11kV Town Feeder 4	-	-	0.173	0.173	0.197	0.034	0.196	0.010	0.798	7.114	0.795	0.795	0.409	0.624
11kV Damthang Feeder 5	-	-	0.648	0.626	0.243	0.041	0.242	0.012	0.968	8.632	1.448	3.312	1.850	1.850
33kV Wanakha/BetikhaFeeder	0.764	0.458	1.018	0.143	0.506	0.019	0.276	0.110	1.378	10.192	1.099	3.189	-	1.374
33 kV Dorokha	-	-	-	-	-	-	0.920	3.620	-	-	14.000	14.070	11.000	57.030
2019														
11kV Dumchu Feeder 1	0.241	0.026	0.241	0.205	-	-	-	-	2.147	36.262	2.139	1.690	0.710	0.341
11kV Imtrat Feeder 2	0.024	0.006	0.056	0.056	0.024	0.097	0.024	-	0.024	1.360	0.024	0.051	0.024	0.017
11kV Hospital& New Admin Block Feeder 3	-	-	-	0.007	-	0.009	-	-	-	0.157	0.003	0.006	0.003	0.000
11kV Town Feeder 4	0.194	0.506	0.194	-	0.192	-	0.193	-	0.111	0.111	0.192	0.385	0.191	-
11kV Damthang Feeder 5	0.451	-	0.451	-	0.448	-	-	0.449	0.686	-	0.445	0.445	0.207	0.072
33kV Wanakha/BetikhaFeeder	0.492	0.023	0.468	0.451	0.464	1.801	0.465	1.084	0.763	0.497	1.000	30.170	0.264	1.152
33 kV Dorokha-Sombeykha	17.000	16.410	15.000	22.790	26.000	163.350	21.000	180.070	29.000	26.970	50.000	66.260	50.000	53.310

2017												
Name of Feeders	Aug		Sept		Oct		Nov		Dec		**Total**	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	**SAIFI**	**SAIDI**
11kV Dumchu Feeder 1	-	-	0.644	2.223	0.644	0.741	0.642	1.451	0.640	0.979	**7.821**	**15.858**
11kV Imtrat Feeder 2	0.018	0.005	0.018	0.019	0.018	0.019	0.018	0.006	0.018	0.012	**0.167**	**0.209**
11kV Town Feeder 4	0.521	0.076	-	-	-	-	0.345	0.043	-	-	**1.760**	**1.055**
11kV Damthang Feeder 5	0.870	0.154	0.216	0.017	0.216	0.017	0.862	0.645	0.215	0.054	**4.992**	**5.498**
33kV Wanakha/BetikhaFeeder	0.768	0.218	1.273	0.395	1.273	0.395	-	-	1.014	1.508	**9.533**	**5.069**
2018												
11kV Dumchu Feeder 1	0.521	0.193	-	-	0.253	-	0.519	0.581	0.266	0.053	**9.074**	**26.554**
11kV Imtrat Feeder 2	0.024	0.005	-	-	0.022	-	-	-	0.026	0.005	**0.389**	**3.663**
11kV Hospital& New Admin Block Feeder 3	0.001	0.004	-	-	-	-	0.002	0.001	0.003	0.001	**0.006**	**0.006**
11kV Town Feeder 4	1.220	3.229	0.609	2.091	-	-	-	-	0.214	-	**4.612**	**14.070**
11kV Damthang Feeder 5	0.978	0.423	0.242	0.138	-	-	0.483	0.287	0.498	0.225	**7.600**	**15.548**
33kV Wanakha/BetikhaFeeder	1.849	0.602	-	-	-	-	-	-	0.516	0.749	**7.406**	**16.837**
33 kV Dorokha	9.000	2.200	26.000	19.840	10.000	0.630	6.000	4.420	6.000	2.120	**82.920**	**103.930**
2019												
11kV Dumchu Feeder 1	-	-	0.236	0.276	0.237	0.114	0.235	-	0.235	-	**6.421**	**38.914**
11kV Imtrat Feeder 2	0.024	-	0.024	-	0.024	0.017	0.023	-	0.023	-	**0.317**	**1.605**
11kV Hospital& New Admin Block Feeder 3	0.003	-	0.003	-	0.003	0.000	0.003	0.001	0.003	-	**0.019**	**0.181**
11kV Town Feeder 4	0.191	-	0.190	-	0.191	-	0.190	-	0.189	-	**2.217**	**1.002**
11kV Damthang Feeder 5	0.207	0.581	2.118	13.452	0.207	0.072	0.206	-	0.205	0.501	**5.630**	**15.572**
33kV Wanakha/BetikhaFeeder	0.264	0.716	0.264	0.714	0.264	1.152	0.263	2.188	0.262	3.364	**5.234**	**43.312**
33 kV Dorokha-Sombeykha	20.000	45.010	39.000	17.130	22.000	68.170	7.000	6.690	15.000	9.750	**311.000**	**675.910**

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

FEEDER E10(DOMCHU 1)

Sl. No.	Name	TFR. Rating	Loading (kVA)	Loading (kW)	% Loading Present	Peak Load(kVA) in 2025	% Loading in 2025	Peak Load(kVA) in 2030	% Loading in 2030
						0.574469305		**0.702455307**	
						1.574469305		**1.702455307**	
1	IMTRAT Hospital	163	86.50	73.52	**53.07%**	136.185	**84%**	147.256	**90%**
2	Dumchu	250	79.70	67.75	**31.88%**	125.485	**50%**	135.686	**54%**
3	Jawang gompa	16	1.80	1.53	**11.26%**	2.836	**18%**	3.067	**19%**
4	Takchu Gompa	63	7.27	6.18	**11.54%**	11.443	**18%**	12.373	**20%**
5	Tshilungkha	125	27.70	23.54	**22.16%**	43.610	**35%**	47.155	**38%**
6	Betsho	63	11.76	9.99	**18.66%**	18.510	**29%**	20.015	**32%**
7	Tshaphel 1	63	22.11	18.79	**35.10%**	34.812	**55%**	37.641	**60%**
8	Damtikha	16	1.45	1.23	**9.04%**	2.277	**14%**	2.462	**15%**
9	Tshaphel 2	63	24.38	20.73	**38.71%**	38.392	**61%**	41.513	**66%**
10	Tshaphel 3	250	32.82	27.89	**13.13%**	51.670	**21%**	55.870	**22%**
11	Kana 1	16	1.48	1.25	**9.23%**	2.324	**15%**	2.513	**16%**
12	Sangkari	63	5.21	4.43	**8.27%**	8.206	**13%**	8.873	**14%**
13	Kana 2	125	30.68	26.07	**24.54%**	48.299	**39%**	52.225	**42%**
14	Gerena	63	10.88	9.25	**17.27%**	17.129	**27%**	18.521	**29%**
15	Pajaykha	25	1.88	1.60	**7.52%**	2.960	**12%**	3.200	**13%**
16	Chuzokha/Sacho Goenpa	16	0.39	0.33	**2.42%**	0.610	**4%**	0.660	**4%**
17	Jyenkana School	63	34.12	29.00	**54.15%**	53.717	**85%**	58.084	**92%**
18	Puduna	25	3.29	2.79	**13.14%**	5.172	**21%**	5.593	**22%**
19	Jyenkana 2	63	22.97	19.52	**36.46%**	36.165	**57%**	39.105	**62%**
20	Balamna 1	63	14.80	12.58	**23.50%**	23.308	**37%**	25.203	**40%**
21	Balamna 2	16	4.48	3.81	**28.00%**	7.054	**44%**	7.627	**48%**
22	Balamna 3	16	1.11	0.95	**6.96%**	1.754	**11%**	1.897	**12%**
23	Shari 1	63	6.76	5.74	**10.73%**	10.640	**17%**	11.505	**18%**
24	Shari 2	63	13.48	11.46	**21.40%**	21.229	**34%**	22.954	**36%**
25	Gangkha	25	2.13	1.81	**8.52%**	3.355	**13%**	3.628	**15%**
26	Nobgang	25	2.26	1.92	**9.03%**	3.556	**14%**	3.845	**15%**
27	Borokha	63	7.29	6.19	**11.56%**	11.471	**18%**	12.404	**20%**
28	Lhenkha	16	4.48	3.81	**28.00%**	7.054	**44%**	7.627	**48%**
29	Dorikha	25	9.55	8.12	**38.20%**	15.037	**60%**	16.260	**65%**
30	Lamjigang	16	4.48	3.81	**28.00%**	7.054	**44%**	7.627	**48%**
31	BOD	25	10		**40%**	15.745	**63%**	17.025	**68%**
		1947	487.19	405.61	**25.02%**				
			0.414108						

FEEDER E40(BAZAAR 4)

Sl. No.	Name	TFR. Rating	Loading (kVA)	Loading (kW)	% Loading	Peak Load(kVA)	% Loading	Peak Load(kVA)	% Loading
						1.009826412		**1.46094844**	
						2.009826412		**2.46094844**	
1	Lower Market	500	97.90	83.22	19.58%	196.7628	39%	240.9278612	48%
2	Bali	500	153.92	130.84	30.78%	309.3601	62%	378.7985599	76%
3	Lhayulkha	315	126.32	107.37	40.10%	253.8770	81%	310.8618142	99%
4	Near Jamyang Store	1000				0.0000			
			378.14	321.42					
			0.321421						

FEEDER N190 FROM WATSA SS

Sl. No.	Name	TFR. Rating	Loading (kVA)	Loading (kW)	% Loading	Peak Load(kVA) in 2025	% Loading	Peak Load(kVA) in 2030	% Loading
						0.6		0.85	
						1.6		1.85	
1	Lower Wanakha	63	15.82	13.45	25.11%	25.7	41%	29.23	46%
2	Wanakha School(Tsekha)	63	29.61	25.17	47.00%	48.1	76%	54.70	87%
3	Susuna	63	19.55	16.61	31.03%	31.7	50%	36.11	57%
4	Neymo	63	3.36	2.85	5.33%	5.5	9%	6.20	10%
5	Ganghe	63	13.51	11.48	21.44%	21.9	35%	24.96	40%
6	Labana	63	5.56	4.73	8.83%	9.0	14%	10.28	16%
7	Domzegzng	63	5.34	4.54	8.48%	8.7	14%	9.87	16%
8	Powgang	63	3.92	3.33	6.22%	6.4	10%	7.24	11%
9	Jashina	63	14.29	12.15	22.68%	23.2	37%	26.40	42%
10	Gurugang	63	8.43	7.16	13.38%	13.7	22%	15.57	25%
11	Rashi Gang	63	23.44	19.93	37.21%	38.1	60%	43.31	69%
12	Tshipji	63	6.62	5.63	10.51%	10.8	17%	12.24	19%
.	Chamji	63	1.48	1.26	2.34%	2.4	4%	2.73	4%
14	Sagu	63	3.28	2.79	5.21%	5.3	8%	6.06	10%
15	Jangkha	63	5.34	4.54	8.48%	8.7	14%	9.87	16%
16	Betikha	125	83.14	70.67	66.51%	135.0	108%	153.59	123%
17	Jelekha	63	14.92	12.68	23.68%	24.2	38%	27.56	44%
18	Lhazukha	63	5.25	4.46	8.33%	8.5	14%	9.70	15%
19	Nago	63	20.36	17.30	32.31%	33.1	52%	37.61	60%
20	Lingshi 1	63	9.43	8.02	14.98%	15.3	24%	17.43	28%
21	Lingshi 2	63	9.03	7.68	14.34%	14.7	23%	16.69	26%
22	Jatakha	63	6.54	5.56	10.38%	10.6	17%	12.08	19%
23	Bampo	25	4.33	3.68	17.33%	7.0	28%	8.00	32%
24	Aringkha	10	0.03	0.03	0.30%	0.0	0%	0.06	1%
25	Reringkha	16	1.54	1.31	9.62%	2.5	16%	2.84	18%
26	Babana	10	0.38	0.32	3.80%	0.6	6%	0.70	7%
27	Khumri	16	0.42	0.36	2.65%	0.7	4%	0.78	5%
28	Chashi	25	2.23	1.89	8.91%	3.6	14%	4.12	16%
29	Papali	25	4.22	3.58	16.86%	6.8	27%	7.79	31%
30	Shacho Gampa	10	0.20	0.17	1.97%	0.3	3%	0.36	4%
31	Stone Crasher	250	100.00	85	40%	162.4	65%	184.74	74%
			421.58	358.34					
			0.358339						

FEEDER E50(DAMTHNG 5)

Sl. No.	Name	TFR. Rating	Serial No.	Loading (kVA)	Loading (kW)	% Loading	Peak Load(kVA) in	% Loading	Peak Load(kVA) in	% Loading
							0.56104037		**0.844349846**	
							1.56104037		**1.844349846**	
1	Lower Wangtsa	125	S/3300	19.01	16.16	**15.21%**	29.6804	**24%**	35.0670	**28%**
2	Upper wangtsa	63	72271	28.58	24.30	**45.37%**	44.6204	**71%**	52.7184	**84%**
3	Yatom	63	008.315.11.960	36.11	30.69	**57.31%**	56.3636	**89%**	66.5929	**106%**
4	Ingo	315	2005.25.11.750	80.15	68.13	**25.45%**	125.1214	**40%**	147.8294	**47%**
5	Dranadingkha	25	31.12.2009	3.08	2.62	**12.31%**	4.8039	**19%**	5.6758	**23%**
6	Nagtsho	160	94FD-103/03	32.50	27.62	**20.31%**	50.7291	**32%**	59.9358	**37%**
7	Yangto	250	2806/1	40.52	34.44	**16.21%**	63.2505	**25%**	74.7297	**30%**
8	Yangto Gampa	25	3849/13-14	1.82	1.55	**7.27%**	2.8383	**11%**	3.3534	**13%**
9	Jangkhakha	125	2001-02	64.59	54.90	**51.67%**	100.8214	**81%**	119.1192	**95%**
10	Chumdu school	1000		300.00	255.00	**30.00%**	468.3121	**47%**	553.3050	**55%**
11	Jamtey Gampa	63	36931	18.90	16.07	**30.00%**	29.5037	**47%**	34.8582	**55%**
12	Makana	63	1999-07	16.51	14.03	**26.20%**	25.7659	**41%**	30.4421	**48%**
13	Langlo	125	KT-03/245	20.26	17.22	**16.21%**	31.6236	**25%**	37.3629	**30%**
14	Tshenkha	63	94DD-083/04	8.05	6.84	**12.78%**	12.5639	**20%**	14.8441	**24%**
15	Tokey	160	12271	32.03	27.23	**20.02%**	50.0057	**31%**	59.0812	**37%**
16	Jampel School	125	1996-25	25.51	21.68	**20.41%**	39.8221	**32%**	47.0494	**38%**
17	Chumpa	63	1996-21	18.73	15.92	**29.73%**	29.2430	**46%**	34.5502	**55%**
18	Hatey	63	2001-01	30.59	26.00	**48.56%**	47.7557	**76%**	56.4227	**90%**
19	Gaychukha	63	KT-500/260	3.66	3.11	**5.81%**	5.7187	**9%**	6.7565	**11%**
20	Damthang 1	315	94GD-143/01	163.61	139.07	**51.94%**	255.4038	**81%**	301.7565	**96%**
21	Damthang 2	500	6044	94.70	80.49	**18.94%**	147.8276	**30%**	174.6564	**35%**
22	Bamporama	125	SS7354725000	0.98	0.83	**0.79%**	1.5329	**1%**	1.8112	**1%**
23	Bamporama	500		100	85	**20.00%**	156.1040	**31%**	184.4350	**37%**
		4379		1139.89	968.91	**26.03%**				
				0.968905						

FEEDER E30(ADM DZON AND HOSPITAL 3)

Sl. No.	Name	TFR. Rating	Serial No.	Loading (kVA)	Loading (kW)	% Loading	Peak Load(kVA) in	% Loading	Peak Load(kVA)	% Loading
							0.19		0.48	
							1.19		1.48	
1	New Hospital	750		114.71	97.50	15.29%	136.67	18%	169.21	23%
2	New ADM Block	1000	MYV0331	300.00	88.333	30.00%	357.45	36%	442.55	44%
				414.7059	185.833					
				0.3525						

FEEDER E20(IMTRAT 2)

Sl. No.	Name	TFR. Rating	Serial No.	Loading (kVA)	Loading (kW)	% Loading Present	Peak Load(kVA) in 2025	% Loadin g in	Peak Load(kVA) in 2030	% Loading in 2030
							0.177905653		**0.177905653**	
							1.177905653		**1.177905653**	
1	DEMO,RBA	160	2010.160.11.12278	126.22	107.29	**78.89%**	148.675	**93%**	148.6752516	**93%**
2	IMTRAT.Power House	500	3808/14 &11/1331	245.99	209.09	**49.20%**	289.753	**58%**	289.7530116	**58%**
3	Civil camp, Imtrat / Imtrat	315	11/1332	184.31	156.66	**58.51%**	217.094	**69%**	217.0939014	**69%**
4	Nyachu	63	10450	12.60	10.71	**20.00%**	14.842	**24%**	14.84161123	**24%**
5	Bangina	160	94DD-083/02	43.97	37.37	**27.48%**	51.792	**32%**	51.79226539	**32%**
6	IMTRAT.ENGG CELL	500	75127	307.93	261.74	**61.59%**	362.712	**73%**	362.7124878	**73%**
7	Janatsham	63	10447	6.55	5.57	**10.40%**	7.720	**12%**	7.719706242	**12%**
		1761		927.57	788.43	**52.67%**				
				0.7884333						

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**