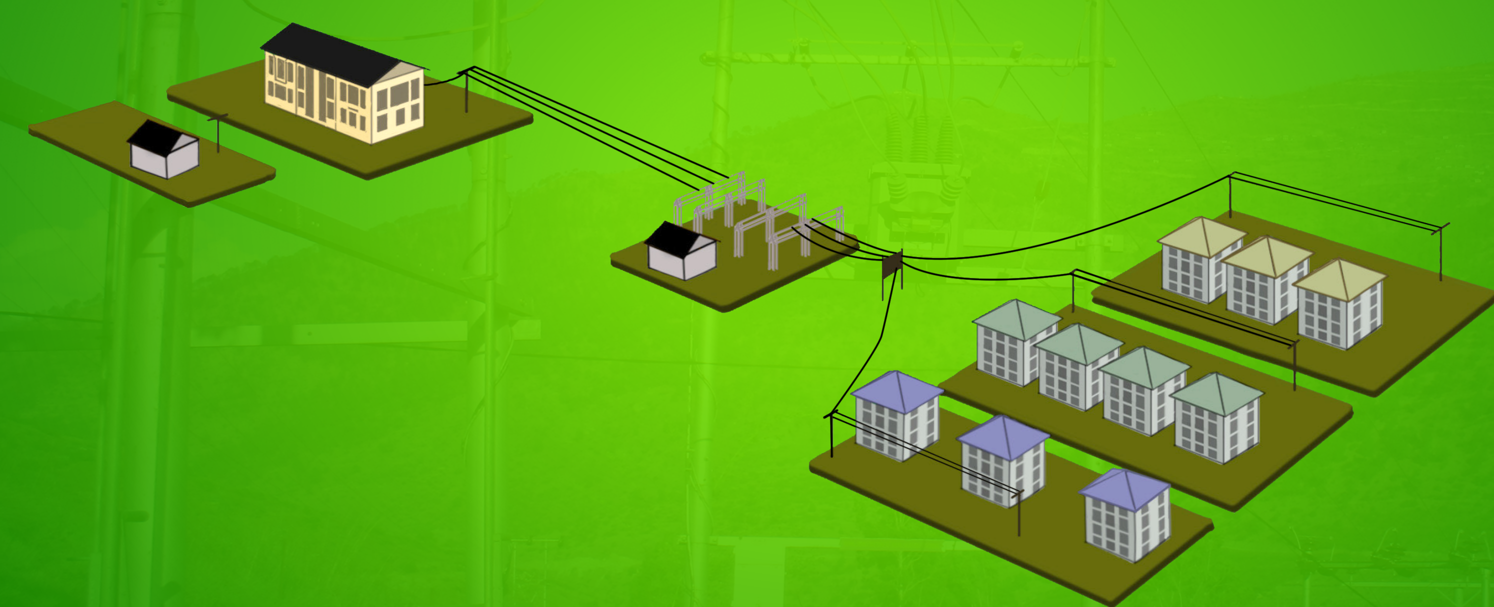
BHUTAN POWER CORPORATION LIMITED
(An ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 Certified Company)
P.O. Box : 580, Yarden Lam
Thimphu, Bhutan (Registered Office)
Website: www.bpc.bt

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

WANGDUE DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)
WANGDUE DZONGKHAG

Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

FOREWORD

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

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

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

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

(Sonam Tobjey)
Chief Executive Officer

Preparation, Review & Approval of the Document

Prepared by:	Distribution & Customer Services Department, Distribution Services, Bhutan Power Corporation Limited, Thimphu.	**GM, DCSD**
Reviewed& Vetted by:	Management, Bhutan Power Corporation Limited, Thimphu. (22nd December 2019 – Meeting No. 557)	**CEO, BPC**
Approved by:	Board Tender & Technical Committee (BTTC), Bhutan Power Corporation Limited, Thimphu. (26th December, 2019 - 15th BTTC Meeting)	**Chairman, BTCC**

Table of Contents

List of Tables

List of Figures

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 Electrotechnical Commission
DT: Distribution Transformer
TSA: Time Series Analysis
LRM: Linear Regression Method
MV: Medium voltage (33kV, 11kV and 6.6kV (if it exists))
DDCS: Distribution Design and Construction Standards
kVA: Kilo Volt Ampere
W: Watt
kWh: Kilo Watt Hour
RMU: Ring Main Unit
PHCB: Population and Housing and Census of Bhutan
BDBL: Bhutan Development Bank Limited
BNB: Bhutan National Bank
RSTA: Road Safety and Transport Authority
RICB: Royal Insurance Corporation Limited
BoB: Bank of Bhutan Limited
USS: Unitized Substation
DMS: Distribution Management System
ADMS: Advanced DMS
SCADA: Supervisory Control and Data Acquisition
DSCADA: Distribution SCAD

Definitions

Asset Life: The period of time (or 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 service, such as during short-term emergencies or longer unplanned outages, and during periods of scheduled maintenance when the units must be shut sown. 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. Facilities and place to serve electric customers. 2) The total amount of electrical energy a power line is able to 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 the 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 is interconnected with a number of other bulk power supply agencies on a regional basis. A grid enables power to be transmitted from areas having a surplus to areas experiencing a shortage. A grid also eliminates some duplication of costly facilities in a given region.

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

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

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

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

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

Load Growth: The increase in the demand of 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 is not on line, it is said to be "down."

Outage - Interruption of service to an electric consumer.

Overload - Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of 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 is able to maintain its delivery of electric energy within the tolerable limits of voltage and without outages or other problems with 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 the 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 network established across the country. Towards realizing the mission, vision and destination statement of BPC as outlined in the Corporate Strategic Plan (2020-2030), there is a need to carry out comprehensive studies of the distribution system to address the system deficiencies as the ground realities are different triggered by technological advancement and economic growth.

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

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

The details on the distribution grid modernization are outlined in Smart Grid Master Plan 2019 including the investment (2020-20230). The identification of the system deficiencies and qualitative remedial measures which would require system automation and remote control as per the existing and projected load are only outlined in this report.

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

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

2. Introduction

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

Some of the prominent driving factors required for the development of the master plan includes but not limited to reliable power supply to the customers, reduction of distribution losses, network capability with the anticipated load growth, optimization of the resources and to develop 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) is 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

In order to better understand the existing distribution system and postulate the credible investment plans; standard framework and procedures had been adopted. However, in the absence of any standardized procedures in BPC for 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.

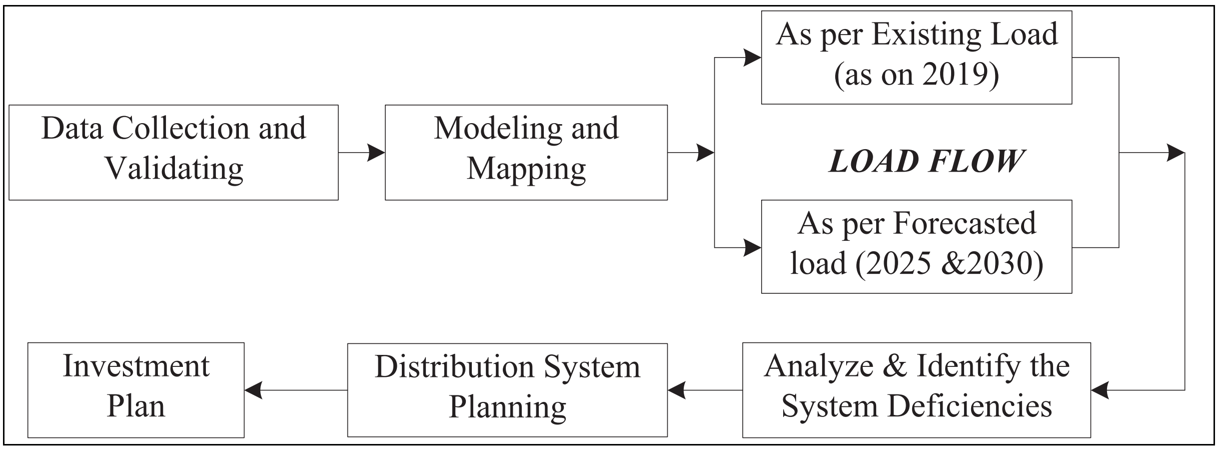


Figure 1: Block diagram for distribution system planning for thematic studies

5.1 Data Collection and Validation

In order to carry out the detailed studies with greater accuracy, complete and reliable data of the existing distribution infrastructure is required. Therefore, intensive field investigation was carried out during the months of April and May (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 Modelling and Mapping

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

5.3 Analysis and Identification of System Deficiencies

The existing distribution system model was analyzed in the ETAP involving balanced load flow to figure out the network capabilities against the set distribution standards. The load growth was projected using the commonly adopted methodology that is LRM in conjunction to TSA which is based on the historical data and accordingly the behavior of the distribution system was analyzed, and the system deficiencies were identified. The details on load forecast methodology is attached as **Annexure-3.**

5.4 Distribution System Planning

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

5.5 Investment Plan

The approved investment plans (from 2020 to 2023) have been validated based on the outcome of the system studies and accordingly, the yearly investment plans are outlined as per the priority matrix as detailed in **Section 9.**

6. Existing Electricity Distribution Network

6.1 Overview of the Power Supply Sources

The power supply to fifteen (15) Gewogs and towns of Wangdue Dzongkhag is being fed from 66/33/11 kV Lobeysa substation (2x5MVA-66/33kV & 2x5MVA-66/11kV). The basic electricity distribution network model as seen from the source at Lobeysa is illustrated in the schematic is predominantly redial as shown in **Figure 2.**

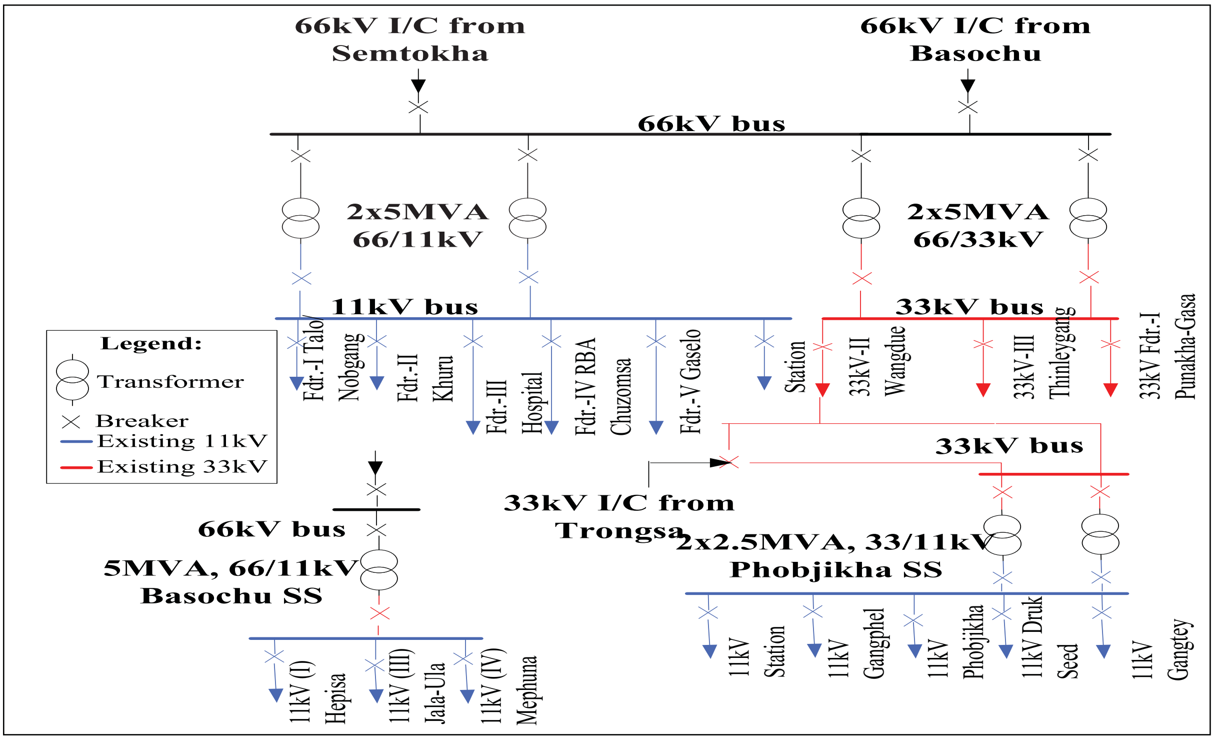


Figure 2: Electricity Distribution Schematic Diagram of Wangdue Dzongkhag

All the power supply to Gasa, Wangdue and Punakha Dzongkhags are fed from Lobeysa substation.

There are thirteen (13) feeders for the customers of Wangdue Dzongkhag operated and maintained by ESD, Wangdue including the station feeders. The 33kV MV line from Trongsa is also interconnected at Dungdungnyesa at Nobding and acts as an alternate source to 33/11kV Phobjikha in addition to 33kV line of Lobeysa substation.

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Details

33 kV		11 kV			Total MV line			LV lines*			Total length (km)
OH	UG	OH	UG	HV ABC	OH	UG	HV ABC	OH	UG	LV ABC	
248.86	0.05	162.04	15.05	42.06	410.91	15.1	42.06	471.01	173.65	644.66	1,113

**LV line length is as per Power Data Book 2018.*

The total MV line length is 468.06 km and the total LV line length is 644.66km. The ratio of LV to MV line length is 1.38 which reflects a high proportion of power distribution through LV network. While the ratio of LV to MV line length would vary according to the site conditions, as a general thumb rule, network ratio of 1.2:1 (LV to MV) should be maintained for optimum initial capex and the running and maintenance costs. The majority of the MV distribution network is through 33 kV and 11 kV overhead lines with some network in the town and protected areas being through underground cables. Since, the Phobjikha is the protected area; the LV network is also through underground system.

6.3 Distribution Transformers

The number of distribution transformers operated and maintained by the ESD, Wangdue is tabulated in **Table 2**.

Table 2: Total Numbers of Transformers, Installed Capacity and Customers

Sl.No.	Name of Feeder	Voltage Ratio	Number of Transformers	Installed capacity (kVA)	Total Customers
1	33kV Khotokha - Phobjikha Feeder II (S20) (Lobeysa S/S)	33/0.415kV	113.00	8,136.00	3,276.00
		33/0.240kV	33.00	671.00	
2	11kV Feeder III (S30) (Lobeysa S/S)	11/0.415kV	4.00	3,000.00	102.00
3	11kV Feeder IV (S40) (Lobeysa S/S)	11/0.415kV	36.00	7,110.00	2,060.00
		11/0.240kV	1.00	16.00	
4	11kV Feeder V (S50) (Lobeysa S/S)	11/0.415kV	18.00	5,266.00	2,022.00
5	11kV Feeder I (S100) (Basochu S/S)	11/0.415kV	4.00	1,376.00	132.00
6	11kV Feeder III (S70) (Basochu S/S)	11/0.415kV	31.00	2,280.00	886.00
		11/0.240kV	9.00	108.00	
7	11kV Feeder IV (S10) (Basochu S/S)	11/0.415kV	9.00	1,757.00	105.00
		11/0.240kV	2.00	32.00	
8	11 kV Feeder I (S110) (Phobjikha S/S)	11/0.415kV	1.00	125.00	7.00
9	11kV Feeder II (S120) (Phobjikha S/S)	11/0.415kV	1.00	250.00	40.00
10	11kV Feeder III (S80) (Phobjikha S/S)	11/0.415kV	22.00	1,328.00	500.00
11	11kV Feeder IV (S130) (Phobjikha S/S)	11/0.415kV	5.00	579.00	400.00
12	11kV Feeder V (S90) (Phobjikha S/S)	11/0.415kV	17.00	1,564.00	300.00
	Total		**306.00**	**33,598.00**	**9,830.00**

As of June 2019, there were 306 transformers with a total installed capacity of 33,598.00kVA. As can be inferred from **Table 2,** the installed capacity of transformer per customer 3.42kVA as of June 2019. The installed transformers are generally large in capacity and few in number rather than generally small in capacity and more in numbers.

7. Analysis of Existing System

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

7.1 Assessment of Power Sources

The assessments of the capabilities of the power sources were exclusively done based on the existing (as on 2019) 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 source capability assessment had been carried out bifurcating HV and MV substations as detailed below.

7.1.1 HV Substation

It is forecasted that the peak power demand of Wangdue Dzongkhag is expected to increase from 9.87MW in 2019 to 13.51MW & 16.56MW in 2025 & 2030 respectively. Similarly, it is forecasted that total peak load of Punakha (including that of Gasa) would increase from 7.64MW in 2019 to 10.05MW & 12.2MW in 2025 & 2030 respectively against the installed capacity of 20MVA (17MW @ 0.85pf) as detailed in **Table 3**. The total peak power requirement of the two Dzongkhags would reach 23.55MW in 2025 and 28.76MW by 2030 surpassing the installed capacity. With the commissioning of Damji substation, some of the load of Lobeysa substation can be relived, but the existing installed capacity will not be adequate as the forecasted load would reach 28.76MW against the total installed capacity of 25.50MW (30MVA @ 0.85 pf).

Nevertheless, with the completion of Punatsangchu projects (scheduled to be complete by 2024-2025-PHPA-I and 2022 for PHPA-II), some of the load can be also catered from the 66/33/11kV, 2x12.5MVA Gewathang substation. Similarly, 33/11kV, 5xMVA substation each in Dam and Power House constructed for the projects would be available. Therefore, the power requirement for customers of Wangdue, Punakha and Gasa can be adequately met from Damji, Lobyesa and Gewathang substations.

Currently, the customers of the PHPA-II are fed from 11kV feeder III of Basochu substation and the circuit length is longer, and the power supply is also unreliable. Therefore, entire customers of Adha, Rukha, Taksha and Silly of Daga Gewog till Kamichu can be fed from this substation instead of Basochu.

The PHPA-I substation at Bjemethangka can be interconnected with the 11kV feeder IV of Lobeysa and supply the power to the customers of Gaselo and town area. However, due to longer circuit length and rugged terrain there will be reliability issue with the feeder. Therefore, should Lobeysa 11kV feeder IV fails, the power can only be arranged from PHAPA-I substation.

Table 3: HV Power Sources

Sl.No.	Power Source	Dzongkhag	Installed Capacity (MVA)		Total Forecasted Load Growth (MW)		
			MV	MW*	2019	2025	2030
1	66/33kV, 2x5MVA Lobeysa SS	Punakha	10	8.5	3.35	4.44	5.37
2		Wangdue			3.47	4.84	5.97
3	66/33kV, 2x5MVA Damji SS	Gasa	10	8.5			
	Total 33kV		**20**	**17.00**	**6.82**	**9.28**	**11.34**
1	66/11kV, 2x5MVA Lobeysa SS	Punakha	10	8.5	4.29	5.6	6.83
2		Wangdue			6.40	8.67	10.59
	Total 11kV		**10**	**8.5**	**10.69**	**14.27**	**17.42**

Sl.No.	Power Source	Dzongkhag	Installed Capacity (MVA)		Total Forecasted Load Growth (MW)		
			MV	MW*	2019	2025	2030
	Total (11kV +33kV)		**30**	**25.50**	**17.51**	**23.55**	**28.76**

**PF of 0.85 is considered to compute the real power for study purpose.*

7.1.2 MV Substation

Currently, Wangdue has 33/11kV, 2x2.5MVA substation at Phobjikha. In the absence of feeder peak load for the outgoing 11kV feeders of 33/11kV, 2x2.5MVA Phobjikha substation, the load of 33kV incomer has been redistributed to the five 11kV outgoing feeders based on the number of customers connected to the respective feeders. Considering that above framework holds true, the Phobjikha substation would be adequate to cater the load till 2030 as is evident from **Table 4.**

Table 4: MV Power Sources

Sl.No.	Feeder Name	Installed Capacity		Forecasted Peak Load (MW)		
		MVA	MW*	2019	2025	2030
1	11kV Station Feeder I	5	4.25	0.01	0.01	0.01
2	11kV School Feeder II			0.04	0.06	0.07
3	11kV Gangphel Feeder III			0.6	0.84	1.03
4	11kV Drukseed Feeder IV			0.41	0.57	0.71
5	11kV Gangtey Feeder V			0.33	0.45	0.56
	Total	**5**	**4.25**	**1.39**	**1.93**	**2.39**

7.2 Assessment of MV Feeders

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

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

7.2.1 Assessment of MV Feeder with Load

The feeder wise peak power consumption was compiled based on the historical data. The array of daily and monthly peak demand was sorted to obtain the annual peak demand. The feeder-wise historical peak demand recorded at the source is presented in **Table 5** and the corresponding feeder-wise annual load curve is presented in **Figure 3.**

As the peak load records of 33/11kV outgoing feeders were not available (in the absence of the feeder meter), the peak load data recorded at the HV substations were used for the study. However, in order to carry out the system studies for the outgoing feeders of the MV substations, the peak loads of the feeder were prorated and redistributed according to the peak load of the transformers (as of 2019) and accordingly the simulations were carried out.

Table 5: Feeder Wise Peak Power Demand (2016-2019)

Sl.No.	**Feeder**	**Peak Load Consumption Pattern (MW)**			
		2016	**2017**	**2018**	**2019**
1	33kV Phobjikha Feeder II	2.93	2.89	3.06	3.47
2	11kV Rinchengang Feeder III	0.30	0.30	0.34	0.36
3	11kV Gaselo Feeder IV	1.76	1.76	1.84	1.92
4	11kV Bajo Town Feeder V		1.86	2.40	2.48
5	11kV Hebesa Feeder I		0.05	0.05	0.159
6	11kV Jalla Ulla Feeder III	1.11	1.14	1.23	1.27
7	11kV Rurichu Feeder IV	0.08	0.10	0.17	0.21
	Total	**6.18**	**8.10**	**9.09**	**9.87**

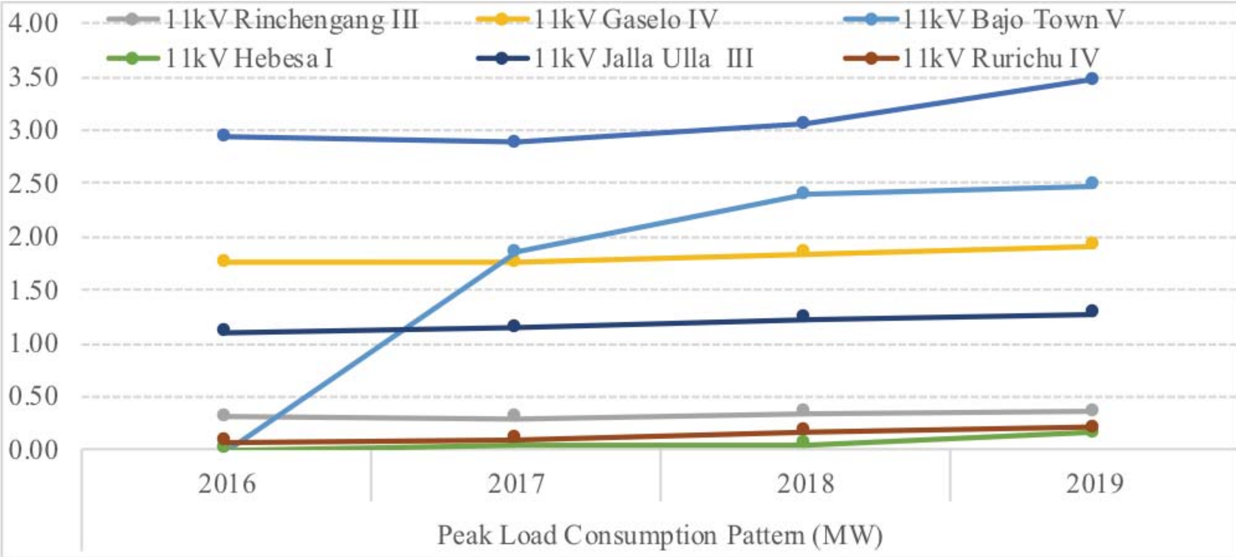


Figure 3: Plot of Feeder Wise Peak Power Demand

As can be inferred from **Figure 3,** the feeder wise peak load has grown steadily from 6.18MW in 2016 to 9.87MW in 2019.

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

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

a) System Study (Existing Load)

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

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

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

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

Ampacity (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.

The ampacity of all the feeders would be within the permissible range with the existing load however, the 11kV Bajo Town feeder would exceed the thermal limit of the conductor marginally as it is forecasted to reach 3.93MW by 2030. However, degree of the feeder loading has to be closely monitored as the accuracy of the forecasted load would deviate more in the distant future.

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

The peak power demand from 2016-2019 has been considered to forecast the peak power demand for the next 10 years (2020-2030) as shown in **Table 7** and **Figure 4** adopting the commonly practiced methodology of LRM and TSA with the help of ETAP. The detailed load simulation result is attached as **Annexure-4.**

The time series load forecast suggests that the peak load requirement of Wangdue would increase to 13.51MW & 16.56MW by 2025 & 2030 respectively.

Table 7: Feeder Wise Peak Power Demand Forecast of ESD, Wangdue

Sl. No.	Feeder Name	Circuit Length (km)	Total Transformer	Installed Capacity (kVA)	Feeder Load (MW)		
					2019	2025	2030
1	33 kV Khotokha/Phobjikha Feeder II	248.91	146.00	8,807.00	3.47	4.84	5.97

Sl. No.	Feeder Name	Circuit Length (km)	Total Transformer	Installed Capacity (kVA)	Feeder Load (MW)		
					2019	2025	2030
2	11kV Rinchengang Feeder III	4.47	4.00	3,000.00	0.36	0.48	0.58
3	11kV Gaselo Feeder IV	37.24	37.00	7,126.00	1.92	2.35	2.71
4	11kV Bajo Town Feeder V	15.24	18.00	5,266.00	2.48	3.27	3.93
5	11kV Hebesa Feeder I	9.97	4.00	1,376.00	0.16	0.47	0.75
6	11kV Jala Ula Feeder III	84.78	40.00	2,388.00	1.27	1.62	1.90
7	11kV Rurichu Feeder IV	16.35	11.00	1,789.00	0.21	0.49	0.72
8	11kV Station Feeder I	0.01	1.00	125.00	There is no data for these feeders as it is the outgoing feeders of unmanned 33/11kV, 5MVA Phobjikha substation		
9	11kV School Feeder II	0.05	1.00	250.00			
10	11kV Gangphel Feeder III	29.64	22.00	1,328.00			
11	11kV Drukseed Feeder IV	5.52	5.00	579.00			
12	11kV Gangtey Feeder V	15.88	17.00	1,564.00			
	Overall Total	**468.06**	**306.00**	**33,598.00**	**9.88**	**13.51**	**16.56**

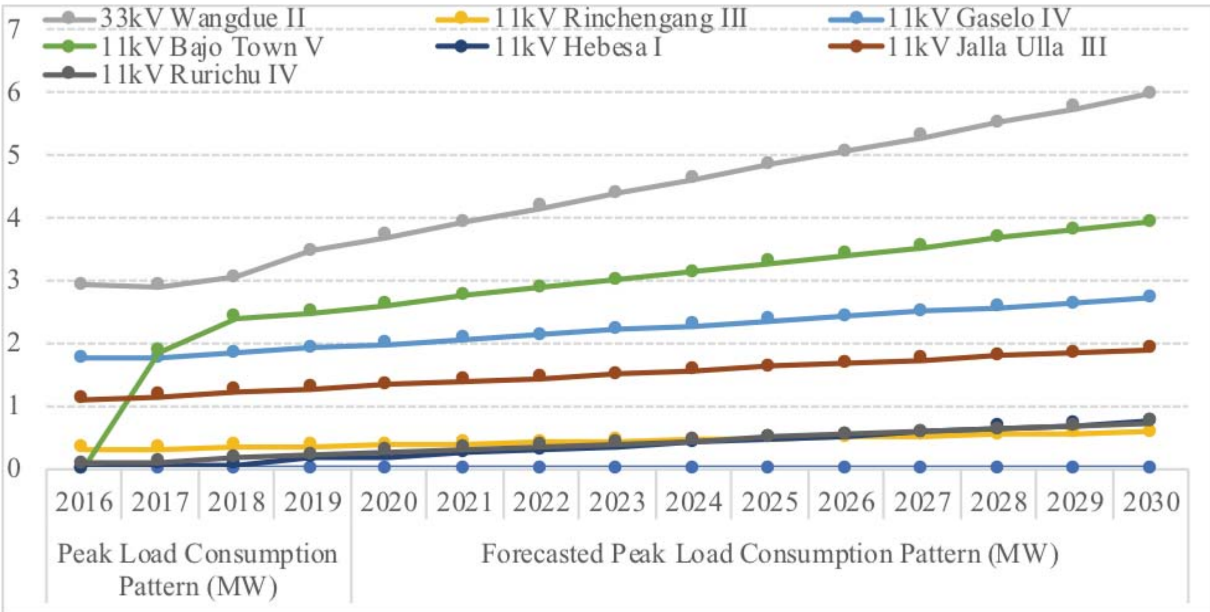


Figure 4: Plot of Feeder Wise Peak Power Demand Forecast

Although it is conclusive that the existing MV lines are adequate to evacuate the power if assessed independently, the voltage profile would go below the standard accepted range of (±)

10% should the existing network supply the forecasted load as tabulated in **Table 8**. The load carrying capacity of a feeder is determined by the line length and degree of load connected in addition to other parameters (e.g., ampacity).

Table 8: Feeders with Poor Voltage Profile (2019, 2025 & 2030)

Sl. No.	Name of Feeder	Conductor	Length (km)	End Voltage (kV)	% Variation	Load (MW)		
						2019	2025	2030
A	**2019**	**No voltage profile issues**						
B	**2025**							
1	33 kV Khotokha/Phobjikha Feeder II	W/D/R	248.91	28.80	13%	2.09	2.91	3.59
2	11kV Gaselo Feeder IV	D/R	37.24	9.88	10%	1.92	2.35	2.71
C	**2030**							
1	33 kV Khotokha/Phobjikha Feeder II	W/D/R	248.91	27.75	16%	2.09	2.91	3.59
2	11kV Gaselo Feeder IV	D/R	37.24	9.71	12%	1.92	2.35	2.71

The 33kV and 11kV feeders which are reflected in the table above would violate the voltage profile with the current loading (as of 2019) and the forecasted load till 2030. Details on each of the feeders with proposal for improving the voltage profile is as follows:

a) 33kV Khotakha/Phobjikha Feeder II

The Khotakha/Phobjikha feeder has circuit length of 248.91km constructed on wolf (22.24km), Dog (130.61km) and Rabbit (111.85km) conductors with 3,276.00 customers connected as on 2019. Most of the loads connected to this feeder are rural customer and therefore, the connected loads are assumed to be static/impedance load (90%) in nature. The simulation results show that the voltage magnitude at the end of the feeder in 2025 would be 13% and 16% in 2030. The existing circuit length (22.24km on Wolf, 103.6km on Dog and 111.85km on Rabbit) can carry quality power if the feeder is loaded less than 1MW of power. Nevertheless, with the available provision of increasing the voltage level from the power transformer (±10%) and ±5% at DT level, the voltage profile would be within the range. The above simulation result is based on if the power supply for Phobjikha is arranged from Trongsa.

b) 11kV Gaselo Feeder IV

The Gaselo feeder has 15.24km constructed with 2060 customers connected as on 2019. Most of the loads connected to this feeder are rural customers without any industries and therefore, the connected loads are assumed to be static/impedance load (90%) in nature. The simulation results show that the voltage magnitude at the ends of the feeder in 2025 would be 10.18% below the nominal range and would worsen as the load is forecasted to grow in 2030. It is expected that the voltage drop would be 12% in 2030. Nevertheless, with the available provision of increasing the voltage level from the power transformer (±10%) and ±5% at DT level, the voltage profile would be within the range.

Table 9: Feeders with Poor Voltage Profile for outgoing feeders of Phobjikha substation

Sl.No.	Name of Feeder	End Voltage (kV)		% Variation	
		Normal	Regulated	Normal	Regulated
A	**2025**				
	Voltage at the Phobjikha substation	**85.00%**	**90.00%**	**15.00%**	**10.00%**
1	11kV Station Feeder I	85.01%	90.99%	14.99%	9.01%
2	11kV School Feeder II	84.99%	90.97%	15.01%	9.03%
3	11kV Gangphel Feeder III	82.96%	88.83%	17.04%	11.17%
4	11kV Drukseed Feeder IV	83.35%	89.24%	16.65%	10.76%
5	11kV Gangtey Feeder V	83.10%	88.98%	16.90%	11.02%
B	**2030**				
	Voltage at the Phobjikha substation	**81.43%**	**87.16%**	**18.57%**	**12.84%**
1	11kV Station Feeder I	81.41%	87.16%	18.59%	12.84%
2	11kV School Feeder II	81.43%	87.00%	18.57%	13.00%
3	11kV Gangphel Feeder III	78.96%	84.57%	21.04%	15.43%
4	11kV Drukseed Feeder IV	79.73%	85.26%	20.27%	14.74%
5	11kV Gangtey Feeder V	79.13%	84.75%	20.87%	15.25%

In normal scenario, the power is being fed from the existing 33kV Khotakha/Phobjikha feeder. Should there be any power interruptions in Lobeysa, the power supply can be also arranged from Trongsa. However, due to longer circuit line length and more loads connected to the feeder, voltage drop would be below the permissible range. The simulation result shows that the voltage profile will be as low as 15.43% in 2030 for 11kV Gangphel Feeder. However, the voltage profile would be within the range as the load connected and the circuit length is shorter when power supply is arranged from Trongsa.

Knowing the degree of significance of quality of power (voltage profile), it is inevitable that voltage regulation be maintained within the permissible range which is required as per the distribution code and the requirement of the end user appliances. Therefore, the feeders whose voltage regulation aren't within the permissible range due to existing or forecasted load would be corrected as detailed in table **Table 10**.

Table 10: Feeder Wise Voltage Improvement

Sl.No.	Name of Feeder	Before		After		Remarks
		Voltage (kV)	% Variation	Voltage (kV)	% Variation	
A	**2025**					
1	33 kV Khotokha/Phobjikha Feeder II	28.80	13%	29.70	90%	Tap of PT utilized
2	11kV Gaselo Feeder IV	9.88	10%	10.56	96%	Taps of PT & DT can be used
B	**2030**					
1	33 kV Khotokha/Phobjikha Feeder II	27.75	16%	28.76	87.16%	Tap of PT utilized
2	11kV Gaselo Feeder IV	9.71	12%	10.23	93%	Taps of PT & DT can be used

Even with the proposal to change the conductor size would not result significant improvement in voltage profile due to longer circuit line length and magnitude of load connected. Therefore, techno-commercial analysis on the different types of mechanism to improve the voltage profile should be explored as some of the literature reviews indicates that AVR would be economical and technically feasible over the other alternatives (resizing, capacitor banks etc.) if it is exclusively meant for improving the voltage profile. Therefore, it is proposed to install AVR (2/3 of the circuit line length) at strategic locations as identified.

7.2.2 Energy Loss Assessment of the MV Feeders

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

To carry out the assessment, the energy sales, purchase and loss is as tabulated in **Table 11** and as shown in **Figure 5.**

Table 11: Summary of Total Energy Loss (MU)

Sl. No.	Particulars	2014	2015	2016	2017	2018	Average (MU)
1	Total Energy Requirement (MU)	65.57	68.60	68.86	68.09	66.93	67.61
2	Total Energy Sales (MU)	60.60	63.45	64.81	64.05	63.55	63.29
3	Total energy loss (MU)	4.97	5.15	4.05	4.03	3.38	4.32
i)	Total Loss (%) (1-2) including HV Customers	7.59%	7.50%	5.88%	5.92%	5.05%	6.39%
ii)	Loss excluding HV industries (%)	18.96%	18.99%	14.98%	14.62%	12.27%	15.97%

Generally, the system loss (MV & LV) is 8.9% and any loss more than this for the distribution network would require in-depth study. An independent study carried out by 19 ESDs for 38 feeders in 2017 (two feeders each in ESD with more loss) showed that average of 6.84% is due to technical loss. The study also showed that loss pattern was never consistent because of variant characteristics of distribution network and loading pattern.

The average energy loss of the entire feeder is 15.97% (4.32 million units on average) from 2014 to 2018. The energy loss has drastically reduced from 18.96% in 2014 to 12.27% in 2018. ESD has to focus more on reducing the commercial loss as it has contributed almost 50% of the entire energy loss of the Dzongkhag.

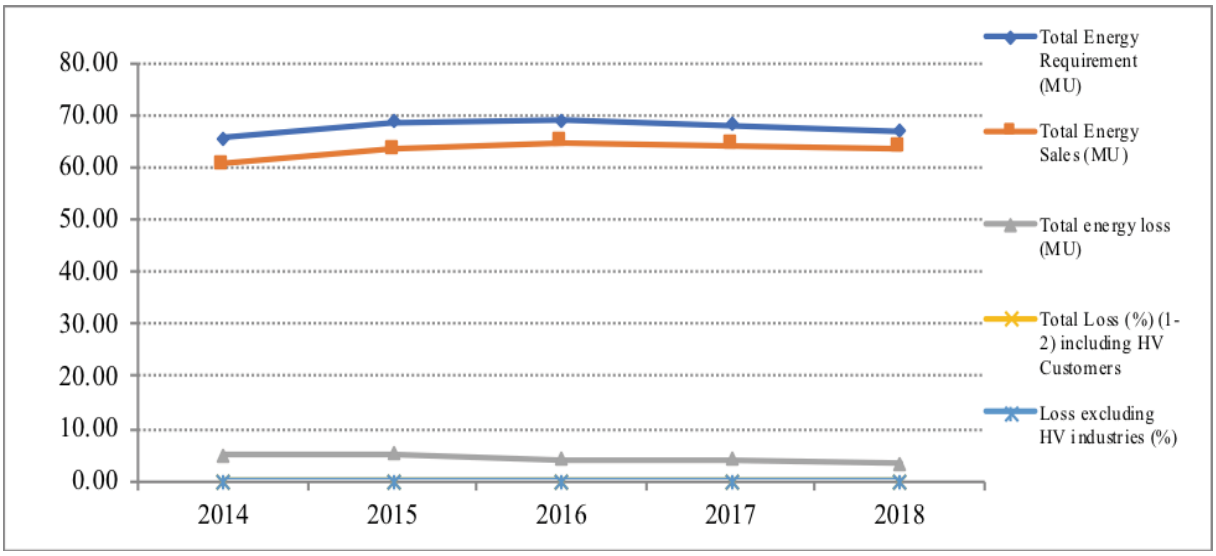


Figure 5: Plot of Total Energy Loss (MU)

As the feeder wise energy record was not available, the energy loss was re-distributed based on the number of customers connected and circuit line length and accordingly the feeder wise energy loss was computed as tabulated in **Table 12** and **Figure 6**. It indicates that 33kV Khotakha-Phobjikha, 11kV Bajo town and 11kV Gaselo feeders had contributed the major portion of the energy loss of ESD, Wangdue. More or less, these feeders have more circuit length and customers than the other feeders.

Table 12: Feeder Wise Energy Loss (in MU)

Sl. No.	Name of Feeder	Circuit Length (km)	2014	2015	2016	2017	2018	Average
1	33 kV Khotokha/Phobjikha Feeder II	248.91	1.40	1.45	1.14	1.13	0.95	1.21
2	11kV Rinchengang Feeder III	4.47	0.01	0.02	0.01	0.01	0.01	0.01
3	11kV Gaselo Feeder IV	37.24	1.00	1.03	0.81	0.81	0.68	0.86
4	11kV Bajo Town Feeder V	15.24	1.29	1.34	1.05	1.05	0.88	1.12
5	11kV Hebesa Feeder I	9.97	0.05	0.06	0.04	0.04	0.04	0.05

6	11kV Jala Ula Feeder III	84.78	0.52	0.54	0.42	0.42	0.35	0.45
7	11kV Rurichu Feeder IV	16.35	0.11	0.12	0.09	0.09	0.08	0.10
8	11kV Station Feeder I	0.01	0.00	0.00	0.00	0.00	0.00	0.00
9	11kV School Feeder II	0.05	0.15	0.15	0.12	0.12	0.10	0.13
10	11kV Gangphel Feeder III	29.64	0.29	0.30	0.24	0.24	0.20	0.25
11	11kV Drukseed Feeder IV	5.52	0.06	0.06	0.05	0.05	0.04	0.05
12	11kV Gangtey Feeder V	15.88	0.09	0.09	0.07	0.07	0.06	0.08
	Total		**4.97**	**5.15**	**4.05**	**4.03**	**3.38**	**4.32**

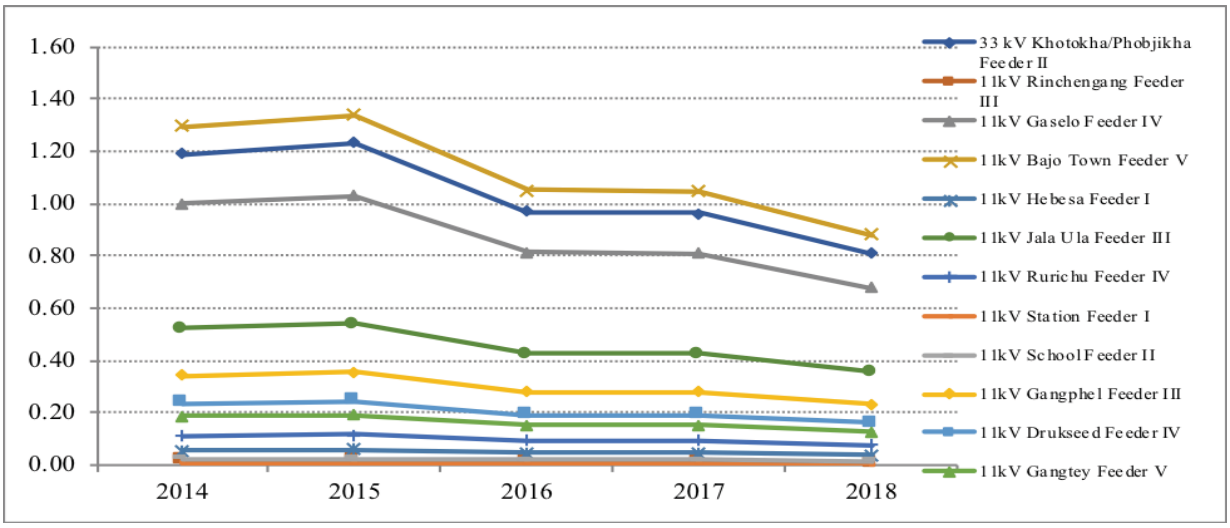


Figure 6: Feeder Wise Energy Losses (MU) of ESD, Wangdue

7.2.3 Reliability Assessment of the MV Feeders

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

In addition to ensuring that the MV feeders have the required capacity, it is also very important to ensure that the MV feeders are reliable. In order to assess the reliability of the distribution system, the historical data was referred. The yearly (2017-2019) feeder reliability indices summary is compiled as tabulated in **Table 13** and details used to derive such summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered for actual representation to compute the reliability indices. The average reliability indices viz. SAIFI & SAIDI compiled from 2016-2019 are 81.71 & 78.12 which is exceptionally high.

Table 13: Feeder Wise Reliability Indices of ESD, Wangdue

Sl.No.	**Year**	**Reliability Indices ***	**33 kV Khotokha/Phobjikha Feeder II**	**11kV Rinchengang Feeder III**	**11kV Gaselo Feeder IV**	**11kV Bajo Town Feeder V**	**11kV Hebesa Feeder I**	**11kV Jala Ula Feeder III**	**11kV Rurichu Feeder IV**
1	2016	SAIFI	90.42	0.00	25.81	7.99	0.05	4.70	0.49
		SAIDI	67.61	0.00	15.83	28.64	1.05	8.50	0.35
2	2017	SAIFI	71.62	0.03	10.33	8.54	0.15	7.46	0.58
		SAIDI	53.17	0.19	8.45	5.82	0.21	7.80	0.42
3	2018	SAIFI	9.40	0.02	4.41	1.59	0.12	1.17	0.26
		SAIDI	21.61	0.01	8.57	2.43	0.26	2.90	0.52
	Overall total	**SAIFI**	**57.15**	**0.02**	**13.10**	**6.04**	**0.11**	**4.44**	**0.44**
		SAIDI	**47.47**	**0.07**	**10.79**	**12.30**	**0.51**	**6.40**	**0.43**
	Average Reliability of Wangdue Dzongkhag					**SAIFI**	**81.71**	**SAIDI**	**78.12**

**The interruptions with interruption duration less than five minutes are omitted*

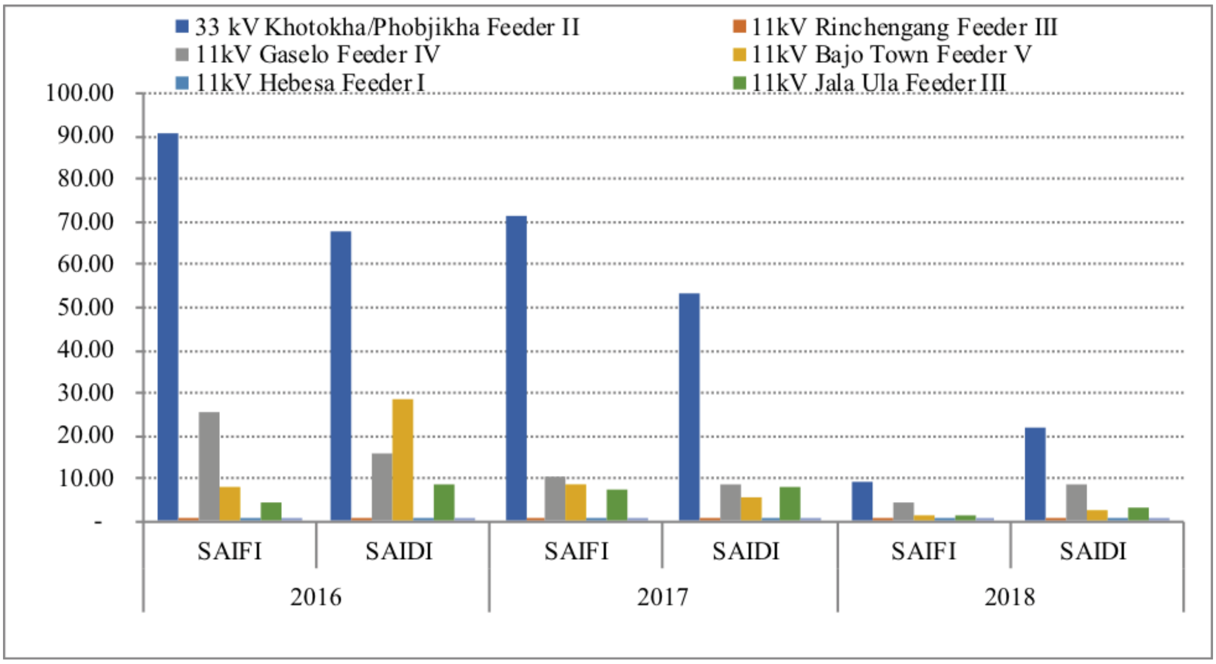


Figure 7: Feeder Wise Plot of SAIFI & SAIDI of ESD, Wangdue

As is evident from **Table 13 & Figure 7,** the reliability of the Wangdue Dzongkhag has steadily improved which perhaps would be due to reinforcement, realignment and more importantly due to re-configuration of distribution network.

The above summary (compiled from 2016-2018) indicates that the 33kV Phobjikha/Khotakha, 11kV Gaselo, 11kV Bajo town and 11kV Jala Ula feeders sustained more interruptions compared to the other feeders. The primary root causes of the power interruptions are attributed HT fuse replacement (75%), followed by maintenance (15%) and over current and earth faults (7%).

Sl.No.	Root Causes	Frequency	% Distribution
1	HT fuse replacement	313	75%
5	Maintenance (Line and others)	61	15%
2	Overcurrent & Earth fault current	28	7%
4	Jumpering	9	2%
3	Transformer maintenance	4	1%
6	Grid Failed	3	1%
	Total	**418**	**100%**

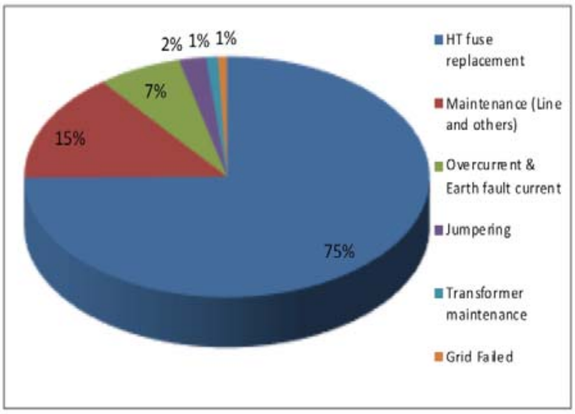


Figure 8: Root causes of interruption

There are switching devices (ARCBs and LBS) installed in these feeders for better operation and maintenance flexibility. In order to address the reliability issue of the feeders, following remedial and corrective measures are proposed:

a) 33kV Phobjikha/Khotakha Feeder

The circuit length of this feeder is 248.91km and passes through thick vegetation and rugged terrain. The feeder recorded SAIFI & SAIDI of 57.15 & 47.47 respectively and has sustained the maximum interruptions compared to other feeders. However, it is encouraging to report that the reliability indices have improved significantly which has resulted due to realigning some of the challenging sections of the feeder and arranging the alternative sources from Trongsa.

- Installation of more and smart switching devices

  Due to many spur lines protruding from the main feeder, fault finding is the key. Therefore, to locate the fault instantly and to isolate the faulty from healthy network it is proposed to install more and smart switching devices like ARCBs (5 numbers at different T-Offs of Wachey, Chuzomsa, Shobla, Chuserbu, Rabuna, Nahi, Sha-Ngawang, Khotokha, and Rubesa), Sectionalizers and FPIs.

b) 11kV Gaselo Feeder

This feeder has circuit length of 37.24km and passes through thick vegetation and rugged terrain especially in the rural areas similar to that of Phobjikha feeder. The reliability indices had also improved a lot in the last three years. The SAIFI & SAIDI were 25.81 & 15.83 in 2016 which had reduced to 4.41 & 8.57 in 2018 respectively. Although, the reliability of Gaselo feeder is comparatively better compared to Phobjikha feeder, it still requires remedial and corrective measures to improve further.

- Installation of more and smart switching devices

  Due to many spur lines protruding from the main feeder, fault finding is the key. Therefore, to locate the fault instantly and to isolate the faulty from healthy network it is proposed to install more and smart switching devices like ARCBs (2), Sectionalizers (1 no.) and FPIs (2 nos).

c) 11kV Bajo Town Feeder

This feeder has a circuit length of 15.24km and this feeder is the most loaded feeder of all the feeders as it caters power supply to Bajo town, part of old town and RBA areas. The reliability indices had also improved a lot in the last three years. The SAIFI & SAIDI were 7.99 & 28.64 in 2016 which had reduced to 1.59 & 2.43 in 2018 respectively. The reliability of Gaselo feeder is comparatively better when compared to the average reliability indices of Wangdue Dzongkhag for last three years.

d) 11kV Jala Ula Feeder

This feeder has the longest 11kV circuit length (84.78km) and passes through thick vegetation and rugged terrain. The reliability indices had also improved a lot in the last three years. Although, the reliability indices of this feeder are within the set target, the feeder has fluctuating data.

The feeder has two ARCBs installed at Pinsa & Basochu and two numbers of LBS at Baychu and Kamichu. The ARCBs are basically not functioning as intended thus affecting the entire customers connected to the feeder.

- Installation of more and smart switching devices

  Due to many spur lines protruding from the main feeder, fault finding is the key. Therefore, to locate the fault instantly and to isolate the faulty from healthy network it is proposed to install more and smart switching devices like ARCBs (2), Sectionalizers (1 no.) and FPIs (2 nos).

e) 11kV Feeder IV from Bashochu and Lobeysa

11kV line from Basochu substation is extended till Tapchakha and 11kV line from Lobeysa substation caters power supply till Upper Shingkay. It is proposed to construct an interconnection line of 3km as a contingency plan which would enable to arrange power supply from Basochu till Gesola and Hesothangka in case the power supply is interrupted in Lobeysa.

7.2.4 Single Phase to Three-phase Conversion

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

a) Alternative -I

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

b) Alternative -II

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

c) Alternative -III

Option 3 is found to be a techno-commercially viable alternative as the lines can be easily upgraded to three-phase by constructing third conductor on existing pole structures. The transformer can be upgraded from single phase to three-phase as and when the demand for 3-phase supply comes. The line up-gradation across the country would amount to Nu. 96.67

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

The total single-phase line length required to be converted to three-phase in the Dzongkhag is 30.71 km and the estimate for such conversion would require Nu. 4.58 Million.

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

7.3 Assessment of the Distribution Transformers

The total number of distribution transformers operated and maintained by the ESD is tabulated in **Table 2.**

7.3.1 Distribution Transformer Loading

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

As per the peak loading pattern, some of the existing transformer capacities would not be adequate to cater the forecasted load growth for next ten (10) years. Assuming that the load growth of the rural homes is not expected to grow similar to that of urban dwellings, it is strongly recommended to closely monitor the actual load growth and accordingly plan remedial measures for those transformers. Nevertheless, considering the actual site-specific growth rate and judgment of the field offices, it is recommended to propose for up-gradation on need basis.

The DTs of the urban areas which would be overloaded as predicted would demand to up-grade their transformer capacities.

7.3.2 Asset life of Distribution Transformers

The DTs are one of the most critical equipment of the distribution network. Therefore, assessment of existing loading pattern together with the remaining asset life is crucial to ascertain its capabilities to cater the projected load growth. The life cycle of transformer and its mapping provides the clear information for its optimal utilization and development of an asset replacement framework. As listed in **Table 15,** for the DTs that outlived its asset life expectancy, proper evaluation and testing should be prerequisite for their continued utilization.

Table 14: List of Outlived Transformers

Sl. No.	Name of Location	Capacity (kVA)	Unit	Qty	Cap.Date	No. of Years put to use	Transformer Sl. No.
1	Rukubji	25	No	1	1986	33	NA
2	Nyelekha	50	No	1	1968	51	C 6043/68
3	Maspoto	63	No	1	1993	26	S/4044
4	Tokha	63	No	1	1970	49	184-06
5	Gumina	100	No	1	1987	32	86BD-160/1
6	Petakap	315	No	1	1990	29	185-07
7	Tashila Ropeway	125	No	1	1988	31	S/3634
8	Bhutan Telecom	250	No	1	1986	33	81 FD-010/67
9	DIWC, Tshokona	315	No	1	1990	29	188-05
10	RNRC,	250	No	1	1994	25	94DD-083/08
	Total			**10**			

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 need basis. Total of Nu. 283.00 million is estimated for replacing all single-phase transformers including the distribution board. The detailed work out is produced as **Annexure-7.**

There are 13 single phase transformers in the Dzongkhag and the estimate for up-grading all the single to three-phase transformers would require Nu. 2.69 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

Wangdue Dzongkhag has plan of extending the present Bajo town towards the west side of existing town as LAP-I and LAP-II in east of the existing town. By January 2020, the land demarcation for LAP-I would be started and developmental works is also expected to be initiated in the same year.

The 11 kV Feeder IV from Lobeysa substation (approximately 1km) passes through the middle of designated area for new town extension (LAP-I) which would necessitate shifting of the line or propose UG system should availing of RoW is not possible. In order meet the power requirement of the extended town for LAP-I, 2X750 kVA USS is necessary where one of the USS would be connected to existing 11kV feeder IV and the other to be connected to 11kV Feeder V thus having two power sources. LT ring network can be also arranged with the existing 750 kVA substation of Bajo town.

LAP-II is expected to formally kick-start from mid 2020 or 2021. Currently, the electricity supply to the customers of LAP-II area are arranged from existing 500kVA substation (meant for old town of Wangdue) connected to feeder V. Therefore, to meet the power requirement of the new extended town of LAP-II, it is proposed to replace the existing outdoor 500kVA by 500kVA USS for safety of the general public and to maintain the aesthetic of the old town.

8. Distribution System Planning

The distribution network of the Dzongkhag has a radial topology with significant risk of high interruptions (fault in one location would mean that the entire customer in the network would experience the outage). Having alternate routes, sources or any contingency plan would significantly improve the reliability and power quality. In order to have robust and hard-lined distribution network, there is a need for good contingency plans with adequate sources to reduce

the downtime. However, any provision to improve the power system would incur additional capital cost in addition to recurring additional preventive and corrective costs.
Therefore, to meet the system shortfalls against the set standard and to keep abreast with the forecasted load growth, proper distribution system planning is required which are detailed from **Section 8.1** through **Section 8.4.**

8.1 Power Supply Sources

8.1.1 HV Substations

As detailed in **Section 7.1.1**, HV substations would not have to be up-graded as after completion of the Punatsangchu projects, the power supply can be also arranged from 66/33kV,2x12.5MVA Gewathang substation. Therefore, HV substations would be adequate to cater the power requirement of Punakha, Wangdue and Gasa Dzongkhags.

8.1.2 MV Substations

As detailed in **Section 7.1.2,** the existing MV substation (Phobjikha) would be adequate to meet the increasing power requirement of the customers of Phobjikha, Wangdue.

8.2 MV and LV Lines

i. Conversion of overhead to UG cables

a) HT bare to UG cable

Conversion of 11kV overhead to UG system in LAP-I, Bajo town.

b) LV to UG cable

Conversion of LT overhead to UG system in LAP-I and Phobjikha.

ii. Construction of new 11kV HV ABC line at Wangdue Dzong form RBA area to Dzong for dual power supply arrangement.

iii. Construction of interconnecting 11kV line from Basochu and 11kV feeder IV of Lobeysa substation (Tapchakha to Singkey)

8.3 Distribution Transformers

As listed in **Section 7.3.1,** these transformers need to be up-graded either by procuring or by cross-swapping the required capacities. However, ESD Wangdue has to closely monitor the load growth in each of the DTs as reflection in the section.

8.4 Switching and Control

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

8.4.1 Intelligent Switching Devices

As reflected in **Section 7.2.3,** 33kV Feeder-I and 33kV Phobjikha, 11kV Bajo Town and 11kV Jala Ula Feeders have sustained more interruptions than other feeders. In order to improve reliability and power quality of these feeders, it is proposed to have technology in place to respond to fault and clear it accordingly rather than through ex post facto approach. Therefore, it is proposed to enhance the existing switching and control system by having latest suitable and user-friendly technology (automatic). The coordinated arrangement of Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers and FPIs would significantly improve the control and operation mechanism of the network. **Table 15** shows the proposed switching devices and RMUs for the distribution network for easing operation and maintenance and for improving the reliability of the power supply of the Dzongkhag.

Reliability of the lines and substations can also be enhanced through training of line staff. They need to be equipped with the knowledge, skills, and the confidence to operate and maintain the distribution infrastructure. For instance, the linemen of the ESDs need to develop the confidence to change DO fuses online using hot sticks instead of the usual practice of taking shut down of the whole feeder. However, having the right tools, equipment, and especially spares (of appropriate specifications) is a prerequisite. Although it is not possible to quantify the reliability indices that can be achieved with preventive and corrective measures in place, the proposed contingency plans would significantly improve the power quality.

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

Table 15: Existing and Proposed Switching Devices

Sl. No.	Feeder Name	ARCBs		Sectionalizers		FPIs		LBS	
		Exist	Prop	Exist	Prop	Exist	Prop	Exist	Prop
1	33kV Phobjikha Feeder	5	5		5		10	6	0
2	11kV Gaselo Feeder IV	1	2		1		2	3	0
3	11kV Jala-Ulla	2	2		1		2	2	
4	11kV Bajo Town Feeder								
	Overall Total	**8**	**9**	**0**	**7**	**0**	**14**	**11**	**0**

8.4.2 Distribution System Smart Grid

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

9. Investment Plan

In accordance to the above mentioned contingency plans targeted to improve the power quality, reduce losses and improve reliability indices of the Dzongkhag, investment proposal is developed. The investment plan has been confined to power supply sources, MV lines, DTs, switching and control equipment and RoW. The proposed/approved (2020-2024) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 9.**

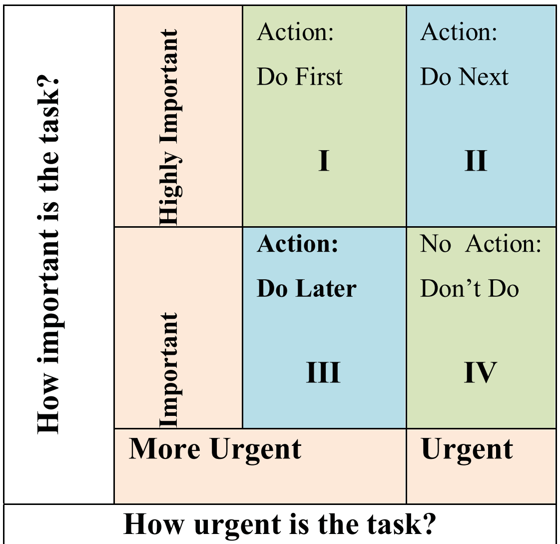


Figure 9: Priority Matrix

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 switchgears and equipment will have the highest level of importance and urgency. These activities have to be prioritized and invested in the initial years which are grouped in the first quadrant (Do First).

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

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 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 the actual investment cost for the following years.

In the span of next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Wanduephodrang Dzongkhag is Nu. 53.84 million (Nu. 5.38 million per year).

Table 16: Yearly Investment Plans (2020-2030)

Sl. No.	Project Activities	Investment Plan											Total
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
1	Installation of four (4) numbers of 11kV Indoor RMU at Phobjikha Substation	4.67											**4.67**
2	Installation of 2X750 kVA USS for LAP I Bajo town		5.92										**5.92**
3	Conversion of 11kV overhead line to UG system in LAP I Bajo Town		1.45										**1.45**
4	Construction of LT UG network for LAP I Bajo town		1.12										**1.12**
5	Upgradation of 35 sq.mm to 70 sq.mm LV UG at Phobjikha		1.93										**1.93**
6	Construction of New 11kV HV ABC line at Wangdue Dzong from RBA area to Dzong (for providing dual power supply to Dzong)			1.64									**1.64**
7	Interconnection of 11kV feeder IV from Basochu and 11kV feeder IV from Lobeysa substation (From Tapchakha to Shingkey)				2.33								**2.33**
8	Construction of 500kVA USS for LAP II Bajo town					3.00							**3.00**
9	Upgradation of 11/0.415kV, 25kV Martolungchu substation to 250kVA		0.51										**0.51**
10	Upgradation of 11/0.415 kV, 25 kVA Lumpa substation to 125kVA			0.44									**0.44**
11	Upgradation of 11/0.415 kV, 125 kVA Omtokha substation to 250 kVA			0.52									**0.52**
12	Upgradation of 11/0.415 kV, 63 kVA Dogsina substation to 125 kVA						0.48						**0.48**

Sl. No.	Project Activities	Investment Plan											Total
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
13	Upgradation of 11/0.415 kV, 25 kVA Kumbu substation to 125 kVA								0.48				**0.48**
14	Upgradation of 33/0.415 kV, 63 kVA substation to 125 kVA										0.47		**0.47**
15	Conversion of single to three-phase line			0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	**4.59**
16	Replacement of single phase by three-phase transformers			0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	**2.70**
17	Rural Electrification (Refill In)	1.99	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	**21.59**
	Total	**6.66**	**12.89**	**5.37**	**5.10**	**5.77**	**3.25**	**2.77**	**3.25**	**2.77**	**3.24**	**2.77**	**53.84**

10. Conclusion

Based on the inputs from ESD Wangdue, 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 actually implemented.

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

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

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

11. Recommendation

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	It is forecasted that the forecasted load of Gasa, Wangdue and Punakha Dzongkhags would surpass the installed capacity (inclusive of Damji substation). Nevertheless, the HV substation would be adequate provided the Punatsangchu projects are completed on schedule and Gewathang HV substation can be used to cater the loads of Wangdue.
2	MV Substations	The Dam and Power House's 33/11kV, 2.5MVA MV substations of Punatsangchu projects would immensely help in reducing the total 11kV load dependency to Lobeysa substation thereby relieving the Lobeysa substation.
B. MV Feeders		
1	MV Line arrangement from Gewathang substation	Both the 33kV and 11kV loads of Wangdue could be fed from the 66/33kV Gewathang and 33/11kV Dam and Power House substations. However, interconnecting MV line has to be constructed so that Wangdue would have alternate power sources.
2	Realignment/re-routing	The causes of line faults are due to trees and branches snapping the line, unstable landscape resulting in landslides thereby damaging lines and substations. Periodic preventive maintenance does not guarantee the reliable power supply in such scenarios. Therefore, the only option left is to realign/reroute the lines.
3	Single to Three Phase Lines	As reported in the "Technical and Financial Proposal on Converting Single Phase Power Supply to Three Phase in Rural Areas", it is recommended to convert the single to three phase lines based on need basis.
C. Distribution Transformers		
1	Distribution	As reflected in Section **7.3.1** of this report, it is proposed to regularly

Sl. No.	Parameters	Recommendations
	Transformer	monitor the loading pattern especially of the urban transformers. It is desired to load the transformers less than 85% so as to ensure that transformer is operated at maximum efficiency. As the system study is restricted to DTs, the loads need to be uniformly distributed amongst the LV feeders to balance the load.
2	Single to Three Phase Transformers	As reported in the “Technical and Financial Proposal on Converting Single Phase Power Supply to Three Phase in Rural Areas”, it is recommended to replace the single to three phase transformers on need basis.
D. Switching and Control Equipment		
1	Switching and Control Equipment	It is recommended to install Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers and FPIs as proposed which would reduce the downtime for clearing faults. 1) Install FPI, Sectionalizes and ARCBs at various identified locations. 2) Installation of 11kV& 33kV RMUs at various identified locations.
E. others		
1	Investment Plan	As reflected in Section 9 of this report, overall investment plan as proposed is recommended.
2	Review of the DSMP	Practically the projections will hold only true in the nearest future therefor, it is strongly recommended to review the DSMP in 2025 (after five years) or if need be as and when situation demands.
3	System Studies beyond DT	It is observed that distribution of electricity is more through LV than MV & HV and the scope of DSMP terminates at DT. However, it is equally important to carry out similar system studies for LV networks till meter point. Due to time constraint and non-availability of required LV data, it is recommended that ESD Wangdue should carry out the studies on LV

Sl. No.	Parameters	Recommendations
		network including the DTs. Nevertheless, with the entire distribution network captured in the GIS and ISU, the system studies should be carried out including the LV network in the future.
4	Customer Mapping	One of the important parameters required especially for reaffirming the capability of the DTs is by examining customer growth patterns. Therefore, it is recommended to consistently update the customers via customer mapping process carried out annually.
5	Right of Way	RoW should be maintained as per the DDCS 2016. However, increased frequency of RoW clearing in the problematic sections of the line and in fast growth sub-tropical forest is recommended.
6	Asset life of DTs	The asset life of DTs need to be gathered to enable development of asset replacement framework. However, it is recommended to regularly monitor the health of the transformers which have already outlived their lives.
7	Overloading of DTs	As per the load forecast, some of the rural DTs might overload. While the probability of realizing such an event is quite low. It is, however, recommended that the DTs that have already exhausted its statutory life (25 years and above) be regularly monitored.
8	New extension through 33kV network	The power carrying capacity of 33kV system is almost 3-fold compared to that of 11kV system. Therefore, any new extension of lines may be done through 33kV system (based on fund availability and practical convenience).
9	Reliability	In order to improve the reliability of the feeder/network, it is recommended either that fault should be located within short period of time there by reducing the restoration time and the number of customers affected. In this regard, the following initiatives are recommended: 1) To install ISDs (communicable FPIs, Sectionalizers & ARCBs); 2) To explore with construction of feeders with customized 11kV &

Sl. No.	Parameters	Recommendations
		33kV towers; and 3) To increase the frequency of Row clearing in a year.
10	Conversion Works	As the joint survey for laying the UG had not be done, the investment has been worked based on assumptions of likely scenarios. Therefore, ESD Wangdue should incorporate the actual activities during the rolling out of the investment plans.

12. Annexure

Annexure-1: MV Line Details and Single Line Diagram

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

Annexure-3: The details on load forecast methodology

Annexure-4: Detailed Simulation Results

Annexure 5: Feeder Wise Reliability Indices

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

Annexure-7: 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, ratio of 80% (static load) to 20% (industrial feeders) were assumed;
3. The voltage level of ±10% is given as critical value which is indicated by red color while simulating and voltage level of ±5% is given as marginal value which is indicated by pink color while simulating.
4. The typical inbuilt value of X/R ratio of ETAP tool was considered for all the transformers;
5. Dimensions and parameters of some cables/UG cables are customized in the library as per the requirement;
6. The technical parameters which are required for analysis of the distribution network have been considered as per the set standard of DDCS.

15. Challenges

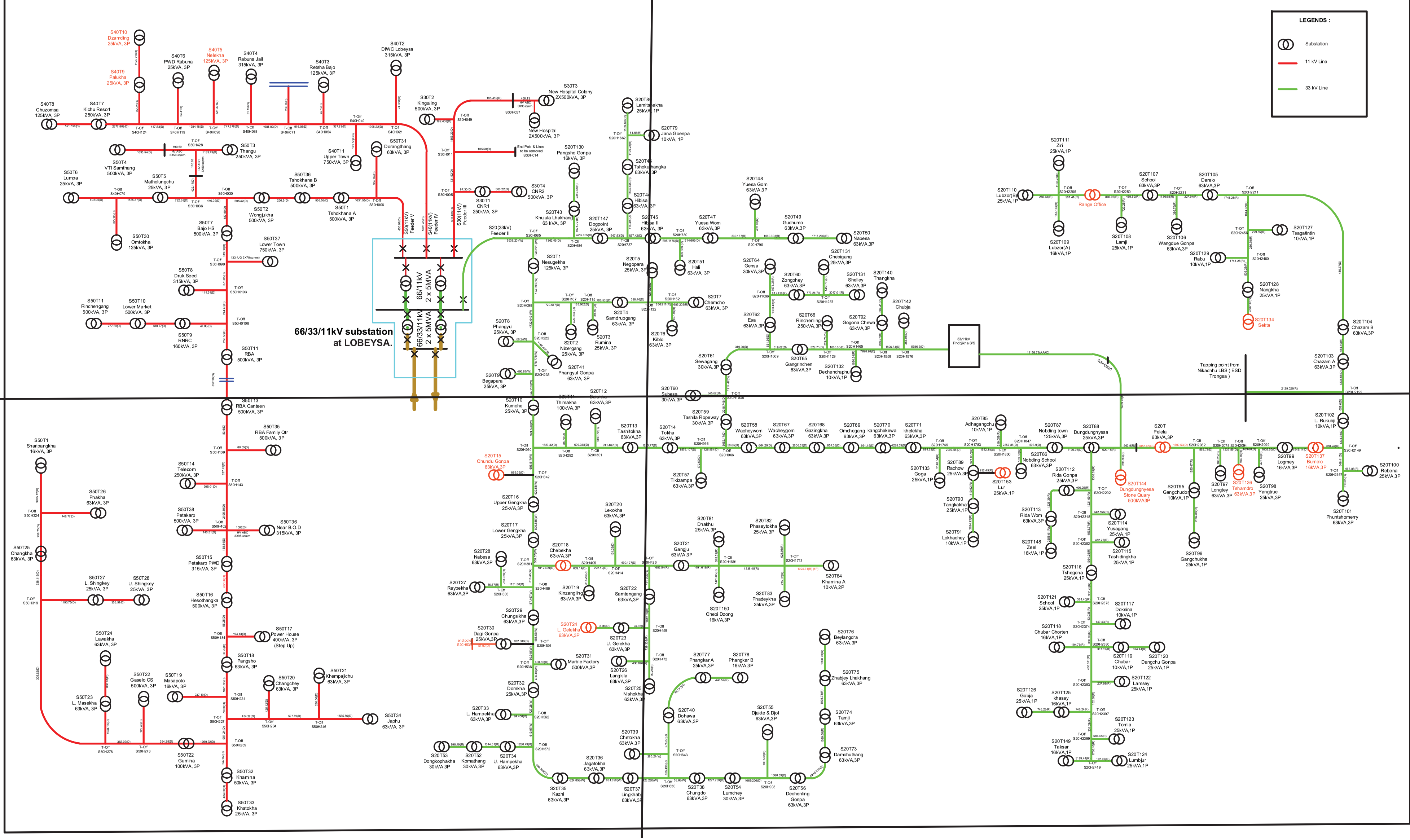
Sl. No.	Parameters	Challenges	Opportunities/Proposals
1	Software Tool (ETAP)	a) Only one key & offline Key a) Balanced Load Flow b) Limitations of No. of buses (1000)	a) Can opt for on line key with fewer more modules specially to carry out the technical evaluation of un-balanced load flow system. This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

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

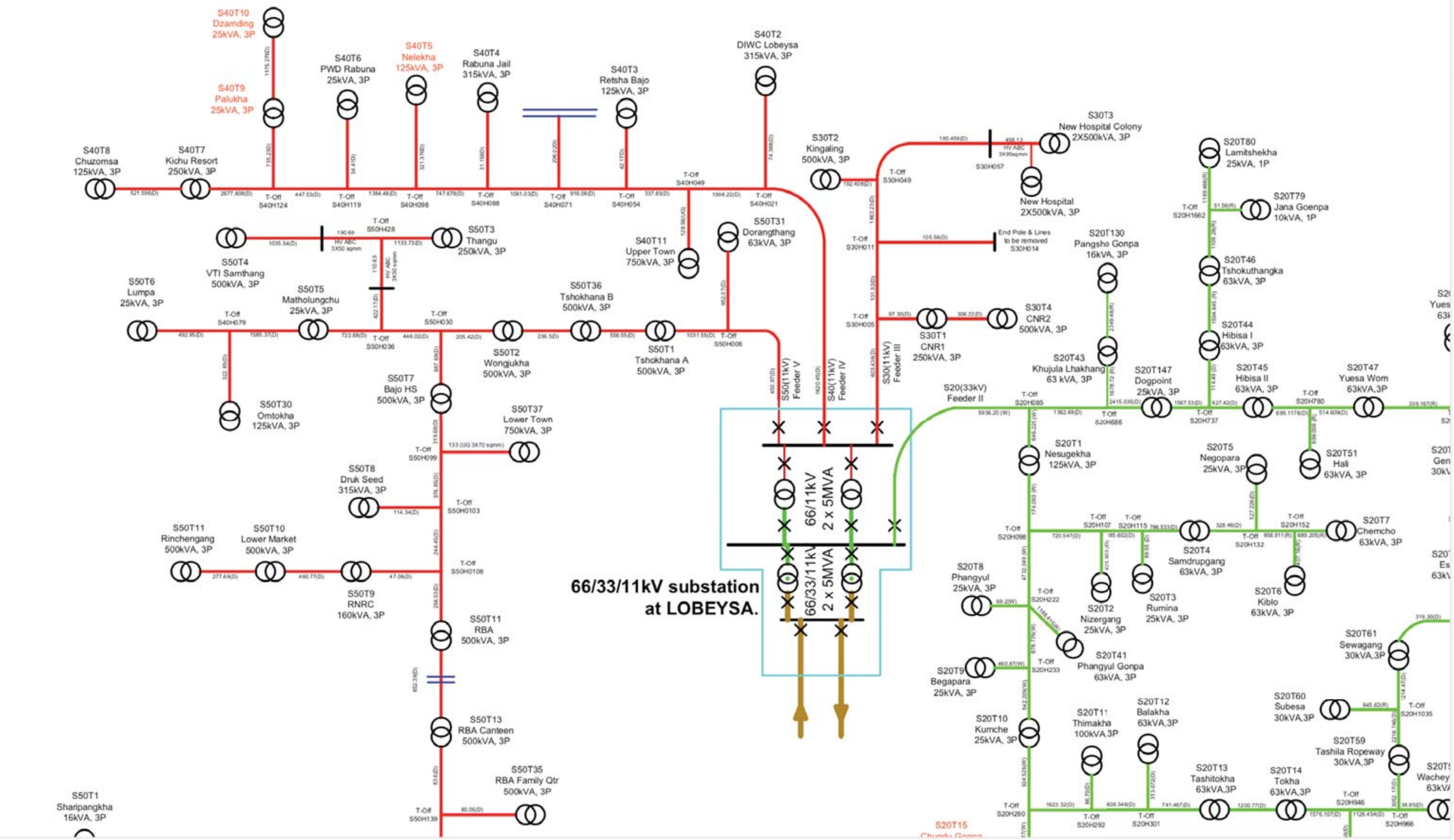
12.Annexures

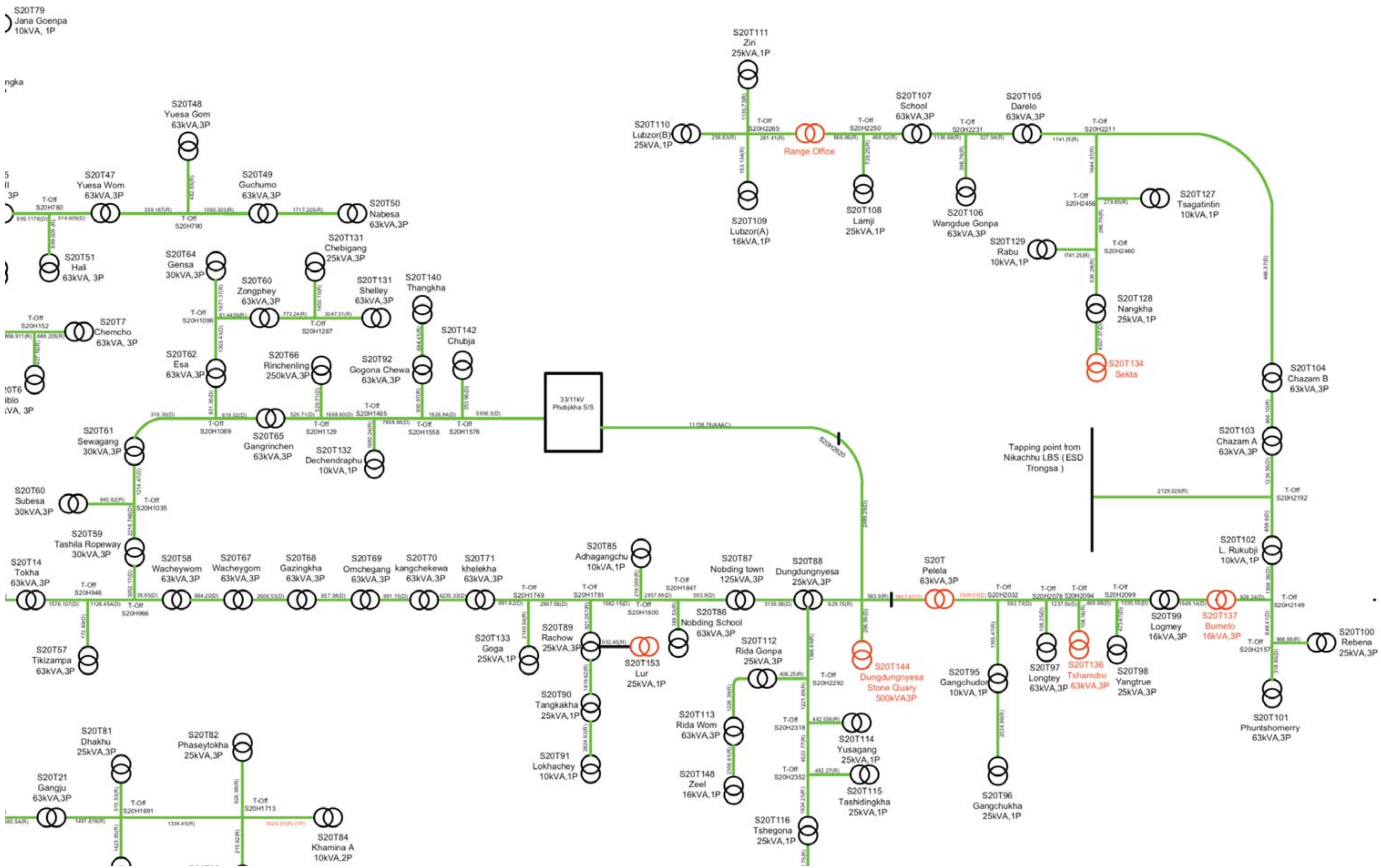
Annexure-1: MV Line Details and Single Line Diagram

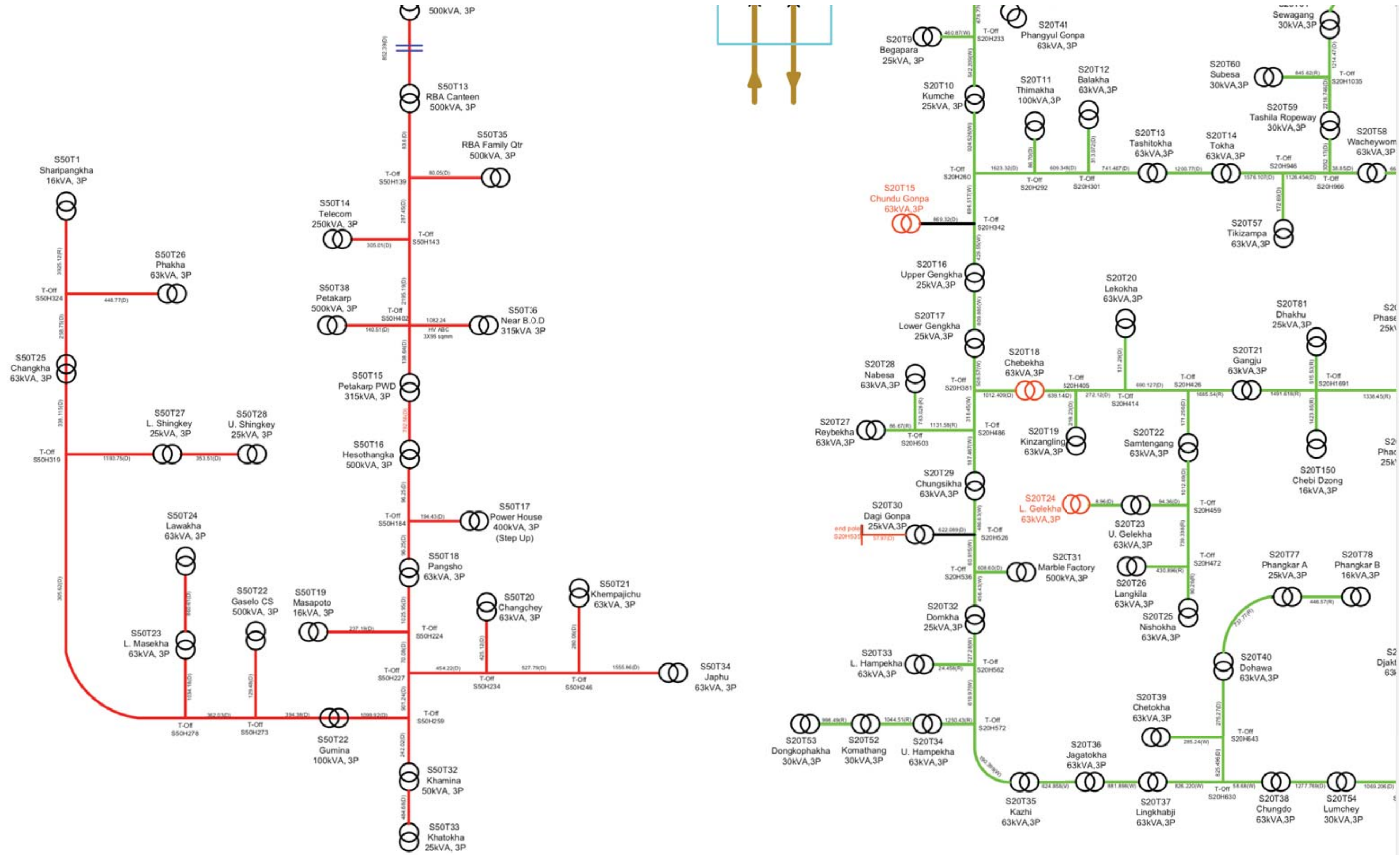
SINGLE LINE DIAGRAM OF ESD WANGDUE

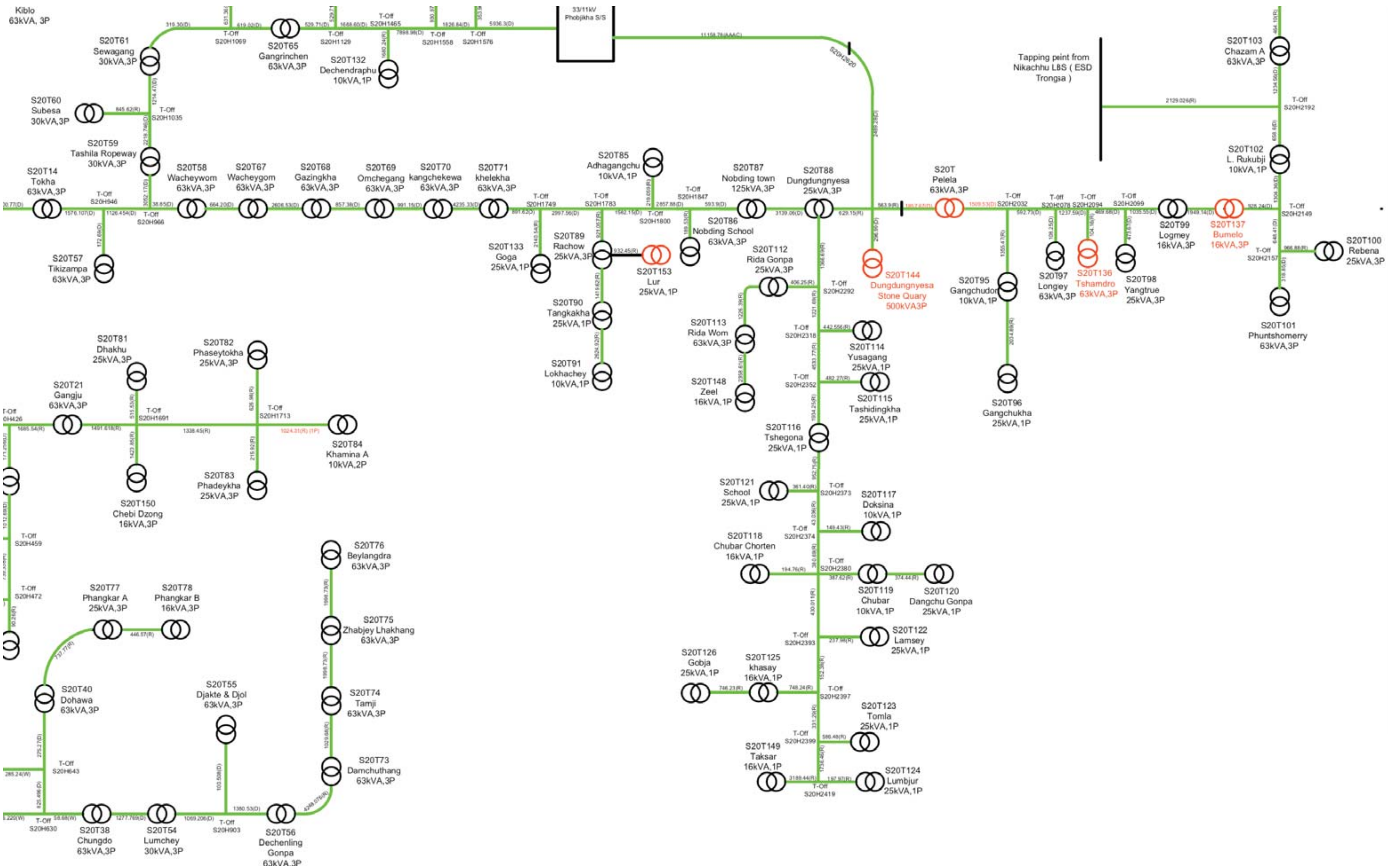


SINGLE LINE DIAGRAM OF ESD WANGDUE



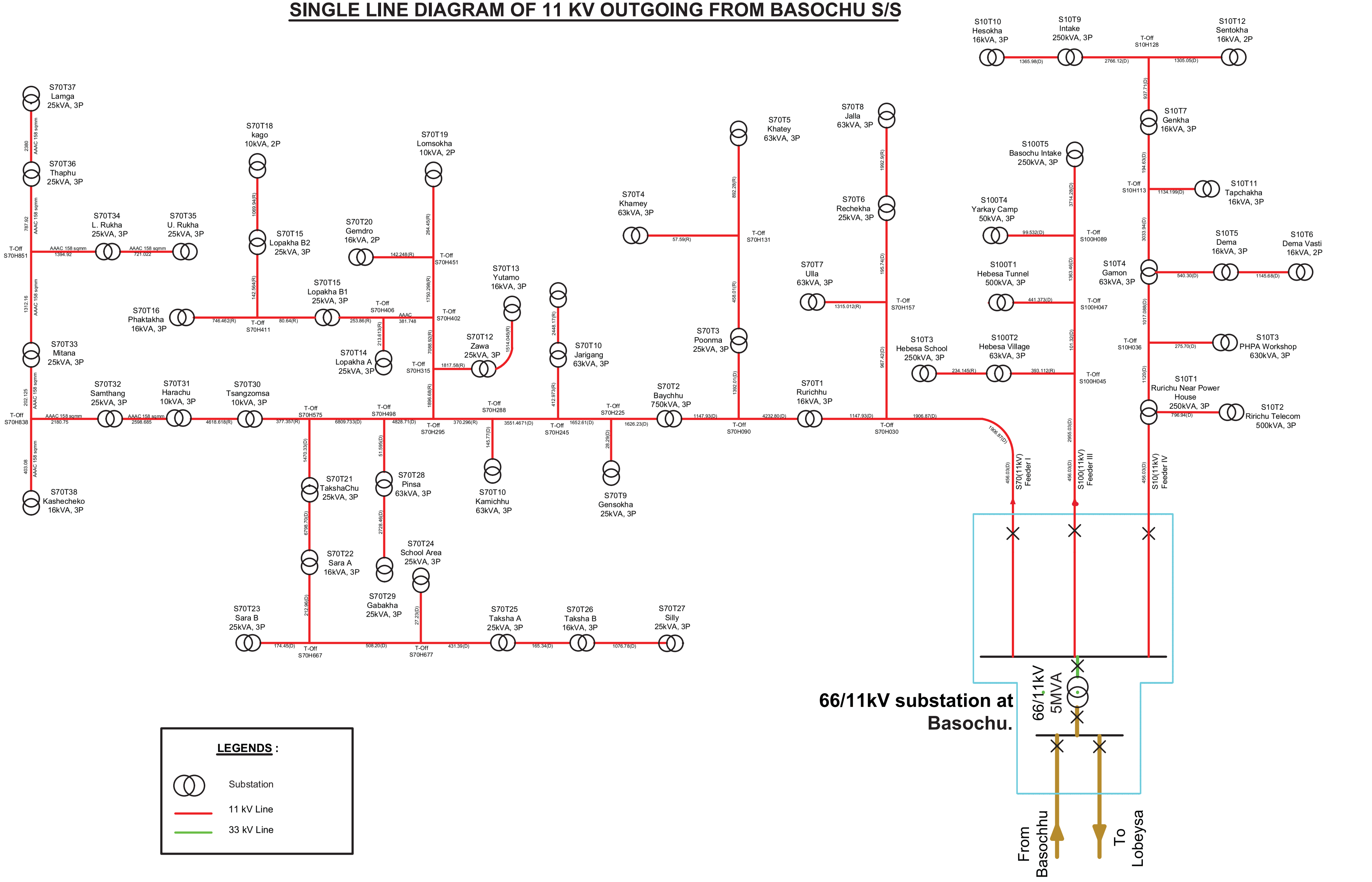

33/11kV Phobjikha S/S
Tapping point from Nikachhu LBS (ESD Trongsa)
S20T79 Jana Goenpa 10kVA, 1P
S20T48 Yuesa Gom 63kVA,3P
S20T47 Yuesa Wom 63kVA,3P
S20T49 Guchumo 63kVA,3P
S20T50 Nabesa 63kVA,3P
S20T51 Hali 63kVA, 3P
S20T64 Gensa 30kVA,3P
S20T131 Chebigang 25kVA,3P
S20T60 Zongphey 63kVA,3P
S20T131 Shelley 63kVA,3P
S20T140 Thangkha
S20T142 Chubja
S20T7 Chemcho 63kVA, 3P
S20T62 Esa 63kVA,3P
S20T66 Rinchenling 250kVA,3P
S20T92 Gogona Chewa 63kVA,3P
S20T61 Sewagang 30kVA,3P
S20T65 Gangrinchen 63kVA,3P
S20T132 Dechendraphu 10kVA,1P
S20T60 Subesa 30kVA,3P
S20T59 Tashila Ropeway 30kVA,3P
S20T14 Tokha 63kVA,3P
S20T58 Wacheywom 63kVA,3P
S20T67 Wacheygom 63kVA,3P
S20T68 Gazingkha 63kVA,3P
S20T69 Omchegang 63kVA,3P
S20T70 kangchekewa 63kVA,3P
S20T71 khelekha 63kVA,3P
S20T57 Tikizampa 63kVA,3P
S20T133 Goga 25kVA,1P
S20T85 Adhagangchu 10kVA,1P
S20T89 Rachow 25kVA,3P
S20T153 Lur 25kVA,1P
S20T90 Tangkakha 25kVA,1P
S20T91 Lokhachey 10kVA,1P
S20T87 Nobding town 125kVA,3P
S20T86 Nobding School 63kVA,3P
S20T88 Dungdungnyesa 25kVA,3P
S20T112 Rida Gonpa 25kVA,3P
S20T113 Rida Wom 63kVA,3P
S20T148 Zeel 16kVA,1P
S20T114 Yusagang 25kVA,1P
S20T115 Tashidingkha 25kVA,1P
S20T116 Tshegona 25kVA,1P
S20T144 Dungdungnyesa Stone Quary 500kVA3P
S20T Pelela 63kVA,3P
S20T95 Gangchudor 10kVA,1P
S20T96 Gangchukha 25kVA,1P
S20T97 Longtey 63kVA,3P
S20T136 Tshamdro 63kVA,3P
S20T98 Yangtrue 25kVA,3P
S20T99 Logmey 16kVA,3P
S20T137 Bumelo 16kVA,3P
S20T100 Rebena 25kVA,3P
S20T101 Phuntshomerry 63kVA,3P
S20T102 L. Rukubji 10kVA,1P
S20T103 Chazam A 63kVA,3P
S20T104 Chazam B 63kVA,3P
S20T111 Ziri 25kVA,1P
S20T110 Lubzor(B) 25kVA,1P
S20T109 Lubzor(A) 16kVA,1P
Range Office
S20T108 Lamji 25kVA,1P
S20T107 School 63kVA,3P
S20T106 Wangdue Gonpa 63kVA,3P
S20T105 Darelo 63kVA,3P
S20T127 Tsagatintin 10kVA,1P
S20T129 Rabu 10kVA,1P
S20T128 Nangkha 25kVA,1P
S20T134 Sekta
S20T81 Dhakhu 25kVA,3P
S20T82 Phaseytokha 25kVA,3P
S20T21 Gangju 63kVA,3P
S20T84 Khamina A 10kVA,2P


500kVA, 3P
S50T13 RBA Canteen 500kVA, 3P
S50T35 RBA Family Qtr 500kVA, 3P
S50T14 Telecom 250kVA, 3P
S50T38 Petakarp 500kVA, 3P
S50T36 Near B.O.D 315kVA 3P
S50T15 Petakarp PWD 315kVA, 3P
S50T16 Hesothangka 500kVA, 3P
S50T17 Power House 400kVA, 3P (Step Up)
S50T18 Pangsho 63kVA, 3P
S50T19 Masapoto 16kVA, 3P
S50T20 Changchey 63kVA, 3P
S50T21 Khempajichu 63kVA, 3P
S50T34 Japhu 63kVA, 3P
S50T22 Gumina 100kVA, 3P
S50T32 Khamina 50kVA, 3P
S50T33 Khatokha 25kVA, 3P
S50T22 Gaselo CS 500kVA, 3P
S50T23 L. Masekha 63kVA, 3P
S50T24 Lawakha 63kVA, 3P
S50T1 Sharipangkha 16kVA, 3P
S50T26 Phakha 63kVA, 3P
S50T25 Changkha 63kVA, 3P
S50T27 L. Shingkey 25kVA, 3P
S50T28 U. Shingkey 25kVA, 3P
S20T9 Begapara 25kVA, 3P
S20T41 Phangyul Gonpa 63kVA, 3P
S20T10 Kumche 25kVA, 3P
S20T11 Thimakha 100kVA,3P
S20T12 Balakha 63kVA,3P
S20T13 Tashitokha 63kVA,3P
S20T14 Tokha 63kVA,3P
S20T60 Subesa 30kVA,3P
S20T59 Tashila Ropeway 30kVA,3P
Sewagang 30kVA,3P
S20T58 Wacheywom 63kVA,3P
S20T57 Tikizampa 63kVA,3P
S20T15 Chundu Gonpa 63kVA,3P
S20T16 Upper Gengkha 25kVA,3P
S20T17 Lower Gengkha 25kVA,3P
S20T18 Chebekha 63kVA,3P
S20T20 Lekokha 63kVA,3P
S20T81 Dhakhu 25kVA,3P
S20T21 Gangju 63kVA,3P
S20T150 Chebi Dzong 16kVA,3P
S20T28 Nabesa 63kVA,3P
S20T27 Reybekha 63kVA,3P
S20T19 Kinzangling 63kVA,3P
S20T22 Samtengang 63kVA,3P
S20T29 Chungsikha 63kVA,3P
S20T24 L. Gelekha 63kVA,3P
S20T23 U. Gelekha 63kVA,3P
S20T30 Dagi Gonpa 25kVA,3P
end pole S20H535
S20T31 Marble Factory 500kVA,3P
S20T26 Langkila 63kVA,3P
S20T25 Nishokha 63kVA,3P
S20T77 Phangkar A 25kVA,3P
S20T78 Phangkar B 16kVA,3P
S20T32 Domkha 25kVA,3P
S20T33 L. Hampekha 63kVA,3P
S20T40 Dohawa 63kVA,3P
S20T39 Chetokha 63kVA,3P
S20T53 Dongkophakha 30kVA,3P
S20T52 Komathang 30kVA,3P
S20T34 U. Hampekha 63kVA,3P
S20T36 Jagatokha 63kVA,3P
S20T35 Kazhi 63kVA,3P
S20T37 Lingkhabji 63kVA,3P
S20T38 Chungdo 63kVA,3P
S20T54 Lumchey 30kVA,3P



Kiblo 63kVA, 3P
S20T61 Sewagang 30kVA,3P
S20T65 Gangrinchen 63kVA,3P
S20T132 Dechendraphu 10kVA,1P
33/11kV Phobjikha S/S
Tapping point from Nikachhu L8S (ESD Trongsa)
S20T103 Chazam A 63kVA,3P
S20T60 Subesa 30kVA,3P
S20T59 Tashila Ropeway 30kVA,3P
S20T102 L. Rukubji 10kVA,1P
S20T14 Tokha 63kVA,3P
S20T58 Wacheywom 63kVA,3P
S20T67 Wacheygom 63kVA,3P
S20T68 Gazingkha 63kVA,3P
S20T69 Omchegang 63kVA,3P
S20T70 kangchekewa 63kVA,3P
S20T71 khelekha 63kVA,3P
S20T85 Adhagangchu 10kVA,1P
S20T87 Nobding town 125kVA,3P
S20T88 Dungdungnyesa 25kVA,3P
S20T Pelela 63kVA,3P
S20T99 Logmey 16kVA,3P
S20T137 Bumelo 16kVA,3P
S20T100 Rebena 25kVA,3P
S20T57 Tikizampa 63kVA,3P
S20T133 Goga 25kVA,1P
S20T89 Rachow 25kVA,3P
S20T153 Lur 25kVA,1P
S20T86 Nobding School 63kVA,3P
S20T112 Rida Gonpa 25kVA,3P
S20T144 Dungdungnyesa Stone Quary 500kVA3P
S20T95 Gangchudor 10kVA,1P
S20T97 Longey 63kVA,3P
S20T136 Tshamdro 63kVA,3P
S20T98 Yangtrue 25kVA,3P
S20T101 Phuntshomerry 63kVA,3P
S20T90 Tangkakha 25kVA,1P
S20T91 Lokhachey 10kVA,1P
S20T113 Rida Wom 63kVA,3P
S20T114 Yusagang 25kVA,1P
S20T148 Zeel 16kVA,1P
S20T115 Tashidingkha 25kVA,1P
S20T96 Gangchukha 25kVA,1P
S20T81 Dhakhu 25kVA,3P
S20T82 Phaseytokha 25kVA,3P
S20T21 Gangju 63kVA,3P
S20T84 Khamina A 10kVA,2P
S20T150 Chebi Dzong 16kVA,3P
S20T83 Phadeykha 25kVA,3P
S20T116 Tshegona 25kVA,1P
S20T121 School 25kVA,1P
S20T117 Doksina 10kVA,1P
S20T118 Chubar Chorten 16kVA,1P
S20T119 Chubar 10kVA,1P
S20T120 Dangchu Gonpa 25kVA,1P
S20T76 Beylangdra 63kVA,3P
S20T75 Zhabjey Lhakhang 63kVA,3P
S20T77 Phangkar A 25kVA,3P
S20T78 Phangkar B 16kVA,3P
S20T122 Lamsey 25kVA,1P
S20T126 Gobja 25kVA,1P
S20T125 khasay 16kVA,1P
S20T40 Dohawa 63kVA,3P
S20T55 Djakte & Djol 63kVA,3P
S20T74 Tamji 63kVA,3P
S20T123 Tomla 25kVA,1P
S20T149 Taksar 16kVA,1P
S20T124 Lumbjur 25kVA,1P
S20T73 Damchuthang 63kVA,3P
S20T38 Chungdo 63kVA,3P
S20T54 Lumchey 30kVA,3P
S20T56 Dechenling Gonpa 63kVA,3P

SINGLE LINE DIAGRAM OF 11 KV OUTGOING FROM BASOCHU S/S



SINGLE LINE DIAGRAM OF 11 KV FEEDERS AT PHOBJIKHA (33/11kV SS)

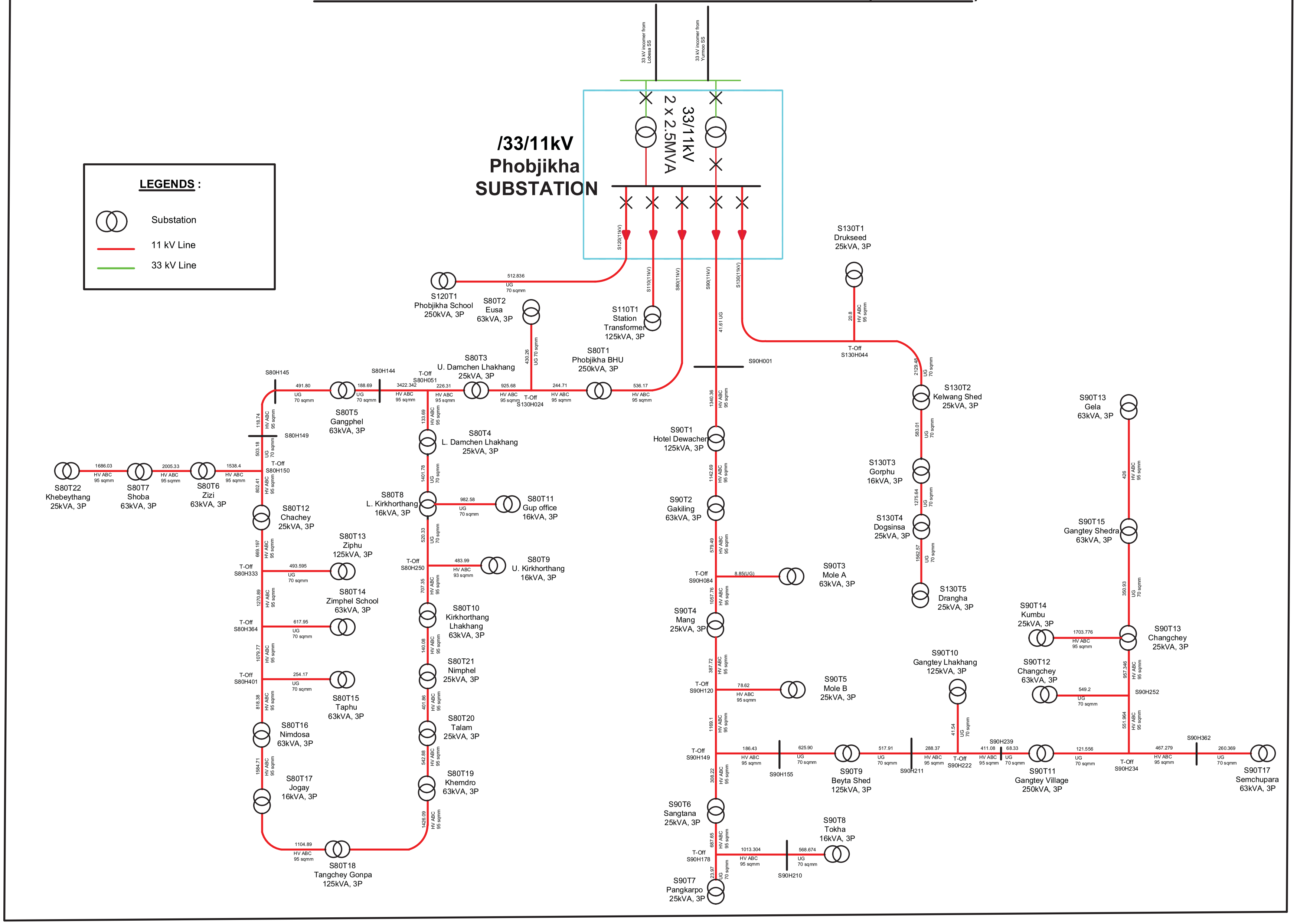


Table 1: Line details for 33 kV line from Lobeysa Substation to Khotokha, Nobding, Dangchu,Phobjikha.

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
33kV Feeder II Lobeysa to Phobjikha																
				Lobeysa(H000) to H085 (T off)	5.969					5.969	5.969	3				
				H085 to H094 (Nesugekha S/S)	0.647					0.647	6.616	3	125	3	S20T1	BPC
				H094 to H098 (T off)	0.174					0.174	6.790	3				
				H098 to H107 (T off)		0.721				0.721	7.511	3				
				H107 to H112 (Nizergang S/S)		0.426				0.426	7.937	3	25	3	S20T2	BPC
				H107to H115 (T off)		0.186				0.186	8.123	3				
				H115 to H117 (Rumina S/S)		0.090				0.090	8.213	3	25	3	S20T3	BPC
				H115 to H126(Samdrupgang S/S)		0.787				0.787	9.000	3	63	3	S20T4	BPC
				H126 to H132 (T off)		0.329				0.329	9.329	3				
				H132 to H140(Negopara S/S)		0.528				0.528	9.857	3	25	3	S20T5	BPC
				H132 to H152 (T off)			0.858			0.858	10.715	3				
				H152 to H157 (Kiblo S/S)			0.407			0.407	11.122	3	63	3	S20T6	BPC
				H152 to H167 (Chemcho S/S)			0.690			0.690	11.812	3	63	3	S20T7	BPC
				H098 to H222 (T off)	4.736					4.736	16.547	3				
				H222 to H223 (Phangyul S/S)	0.069					0.069	16.616	3	25	3	S20T8	BPC
				H222 to H233 (T off)	0.679					0.679	17.295	3				
				H233 to H239 (Begapara S/S)	0.461					0.461	17.756	3	25	3	S20T9	BPC
				H233 to H247 (Kumche S/S)	0.543					0.543	18.299	3	25	3	S20T10	BPC
				H247 to H260 (T off)	0.925					0.925	19.224	3				
				H260 to H292 (T off)		1.624				1.624	20.848	3				
				H292 to H293 (Thimakha S/S)		0.087				0.087	20.935	3	100	3	S20T11	BPC
				H292 to H301 (T off)		0.610				0.610	21.545	3				
				H301 to H307 (Balakha S/S)		0.313				0.313	21.858	3	63	3	S20T12	BPC
				H301 to H314 (Tashitokha S/S)		0.742				0.742	22.600	3	63	3	S20T13	BPC
				H314 to H332 (Tokha S/S)		1.202				1.202	23.802	3	63	3	S20T14	BPC
				H260 to H342 (T off)	0.697					0.697	24.499	3				
				H342 to H354 (Chundo Goenpa S/S)		0.870				0.870	25.369	3	63	3	S20T15	BPC
				H342 to H361(Upper Gangkha S/S)	0.430					0.430	25.799	3	25	3	S20T16	BPC
				H361 to H373(Lower Gangkha S/S)	0.810					0.810	26.609	3	25	3	S20T17	BPC
				H373 to H381 (T off)	0.509					0.509	27.118	3				
				H381 to H398 (Chebekha S/S)		1.013				1.013	28.131	3	63	3	S20T18	BPC
				H398 to H405 (T off)		0.640				0.640	28.771	3				
				H405 to H408 (Kinzangling S/S)		0.218				0.218	28.989	3	63	3	S20T19	BPC
				H405 to H414 (T off)		0.272				0.272	29.261	3				
				H414 to H416 (Lekokha S/S)		0.131				0.131	29.392	3	63	3	S20T20	BPC
				H414 to H426 (T off)		0.691				0.691	30.083	3				
				H426 to H443 (Gangju S/S)			1.687			1.687	31.770	3	63	3	S20T21	BPC
				H426 to H446 (Samtengang S/S)		0.171				0.171	31.941	3	63	3	S20T22	BPC
				H446 to H459 (T off)		1.013				1.013	32.954	3				
				H459 to H461 (Upper Gelekha S/S)		0.094				0.094	33.048	3	63	3	S20T23	BPC
				H461 to H462 (Lower Gelekha S/S)		0.009				0.009	33.057	3	63	3	S20T24	BPC
				H459 to H472 (T off)			0.740			0.740	33.797	3				
				H472 to H474 (Nishokha S/S)			0.090			0.090	33.887	3	63	3	S20T25	BPC
				H472 to H482 (Langkilo S/S)			0.431			0.431	34.318	3	63	3	S20T26	BPC
				H381 to H486 (T off)	0.319					0.319	34.637	3				
				H486 to H503(T off)			1.132			1.132	35.769	3				
				H503 to H505 (Reybekha S/S)			0.087			0.087	35.856	3	63	3	S20T27	BPC
				H503 to H517 (Nabesa S/S)			0.784			0.784	36.640	3	63	3	S20T28	BPC
				H486 to H520 (Chungsikha S/S)	0.187					0.187	36.827	3	63	3	S20T29	BPC
				H520 to H526 (T off)	0.483					0.483	37.310	3				
				H526 to H534 (Dagi Gonpa S/S)		0.623				0.623	37.933	3	25	3	S20T30	BPC
				H534 to H535 (End pole)		0.058				0.058	37.991	3				
				H526 to H536 (T off)		0.061				0.061	38.052	3				
				H536 to H546 (Marbole Factory)		0.609				0.609	38.661	3	500	3	S20T31	PVT

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H536 to H552 (Domkha S/S)	0.457					0.457	39.118	3	25	3	S20T32	BPC
				H552 to H562 (T Off)	0.728					0.728	39.846	3				
				H562 to H563 (Lower Ampekha S/S)		0.024				0.024	39.870	3	63	3	S20T33	BPC
				H562 to H572 (T off)	0.628					0.628	40.498	3				
				H572 to H590 (Upper Ampekha S/S)			1.251			1.251	41.749	3	63	3	S20T34	BPC
				H572 to H594 (Kazhi S/S)	0.191					0.191	41.940	3	63	3	S20T35	BPC
				H594 to H604 (Jagatokha S/S)	0.625					0.625	42.565	3	63	3	S20T36	BPC
				H604 to H618 (Lingkhabji S/S)	0.883					0.883	43.448	3	63	3	S20T37	BPC
				H618 to H630 (T off)	0.827					0.827	44.275	3				
				H630 to H631 (Chungdu S/S)	0.059					0.059	44.334	3	63	3	S20T38	BPC
				H630 to H643 (T off)		0.819				0.819	45.153	3				
				H643 to H646 (Chetokha S/S)		0.285				0.285	45.438	3	63	3	S20T39	BPC
				H643 to H649 (Dohawa S/S)		0.275				0.275	45.713	3	63	3	S20T40	BPC
				H222 to H662 (Phangyul Gonpa S/S)			1.189			1.189	46.902	3	63	3	S20T41	BPC
				H85 to H686(T off)		1.363				1.363	48.265	3				
				H686 to H711 (Khujula Lhakhang S/S)			1.680			1.680	49.945	3	63	3	S20T43	BPC
				H686 to H737 (T off)		2.417				2.417	52.362	3				
				H737 to H740 (Hebesa I S/S)		0.115				0.115	52.477	3	63	3	S20T44	BPC
				H737 to H750 (Hebesa II S/S)		0.828				0.828	53.305	3	63	3	S20T45	BPC
				H740 to H771 (Tshokothangka S/S)			1.596			1.596	54.901	3	63	3	S20T46	BPC
				H750 to H780 (T off)		0.696				0.696	55.597	3				
				H780 to H785 (Yuesa Wom S/S)		0.515				0.515	56.112	3	63	3	S20T47	BPC
				H785 to H790 (T off)			0.339			0.339	56.451	3				
				H790 to H799 (Yusa Gom S/S)			0.433			0.433	56.884	3	63	3	S20T48	BPC
				H790 to H813 (Gomchumo S/S)			1.061			1.061	57.945	3	63	3	S20T49	BPC
				H813 to H838 (Nabesa S/S)			1.719			1.719	59.664	3	63	3	S20T50	BPC
				H780 to H851 (Hali S/S)			0.900			0.900	60.564	3	63	3	S20T51	BPC
				H590 to H864 (Lower Komathang S/S)			1.045			1.045	61.609	3	63	3	S20T52	BPC
				H864 to H876 (Komathang Dzong S/S)			0.999			0.999	62.608	3	30	3	S20T53	BPC
				H631 to H891 (Lumchey S/S)		1.279				1.279	63.887	3	30	3	S20T54	BPC
				H891 to H903 (T off)		1.070				1.070	64.957	3				BPC
				H903 to H904 (Djakte & JOLO S/S)		0.101				0.101	65.058	3	63	3	S20T55	BPC
				H903 to H919 (Decholing Gonpa S/S)		1.381				1.381	66.439	3	25	3	S20T56	BPC
				H332 to H946 (T off)		1.577				1.577	68.016	3				
				H496 to H949 (Tiket zampa S/S)		0.173				0.173	68.189	3	63	3	S20T57	BPC
				H946 to H966 (T off)		1.127				1.127	69.316	3				
				H966 to H967 (Wachey wom S/S)		0.039				0.039	69.355	3	63	3	S20T58	BPC
				H966 to H1003 (Tasila Ropeway S/S)		3.054				3.054	72.409	3	125	3	S20T6	BPC
				H1003 to H1035 (T off)		2.170				2.170	74.579	3				
				H1035 to H1046 (Subesa S/S)			0.846			0.846	75.425	3	30	3	S20T59	BPC
				H1035 to H1065 (Sewagang S/S)		1.215				1.215	76.640	3	30	3	S20T65	BPC
				H1065 to H1069 (T off)		0.320				0.320	76.960	3				
				H1069 to H1078 (Esa S/S)		0.632				0.632	77.592	3	63	3	S20T62	BPC
				H1078 to H1096 (T off)			1.304			1.304	78.896	3				
				H1096 to H1097 (Zongphey S/S)			0.082			0.082	78.978	3	63	3	S20T60	BPC
				H1096 to H1119 (Gensa S/S)			1.973			1.973	80.951	3	30	3	S20T64	BPC
				H1069 to H1128 (Gangrichen S/S)		0.619				0.619	81.570	3	63	3	S20T65	BPC
				H1128 to H1136 (Rinchenling S S/S)			0.530			0.530	82.100	3	250	3	S20T66	BPC
				H967 to H1148 (Wachey gomo S/S)		0.665				0.665	82.765	3	63	3	S20T67	BPC
				H1148 to H1185 (Ganzingkha S/S)		2.608				2.608	85.373	3	63	3	S20T68	BPC
				H1185 to H1200 (Omchengang S/S)		0.858				0.858	86.231	3	30	3	S20T69	BPC
				H1200 to H1214 (Kangchikewa S/S)		0.993				0.993	87.224	3	63	3	S20T70	BPC
				H1214 to H1277 (Khelekha S/S)		4.238				4.238	91.462	3	63	3	S20T71	BPC
				H1097 to H1287 (T off)			0.774			0.774	92.236	3				
				H1287 to H1326 (Shelley S/S)			3.044			3.044	95.280	3	63	3	S20T72	BPC
				H919 to 1348 (T off)			2.033			2.033	97.313	3				
				H1348 to H1373 (Damchuthang S/S)			2.218			2.218	99.531	3	63	3	S20T73	BPC
1	Lobeysa Substation (66/33kV,	33kV Feeder II Lobeysa to Phobjikha		H1373 to H1384 (Tamji S/S)			1.030			1.030	100.561	3	63	3	S20T74	BPC

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
	2x5MVA)			H1384 to H1412 (Zhabjey Lhakhang S/S)			2.000			2.000	102.561	3	63	3	S20T75	BPC
				H1412 to H1430 (Yeshi Samteling S/S)			1.050			1.050	103.611	3	63	3	S20T76	BPC
				H649 to H1436 (Pangkhar A S/S)			0.738			0.738	104.349	3	25	2	S20T77	BPC
				H1436 to 1439 (Phangkhar B S/S)			0.447			0.447	104.796	3	25	2	S20T78	BPC
				H1129 to H1465 (T off)		1.670				1.670	106.466	3				
				H1465 to H1558 (T off)		7.904				7.904	114.370	3				
				H1558 to H1576 (T off)		1.828				1.828	116.198	3				
				H1576 to H1647		5.721				5.721	121.919	3				
				H771 to H1662 (T off)			1.110			1.110	123.029	3				
				H1162 to H1163 (Jana Goenpa S/S)			0.052			0.052	123.081	3	10	2	S20T79	BPC
				H1662 to H1675 (Lamitshekha S/S)			1.190			1.190	124.271	3	25	2	S20T80	BPC
				H443 to H11691 (T off)			1.493			1.493	125.764	3				
				H1691 to H1699 (Dhakhu S/S)			0.516			0.516	126.280	3	25	2	S20T81	BPC
				H1691 to H1713 (T-off)			1.339			1.339	127.619	3				
				H1713 to H1721 (Phaseytokha S/S)			0.627			0.627	128.246	3	25	2	S20T82	BPC
				H1713 to H1725 (Phadeykha S/S)			0.216			0.216	128.462	3	25	2	S20T83	BPC
				H1713 to H1738 (Khamina A S/S)			1.025			1.025	129.487	2	10	2	S20T84	BPC
				H1277 to H1749 (T off)		0.890				0.890	130.377	3				
				H1749 to H1783 (T Off)		2.999				2.999	133.376	3				
				H1783 to H1800 (T off)		1.583				1.583	134.959	3				
				H1800 to H1806 (Adha Gangchu S/S)			0.219			0.219	135.178	2	10	2	S20T85	BPC
				H1800 to H1847 (T off)		2.860				2.860	138.038	3				
				H1847 to H1850 (Nobding School S/S)		0.190				0.190	138.228	3	63	3	S20T86	BPC
				H1847 to H1855 Nobding Town S/S)		0.594				0.594	138.822	3	125	3	S20T87	BPC
				H1855 to H1893 (Dungdunesa S/S)		3.141				3.141	141.963	3	63	3	S20T88	BPC
				H1783 to H1903 (Rachow S/S)			0.922			0.922	142.885	3	25	3	S20T89	BPC
				H1903 to H1919 (Tangakha S/S)			1.449			1.449	144.334	3	25	3	S20T90	BPC
				H1919 to H1944 (Lokhachey S/S)			2.626			2.626	146.960	3	16	3	S20T91	BPC
				H1558 to H1956 (Gogona Chewa S/S)			0.932			0.932	147.892	3	63	3	S20T92	BPC
				H1956 to H1967 (Thangka S/S)			0.685			0.685	148.577	3	25	3	S20T140	BPC
				H1893 to H1975 (T off)		0.629				0.629	149.206	3				
				H1975 to H2009 (Pelela Telecom S/S)		2.421				2.421	151.627	3	63	3	S20T154	BPC
				H2008 to H2032 (T off)		1.518				1.518	153.145	3				
				H2032 to H2050 (Gangchudor S/S)			1.356			1.356	154.501	2	10	2	S20T95	BPC
				H2050 to H2072 (Gangchukha S/S)			2.035			2.035	156.536	2	25	2	S20T96	BPC
				H2032 to H2078 (T off)		0.593				0.593	157.129	3				
				H2078 to H2080 (Longtey S/S)		0.108				0.108	157.237	2	63	2	S20T97	BPC
				H2078 to 2094 (T off)		1.238				1.238	158.475	3				
				H2094 to 2099 (T off)		0.469				0.469	158.944	3				
				H2099 to 2105 (Yangtrue S/S)		0.473				0.473	159.417	3	25	2	S20T98	BPC
				H2099 to 2117 (Logmey S/S)		1.036				1.036	160.453	3	250	3	S20T99	BPC
				H2117 to H2140 (Bumelo S/S)		1.950				1.950	162.403	3	63	3	S20T137	BPC
				H2140 toH2149 T off)		0.928				0.928	163.331	3				
				H2149 to H2157 (T off)		0.648				0.648	163.979	3				
				H2157 to H2166 (Rebena S/S)		0.967				0.967	164.946	3	25	2	S20T100	BPC
				H2157 to H2169 (Phuntsho Merry S/S)		0.319				0.319	165.265	3	63	3	S20T101	BPC
				H2149 to H2183 (Lower Rukubji S/S)		1.304				1.304	166.569	3	10	2	S20T102	BPC
				H2183 to H2192 (T off)		0.658				0.658	167.227	3				
				H2192 to H2202 (Chazam A S/S)		1.235				1.235	168.462	3	63	3	S20T103	BPC
				H2202 to H2206 (Chazam B S/S)			0.464			0.464	168.926	3	63	3	S20T104	BPC
				H2206 to H2211 (T off)			0.486			0.486	169.412	3				
				H2211 to H2227 (Darelo S/S)			1.739			1.739	171.151	3	63	3	S20T105	BPC
				H2227 to H2231 (T off)			0.328			0.328	171.479	3				
				H2231 to H2236 (Wangdue Gonpa S/S)			0.396			0.396	171.875	3	63	3	S20T106	BPC
				H2231 to H2246 (School S/S)			1.137			1.137	173.012	3	63	3	S20T107	BPC
				H2246 to H2250 (T off)			0.469			0.469	173.481	3				
				H2250 to H2256 (Lamji S/S)			0.729			0.729	174.210	2	25	2	S20T108	BPC
				H2250 to H2263 (Range office S/S)			0.867			0.867	175.077	3	63	3	S20T155	BPC

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H2263 to H2265 (T off)			0.281			0.281	175.358	2				
				H2265 to H2266 (Lubzor A S/S)			0.153			0.153	175.511	2	16	2	S20T109	BPC
				H2265 to H2269 (Lubzor B S/S)			0.256			0.256	175.767	2	25	2	S20T110	BPC
				H2265 to H2275 (Ziri S/S)			1.136			1.136	176.903	2	25	2	S20T111	BPC
				H1893 to H2292 (T off)			1.367			1.367	178.270	2				
				H2292 to H2296 (Rida Gonpa S/S)			0.406			0.406	178.676	2	63	2	S20T112	BPC
				H2296 to H2310 (Rida Wom S/S)		1.227				1.227	179.903	2	63	2	S20T113	BPC
				H2292 to H2318 (T off)			1.222			1.222	181.125	2				
				H2318 to H2324 (Yusagang S/S)			0.442			0.442	181.567	2	25	2	S20T114	BPC
				H2318 to H2352 (T off)			4.536			4.536	186.103	2				
				H2352 to H2355 (Tashidingkha S/S)			0.482			0.482	186.585	2	25	2	S20T115	BPC
				H2352 to H2366 (Tshegona S/S)			1.937			1.937	188.522	2	25	2	S20T116	BPC
				H2366 to H2373 (T off)			0.953			0.953	189.475	2				
				H2373 to H2374 (T off)			0.043			0.043	189.518	2				
				H2374 to H2376 (Dosina S/S)			0.142			0.142	189.660	2	10	2	S20T117	BPC
				H2374 to H2380 (T off)			0.380			0.380	190.040	2				
				H2380 to H2382 (Chubar Chorten S/S)			0.194			0.194	190.234	2	16	2	S20T118	BPC
				H2380 to H2385 (Chubr S/S)			0.387			0.387	190.621	2	10	2	S20T119	BPC
				H2385 to H2388 (Dangchu Gonpa S/S)			0.374			0.374	190.995	2	25	2	S20T120	BPC
				H2373 to H2390 (School S/S)			0.361			0.361	191.356	2	25	2	S20T121	BPC
				H2380 to H2393 (T off)			0.430			0.430	191.786	2				
				H2393 to H2395 (Lamsay S/S)			0.238			0.238	192.024	2	25	2	S20T122	BPC
				H2393 to H2397 (T off)			0.152			0.152	192.176	2				
				H2397 to H2399 (T off)			0.331			0.331	192.507	2				
				H2399 to H2405 (Tamla S/S)			0.586			0.586	193.093	2	25	2	S20T123	BPC
				H2399 to H2421 (Lumzur S/S)			1.936			1.936	195.029	2	25	2	S20T124	BPC
				H2397 to H2426 (Khasay S/S)			0.709			0.709	195.738	2	16	2	S20T125	BPC
				H2426 to H2432 (Gobja S/S)			0.746			0.746	196.484	2	25	2	S20T126	BPC
				H2211 to H2456 (T off)			1.645			1.645	198.129	3				
				H2456 to H2458 (Tsagatintin S/S)			0.279			0.279	198.408	2	10	2	S20T127	BPC
				H2456 to H 2460 (T off)			0.286			0.286	198.694	3				
				H2460 to H2464 (Nangkha S/S)			0.536			0.536	199.230	2	25	2	S20T128	BPC
				H2460 to H2468 (Rabu S/S)			0.591			0.591	199.821	2	10	2	S20T129	BPC
				H711 to H2490 (Pangsho S/S)			2.351			2.351	202.172	3	16	2	S20T130	BPC
				H1287 to H2506 (Chebigang S/S)			1.451			1.451	203.623	3	25	2	S20T131	BPC
				H1465 to H2526 (Dechendraphu S/S)			1.681			1.681	205.304	3	10	2	S20T132	BPC
				H1749 to H2546 (Goga S/S)			2.141			2.141	207.445	2	25	2	S20T133	BPC
				H1645 to H2549 (Phobjikha S/S)			0.201			0.201	207.646	3				
				H2464 to H2587 (Sekta S/S)		4.509				4.509	212.155	2	25	2	S20T134	BPC
				H2094 to H2588 (Tshamdro S/S Pvt)			0.104			0.104	212.259	3	63	3		PVT
				H1576 to H2593 (Chubja S/S)		0.354				0.354	212.613	3	25	3	S20T142	BPC
				H1975 to H2596 (Dungdunesa Stone Quarry S/S)		0.297				0.297	212.910	3	500	3		PVT
				H1975 to H2619		2.469				2.469	215.379	3	250		S20T144	
				H2620 to H2731				11.165		11.165	226.544	3				
				H2311 to H2753 (Zeel S/S)		2.359				2.359	228.903	3	16	3	S20T148	BPC
				H2420 to 2783 (Taksar S/S)		3.129				3.129	232.032	3	16	3	S20T149	BPC
				H1691 to 2798 (Cheni Dzong S/S)			1.424			1.424	233.456	3	16	3	S20T150	BPC
				H2192 to H2821 (Chuserbu S/S)			2.130			2.130	235.586	3	315		S20T156	PvT
				H2821 to H2908 (Tapping from Nikachu)			9.899			9.899	245.485					
				H1348 to H2921 (Seel S/S)			1.105			1.105	246.590	3	30	3	S20T152	BPC
				H1903 to H2934 (Lur S/S)			1.230			1.230	247.820	3	25	2	S20T153	BPC
				H2731 to Phobjikha S/S					0.020		247.840	3	2X2.5MVA	3		BPC
				Total	**22.036**	**105.791**	**108.828**	**11.165**	**0.020**	**247.820**	**247.840**		**8350.000**			
11kV Feeder III Lobeysa SS to Kingaling																
				Lobesa(H000) to H05 (T off to)			0.604				0.604	0.604	3			
				H05 to H08 (CNR Substation)			0.097				0.097	0.701	3	500	3	S30T1
				H05 to H011(T Off)			0.132				0.132	0.833	3			

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
2	Lobeysa Substation (66/11kV, 2x5MVA)	11kV feeder II Lobeysa SS to Kingaling	11	H011 to H014 (End point, to be removed)			0.106				0.106	0.939	3			
				H011 to H028	0.568						0.568	1.507	3			
				H028 to 49 (T Off)			1.297				1.297	2.804	3			
				H049 to H053 Kingaling Hotel S/S			0.193				0.193	2.996	3	500	3	S30T2
				H049 to H57			0.186				0.186	3.182	3			
				H057 to H67 (New Hospital S/S)	0.885						0.885	4.067	3	2000	3	S30T3
				H008 to H70 (To CNR Package S/S)	0.092						0.092	4.159	3			
				H70 to H71 (CNR package S/S)						0.250	0.250	4.409	3	500	3	S30T4
				Total	**1.545**	**0.00**	**2.614**	**0.00**	**0.00**	**0.25**	**4.409**	**4.409**		**3500**		
11kV Feeder IV Lobeysa SS to Chuzomsa/Gaselo Area																
3	Lobeysa Substation (66/11kV, 2x5MVA)	11kV feeder IV From Lobeysa SS to Chuzomsa/Gaselo area	11	H000 to H006			0.524				0.524	0.524	3			
				H006 to H021 (T off)			1.098				1.098	1.622	3			
				H021 to H022 (DIWC S/S)			0.074				0.074	1.696	3	315	3	S40T2
				H021 to H049 (T off)			2.200				2.200	3.896	3			
				H049 to H190 (Upper Town S/S)						0.122	0.122	4.018	3	750	3	S40T11
				H049 to H054 (T off)			0.335				0.335	4.353				
				H54 to H055 (Retsha S/S)			0.042				0.042	4.395	3	250	3	S40T3
				H054 to H071 (T off)			0.917				0.917	5.312	3			
				H071 to H0138 (RBA Canteen SS)			0.481				0.481	5.793	3	750	3	S40T13
				H071 to H088(T off)			1.082				1.082	6.875	3			
				H088 to H089 (Rabuna Jail S/S)			0.031				0.031	6.906	3	63	3	S40T4
				H088 to H098 (T off)			0.748				0.748	7.654	3			
				H098 to H105 (Nyelekha S/S)			0.322				0.322	7.976	3	50	3	S40T5
				H098 to H119 (T off)			1.386				1.386	9.362	3			
				H119 to H120 (PWD Rabuna S/S)			0.034				0.034	9.396	3	25	3	S40T6
				H119 to H124 (T off)			0.448				0.448	9.844	3			
				H124 to H132 (Rabuna SS)			0.630				0.630	10.474	3	25	3	S40T140
				H132 to H153 (Kichu Resort S/S)			2.050				2.050	12.525	3	250	3	S40T7
				H153 to H158 (Chuzomsa S/S)			0.522				0.522	13.046	3	125	3	S40T8
				H124 to H171 (Palukha S/S)			0.756				0.756	13.802	3	25	3	S40T9
				H171 to H189 (Zamding S/S)			1.176				1.176	14.979	3	63	3	S40T10
				H138 to H139 (T off)			0.084				0.084	15.063	3			
				H139 to H143 (T off)			0.288				0.288	15.351	3			
				H143 to H148 (Telecom S/S)			0.306				0.306	15.657	3	250	3	S40T14
				H143 to H171(T off)			2.316				2.316	17.973	3			
				H171 to H177 (Petakarp S/S)			0.321				0.321	18.294	3	315	3	S40T15
				H171 to H183 (PWD Hesothangka S/S)			0.461				0.461	18.755	3	500	3	S40T16
				H183 to H184 (T off)			0.084				0.084	18.839	3			
				H184 to H189 (Micro Power Hose S/S)			0.362				0.362	19.201	3	400	3	S40T17
				H184 to H212 (Pangtsho S/S)			1.437				1.437	20.638	3	63	3	S40T18
				H212 to H224 (T off)			1.027				1.027	21.665	3			
				H224 to H226 (Masapoto S/S)			0.235				0.235	21.900	3	63	3	S40T19
				H224 to H234(T off)			0.525				0.525	22.425	3			
				H234 to H239 (Changchey S/S)			0.425				0.425	22.850	3	63	3	S40T20
				H234 to H246 (T off)			0.528				0.528	23.378	3			
				H246 to H251 (Khempajichu S/S)			0.28				0.28	23.658	3	63	3	S40T21
				H227 to H259 (T off)			0.902				0.902	24.560	3			
				H259 to H268 (Gumina S/S)			1.101				1.101	25.661	3	50	3	S40T22
				H268 to H298(Lower Masakha S/S)			1.792				1.792	27.453	3			
				H298 to H316 (Lawakha S/S)			0.861				0.861	28.314	3	63	3	S40T24
				H278 to H319 (T off)			0.306				0.306	28.620	3			
				H319 to H322 (Changkha S/S)			0.338				0.338	28.958	3	63	3	S40T25
				H322 to H324 (T off)			0.254				0.254	29.212	3			
				H324 to H328 (Phakha S/S)			0.451				0.451	29.663	3	25	3	S40T26
				H319 to H339 (Lower Shingkhe S/S)			1.195				1.195	30.858	3	25	3	S40T27
				H339 to H344 (Upper Shingkhe S/S)			0.354				0.354	31.212	3	25	3	S40T28

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H273 to H346 (Gaselo High School S/S)			0.13				0.13	31.342	3	250	3	S40T29
				H259 to H368 (Khamina S/S)			0.242				0.242	31.584	3	50	3	S40T32
				H368 to H375 (Khatokha S/S)			0.485				0.485	32.069	3	25	3	S40T33
				H246 to H400 (Japhu S/S)			1.557				1.557	33.626	3	63	3	S40T34
				H139 to H401 (RBA fimily S/S)			0.08				0.08	33.706	3	500	3	S40T35
				H487 to H402 (T off)			0.099				0.099	33.805	3			
				H402 to H424 (Rinchengang Near BoD)	1.049						1.049	34.854	3	315	3	S40T36
				H99 H425 (End pole)			0.055				0.055	34.909	3			
				H324 to H485 (Sharipangkha S/S)				3.810			3.81	38.719	2	16	2	S40T39
				H168 to H488 (T Off)			0.295				0.295	39.014	3			
				H488 to H491 Petakap S/S)			0.139				0.139	39.153	3	500	3	S40T38
				New Dzong USS						0.26	0.26	39.413	3	500	3	S40T41
				Wind power			0.21				0.21	39.623	3	50	3	S40T50
				H491 to H495 (New Dangchuk S/S)			0.112				0.112	39.735	3	250	3	S40T39
				Total	**1.049**	**0.000**	**34.494**	**3.810**	**0.000**	**0.382**	**39.735**	**39.735**		**7178**		
11kV Feeder V Lobeysa SS to Bajo Town&RBA area																
				H000 to H006 (T off)			0.451				0.451	0.451	3			
				H006 to H018 (Tshokhana A S/S)			1.032				1.032	1.483	3	100	3	S50T1
				H018 to H025 (Tshokhana B S/S)			0.557				0.557	2.04	3	63	3	S50T36
				H025 to H027 (Wangjokha S/S)			0.237				0.237	2.277	3	250	3	S50T2
				H027 to H030 (T off)			0.206				0.206	2.483	3			
				H030 to H036 (T off)			0.446				0.446	2.929	3			
				H036 to H041			0.457				0.457	3.386	3			
				H040 to H042	0.034						0.034	3.42	3			
				H034 to H043	0.028						0.028	3.448	3			
				H043 to H054 (VTI Samthang S/S)			1.03				1.03	4.478	3	500	3	S50T4
				H036 to H064 (Matalungchu S/S)			0.723				0.723	5.201	3	25	3	S50T5
				H064 to H079 (T off)			1.587				1.587	6.788	3			
				H079 to H084 (Lumpa S/S)			0.493				0.493	7.281	3	25	3	S50T6
4	Lobeysa Substation (66/11kV,2x5MVA)	11kV Feeder V Lobeysa SS to Bajo Town	11	H030 to H097 (Bajo High School S/S)			0.828				0.828	8.109	3	500	3	S50T7
				H97 to H99 (T off)			0.112				0.112	8.221	3			
				H99 H103 (T off)			0.377				0.377	8.598	3			
				H103 to H105 (Naseep S/S)			0.114				0.114	8.712	3	315	3	S50T8
				H103 to H108 (T off)			0.245				0.245	8.957	3			
				H108 to H109 (RNRRC Bajo S/S)			0.047				0.047	9.004	3	250	3	S50T9
				H109 to H117 (Lower Market S/S)			0.481				0.481	9.485	3	500	3	S50T10
				H117 to H119 (Rinchengang S/S)			0.278				0.278	9.763	3	315	3	S50T11
				H108 to H124 (RBA S/S)			0.257				0.257	10.02	3	500	3	S50T12
				H79 to H349 (Omtokha S/S)			0.323				0.323	10.343	3	125	3	S50T30
				H006 to H363 (Dorangthang S/S)			0.953				0.953	11.296	3	63	3	S50T31
				H425 to H426 (Lower Town S/S)						0.069	0.069	11.365	3	750	3	S50T37
				H41 to H428 (T off)	0.072						0.072	11.437	3			
				H428 to H432 (Thangu S/S)	0.11						0.11	11.547	3	250	3	S50T3
				Total	**0.244**		**11.234**	**0.000**		**0.069**	**11.547**	**11.547**		**4531**		
11kV Feeder IV Basochu SS to Mephuna, Hebesa, Tapchakha area																
				Basochu (H000 to H008) Rurichu Power House S/S	0.430			0.430	0.430	3	250	3	S10T1	BPC		
				H008 to H020 (Rurichu Telecom S/S)	0.798			0.798	1.228	3	500	3	S10T2	BPC		
				H008 to H036(T-off)	1.116			1.116	2.344	3				BPC		
				H036 to H040 (PHPA Workshop S/S)	0.276			0.276	2.620	3	630	3	S10T3	PVT		
				H036 to H052 (Toff)	1.018			1.018	3.638	3	63	3	S10T4	BPC		
				H052 to H072(Dema Vasti S/S)	1.688			1.688	5.326	3	16	2	S10T6	BPC		
				H052 to H085(Mephuna S/S)	0.949			0.949	6.275	3	16	3	S10T13	BPC		
5	Basochu Substation (66/11kV,5MVA)	11 kV Feeder IV from Basochu to Hesokha	11 kV	H085 to H113 (T-Off)	2.087			2.087	8.362	3						
				H113 to H116 (Genkha S/S)	0.195			0.195	8.557	3	16	3	S10T7	BPC		

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H116 to H128 (T off)	0.944			0.944	9.501	3						
				H128 to H144(T off to Intake)	1.221			1.221	10.722	3						
				H144 to H146 (Intake S/S)	0.089			0.089	10.811	3			S10T8		Transformer Removed at S	
				H146 to H168 (Intake top S/S)	1.707			1.707	12.518	3	250	3	S10T9	BPC		
				H168 to H180 (Hesokha S/S)	1.367			1.367	13.885	3	16	3	S10T10	BPC		
				H113 to H195 (Tapcheykha S/S)	1.135			1.135	15.020	3	16	3	S10T11	BPC		
				H129 to H208 (Sentokha S/S)		1.328		1.328	16.348	2	16	2	S10T12	BPC		
				Total	**15.020**	**1.328**	**0**	**16.348**	**16.348**		**1789**					
11kV Feeder III Basochu SS to Jalla/Ulla area																
				H000 to H030 (T off)			1.901				1.901	1.901	3			
				H030 to H036 (Rurichu S/S)			0.357				0.357	2.258	3	250	3	S70T1
				H036 to H090 (T off)			4.236				4.236	6.493	3			
				H090 to H108 (Baychu S/S)			1.149				1.149	7.642	3	750	3	S70T2
				H090 to H127 (Poonma S/S)			1.393				1.393	9.035	3	25	3	S70T3
				H127 to H131 (T off)				0.471			0.471	9.506	3			
				H131 to H132 (Khamey S/S)				0.056			0.056	9.561	3	63	3	S70T4
				H131 to H144 (Khatey S/S)				0.864			0.864	10.425	3	63	3	S70T5
				H30 to H157 (T off)			0.952				0.952	11.377	3			
				H157 to H160 (Rechekha S/S)			0.196				0.196	11.573	3	25	3	S70T6
				H157 to H179 (Ulla S/S)				1.316			1.316	12.889	3	63	3	S70T7
				H160 to H204 (Jalla S/S)				1.994			1.994	14.883	3	63	3	S70T8
				H108 to H225 (T off)			1.629				1.629	16.512	3			
				H225 to H226 (Gesokha S/S)			0.028				0.028	16.540	3	25	3	S70T9
				H225 to H245 (T off)			1.646				1.646	18.186	3			
				H245 to H252 (Jarigang S/S)			0.413				0.413	18.599	3	63	3	S70T10
				H245 to H288 (T off)			3.415				3.415	22.014	3			
				H288 to H290 (Kamichu S/S)			0.139				0.139	22.153	3	63	3	S70T11
				H288 to H295(T off)				0.371			0.371	22.524	3			
				H295 to H315 (T off)				1.898			1.898	24.422	3			
				H315 to H330 (Zawa S/S)				1.819			1.819	26.241	3	25	3	S70T12
				H330 to H343 (Yutamo S/S)				1.515			1.515	27.756	3	16	3	S70T13
				H315 to H402 (T off)				7.093			7.093	34.849	3			
				H402 to H406 (T off)				0.382			0.382	35.231	3			
				H406 to H408 (Lopakha A S/S)				0.214			0.214	35.445	3	25	3	S70T14
				H406 to H410 (Lopakha B S/S)				0.254			0.254	35.699	3	25	3	S70T15
				H410 to H411 (T off)				0.081			0.081	35.780	3			
	Basochu Substation (66/11kV, 5MVA)	11kV Feeder III from Basochu Substation to Jalla/Ulla		H411 to H420 (Phaktakha S/S)				0.747			0.747	36.527	2	16	2	S70T16
6			11 kV	H411 to H422(Lopokha B2 S/S)				0.143			0.143	36.670	3	25	3	S70T17
				H422 to H432 (Kago S/S)				1.071			1.071	37.741	2	10	2	S70T18
				H402 to H451 (T off)				1.751			1.751	39.492	3			
				H451 to H454 (Lomsokha S/S)				0.265			0.265	39.757	2	10	2	S70T19
				H451 to H455 (Gemdro S/S)				0.142			0.142	39.899	3	16	3	S70T20
				H295 to H498 (T off)			4.832				4.832	44.731	3			
				H498 to H575 (T off)			6.814				6.814	51.545	3			
				H575 to H594 (Takshachhu S/S)			1.471				1.471	53.016	3	125	3	S70T21
				H594 to H666 (Tshara A S/S)			6.839				6.839	59.855	3	25	3	S70T22
				H666 to H667 (T off)			0.212				0.212	60.067	3			
				H667 to H670 (Tshara B S/S)			0.173				0.173	60.240	3	16	3	S70T23
				H667 to H677 (T off)			0.508				0.508	60.748	3			
				H677 to H678 (School S/S)			0.025				0.025	60.773	3	25	3	S70T24
				H677 to H683 (Taksha S/S)			0.429				0.429	61.202	3	25	3	S70T25
				H683 to H686 (Taksha B S/S)			0.163				0.163	61.365	3	16	3	S70T26
				H686 to H700 (Silley S/S)			1.082				1.082	62.447	3	25	3	S70T27
				H498 to H702 (Pinsa S/S)			0.052				0.052	62.499	3	63	3	S70T28
				H702 to H732 (Gabakha S/S)				2.730			2.730	65.229	3	25	3	S70T29
				H575 to H737 (Tsangzomsa S/S)				0.377			0.377	65.606	3	10	2	S70T30

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H737 to H789 (Harachhu S/S)					4.646		4.646	70.252	3	16	3	S70T31
				H789 to H823 (Samthang S/S)					2.6		2.600	72.852	3	25	3	S70T32
				H823 to H838 (T off)					2.182		2.182	75.034	3			
				H383 to H840 (Mitina S/S)					0.202		0.202	75.236	3	25	3	S70T33
				H840 to H851 (T off)					1.313		1.313	76.549	3			
				H851 to H862 (Lower Rukha S/S)					1.395		1.395	77.944	3	25	3	S70T34
				H862 to H868 (Upper Rukha S/S)					0.721		0.721	78.665	3	25	3	S70T35
				H851 to H876 (Thaphu s/S)					0.788		0.788	79.453	3	25	3	S70T36
				H875 to H892 (Lamga S/S)					2.381		2.381	81.834	3	25	3	S70T37
				H838 to H894 (Kashecheko S/S)					0.403		0.403	82.237	3	10	2	S70T38
				H252 to H919 (Jarigang Top S/S)				2.449			2.449	84.686	3	10	3	S70T39
				Total			**40.053**	**28.002**	**16.631**	**0**	**84.686**	**84.686**		**2162**		
11kV Feeder I Basochu SS to Hebesa area																
7	Basochu substation (66/11kV, 5MVA)	11kV Feeder I from Basochu Substation to Hebesa	11kV	11kV Basochu to H000						0.02	0.02					
				H001 to H047			2.937				2.937	2.937				
				H047 to H054 (Hebesa Tunnel)			0.442				0.442	3.379	3	500		S100T1
				H54 to H60 (Hebesa village S/S)				0.92			0.92	4.299	3	63		S100T2
				H60 to H64 (Hebesa School)				0.234			0.234	4.533	3	250		S100T3
				H47 to H65 (T off)			0.059				0.059	4.592	3			
				H65 to H71 (T off)			0.156				0.156	4.748	3			
				H71 to H90 (Yarkay Camp)			1.25				1.25	5.998	3	50		S100T4
				H90 to H91 (Toff)			0.092				0.092	6.09	3			
				H91 to H139 (Intake Basachu)	3.657						3.657	9.747	3	250		S100T5
				H139 to H 142 (End Pole)			0.2				0.2	9.947	3			
				Total	**3.657**		**5.136**	**1.154**		**0.02**	**9.967**	**9.947**		**1113**		
11kV Feeder II (Gangphel)																
8	Phobjikha S/S (33/11kV), 2x2.5MVA	11kV Gangphel Feeder	11	Phobjikha S/S to H001						0.078	0.078	0.078	3			
				H001 to H16 (T off)	0.518						0.518	0.596	3			
				H16 to H017 (Phobjikha BHU S/S)	0.018						0.018	0.614	3	250	3	S80T1
				H017 to H024 (T off)	0.245						0.245	0.859	3			
				H024 to P1 (Eusa Shed S/S)						0.431	0.431	1.29	3	63	3	S80T2
				H024 to H046 (Upper Damchen Lhakhang S/S)	0.926						0.926	2.216	3	25	3	S80T3
				H046 to H051 (T off)	0.226						0.226	2.442	3			
				H051 H055 (Lower Damchen Lhakhang S/S)	0.134						0.134	2.576	3	63	3	S80T4
				H051 to H144(Tapping to UG)	3.235						3.235	5.811	3			
				H144 to P2 (Gangphel Shed S/S)							0	5.811	3	63	3	S80T5
				P2 to H145(Tapping to HV ABC)						0.483	0.483	6.294	3			
				H145 to H149(Tapping to UG)	0.12						0.12	6.414	3			
				H149 to H150 (T off)						0.501	0.501	6.915	3			
				H150 to H183 (Zizi S/S)	1.539						1.539	8.454	3	63	3	S80T6
				H183 to H249 (Shoba S/S)	2.006						2.006	10.46	3	63	3	S80T7
				H055 to P3 (Lower Kilkhorthang S/S)						1.403	1.403	11.863	3	63	3	S80T8
				P3 to H250 (T off)						0.521	0.521	12.384	3			
				H250 to H269 (Upper Kirkhorthang S/S)	0.484						0.484	12.868	3	16	3	S80T9
				H250 to H270 (T off)	0.004						0.004	12.872	3			
				H270 to H298 (Kilkhorthang Lhakhang S/S)	0.708						0.708	13.58	3	63	3	S80T10
				P3 to P4 (Phobjikha Gup office S/S)						0.983	0.983	14.563	3	16	3	S80T11
				H150 to H317 (Chakchey S/S)	0.802						0.802	15.365	3	25	3	S80T12
				H317 to H333 (T off)	0.67						0.67	16.035	3			
				H333 to P5 (Ziphu Shed S/S)						0.494	0.494	16.529	3	125	3	S80T13
				H333 to H364 (T off)	1.756						1.756	18.285	3			
				H364 to P6 (Ziphu School Shed)						0.618	0.618	18.903	3	63	3	S80T14
				H364 to H401 (T off)	1.08						1.08	19.983	3			
				H401 to P7 (Taphu Shed S/S)	0.254						0.254	20.237	3	63	3	S80T15
				H401 to H425 (Nimdrosa S/S)	0.819						0.819	21.056	3	63	3	S80T16
				H425 to H465 (Jogay S/S)	1.586						1.586	22.642	3	16	3	S80T17
				H465 to 494 (Tangchey gonpa S/S)	1.105						1.105	23.747	3	125	3	S80T18

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
				H494 to H530 (Khemdro S/S)	1.427						1.427	25.174	3	63	3	S80T19
				H530 to H542 (Talam S/S)	0.543						0.543	25.717	3	25	3	S80T20
				H542 to H550 (Nimphel S/S)	0.402						0.402	26.119	3	25	3	S80T21
				H550 to HH583 (End pole)	1.402						1.402	27.521	3			
				H249 to H600 (Khebeythang S/S)				1.687			1.687	29.208	3	25	3	S80T22
				Total	**22.009**			**1.687**		**5.512**	**29.208**	**29.208**		**1366**		
11kV Feeder IV (Gangtey)																
9	Phobjikha substation (33/11kV, 2x2.5MVA)	11kV Gangtey Feeder	11kV	Phobjikha S/S to H001						0.046	0.046	0.046	3			
				H001 to H024 (T off)	0.778						0.778	0.824	3			
				H0224 to H038 (Dewachen S/S)	0.552						0.552	1.376	3	25	3	S90T1
				H038 to H068 (Gakiling S/S)	1.143						1.143	2.519	3	100	3	S90T2
				H068 to H084 (T off)	0.579						0.579	3.098	3			
				H084 to P1 (Mole A Shed)						0.009	0.009	3.107	3	25	3	S90T3
				H084 to H110(Mang S/S)	1.058						1.058	4.165	3	25	3	S90T4
				H110 to H120 (T off)	0.388						0.388	4.553	3			
				H120 to P2 (Mole B)						0.079	0.079	4.632	3	25	3	S90T5
				H120 to H149 (T off)	1.17						1.17	5.802	3			
				H149 to H155 (T off)	0.187						0.187	5.989	3			
				H149 to H162 (Sangtana S/S)	0.308						0.308	6.297	3	100	3	S90T6
				H162 to H178 (T off)	0.688						0.688	6.985	3			
				H178 to P3 (Pangkarp S/S)						0.024	0.024	7.009	3	25	3	S90T7
				H178 to H210	1.014						1.014	8.023	3			
				H210 to P4 (Tokha S/S)	0.569						0.569	8.592	3	250	3	S90T8
				H155 to P5 (Bayta Shed)						0.628	0.628	9.22	3	125	3	S90T9
				P5 to H211 (T off)						0.517	0.517	9.737	3			
				H211 to H22 (T off)	0.294						0.294	10.031	3			
				H222 to P6 (Gangtey Lhakhang S/S)						0.042	0.042	10.073	3	125	3	S90T10
				H222 to 233 (Gangtey village S/S)						0.411	0.411	10.484	3	250	3	S90T11
				P7 to H234 (T off)						0.122	0.122	10.606	3			
				H234 to H252 (T off)	0.552						0.552	11.158	3			
				H252 to P8 (Jhangchey Shed)						0.552	0.552	11.71	3	63	3	S90T12
				H252 to H285 (Drupkhang S/S)	0.958						0.958	12.668	3	25	3	S90T13
				H285 to H334 (Kumbu S/S)	1.704						1.704	14.372	3	25	3	S90T14
				H285 to P9 (Gangtey Shedra S/S)						0.351	0.351	14.723	3	250	3	S90T15
				P9 to H346	0.391						0.391	15.114	3			
				H346 to P10 (Gela Shed)						0.037	0.037	15.151	3	63	3	S90T16
				H234 to H362	0.468						0.468	15.619	3			
				H362 to P11 (Semchubara S/S)						0.261	0.261	15.88	3	63	3	S90T17
				Total	**12.801**					**3.079**	**15.88**	**15.88**		**1564**		
11kV Feeder V (Station)																
10	Phobjikha Substation (33/11kV, 2x2.5MVA)	11kV Station Feeder	11	33/11 Phobjikha to S110P1						0.01	0.01	0.01	3	125	3	S110T1
				Total						**0.01**	**0.01**	**0.01**		**125**		
11kV Feeder II(School)																
11	Phobjikha Substation (33/11kV, 2x2.5MVA)	11kV School feeder	11	Substation to S120P1						0.513	0.513	0.513	3	250	3	
				Total						**0.513**	**0.513**	**0.513**		**250**		
11kV Feeder III (Drukseed)																
12	Phobjikha Substation (33/11kV,	11kV Drukseed Feeder	11 kV	S90H24 to S130H044 (T off)	0.16						0.16	0.16	3			
				H044 to H045 (Druk seed)	0.02						0.02	0.18	3	125	3	S130T1
				H045 to P1 (Khelwang S/S)						2.144	2.144	2.324	3	250	3	S130T2
				P1 to P2 (Gorphu S/S)						0.583	0.583	2.907	3	16	3	S130T3

Sl. No.	Source	Feeder Details	Voltage	Section	Conducor Type & Line length (km)								Distribution transfomer			
		Name			WLF	DG	RAB	AAAC	UG	Sec_Len	Cum_Len	Phase	Capacity (kVA)	Phase	ID	Pvt/BPC
	2x2.5MVA)			P1 to P3 (Dogssina S/S)						1.054	1.054	3.961	3	63	3	S130T4
				P2 to P4 (Drangkha S/S)						1.563	1.563	5.524	3	125	3	S130T5
				Total	**0.18**					**5.344**	**5.524**	**5.524**		**579**		

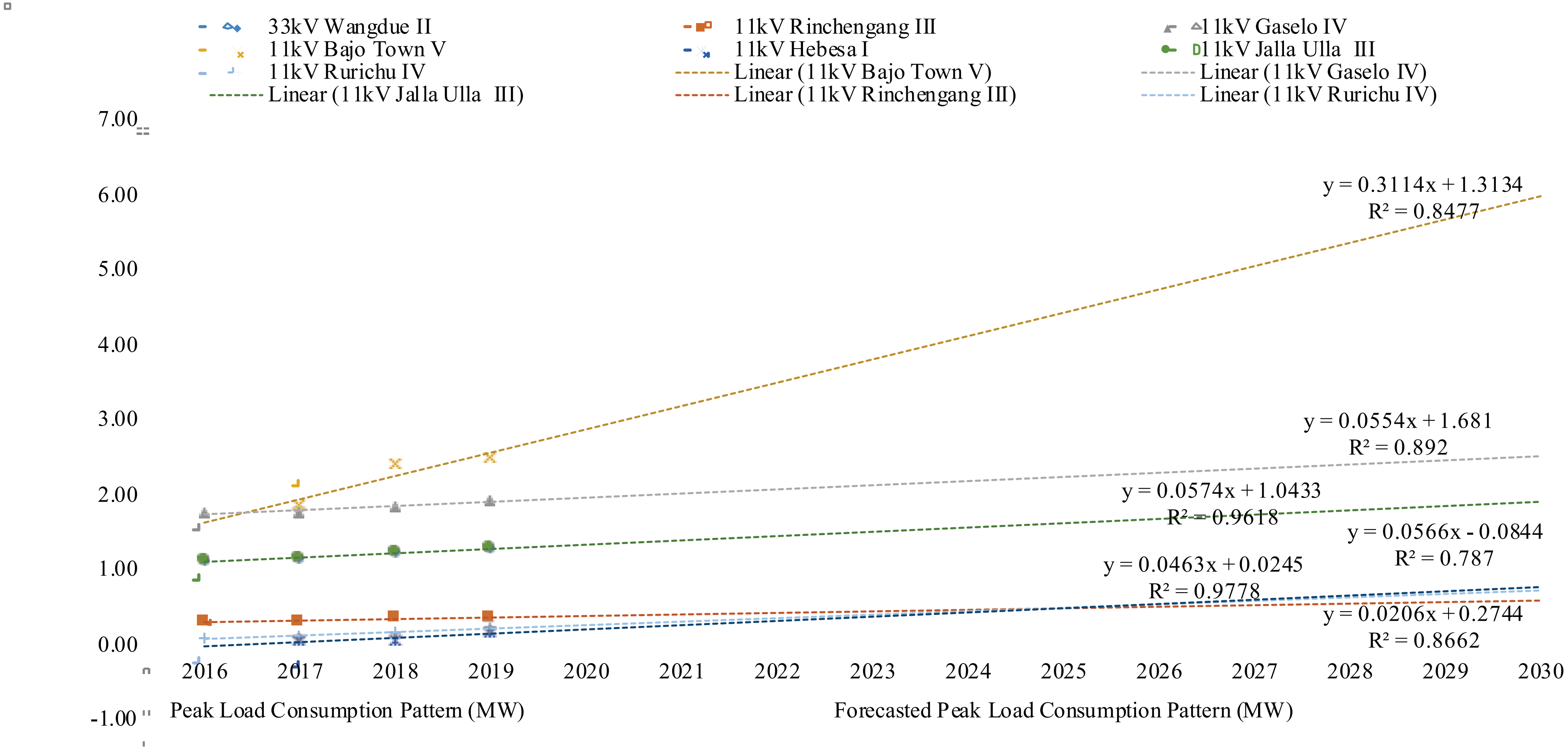
Annexure-2: IS 2026, IEC 60076 (Technical parameters for Distribution Lines and Transformers)

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	55°C
	· Max. Top oil temperature	50°C
13	Insulation levels	
	· Primary	170 kVp-70 kV/75 kVp-28 kV
	· Secondary	7500 Vp-3000 V

Annexure-3: Load Forecast adopting LRM & TSA

Load Forecast for Wangdue Dzongkhag

Sl.No.	Feeder	Load Consumption Pattern (				Forecasted Peak Load Consumption Pattern (MW)										
		2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
1	33kV Wangdue II	2.93	2.89	3.06	3.47	3.70	3.93	4.16	4.38	4.61	4.84	5.06	5.29	5.52	5.75	5.97
2	11kV Rinchengang III	0.30	0.30	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58
3	11kV Gaselo IV	1.76	1.76	1.84	1.92	1.99	2.06	2.13	2.21	2.28	2.35	2.42	2.49	2.57	2.64	2.71
4	11kV Bajo Town V		1.86	2.40	2.48	2.61	2.75	2.88	3.01	3.14	3.27	3.40	3.53	3.66	3.79	3.93
5	11kV Hebesa I		0.05	0.05	0.159	0.18	0.24	0.29	0.35	0.41	0.465	0.52	0.58	0.64	0.69	0.751
6	11kV Jalla Ulla III	1.11	1.14	1.23	1.27	1.33	1.39	1.44	1.50	1.56	1.62	1.67	1.73	1.79	1.84	1.90
7	11kV Rurichu IV	0.08	0.10	0.17	0.21	0.26	0.30	0.35	0.39	0.44	0.49	0.53	0.58	0.62	0.67	0.72
	Total	**6.18**	**8.10**	**9.09**	**9.87**	**10.45**	**11.06**	**11.67**	**12.28**	**12.90**	**13.51**	**14.11**	**14.73**	**15.34**	**15.94**	**16.56**



Load forecast methodolgy

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.**

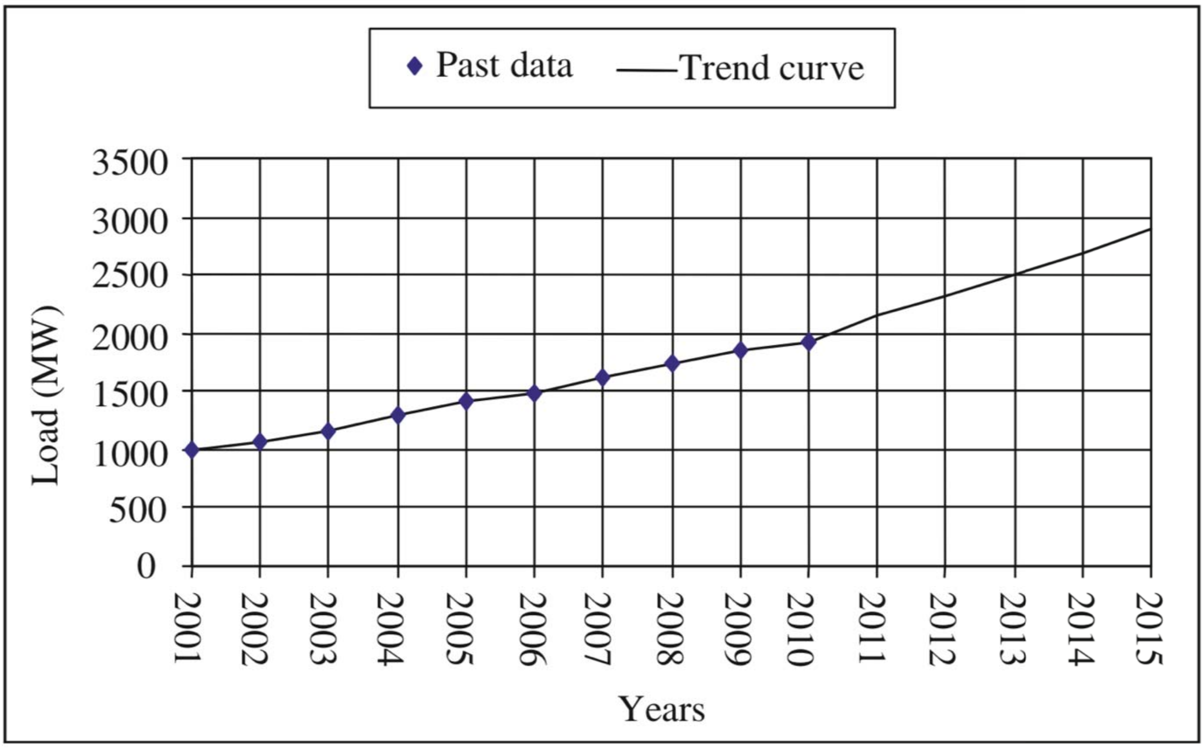


Figure 1: Typical trend curve[1]

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.

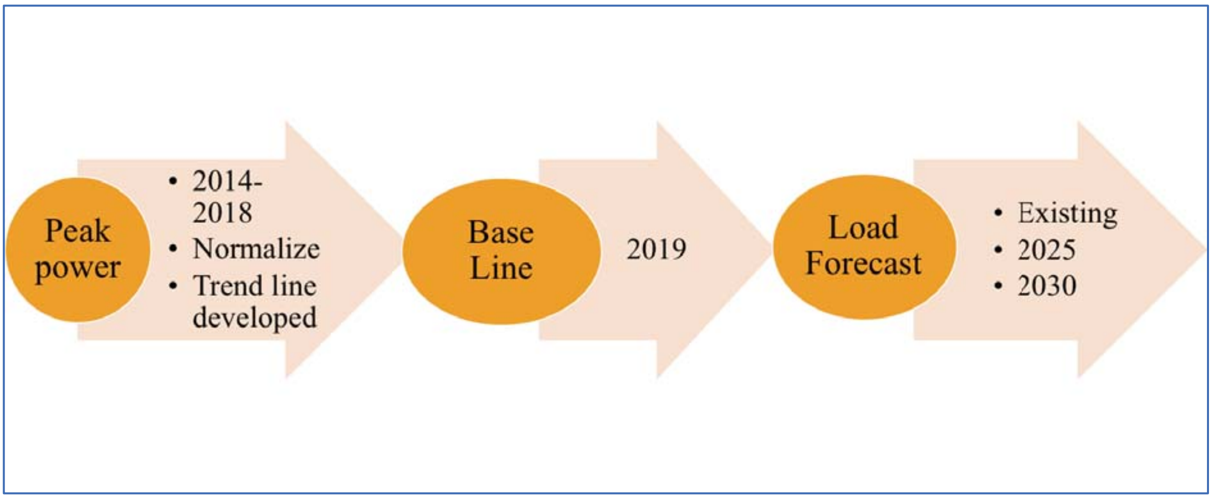


Figure 2: Flow diagram for load forecast

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**

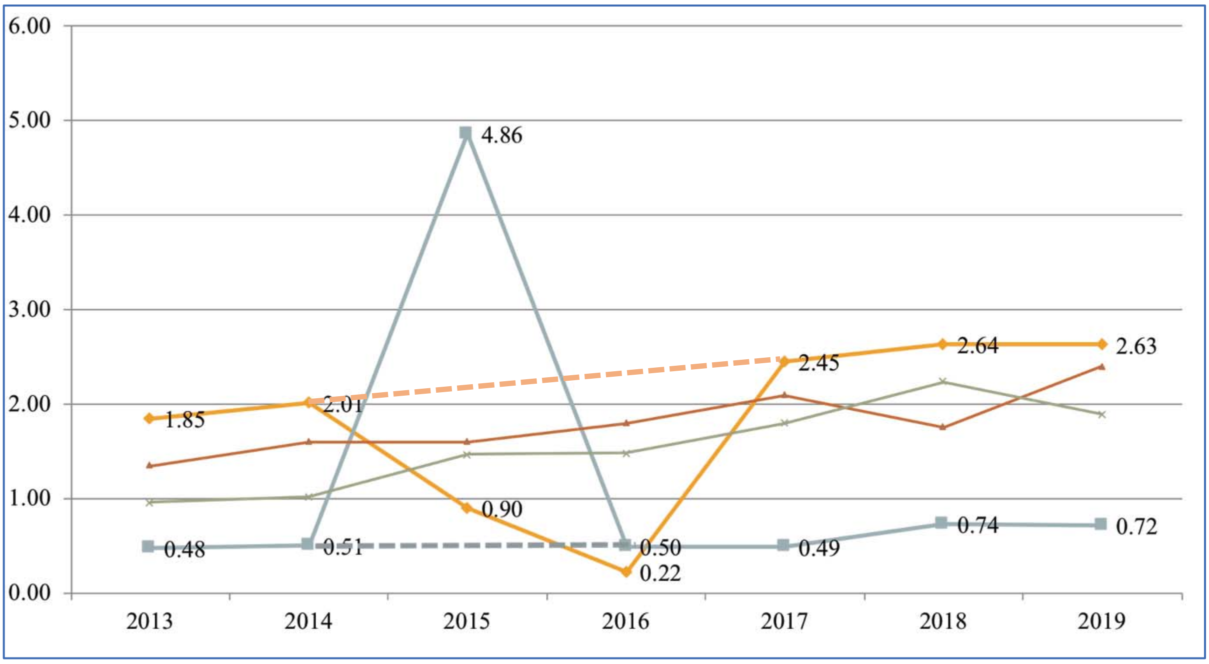


Figure 3: Actual data of Punakha Dzongkhag

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

Where:
x is the normalized data

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

Table 2: Normalized power data of Punakha Dzongkhag

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

1.3.2 Trend Line and Load Forecast

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

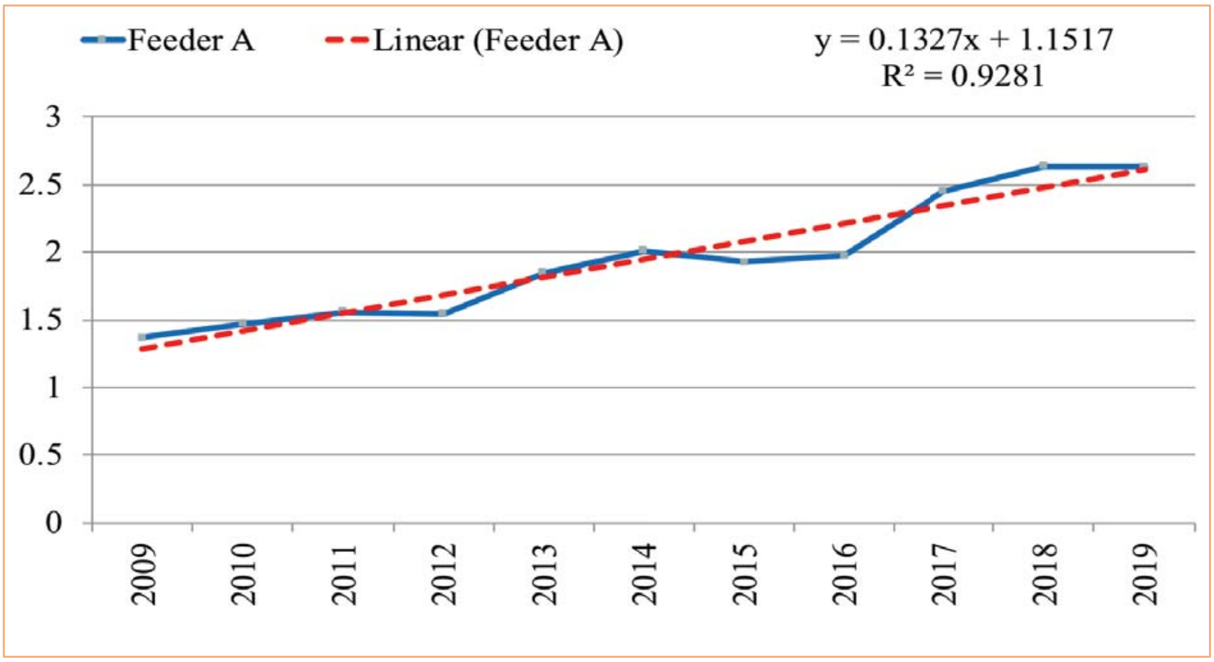


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$y = ax + b$

$Where:$

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

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

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

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

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

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.

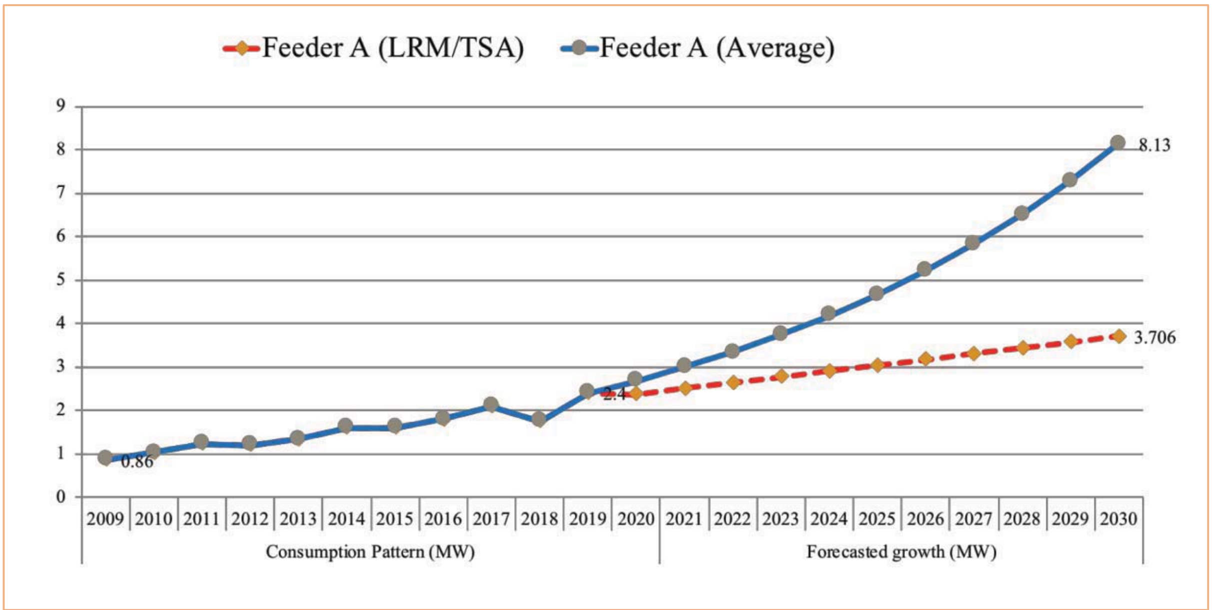


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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

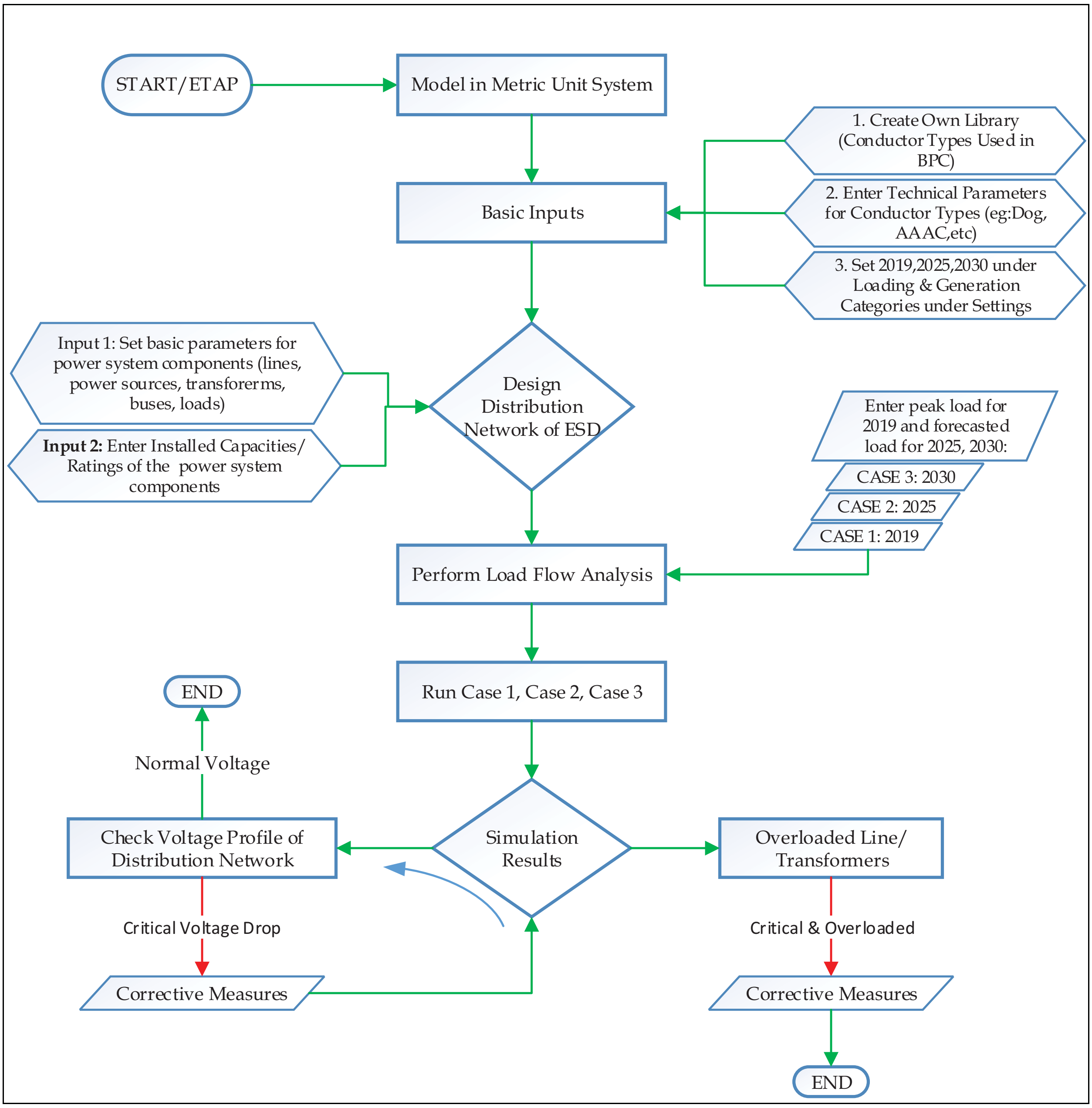


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

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

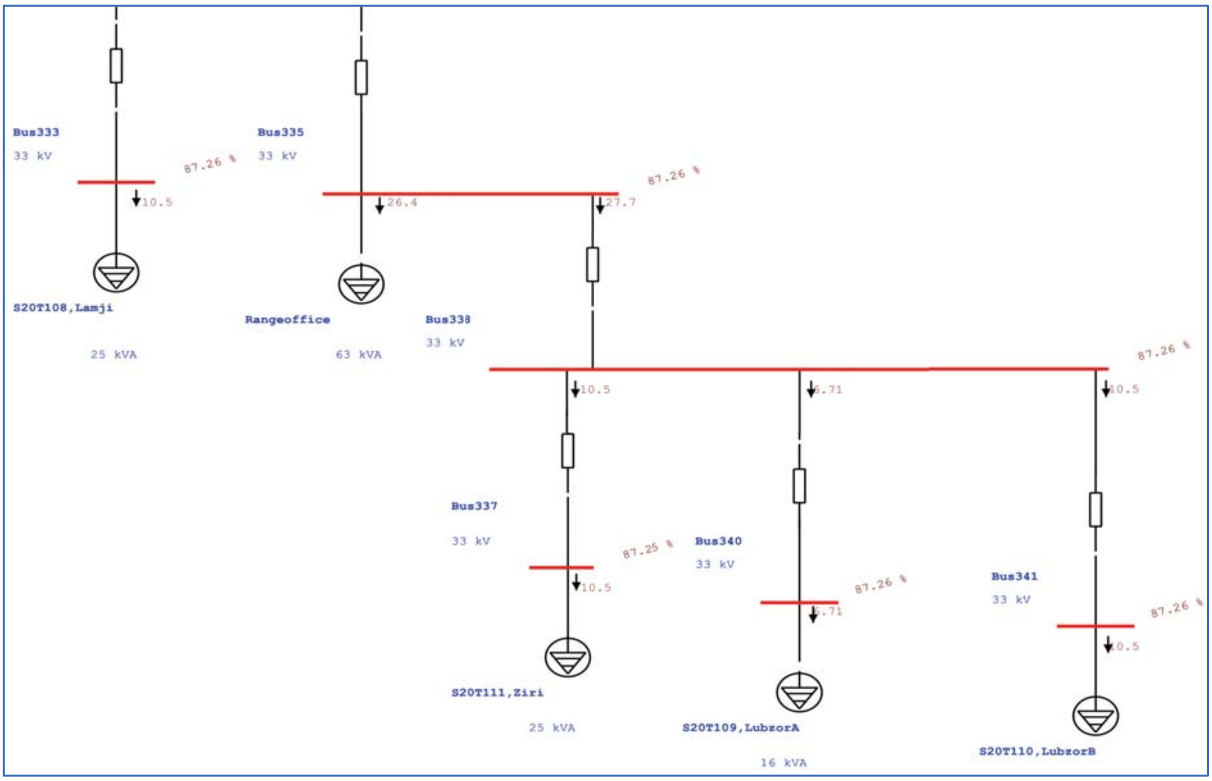
[2]http://sites.utexas.edu/sos/guided/inferential/numeric/bivariate/cor/: dated September 29, 2020

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

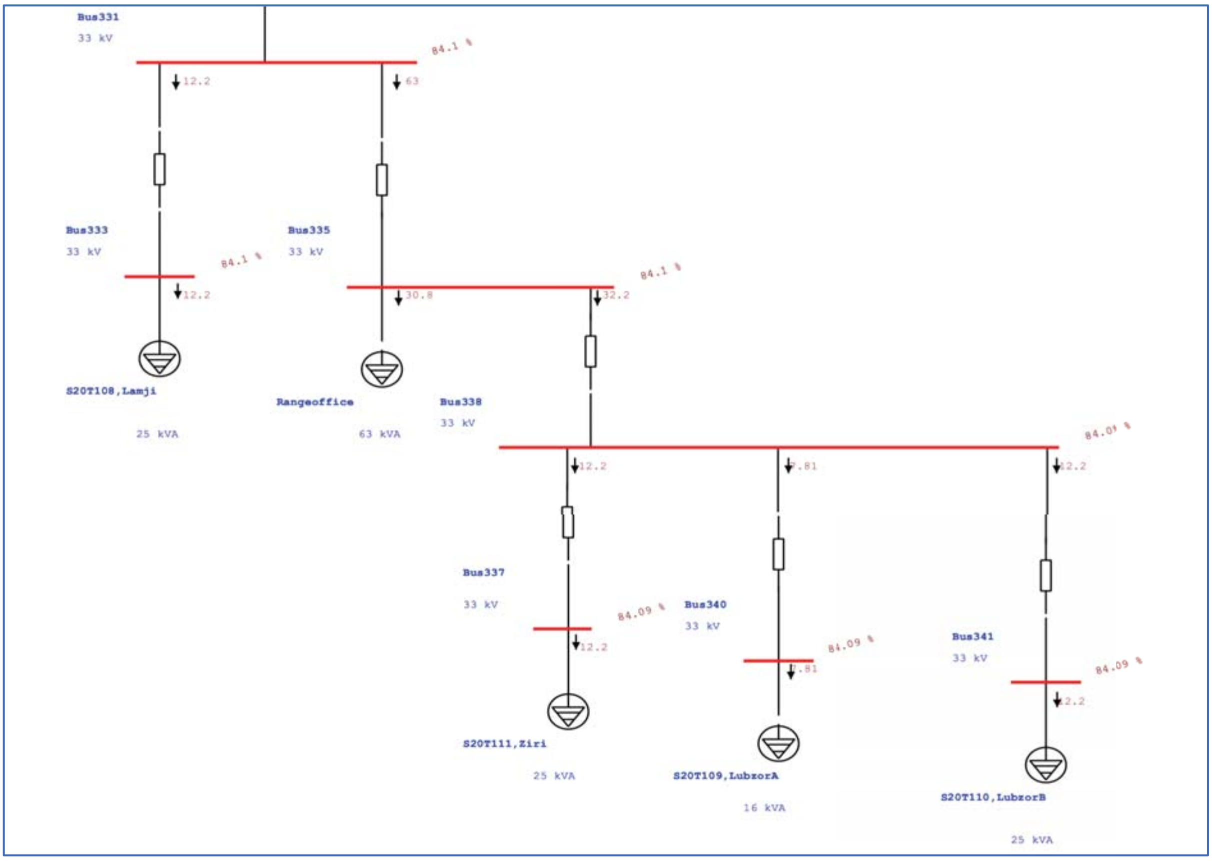
Annexure 4: The Simulation Results

Simulation reuslts for feeders with voltage profile issues

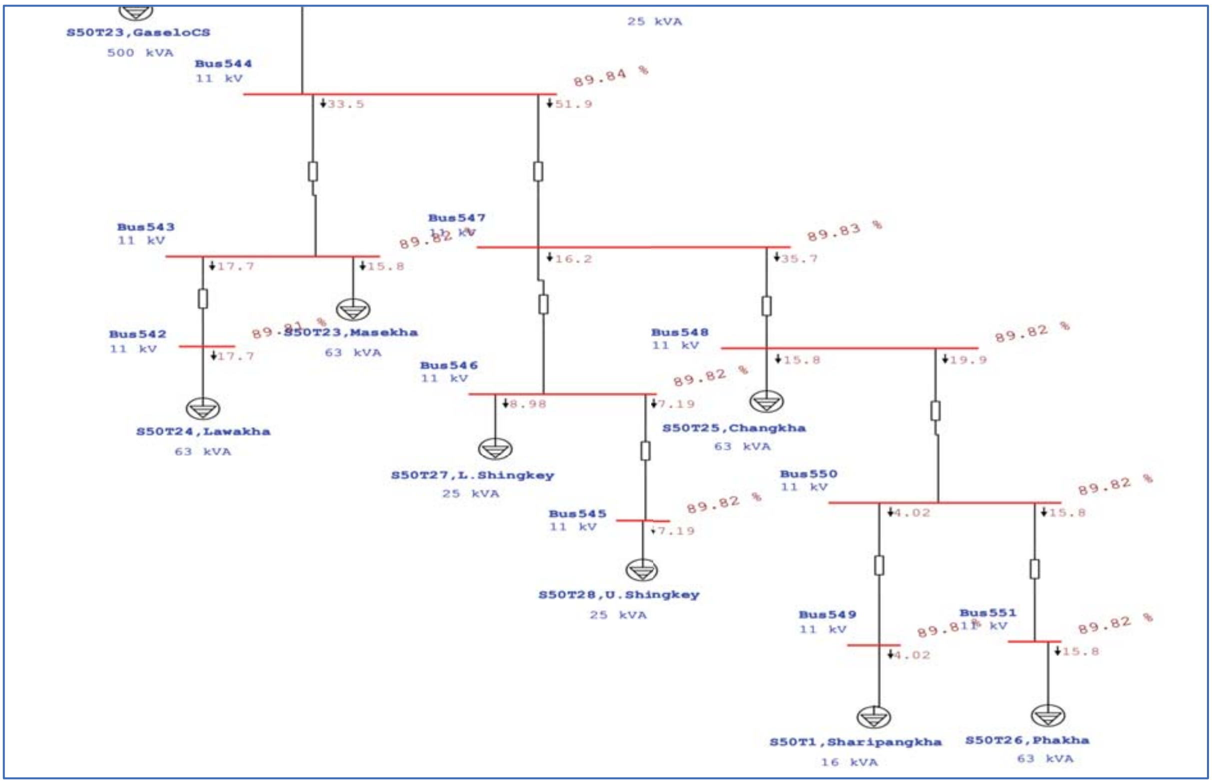
33kV Phobjikha 2025



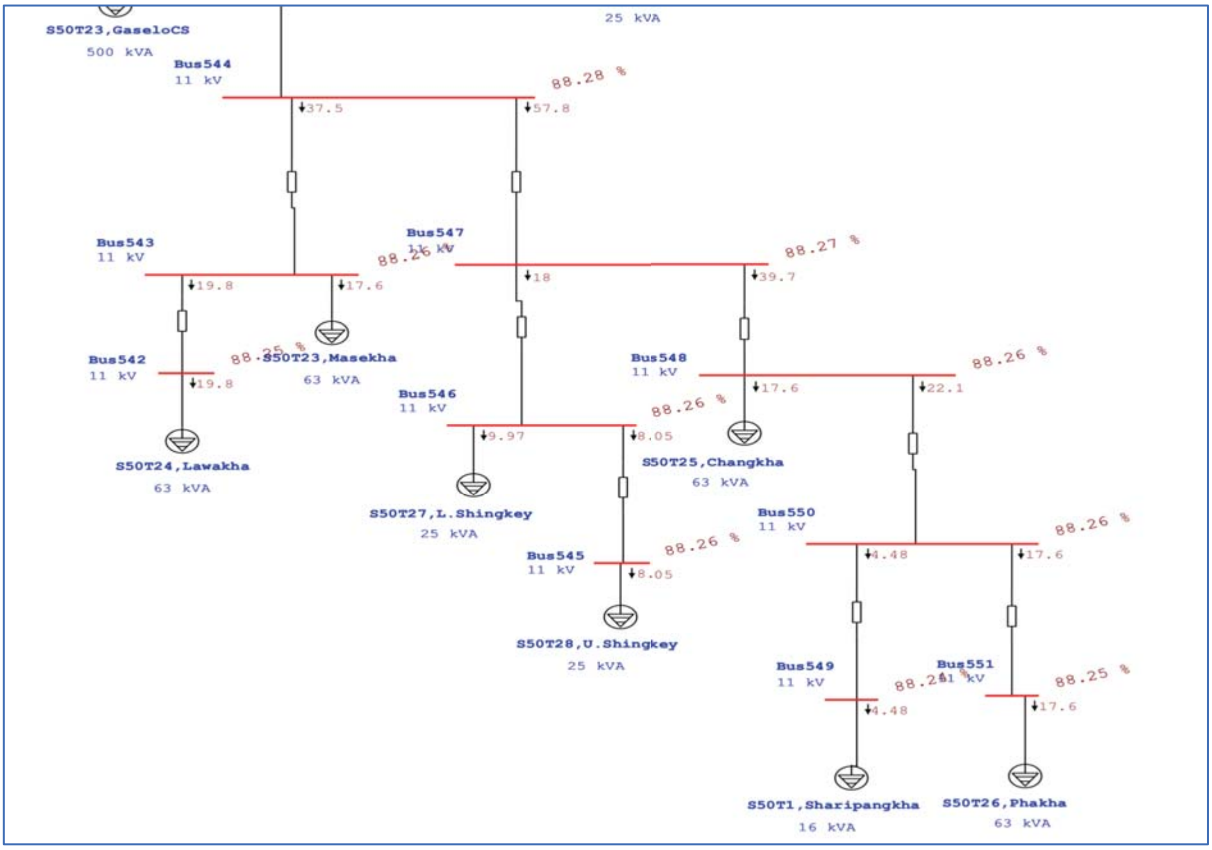
33kV Phobjikha 2030



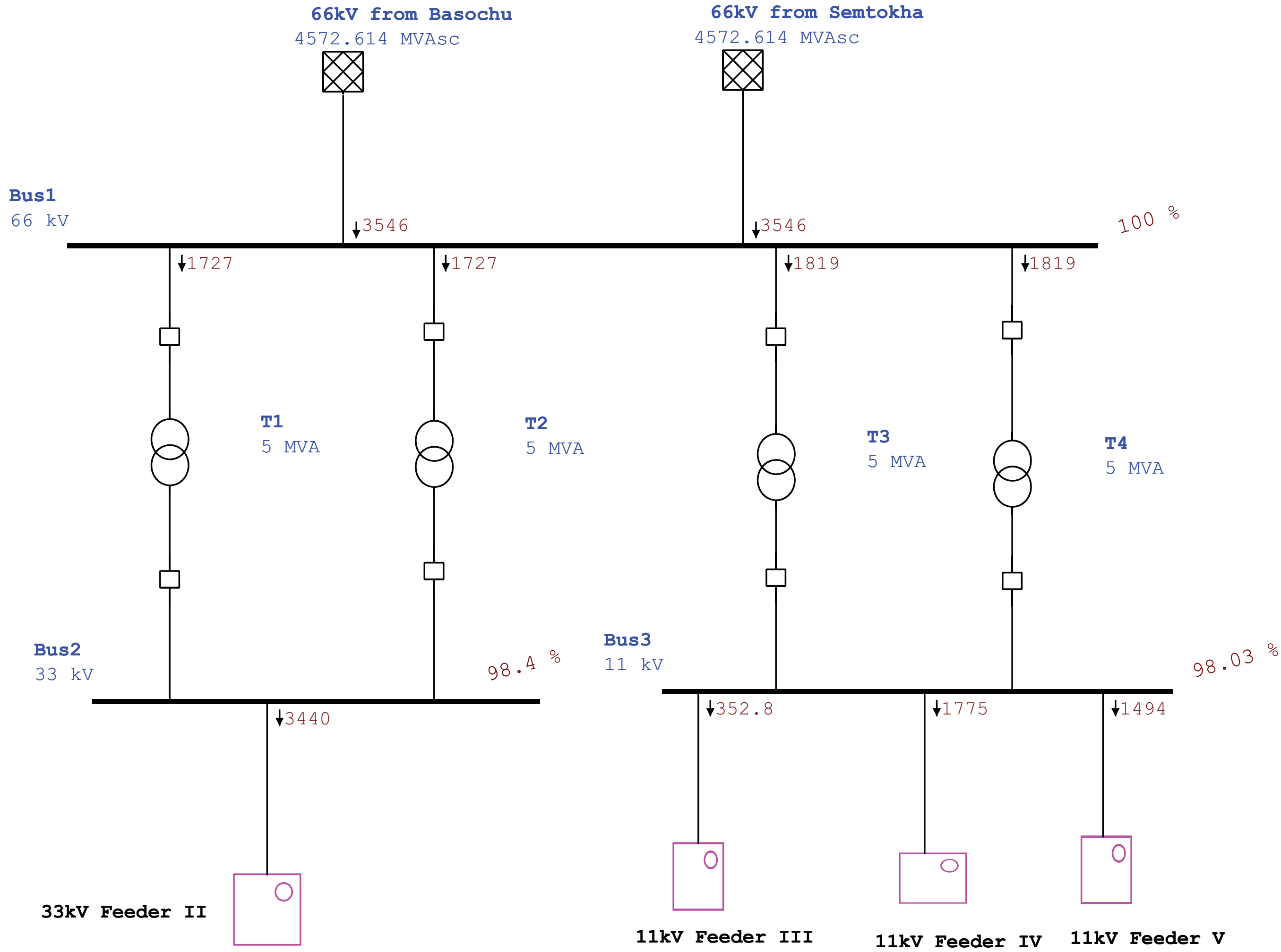
11kV Gaselo 2025



11kV Gaselo 2030



One-Line Diagram - OLV1 (Load Flow Analysis)



Basochu substation

Project:		ETAP	Page: 1
Location:		16.1.1C	Date: 05-11-2019
Contract:			SN: BHUTANPWR
Engineer:		Study Case: 2030 LFC	Revision: Base
Filename:	BASOCHU ETAP SLD		Config.: Normal

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
Bus1	66.000										2.689	83.8	23.5	
Bus2	11.000										2.625	85.4	141.1	
Bus22	11.000		0.082	0.051	0.309	0.191					0.459	85.0	24.8	
Bus23	11.000		0.007	0.004	0.026	0.016					0.842	85.1	45.4	
Bus27	11.000		0.035	0.022	0.132	0.082					0.197	85.0	10.6	
Bus28	11.000		0.004	0.003	0.016	0.010					0.410	85.7	22.1	
Bus29	11.000		0.020	0.013	0.077	0.048					0.115	85.0	6.2	
Bus30	11.000										0.189	86.3	10.2	
Bus31	11.000		0.002	0.001	0.008	0.005					0.075	87.9	4.0	
Bus32	11.000		0.001	0.000	0.002	0.001					0.006	86.5	0.3	
Bus33	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus34	11.000										0.055	87.7	3.0	
Bus35	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus36	11.000		0.001	0.000	0.002	0.001					0.058	88.1	3.1	
Bus37	11.000		0.001	0.000	0.002	0.001					0.053	87.4	2.8	
Bus38	11.000										0.050	87.3	2.7	
Bus39	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus40	11.000		0.008	0.005	0.030	0.019					0.048	86.0	2.6	
Bus41	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus43	11.000		0.054	0.034	0.205	0.127					0.305	85.0	16.5	
Bus46	11.000										0.343	85.1	18.6	
Bus49	11.000		0.007	0.004	0.026	0.016					0.038	85.0	2.1	
Bus52	11.000										1.354	85.5	73.7	
Bus53	11.000		0.017	0.010	0.062	0.038					1.123	85.6	61.4	
Bus55	11.000										0.225	85.2	12.3	
Bus56	11.000		0.015	0.009	0.055	0.034					0.162	85.2	8.8	
Bus58	11.000		0.011	0.007	0.042	0.026					0.063	85.0	3.5	
Bus59	11.000		0.014	0.009	0.054	0.033					0.080	85.0	4.4	
Bus60	11.000										1.010	85.8	56.4	
Bus61	11.000		0.004	0.003	0.016	0.010					0.181	85.1	10.1	
Bus62	11.000										0.158	85.1	8.8	
Bus63	11.000		0.016	0.010	0.061	0.038					0.091	85.0	5.1	
Bus64	11.000		0.013	0.008	0.044	0.027					0.067	85.0	3.7	
Bus65	11.000		0.013	0.008	0.045	0.028					0.825	85.9	46.3	
Bus66	11.000										0.753	86.0	42.5	
Bus67	11.000		0.014	0.009	0.049	0.031					0.075	85.0	4.2	
Bus68	11.000										0.675	86.2	38.3	
Bus69	11.000		0.011	0.007	0.037	0.023					0.064	85.5	3.6	
Bus70	11.000		0.001	0.001	0.005	0.003					0.008	85.0	0.4	

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
Bus71	11.000										0.605	86.3	34.7	
Bus72	11.000		0.016	0.010	0.055	0.034					0.084	85.0	4.8	
Bus73	11.000										0.520	86.4	29.9	
Bus74	11.000										0.137	86.5	7.9	
Bus75	11.000		0.005	0.003	0.017	0.011					0.043	85.5	2.5	
Bus76	11.000		0.003	0.002	0.011	0.007					0.017	85.0	1.0	
Bus78	11.000										0.094	85.7	5.5	
Bus79	11.000										0.020	85.3	1.1	
Bus80	11.000										0.075	85.5	4.3	
Bus81	11.000		0.004	0.002	0.012	0.008					0.019	85.0	1.1	
Bus82	11.000		0.004	0.002	0.012	0.008					0.056	85.5	3.3	
Bus83	11.000		0.001	0.001	0.005	0.003					0.008	85.0	0.4	
Bus85	11.000		0.002	0.001	0.008	0.005					0.012	85.0	0.7	
Bus86	11.000										0.037	85.7	2.2	
Bus87	11.000		0.004	0.003	0.015	0.009					0.023	85.0	1.3	
Bus88	11.000		0.001	0.001	0.005	0.003					0.015	86.0	0.9	
Bus89	11.000		0.001	0.001	0.005	0.003					0.008	85.0	0.4	
Bus90	11.000										0.381	86.2	22.1	
Bus91	11.000		0.011	0.007	0.035	0.022					0.080	85.5	4.6	
Bus92	11.000		0.005	0.003	0.017	0.010					0.026	85.0	1.5	
Bus93	11.000										0.299	86.2	17.5	
Bus94	11.000		0.002	0.001	0.006	0.004					0.136	86.6	8.0	
Bus96	11.000		0.007	0.004	0.022	0.013					0.163	85.8	9.6	
Bus97	11.000		0.004	0.002	0.013	0.008					0.130	85.3	7.7	
Bus98	11.000										0.110	85.3	6.5	
Bus99	11.000		0.002	0.001	0.008	0.005					0.012	85.0	0.7	
Bus100	11.000										0.099	85.2	5.8	
Bus101	11.000		0.005	0.003	0.016	0.010					0.025	85.0	1.5	
Bus102	11.000		0.004	0.002	0.012	0.007					0.074	85.2	4.4	
Bus103	11.000		0.003	0.002	0.009	0.006					0.056	85.3	3.3	
Bus104	11.000		0.009	0.005	0.027	0.017					0.042	85.0	2.5	
Bus105	11.000		0.002	0.001	0.008	0.005					0.128	86.3	7.5	
Bus106	11.000		0.004	0.002	0.012	0.007					0.116	86.1	6.8	
Bus107	11.000										0.098	86.0	5.8	
Bus109	11.000		0.001	0.001	0.005	0.003					0.007	85.0	0.4	
Bus110	11.000		0.004	0.002	0.012	0.007					0.091	86.0	5.3	
Bus111	11.000										0.073	86.0	4.3	
Bus112	11.000		0.004	0.002	0.012	0.007					0.037	85.3	2.2	
Bus113	11.000		0.004	0.002	0.012	0.007					0.036	85.9	2.1	
Bus114	11.000		0.004	0.002	0.012	0.007					0.018	85.0	1.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus115	11.000		0.004	0.002	0.012	0.007					0.018	85.0	1.1	

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

Branch Loading Summary Report

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
T1	Transformer				5.000	2.689	53.8	2.625	52.5

* 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
T1	2.252	1.468	-2.241	-1.368	11.8	100.5	100.0	97.6	2.37
Line1	1.171	0.712	-1.158	-0.701	13.0	10.7	97.6	96.4	1.21
Line33	0.718	0.444	-0.716	-0.443	1.9	1.4	97.6	97.3	0.29
Line39	0.352	0.212	-0.351	-0.212	0.3	0.1	97.6	97.5	0.08
Line34	-0.390	-0.242	0.391	0.242	0.3	0.0	97.3	97.3	0.06
Line35	0.293	0.180	-0.292	-0.180	0.9	0.0	97.3	97.0	0.32
Line40	-0.167	-0.104	0.167	0.103	0.1	-0.2	97.5	97.5	0.07
Line41	0.164	0.096	-0.163	-0.096	0.1	-0.3	97.5	97.5	0.10
Line42	-0.098	-0.061	0.098	0.060	0.0	-0.1	97.4	97.5	0.01
Line43	0.066	0.035	-0.066	-0.036	0.0	-0.4	97.5	97.4	0.03
Line44	0.005	0.003	-0.005	-0.003	0.0	-0.2	97.4	97.4	0.00
Line46	0.051	0.027	-0.051	-0.027	0.0	-0.3	97.4	97.4	0.02
Line48	0.002	0.001	-0.002	-0.002	0.0	-0.2	97.4	97.4	0.00
Line50	0.002	0.001	-0.002	-0.002	0.0	-0.4	97.3	97.3	0.00
Line52	-0.049	-0.027	0.049	0.026	0.0	-0.8	97.3	97.4	0.05
Line54	0.046	0.026	-0.046	-0.026	0.0	-0.1	97.3	97.3	0.00
Line56	0.044	0.024	-0.044	-0.024	0.0	-0.3	97.3	97.3	0.02
Line58	0.002	0.001	-0.002	-0.002	0.0	-0.5	97.3	97.3	0.00
Line60	0.041	0.023	-0.041	-0.024	0.0	-1.1	97.3	97.3	0.06
Line62	0.002	0.000	-0.002	-0.002	0.0	-1.1	97.3	97.3	0.00
Line64	-0.259	-0.160	0.259	0.160	0.1	0.0	97.0	97.0	0.06
Line74	0.033	0.020	-0.033	-0.020	0.0	-0.5	97.0	97.0	0.02
Line82	0.965	0.584	-0.962	-0.581	3.7	2.9	96.4	96.0	0.41
Line84	0.192	0.118	-0.192	-0.118	0.2	-0.2	96.4	96.3	0.10
Line91	0.883	0.532	-0.867	-0.519	16.4	12.8	96.0	94.0	1.99
Line86	0.054	0.033	-0.054	-0.033	0.0	-0.4	96.3	96.3	0.06
Line87	0.138	0.085	-0.138	-0.085	0.0	-0.1	96.3	96.3	0.01
Line89	0.068	0.041	-0.068	-0.042	0.1	-0.6	96.3	96.2	0.12
Line93	0.155	0.095	-0.154	-0.095	0.2	-0.3	94.0	93.9	0.12
Line94	0.712	0.424	-0.709	-0.422	3.0	2.2	94.0	93.6	0.44
Line96	0.134	0.083	-0.134	-0.083	0.1	-0.1	93.9	93.8	0.06
Line98	0.077	0.048	-0.077	-0.048	0.0	0.0	93.8	93.8	0.00
Line99	0.057	0.035	-0.057	-0.035	0.0	-0.3	93.8	93.8	0.04
Line101	0.652	0.386	-0.648	-0.384	3.6	2.6	93.6	93.0	0.58

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
Line103	0.064	0.039	-0.064	-0.039	0.0	0.0	93.0	93.0	0.00
Line105	0.585	0.344	-0.582	-0.342	2.9	2.0	93.0	92.5	0.53
Line107	0.054	0.033	-0.054	-0.033	0.0	-0.1	92.5	92.5	0.01
Line111	0.527	0.310	-0.522	-0.306	5.0	3.2	92.5	91.5	0.99
Line109	0.007	0.003	-0.007	-0.004	0.0	-0.8	92.5	92.4	0.01
Line113	0.072	0.044	-0.072	-0.044	0.0	0.0	91.5	91.5	0.01
Line115	0.450	0.262	-0.450	-0.262	0.8	0.3	91.5	91.3	0.15
Line117	0.119	0.068	-0.118	-0.068	0.3	-0.5	91.3	91.1	0.21
Line119	0.331	0.194	-0.328	-0.193	2.9	0.9	91.3	90.4	0.89
Line121	0.037	0.022	-0.037	-0.022	0.0	-0.5	91.1	91.1	0.06
Line125	0.081	0.047	-0.081	-0.049	0.5	-1.9	91.1	90.6	0.53
Line123	0.015	0.009	-0.015	-0.009	0.0	-0.5	91.1	91.0	0.02
Line128	0.017	0.010	-0.017	-0.010	0.0	-0.5	90.6	90.6	0.03
Line130	0.064	0.039	-0.064	-0.039	0.0	-0.1	90.6	90.6	0.02
Line136	0.010	0.006	-0.010	-0.006	0.0	0.0	90.6	90.6	0.00
Line137	0.006	0.004	-0.006	-0.004	0.0	-0.1	90.6	90.6	0.00
Line132	0.016	0.010	-0.016	-0.010	0.0	-0.1	90.6	90.6	0.00
Line134	0.048	0.029	-0.048	-0.029	0.0	-0.1	90.6	90.6	0.01
Line140	0.032	0.019	-0.032	-0.019	0.0	0.0	90.6	90.5	0.00
Line142	0.019	0.012	-0.019	-0.012	0.0	-0.2	90.5	90.5	0.01
Line144	0.013	0.008	-0.013	-0.008	0.0	0.0	90.5	90.5	0.00
Line146	0.006	0.004	-0.006	-0.004	0.0	-0.3	90.5	90.5	0.01
Line148	0.068	0.041	-0.068	-0.041	0.0	0.0	90.4	90.4	0.00
Line152	0.260	0.151	-0.258	-0.151	2.5	0.1	90.4	89.4	0.99
Line150	0.022	0.013	-0.022	-0.013	0.0	-0.8	90.4	90.4	0.06
Line154	0.140	0.084	-0.140	-0.084	0.2	-0.3	89.4	89.3	0.12
Line155	0.118	0.068	-0.118	-0.068	0.1	-0.1	89.4	89.4	0.04
Line173	0.110	0.063	-0.110	-0.064	0.2	-1.2	89.4	89.2	0.21
Line157	0.111	0.066	-0.111	-0.068	0.5	-1.7	89.3	88.9	0.44
Line159	0.094	0.058	-0.094	-0.058	0.0	-0.1	88.9	88.9	0.01
Line161	0.010	0.006	-0.010	-0.006	0.0	-0.1	88.9	88.9	0.00
Line163	0.084	0.052	-0.084	-0.052	0.0	-0.1	88.9	88.9	0.02
Line165	0.021	0.013	-0.021	-0.013	0.0	0.0	88.9	88.9	0.00
Line167	0.063	0.039	-0.063	-0.039	0.0	-0.1	88.9	88.8	0.02
Line169	0.047	0.029	-0.047	-0.029	0.0	0.0	88.8	88.8	0.00
Line171	0.036	0.022	-0.036	-0.022	0.0	-0.3	88.8	88.8	0.02
Line175	0.100	0.058	-0.100	-0.059	0.1	-0.7	89.2	89.1	0.10

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line177	0.084	0.049	-0.084	-0.050	0.1	-0.6	89.1	89.0	0.07
Line179	0.006	0.004	-0.006	-0.004	0.0	-0.1	89.0	89.0	0.00
Line181	0.078	0.046	-0.078	-0.046	0.0	-0.1	89.0	89.0	0.01
Line183	0.062	0.037	-0.062	-0.037	0.0	-0.4	89.0	89.0	0.03
Line185	0.031	0.019	-0.031	-0.019	0.0	-0.4	89.0	89.0	0.02
Line186	0.031	0.018	-0.031	-0.019	0.0	-0.2	89.0	89.0	0.01
Line188	0.016	0.009	-0.016	-0.010	0.0	-0.2	89.0	89.0	0.00
Line190	0.016	0.009	-0.016	-0.010	0.0	-0.8	89.0	89.0	0.02
					72.0	116.8			

Alert Summary Report

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

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus100	Bus	Under Voltage	11.000	kV	9.774	88.9	3-Phase
Bus101	Bus	Under Voltage	11.000	kV	9.77	88.9	3-Phase
Bus102	Bus	Under Voltage	11.000	kV	9.77	88.8	3-Phase
Bus103	Bus	Under Voltage	11.000	kV	9.77	88.8	3-Phase
Bus104	Bus	Under Voltage	11.000	kV	9.77	88.8	3-Phase
Bus105	Bus	Under Voltage	11.000	kV	9.81	89.2	3-Phase
Bus106	Bus	Under Voltage	11.000	kV	9.80	89.1	3-Phase
Bus107	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus109	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus110	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus111	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus112	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus113	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus114	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus115	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus93	Bus	Under Voltage	11.000	kV	9.839	89.4	3-Phase
Bus94	Bus	Under Voltage	11.000	kV	9.83	89.4	3-Phase
Bus96	Bus	Under Voltage	11.000	kV	9.83	89.3	3-Phase
Bus97	Bus	Under Voltage	11.000	kV	9.78	88.9	3-Phase
Bus98	Bus	Under Voltage	11.000	kV	9.78	88.9	3-Phase
Bus99	Bus	Under Voltage	11.000	kV	9.78	88.9	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus60	Bus	Under Voltage	11.000	kV	10.342	94.0	3-Phase
Bus61	Bus	Under Voltage	11.000	kV	10.33	93.9	3-Phase
Bus62	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
Bus63	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
Bus64	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
Bus65	Bus	Under Voltage	11.000	kV	10.29	93.6	3-Phase
Bus66	Bus	Under Voltage	11.000	kV	10.23	93.0	3-Phase
Bus67	Bus	Under Voltage	11.000	kV	10.23	93.0	3-Phase
Bus68	Bus	Under Voltage	11.000	kV	10.17	92.5	3-Phase
Bus69	Bus	Under Voltage	11.000	kV	10.17	92.5	3-Phase
Bus70	Bus	Under Voltage	11.000	kV	10.17	92.4	3-Phase
Bus71	Bus	Under Voltage	11.000	kV	10.06	91.5	3-Phase
Bus72	Bus	Under Voltage	11.000	kV	10.06	91.5	3-Phase
Bus73	Bus	Under Voltage	11.000	kV	10.05	91.3	3-Phase
Bus74	Bus	Under Voltage	11.000	kV	10.02	91.1	3-Phase
Bus75	Bus	Under Voltage	11.000	kV	10.02	91.1	3-Phase
Bus76	Bus	Under Voltage	11.000	kV	10.01	91.0	3-Phase
Bus78	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus79	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus80	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus81	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus82	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus83	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus85	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus86	Bus	Under Voltage	11.000	kV	9.96	90.5	3-Phase
Bus87	Bus	Under Voltage	11.000	kV	9.96	90.5	3-Phase
Bus88	Bus	Under Voltage	11.000	kV	9.96	90.5	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus89	Bus	Under Voltage	11.000	kV	9.959	90.5	3-Phase
Bus90	Bus	Under Voltage	11.000	kV	9.95	90.4	3-Phase
Bus91	Bus	Under Voltage	11.000	kV	9.95	90.4	3-Phase
Bus92	Bus	Under Voltage	11.000	kV	9.94	90.4	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	2.252	1.468	2.689	83.78 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	2.252	1.468	2.689	83.78 Lagging
Total Motor Load:	0.475	0.295	0.559	85.00 Lagging
Total Static Load:	1.705	1.057	2.006	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.072	0.117		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Lobeysa substation

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
Bus1	66.000										13.998	83.1	122.4	
Bus2	33.000										6.985	85.6	126.3	
Bus3	11.000										6.568	84.7	355.8	
Bus4	33.000		0.085	0.053	0.265	0.164					0.412	85.0	8.2	
Bus5	33.000		0.012	0.008	0.044	0.027					6.469	85.5	119.0	
Bus6	33.000										6.401	85.5	117.8	
Bus7	33.000										6.151	85.6	114.5	
Bus8	33.000		0.004	0.002	0.013	0.008					6.086	85.6	113.6	
Bus9	33.000		0.007	0.004	0.025	0.016					0.038	85.0	0.7	
Bus11	33.000		0.003	0.002	0.012	0.008					0.018	85.0	0.3	
Bus13	33.000		0.007	0.004	0.023	0.014					0.035	85.0	0.6	
Bus15	33.000		0.004	0.003	0.015	0.010					6.059	85.6	113.2	
Bus16	33.000										1.503	88.7	28.2	
Bus17	33.000		0.002	0.001	0.006	0.003					0.008	85.0	0.2	
Bus18	33.000		0.003	0.002	0.012	0.007					1.496	88.6	28.0	
Bus19	33.000		0.003	0.002	0.011	0.007					1.479	88.6	27.7	
Bus20	33.000										1.463	88.6	27.4	
Bus21	33.000										1.014	88.4	19.0	
Bus24	33.000										0.050	87.2	0.9	
Bus26	33.000		0.003	0.002	0.011	0.007					0.017	85.0	0.3	
Bus27	33.000		0.007	0.004	0.023	0.014					0.034	85.0	0.6	
Bus28	33.000		0.008	0.005	0.029	0.018					0.965	88.3	18.1	
Bus29	33.000										0.922	88.4	17.3	
Bus34	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus35	33.000										0.909	88.3	17.1	
Bus37	33.000		0.052	0.032	0.180	0.112					0.273	85.0	5.1	
Bus38	33.000		0.002	0.001	0.008	0.005					0.639	89.4	12.0	
Bus39	33.000										0.628	89.4	11.8	
Bus40	33.000		0.011	0.007	0.037	0.023					0.056	85.0	1.0	
Bus41	33.000										0.573	89.6	10.8	
Bus42	33.000		0.007	0.004	0.023	0.014					0.077	88.2	1.5	
Bus44	33.000		0.004	0.002	0.014	0.008					0.044	87.8	0.8	
Bus46	33.000		0.005	0.003	0.017	0.010					0.025	85.0	0.5	
Bus48	33.000		0.010	0.006	0.035	0.021					0.498	89.5	9.3	
Bus49	33.000		0.007	0.004	0.023	0.014					0.446	89.8	8.4	
Bus50	33.000		0.007	0.004	0.023	0.014					0.413	89.9	7.8	
Bus51	33.000										0.380	90.0	7.1	
Bus53	33.000										0.093	87.4	1.8	
Bus55	33.000		0.007	0.004	0.023	0.014					0.034	85.0	0.6	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus60	33.000		0.007	0.004	0.023	0.014					0.060	87.5	1.1	
Bus62	33.000		0.003	0.002	0.009	0.006					0.027	87.1	0.5	
Bus64	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus66	33.000		0.007	0.004	0.023	0.014					0.288	90.4	5.4	
Bus67	33.000		0.003	0.002	0.011	0.007					0.256	90.5	4.8	
Bus71	33.000										0.241	90.3	4.5	
Bus73	33.000		0.007	0.004	0.023	0.014					0.034	85.0	0.6	
Bus77	33.000		0.007	0.004	0.023	0.014					0.209	90.2	3.9	
Bus79	33.000		0.007	0.004	0.023	0.014					0.180	88.4	3.4	
Bus81	33.000		0.007	0.004	0.023	0.014					0.147	88.3	2.8	
Bus83	33.000		0.007	0.004	0.023	0.014					0.116	87.2	2.2	
Bus85	33.000		0.016	0.010	0.056	0.034					0.084	85.0	1.6	
Bus86	33.000										4.509	84.5	84.8	
Bus88	33.000		0.009	0.005	0.032	0.020					0.048	85.0	0.9	
Bus90	33.000		0.010	0.006	0.036	0.022					0.054	85.0	1.0	
Bus92	33.000		0.007	0.004	0.024	0.015					0.081	87.8	1.5	
Bus98	33.000		0.003	0.002	0.010	0.007					0.016	85.0	0.3	
Bus103	33.000		0.013	0.008	0.044	0.027					0.419	94.4	8.0	
Bus104	33.000										0.356	95.1	6.8	
Bus105	33.000										4.261	84.4	81.1	
Bus106	33.000		0.007	0.004	0.022	0.014					0.034	85.0	0.6	
Bus107	33.000		0.007	0.004	0.022	0.014					3.858	83.0	73.4	
Bus108	33.000		0.007	0.005	0.025	0.016					4.393	84.5	82.9	
Bus109	33.000										4.305	84.4	81.7	
Bus110	33.000		0.006	0.004	0.019	0.012					4.348	84.5	82.2	
Bus111	33.000		0.010	0.006	0.033	0.020					0.050	85.0	0.9	
Bus112	33.000										4.449	84.5	83.8	
Bus113	33.000		0.007	0.004	0.025	0.016					0.038	85.0	0.7	
Bus114	33.000		0.003	0.002	0.012	0.008					0.126	87.9	2.3	
Bus115	33.000										0.162	88.0	3.0	
Bus116	33.000										0.189	88.0	3.5	
Bus117	33.000		0.005	0.003	0.018	0.011					0.027	85.0	0.5	
Bus118	33.000										0.116	88.5	2.1	
Bus119	33.000										0.108	88.0	2.0	
Bus120	33.000		0.007	0.004	0.024	0.015					0.152	88.0	2.8	
Bus121	33.000		0.005	0.003	0.017	0.011					0.026	85.0	0.5	
Bus122	33.000		0.005	0.003	0.020	0.012					0.030	85.0	0.5	
Bus123	33.000										0.084	86.7	1.6	
Bus124	33.000		0.044	0.027	0.010	0.006					0.242	88.0	4.5	
Bus125	33.000		0.008	0.005	0.029	0.018					0.044	85.0	0.8	
Bus126	33.000		0.001	0.000	0.003	0.002					0.004	85.0	0.1	
Bus127	33.000		0.008	0.005	0.028	0.018					0.042	85.0	0.8	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus128	33.000										0.414	90.6	7.6	
Bus129	33.000										0.180	88.5	3.3	
Bus130	33.000		0.004	0.002	0.014	0.008					0.039	92.1	0.7	
Bus131	33.000		0.004	0.003	0.015	0.009					0.022	85.0	0.4	
Bus132	33.000		0.003	0.002	0.009	0.006					0.380	89.1	7.0	
Bus133	33.000										0.368	88.7	6.8	
Bus134	33.000		0.016	0.010	0.058	0.036					0.127	88.9	2.3	
Bus135	33.000		0.007	0.004	0.024	0.015					0.043	89.9	0.8	
Bus136	33.000										0.009	94.7	0.2	
Bus137	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus138	33.000										6.024	85.6	112.8	
Bus139	33.000		0.003	0.002	0.010	0.006					0.343	95.0	6.5	
Bus141	33.000										0.327	95.3	6.2	
Bus143	33.000		0.007	0.004	0.022	0.014					0.121	92.8	2.3	
Bus145	33.000		0.007	0.004	0.023	0.015					0.208	96.0	4.0	
Bus147	33.000										0.089	93.7	1.7	
Bus149	33.000		0.003	0.002	0.010	0.006					0.016	85.0	0.3	
Bus151	33.000		0.007	0.004	0.022	0.014					0.076	92.6	1.4	
Bus153	33.000										0.044	95.4	0.8	
Bus155	33.000		0.007	0.004	0.022	0.014					0.034	85.0	0.6	
Bus157	33.000		0.003	0.002	0.010	0.006					0.015	85.0	0.3	
Bus159	33.000										0.182	92.7	3.5	
Bus161	33.000		0.026	0.016	0.087	0.054					0.133	85.0	2.5	
Bus163	33.000										0.060	92.7	1.1	
Bus167	33.000										0.055	93.0	1.0	
Bus169	33.000		0.007	0.004	0.022	0.014					0.046	86.8	0.9	
Bus172	33.000		0.003	0.002	0.009	0.005					0.013	85.0	0.3	
Bus174	33.000										0.021	53.8	0.4	
Bus176	33.000		0.003	0.002	0.009	0.005					0.013	85.0	0.3	
Bus180	33.000		0.009	0.006	0.032	0.020					0.451	88.5	8.5	
Bus182	33.000										0.403	88.7	7.6	
Bus184	33.000		0.016	0.010	0.056	0.035					0.085	85.0	1.6	
Bus186	33.000										0.320	89.4	6.0	
Bus188	33.000										0.280	89.7	5.2	
Bus189	33.000		0.008	0.005	0.027	0.017					0.041	85.0	0.8	
Bus190	33.000		0.011	0.007	0.038	0.024					0.210	86.5	3.9	
Bus191	33.000										0.154	86.1	2.9	
Bus192	33.000		0.008	0.005	0.027	0.017					0.085	85.0	1.6	
Bus193	33.000		0.008	0.005	0.029	0.018					0.045	85.0	0.8	
Bus194	33.000										0.070	85.9	1.3	
Bus196	33.000		0.006	0.004	0.020	0.012					0.030	85.0	0.6	
Bus197	33.000		0.008	0.005	0.027	0.017					0.041	85.0	0.8	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus198	33.000		0.003	0.002	0.009	0.006					0.073	94.6	1.4	
Bus199	33.000										0.061	94.1	1.1	
Bus201	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus202	33.000		0.004	0.003	0.014	0.009					0.021	85.0	0.4	
Bus204	33.000										0.030	91.8	0.6	
Bus206	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus207	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus208	33.000				0.005	0.003					0.005	85.0	0.1	
Bus211	33.000		0.007	0.004	0.022	0.014					3.820	82.9	72.8	
Bus213	33.000		0.007	0.004	0.022	0.013					3.769	82.8	72.3	
Bus215	33.000		0.007	0.004	0.022	0.013					3.730	82.8	71.7	
Bus217	33.000		0.007	0.004	0.022	0.013					3.691	82.8	71.0	
Bus218	33.000		0.007	0.004	0.021	0.013					3.631	82.7	70.5	
Bus220	33.000										3.593	82.6	69.9	
Bus222	33.000										3.555	82.5	69.7	
Bus223	33.000		0.003	0.002	0.008	0.005					0.032	97.6	0.6	
Bus224	33.000		0.001	0.001	0.004	0.002					0.005	85.0	0.1	
Bus225	33.000		0.003	0.002	0.008	0.005					0.018	92.4	0.3	
Bus226	33.000		0.001	0.001	0.004	0.003					0.006	85.0	0.1	
Bus228	33.000										3.517	82.2	69.2	
Bus229	33.000				0.004	0.003					0.005	85.0	0.1	
Bus230	33.000										3.495	82.1	69.2	
Bus231	33.000		0.009	0.006	0.029	0.018					0.046	85.0	0.9	
Bus232	33.000		0.032	0.020	0.101	0.062					3.446	82.0	68.3	
Bus233	33.000		0.006	0.004	0.019	0.012					2.868	81.3	57.1	
Bus234	33.000										0.240	94.0	4.8	
Bus235	33.000		0.007	0.004	0.021	0.013					0.077	88.5	1.5	
Bus236	33.000		0.008	0.005	0.024	0.015					0.045	88.0	0.9	
Bus238	33.000		0.002	0.001	0.006	0.004					0.010	85.0	0.2	
Bus239	33.000										0.165	95.3	3.3	
Bus240	33.000		0.007	0.004	0.020	0.013					0.032	85.0	0.6	
Bus241	33.000										0.139	94.3	2.8	
Bus242	33.000		0.006	0.004	0.018	0.011					0.028	85.0	0.6	
Bus243	33.000		0.003	0.002	0.009	0.006					0.113	94.4	2.3	
Bus244	33.000										0.100	94.6	2.0	
Bus245	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus246	33.000										0.089	95.2	1.8	
Bus248	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus249	33.000										0.084	95.2	1.7	
Bus251	33.000		0.002	0.001	0.005	0.003					0.008	85.0	0.2	
Bus255	33.000		0.001	0.001	0.003	0.002					0.021	87.0	0.4	
Bus256	33.000		0.003	0.002	0.011	0.007					0.017	85.0	0.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus257	33.000										0.057	97.0	1.1	
Bus259	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus261	33.000										0.045	98.3	0.9	
Bus264	33.000		0.002	0.001	0.005	0.003					0.021	88.8	0.4	
Bus266	33.000		0.003	0.002	0.009	0.006					0.014	85.0	0.3	
Bus268	33.000										0.027	96.1	0.5	
Bus270	33.000		0.004	0.002	0.011	0.007					0.017	85.0	0.3	
Bus272	33.000										0.013	86.0	0.3	
Bus273	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus274	33.000		0.002	0.001	0.007	0.004					0.011	85.0	0.2	
Bus275	33.000			0.000							2.607	79.7	52.0	
Bus276	33.000		0.052	0.032	0.159	0.099					0.248	85.0	5.0	
Bus277	33.000			0.000							1.795	73.3	35.9	
Bus278	33.000		0.327	0.309	0.979	0.927					1.798	72.6	36.4	
Bus280	33.000										0.592	92.2	11.8	
Bus282	33.000		0.004	0.003	0.012	0.008					0.594	91.9	11.9	
Bus283	33.000										0.576	91.9	11.5	
Bus284	33.000		0.001	0.001	0.003	0.002					0.015	96.6	0.3	
Bus286	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus287	33.000										0.563	91.4	11.3	
Bus289	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus290	33.000										0.552	91.3	11.0	
Bus291	33.000		0.011	0.007	0.033	0.020					0.051	85.0	1.0	
Bus292	33.000										0.502	91.7	10.0	
Bus294	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus296	33.000		0.004	0.002	0.011	0.007					0.491	91.6	9.8	
Bus297	33.000		0.007	0.004	0.020	0.012					0.475	91.5	9.5	
Bus298	33.000										0.445	91.7	8.9	
Bus299	33.000										0.059	87.5	1.2	
Bus300	33.000		0.007	0.004	0.020	0.012					0.031	85.0	0.6	
Bus302	33.000		0.006	0.004	0.019	0.012					0.030	85.0	0.6	
Bus304	33.000		0.001	0.001	0.003	0.002					0.388	91.8	7.8	
Bus306	33.000										0.384	91.7	7.7	
Bus307	33.000		0.032	0.020	0.098	0.061					0.153	85.0	3.1	
Bus309	33.000		0.007	0.004	0.020	0.012					0.241	92.2	4.8	
Bus311	33.000		0.007	0.004	0.020	0.012					0.210	92.9	4.2	
Bus312	33.000										0.183	92.3	3.7	
Bus313	33.000										0.025	97.9	0.5	
Bus314	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus316	33.000										0.021	97.8	0.4	
Bus318	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus320	33.000		0.003	0.002	0.010	0.006					0.019	86.6	0.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus322	33.000		0.001	0.000	0.002	0.001					0.004	85.0	0.1	
Bus324	33.000		0.007	0.004	0.020	0.012					0.162	88.8	3.2	
Bus326	33.000										0.131	89.4	2.6	
Bus328	33.000		0.007	0.004	0.020	0.012					0.031	85.0	0.6	
Bus330	33.000		0.007	0.004	0.020	0.012					0.102	89.0	2.0	
Bus331	33.000										0.072	90.0	1.4	
Bus333	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus335	33.000		0.007	0.004	0.020	0.012					0.061	88.2	1.2	
Bus337	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus338	33.000										0.031	90.2	0.6	
Bus340	33.000		0.002	0.001	0.005	0.003					0.008	85.0	0.2	
Bus341	33.000		0.003	0.002	0.008	0.005					0.012	85.0	0.2	
Bus346	11.000										0.533	85.1	28.9	
Bus348	11.000		0.007	0.004	0.065	0.040					0.127	85.0	6.9	
Bus349	11.000										0.043	85.1	2.3	
Bus351	11.000										0.405	85.1	22.0	
Bus353	11.000										0.296	85.1	16.1	
Bus354	11.000		0.054	0.033	0.198	0.123					0.296	85.0	16.2	
Bus358	11.000										2.301	85.1	130.0	
Bus359	11.000										2.456	84.9	135.6	
Bus360	11.000		0.019	0.012	0.068	0.042					0.102	85.0	5.6	
Bus362	11.000		0.055	0.034	0.189	0.117					0.287	85.0	16.2	
Bus363	11.000										2.007	85.1	113.8	
Bus364	11.000		0.023	0.014	0.079	0.049					0.120	85.0	6.8	
Bus366	11.000										1.870	85.2	107.0	
Bus370	11.000										0.232	85.5	13.3	
Bus371	11.000		0.002	0.001	0.005	0.003					0.008	85.0	0.5	
Bus372	11.000										0.224	85.4	12.8	
Bus373	11.000		0.004	0.003	0.014	0.009					0.021	85.0	1.2	
Bus374	11.000										0.202	85.4	11.6	
Bus375	11.000		0.002	0.001	0.007	0.005					0.011	85.0	0.6	
Bus376	11.000										0.191	85.4	11.0	
Bus378	11.000		0.004	0.003	0.014	0.008					0.032	85.5	1.9	
Bus380	11.000		0.002	0.001	0.008	0.005					0.012	85.0	0.7	
Bus383	11.000		0.016	0.010	0.054	0.034					0.083	85.0	4.8	
Bus384	11.000		0.015	0.009	0.049	0.031					0.159	85.0	9.1	
Bus388	11.000		0.011	0.007	0.038	0.024					3.382	84.8	187.8	
Bus389	11.000										3.504	84.7	191.3	
Bus390	11.000		0.012	0.007	0.043	0.027					0.065	85.0	3.5	
Bus391	11.000		0.007	0.004	0.024	0.015					3.294	84.9	184.6	
Bus393	11.000		0.028	0.017	0.096	0.060					3.246	84.9	182.6	
Bus394	11.000										3.091	85.0	174.4	

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
Bus395	11.000										0.930	85.1	52.6	
Bus396	11.000		0.099	0.061	0.335	0.207					2.138	85.0	121.8	
Bus397	11.000										1.624	85.0	92.8	
Bus399	11.000		0.116	0.072	0.391	0.243					0.597	85.0	34.1	
Bus400	11.000										1.025	85.0	58.7	
Bus401	11.000		0.052	0.032	0.175	0.108					0.267	85.0	15.3	
Bus403	11.000										0.757	85.0	43.4	
Bus405	11.000		0.025	0.016	0.085	0.053					0.313	85.0	18.0	
Bus407	11.000		0.036	0.022	0.120	0.074					0.183	85.0	10.5	
Bus409	11.000		0.017	0.011	0.057	0.035					0.400	85.0	22.9	
Bus411	11.000		0.070	0.043	0.234	0.145					0.357	85.0	20.5	
Bus459	11.000		0.004	0.003	0.014	0.009					0.169	85.2	9.6	
Bus461	11.000										0.148	85.1	8.4	
Bus462	11.000		0.004	0.003	0.014	0.009					0.022	85.0	1.2	
Bus464	11.000		0.024	0.015	0.083	0.052					0.126	85.0	7.2	
Bus465	11.000		0.054	0.033	0.184	0.114					0.759	85.0	43.0	
Bus467	11.000										0.480	85.1	27.2	
Bus469	11.000										0.429	85.0	24.3	
Bus471	11.000		0.010	0.006	0.034	0.021					0.051	85.0	2.9	
Bus473	11.000		0.082	0.051	0.281	0.174					0.428	85.0	24.3	
Bus474	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus477	33.000		0.011	0.007	0.009	0.005					0.023	85.0	0.4	
Bus478	11.000		0.020	0.012	0.073	0.045					0.108	85.0	5.9	
Bus479	11.000		0.008	0.005	0.029	0.018					0.043	85.0	2.3	
Bus516	11.000		0.051	0.032	0.171	0.106					1.635	85.1	93.7	
Bus517	11.000		0.065	0.041	0.219	0.136					0.335	85.0	19.2	
Bus518	11.000										1.373	85.2	78.7	
Bus519	11.000		0.060	0.037	0.201	0.125					0.308	85.0	17.7	
Bus520	11.000										1.037	85.2	59.5	
Bus521	11.000		0.030	0.018	0.098	0.061					0.150	85.0	8.7	
Bus522	11.000		0.023	0.014	0.075	0.047					0.116	85.0	6.7	
Bus523	11.000										0.723	85.3	41.9	
Bus524	11.000		0.007	0.005	0.025	0.015					0.457	85.5	26.5	
Bus525	11.000		0.007	0.004	0.022	0.014					0.419	85.5	24.3	
Bus526	11.000										0.384	85.6	22.3	
Bus527	11.000		0.004	0.002	0.012	0.008					0.384	85.6	22.3	
Bus528	11.000										0.365	85.6	21.2	
Bus530	11.000		0.004	0.002	0.012	0.008					0.019	85.0	1.1	
Bus531	11.000		0.004	0.002	0.013	0.008					0.020	85.0	1.2	
Bus532	11.000		0.004	0.002	0.012	0.008					0.019	85.0	1.1	
Bus533	11.000										0.038	85.7	2.2	
Bus534	11.000										0.057	85.7	3.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus535	11.000										0.359	85.6	20.9	
Bus536	11.000		0.002	0.001	0.007	0.004					0.011	85.0	0.6	
Bus537	11.000		0.003	0.002	0.010	0.006					0.025	85.3	1.5	
Bus538	11.000										0.302	85.5	17.6	
Bus539	11.000		0.006	0.004	0.019	0.012					0.277	85.5	16.2	
Bus540	11.000		0.030	0.018	0.096	0.060					0.148	85.0	8.6	
Bus541	11.000										0.247	85.5	14.4	
Bus542	11.000		0.004	0.003	0.013	0.008					0.021	85.0	1.2	
Bus543	11.000		0.004	0.002	0.012	0.007					0.039	85.3	2.3	
Bus544	11.000										0.099	86.2	5.8	
Bus545	11.000		0.002	0.001	0.005	0.003					0.008	85.0	0.5	
Bus546	11.000		0.002	0.001	0.007	0.004					0.019	85.3	1.1	
Bus547	11.000										0.060	86.5	3.5	
Bus548	11.000		0.004	0.002	0.012	0.007					0.041	86.5	2.4	
Bus549	11.000		0.001	0.001	0.003	0.002					0.005	85.0	0.3	
Bus550	11.000										0.023	87.5	1.3	
Bus551	11.000		0.004	0.002	0.012	0.007					0.019	85.0	1.1	
Bus552	11.000												-	
Bus553	11.000		0.001	0.001	0.004	0.002					0.006	85.0	0.3	
S20H085	33.000										6.888	85.8	126.5	

* Indicates operating load of a bus exceeds the bus critical limit (100.0% 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	%
T1	Transformer				5.000	3.610	72.2	3.492	69.8
T2	Transformer				5.000	3.610	72.2	3.492	69.8
T3	Transformer				5.000	3.389	67.8	3.284	65.7
T4	Transformer				5.000	3.389	67.8	3.284	65.7

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

Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	3.012	1.989	-2.990	-1.804	21.8	185.1	100.0	96.8	3.25
T2	3.012	1.989	-2.990	-1.804	21.8	185.1	100.0	96.8	3.25
T3	2.801	1.909	-2.782	-1.746	19.2	163.1	100.0	96.9	3.11
T4	2.801	1.909	-2.782	-1.746	19.2	163.1	100.0	96.9	3.11
Line1	5.981	3.609	-5.913	-3.532	67.5	76.3	96.8	95.3	1.49
Line423	0.455	0.280	-0.454	-0.280	0.6	0.3	96.9	96.7	0.15
Line442	2.121	1.330	-2.084	-1.299	36.2	31.2	96.9	95.0	1.84
Line480	2.988	1.881	-2.968	-1.863	20.0	17.4	96.9	96.2	0.72
Line4	-0.350	-0.217	0.350	0.216	0.0	-0.7	88.3	88.3	0.01
Line3	-5.532	-3.355	5.538	3.362	6.5	7.1	95.1	95.3	0.15
Line5	5.476	3.320	-5.474	-3.318	1.7	1.9	95.1	95.1	0.04
Line7	5.308	3.231	-5.264	-3.183	44.1	47.4	95.1	94.0	1.08
Line132	0.166	0.087	-0.166	-0.090	0.0	-2.3	95.1	95.1	0.01
Line11	5.219	3.159	-5.208	-3.148	10.5	11.2	94.0	93.7	0.26
Line17	0.016	0.009	-0.016	-0.010	0.0	-0.2	94.0	94.0	0.00
Line19	0.030	0.014	-0.030	-0.018	0.0	-3.9	94.0	94.0	0.00
Line21	5.192	3.138	-5.187	-3.133	4.9	5.3	93.7	93.6	0.12
Line137	-0.032	-0.020	0.032	0.019	0.0	-1.3	95.1	95.1	0.00
Line23	5.167	3.120	-5.159	-3.111	8.4	9.0	93.6	93.4	0.21
Line25	0.007	0.002	-0.007	-0.004	0.0	-2.8	93.4	93.4	0.00
Line27	1.326	0.693	-1.325	-0.694	0.2	-1.0	93.4	93.3	0.02
Line109	-1.333	-0.695	1.333	0.693	0.7	-1.6	93.4	93.4	0.05
Line29	1.310	0.685	-1.310	-0.687	0.4	-2.0	93.3	93.3	0.04
Line32	1.296	0.678	-1.295	-0.679	0.3	-1.3	93.3	93.3	0.03
Line34	0.896	0.473	-0.896	-0.474	0.1	-0.9	93.3	93.2	0.01
Line198	0.399	0.206	-0.399	-0.210	0.1	-3.0	93.3	93.2	0.02
Line36	0.044	0.021	-0.044	-0.025	0.0	-3.3	93.2	93.2	0.00
Line44	0.852	0.452	-0.852	-0.453	0.0	-0.5	93.2	93.2	0.01
Line40	0.014	0.007	-0.014	-0.009	0.0	-2.3	93.2	93.2	0.00
Line42	0.029	0.018	-0.029	-0.018	0.0	-0.2	93.2	93.2	0.00
Line46	0.815	0.430	-0.815	-0.431	0.1	-1.4	93.2	93.2	0.02
Line48	0.012	0.005	-0.012	-0.007	0.0	-1.9	93.2	93.2	0.00
Line50	0.803	0.426	-0.803	-0.426	0.0	-0.2	93.2	93.2	0.00
Line52	0.232	0.142	-0.232	-0.144	0.0	-1.9	93.2	93.2	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	
Line54	0.571	0.284	-0.571	-0.286	0.0	-1.4	93.2	93.2	0.01
Line56	0.561	0.279	-0.561	-0.282	0.1	-2.3	93.2	93.2	0.02
Line58	0.047	0.029	-0.047	-0.029	0.0	-0.1	93.2	93.2	0.00
Line60	0.514	0.252	-0.514	-0.254	0.1	-1.9	93.2	93.2	0.01
Line63	0.068	0.033	-0.068	-0.036	0.0	-3.6	93.2	93.2	0.01
Line69	0.445	0.222	-0.445	-0.222	0.0	-0.6	93.2	93.2	0.00
Line65	0.039	0.018	-0.039	-0.021	0.0	-3.0	93.2	93.2	0.00
Line67	0.021	0.010	-0.021	-0.013	0.0	-2.9	93.2	93.2	0.00
Line71	0.401	0.195	-0.401	-0.196	0.0	-2.0	93.2	93.2	0.01
Line73	0.372	0.178	-0.372	-0.181	0.0	-2.8	93.2	93.2	0.01
Line75	0.342	0.163	-0.342	-0.166	0.0	-2.6	93.2	93.1	0.01
Line77	0.082	0.043	-0.082	-0.045	0.0	-2.5	93.1	93.1	0.00
Line87	0.261	0.123	-0.261	-0.123	0.0	-0.2	93.1	93.1	0.00
Line79	0.029	0.017	-0.029	-0.018	0.0	-0.9	93.1	93.1	0.00
Line81	0.052	0.028	-0.052	-0.029	0.0	-0.8	93.1	93.1	0.00
Line83	0.023	0.011	-0.023	-0.013	0.0	-2.1	93.1	93.1	0.00
Line85	0.012	0.006	-0.012	-0.007	0.0	-1.3	93.1	93.1	0.00
Line89	0.232	0.105	-0.232	-0.109	0.0	-3.9	93.1	93.1	0.02
Line91	0.218	0.100	-0.218	-0.104	0.0	-3.3	93.1	93.1	0.01
Line93	0.029	0.018	-0.029	-0.018	0.0	-0.3	93.1	93.1	0.00
Line95	0.188	0.086	-0.188	-0.090	0.0	-4.2	93.1	93.1	0.01
Line97	0.159	0.072	-0.159	-0.084	0.1	-12.2	93.1	93.0	0.07
Line99	0.130	0.066	-0.130	-0.069	0.0	-3.0	93.0	93.0	0.01
Line101	0.101	0.051	-0.101	-0.057	0.0	-5.8	93.0	93.0	0.02
Line103	0.072	0.039	-0.072	-0.044	0.0	-5.8	93.0	93.0	0.01
Line105	-3.811	-2.411	3.825	2.418	14.2	7.4	93.0	93.4	0.38
Line107	0.046	0.028	-0.046	-0.029	0.0	-0.3	93.0	93.0	0.00
Line127	3.765	2.382	-3.759	-2.380	5.2	2.7	93.0	92.9	0.14
Line111	-0.041	-0.025	0.041	0.020	0.0	-5.2	95.1	95.1	0.01
Line157	-0.071	-0.039	0.071	0.035	0.0	-3.2	95.1	95.1	0.01
Line122	-0.014	-0.008	0.014	0.006	0.0	-2.4	91.8	91.8	0.00
Line124	0.339	0.103	-0.339	-0.110	0.1	-6.5	91.9	91.8	0.04
Line126	-0.396	-0.138	0.396	0.130	0.2	-8.9	91.9	91.9	0.06
Line160	0.325	0.104	-0.325	-0.107	0.1	-3.3	91.8	91.8	0.02
Line123	3.201	2.155	-3.201	-2.155	0.3	0.1	91.9	91.9	0.01
Line125	-3.597	-2.284	3.606	2.289	9.0	4.5	91.9	92.2	0.26
Line129	-0.029	-0.018	0.029	0.017	0.0	-0.5	92.2	92.2	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
Line239	3.172	2.137	-3.168	-2.135	4.2	1.7	91.9	91.8	0.13
Line15	3.679	2.331	-3.673	-2.328	5.9	3.0	92.7	92.5	0.17
Line131	-3.711	-2.351	3.717	2.354	6.2	3.2	92.7	92.9	0.17
Line128	-3.635	-2.306	3.648	2.313	12.8	6.4	92.2	92.5	0.36
Line130	-0.042	-0.026	0.042	0.025	0.0	-1.0	92.9	92.9	0.00
Line133	-0.032	-0.020	0.032	0.020	0.0	-0.3	95.1	95.1	0.00
Line134	-0.111	-0.060	0.111	0.058	0.0	-2.5	95.1	95.1	0.01
Line138	0.095	0.050	-0.095	-0.051	0.0	-1.1	95.1	95.1	0.00
Line135	-0.143	-0.077	0.143	0.077	0.0	-0.6	95.1	95.1	0.00
Line136	0.023	0.013	-0.023	-0.014	0.0	-1.4	95.1	95.1	0.00
Line139	-0.103	-0.054	0.103	0.053	0.0	-1.0	95.1	95.1	0.00
Line140	0.022	0.012	-0.022	-0.014	0.0	-1.7	95.1	95.1	0.00
Line142	0.073	0.039	-0.073	-0.042	0.0	-2.6	95.1	95.0	0.01
Line141	-0.134	-0.072	0.134	0.071	0.0	-1.7	95.1	95.1	0.00
Line143	-0.025	-0.016	0.025	0.013	0.0	-2.7	95.1	95.1	0.00
Line144	0.037	0.022	-0.037	-0.023	0.0	-1.2	95.0	95.0	0.00
Line146	0.036	0.020	-0.036	-0.022	0.0	-2.1	95.0	95.0	0.00
Line145	0.159	0.081	-0.159	-0.084	0.0	-2.2	95.1	95.1	0.01
Line147	-0.213	-0.115	0.213	0.112	0.0	-2.6	95.1	95.2	0.01
Line149	-0.004	-0.002	0.004	-0.001	0.0	-3.6	95.2	95.2	0.00
Line148	-0.375	-0.175	0.375	0.171	0.1	-4.3	95.2	95.3	0.03
Line150	0.036	0.010	-0.036	-0.015	0.0	-5.1	95.2	95.2	0.01
Line154	0.338	0.165	-0.338	-0.172	0.1	-7.7	95.2	95.2	0.05
Line152	0.019	0.005	-0.019	-0.012	0.0	-7.1	95.2	95.2	0.00
Line156	0.326	0.165	-0.326	-0.170	0.1	-5.0	95.2	95.2	0.03
Line158	0.113	0.058	-0.113	-0.058	0.0	-0.5	95.2	95.2	0.00
Line155	0.039	0.012	-0.039	-0.017	0.0	-4.8	95.2	95.2	0.01
Line151	0.008	-0.002	-0.008	-0.001	0.0	-3.4	95.2	95.2	0.00
Line153	0.005	0.003	-0.005	-0.003	0.0	-0.2	95.2	95.2	0.00
Line162	0.312	0.099	-0.312	-0.100	0.0	-0.9	91.8	91.8	0.01
Line164	0.112	0.043	-0.112	-0.045	0.0	-1.9	91.8	91.8	0.00
Line166	0.199	0.056	-0.199	-0.058	0.0	-1.8	91.8	91.8	0.01
Line168	0.084	0.027	-0.084	-0.031	0.0	-3.9	91.8	91.8	0.01
Line179	0.169	0.039	-0.169	-0.041	0.0	-1.6	91.8	91.8	0.00
Line170	0.014	0.003	-0.014	-0.008	0.0	-5.5	91.8	91.8	0.00
Line172	0.070	0.028	-0.070	-0.029	0.0	-0.2	91.8	91.8	0.00
Line174	0.042	0.011	-0.042	-0.013	0.0	-2.2	91.8	91.8	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line176	0.013	0.004	-0.013	-0.008	0.0	-4.1	91.8	91.8	0.00
Line177	0.029	0.009	-0.029	-0.018	0.0	-8.6	91.8	91.8	0.01
Line181	0.113	0.069	-0.113	-0.070	0.0	-1.6	91.8	91.8	0.00
Line182	0.056	-0.028	-0.056	0.023	0.0	-5.0	91.8	91.8	0.00
Line184	0.005	-0.002	-0.005	-0.003	0.0	-4.7	91.8	91.8	0.00
Line186	0.051	-0.021	-0.051	-0.003	0.0	-23.6	91.8	91.8	0.01
Line188	0.040	0.020	-0.040	-0.023	0.0	-2.6	91.8	91.8	0.00
Line192	0.011	-0.017	-0.011	0.012	0.0	-5.5	91.8	91.8	0.00
Line190	0.011	0.005	-0.011	-0.007	0.0	-1.9	91.8	91.8	0.00
Line194	0.011	0.006	-0.011	-0.007	0.0	-1.1	91.8	91.8	0.00
Line196	0.000	-0.018	0.000	0.000	0.0	-17.8	91.8	91.8	0.00
Line200	0.358	0.184	-0.358	-0.186	0.0	-1.9	93.2	93.2	0.01
Line202	0.072	0.044	-0.072	-0.045	0.0	-0.7	93.2	93.2	0.00
Line204	0.286	0.142	-0.286	-0.143	0.0	-0.8	93.2	93.2	0.00
Line206	0.035	0.021	-0.035	-0.022	0.0	-0.4	93.2	93.2	0.00
Line208	0.251	0.122	-0.251	-0.124	0.0	-2.1	93.2	93.2	0.01
Line210	0.182	0.105	-0.182	-0.105	0.0	-0.5	93.2	93.2	0.00
Line223	0.069	0.019	-0.069	-0.024	0.0	-4.9	93.2	93.2	0.01
Line212	0.133	0.075	-0.133	-0.078	0.0	-3.1	93.2	93.2	0.01
Line214	0.072	0.045	-0.072	-0.045	0.0	-0.3	93.2	93.2	0.00
Line218	0.060	0.034	-0.060	-0.036	0.0	-2.1	93.2	93.2	0.00
Line216	0.038	0.023	-0.038	-0.023	0.0	0.0	93.2	93.2	0.00
Line220	0.026	0.015	-0.026	-0.016	0.0	-1.2	93.2	93.2	0.00
Line221	0.034	0.021	-0.034	-0.021	0.0	-0.3	93.2	93.2	0.00
Line224	0.058	0.016	-0.058	-0.021	0.0	-4.3	93.2	93.2	0.01
Line227	0.012	0.006	-0.012	-0.007	0.0	-1.5	93.2	93.2	0.00
Line228	0.018	0.007	-0.018	-0.011	0.0	-4.1	93.2	93.2	0.00
Line230	0.028	0.008	-0.028	-0.012	0.0	-3.9	93.2	93.2	0.00
Line232	0.012	0.005	-0.012	-0.007	0.0	-1.8	93.2	93.2	0.00
Line233	0.012	0.007	-0.012	-0.007	0.0	-0.6	93.2	93.2	0.00
Line236	0.005	0.000	-0.005	-0.003	0.0	-3.0	93.2	93.2	0.00
Line241	3.139	2.118	-3.123	-2.111	16.5	6.7	91.8	91.3	0.53
Line243	3.095	2.093	-3.089	-2.091	5.3	2.2	91.3	91.1	0.17
Line245	3.061	2.074	-3.055	-2.071	6.1	2.4	91.1	90.9	0.20
Line265	3.027	2.054	-3.001	-2.044	25.6	10.1	90.9	90.0	0.84
Line248	2.973	2.027	-2.968	-2.024	5.3	2.1	90.0	89.9	0.18
Line250	0.019	0.006	-0.019	-0.012	0.0	-5.8	89.9	89.9	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
Line252	2.949	2.018	-2.931	-2.011	17.7	6.9	89.9	89.3	0.59
Line254	0.032	0.004	-0.032	-0.006	0.0	-2.4	89.3	89.3	0.00
Line261	2.900	2.007	-2.890	-2.004	9.2	3.6	89.3	89.0	0.31
Line256	0.005	0.000	-0.005	-0.003	0.0	-2.5	89.3	89.3	0.00
Line257	0.016	-0.001	-0.016	-0.003	0.0	-3.8	89.3	89.3	0.00
Line259	0.005	-0.004	-0.005	-0.003	0.0	-7.0	89.3	89.3	0.00
Line263	0.004	0.002	-0.004	-0.003	0.0	-0.6	89.0	89.0	0.00
Line267	2.886	2.002	-2.870	-1.995	16.6	6.6	89.0	88.4	0.56
Line269	0.039	0.024	-0.039	-0.024	0.0	-0.5	88.4	88.4	0.00
Line271	2.831	1.972	-2.827	-1.970	3.4	1.3	88.4	88.3	0.11
Line273	2.344	1.672	-2.332	-1.669	12.4	2.3	88.3	87.8	0.50
Line275	0.226	0.078	-0.226	-0.082	0.1	-3.5	87.8	87.8	0.03
Line331	2.081	1.576	-2.077	-1.575	4.1	0.3	87.8	87.7	0.15
Line277	0.068	0.035	-0.068	-0.036	0.0	-1.0	87.8	87.8	0.00
Line283	0.158	0.047	-0.158	-0.050	0.0	-3.1	87.8	87.8	0.02
Line279	0.040	0.018	-0.040	-0.021	0.0	-3.1	87.8	87.8	0.01
Line281	0.008	0.002	-0.008	-0.005	0.0	-3.1	87.8	87.8	0.00
Line285	0.027	0.016	-0.027	-0.017	0.0	-1.1	87.8	87.8	0.00
Line287	0.131	0.034	-0.131	-0.046	0.1	-11.6	87.8	87.7	0.06
Line289	0.024	0.013	-0.024	-0.015	0.0	-1.2	87.7	87.7	0.00
Line291	0.107	0.033	-0.107	-0.038	0.0	-5.0	87.7	87.7	0.02
Line293	0.095	0.030	-0.095	-0.033	0.0	-2.4	87.7	87.7	0.01
Line295	0.011	0.006	-0.011	-0.007	0.0	-0.9	87.7	87.7	0.00
Line297	0.084	0.027	-0.084	-0.027	0.0	-0.1	87.7	87.7	0.00
Line299	0.004	0.002	-0.004	-0.003	0.0	-0.4	87.7	87.7	0.00
Line301	0.080	0.025	-0.080	-0.026	0.0	-1.0	87.7	87.7	0.00
Line303	0.007	0.004	-0.007	-0.004	0.0	-0.5	87.7	87.7	0.00
Line305	0.018	0.009	-0.018	-0.010	0.0	-1.0	87.7	87.7	0.00
Line311	0.055	0.013	-0.055	-0.014	0.0	-1.1	87.7	87.7	0.00
Line309	0.014	0.008	-0.014	-0.009	0.0	-1.0	87.7	87.7	0.00
Line313	0.011	0.006	-0.011	-0.007	0.0	-0.6	87.7	87.7	0.00
Line315	0.044	0.008	-0.044	-0.008	0.0	-0.4	87.7	87.7	0.00
Line318	0.019	0.008	-0.019	-0.010	0.0	-1.9	87.7	87.7	0.00
Line322	0.026	0.000	-0.026	-0.001	0.0	-0.8	87.7	87.7	0.00
Line320	0.012	0.005	-0.012	-0.007	0.0	-1.9	87.7	87.7	0.00
Line324	0.014	0.007	-0.014	-0.009	0.0	-1.5	87.7	87.7	0.00
Line326	0.011	-0.006	-0.011	0.002	0.0	-4.5	87.7	87.7	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
Line328	0.002	-0.007	-0.002	-0.001	0.0	-8.2	87.7	87.7	0.00
Line329	0.009	0.005	-0.009	-0.006	0.0	-0.5	87.7	87.7	0.00
Line333	0.211	0.130	-0.211	-0.131	0.0	-0.8	87.7	87.7	0.00
Line335	1.319	1.218	-1.315	-1.221	3.9	-3.4	87.7	87.4	0.25
Line339	0.546	0.228	-0.546	-0.229	0.2	-1.4	87.7	87.6	0.03
Line337	1.315	1.221	-1.305	-1.237	10.1	-15.6	87.4	86.5	0.86
Line341	0.546	0.229	-0.546	-0.234	0.3	-4.8	87.6	87.6	0.06
Line343	0.529	0.223	-0.529	-0.227	0.2	-3.9	87.6	87.5	0.05
Line345	0.015	0.000	-0.015	-0.004	0.0	-3.5	87.5	87.5	0.00
Line349	0.514	0.227	-0.514	-0.228	0.1	-1.5	87.5	87.5	0.02
Line347	0.011	0.001	-0.011	-0.007	0.0	-5.2	87.5	87.5	0.00
Line352	0.011	0.006	-0.011	-0.007	0.0	-0.3	87.5	87.5	0.00
Line354	0.504	0.222	-0.504	-0.225	0.2	-3.2	87.5	87.5	0.04
Line356	0.043	0.027	-0.043	-0.027	0.0	-0.3	87.5	87.5	0.00
Line358	0.460	0.199	-0.460	-0.200	0.1	-1.2	87.5	87.5	0.01
Line360	0.011	0.005	-0.011	-0.007	0.0	-1.3	87.5	87.5	0.00
Line362	0.449	0.195	-0.449	-0.197	0.1	-2.7	87.5	87.4	0.03
Line364	0.435	0.188	-0.435	-0.191	0.1	-2.7	87.4	87.4	0.03
Line366	0.408	0.175	-0.408	-0.177	0.1	-2.4	87.4	87.4	0.02
Line368	0.052	0.027	-0.052	-0.029	0.0	-1.8	87.4	87.4	0.00
Line374	0.356	0.150	-0.356	-0.154	0.1	-3.5	87.4	87.3	0.03
Line370	0.026	0.016	-0.026	-0.016	0.0	-0.9	87.4	87.4	0.00
Line372	0.025	0.013	-0.025	-0.016	0.0	-2.5	87.4	87.4	0.00
Line376	0.352	0.151	-0.352	-0.153	0.0	-1.7	87.3	87.3	0.01
Line378	0.130	0.063	-0.130	-0.068	0.0	-5.4	87.3	87.3	0.03
Line380	0.222	0.090	-0.222	-0.093	0.0	-3.3	87.3	87.3	0.02
Line9	0.000	-0.012	0.000	0.000	0.0	-12.2	87.3	87.3	0.00
Line382	0.195	0.077	-0.195	-0.078	0.0	-1.2	87.3	87.3	0.01
Line384	0.169	0.061	-0.169	-0.063	0.0	-1.3	87.3	87.3	0.00
Line386	0.025	-0.007	-0.025	0.003	0.0	-4.2	87.3	87.3	0.00
Line388	0.144	0.070	-0.144	-0.075	0.0	-4.4	87.3	87.3	0.03
Line390	0.004	0.002	-0.004	-0.003	0.0	-0.7	87.3	87.3	0.00
Line392	0.021	-0.005	-0.021	0.004	0.0	-0.7	87.3	87.3	0.00
Line394	0.004	-0.002	-0.004	-0.003	0.0	-4.4	87.3	87.3	0.00
Line396	0.017	-0.003	-0.017	0.001	0.0	-1.4	87.3	87.3	0.00
Line398	0.003	-0.010	-0.003	-0.002	0.0	-11.5	87.3	87.3	0.00
Line400	0.117	0.058	-0.117	-0.059	0.0	-0.8	87.3	87.3	0.00

Branch ID	From-To Bus Flow MW	From-To Bus Flow Mvar	To-From Bus Flow MW	To-From Bus Flow Mvar	Losses kW	Losses kvar	% Bus Voltage From	% Bus Voltage To	Vd % Drop in Vmag
Line402	0.026	0.015	-0.026	-0.016	0.0	-1.0	87.3	87.3	0.00
Line404	0.091	0.044	-0.091	-0.047	0.0	-2.9	87.3	87.3	0.01
Line406	0.065	0.030	-0.065	-0.031	0.0	-1.2	87.3	87.3	0.00
Line408	0.010	0.005	-0.010	-0.007	0.0	-1.9	87.3	87.3	0.00
Line410	0.054	0.027	-0.054	-0.029	0.0	-2.2	87.3	87.3	0.00
Line414	0.028	0.013	-0.028	-0.013	0.0	-0.7	87.3	87.3	0.00
Line412	-0.010	-0.006	0.010	0.004	0.0	-2.9	87.3	87.3	0.00
Line416	0.007	0.004	-0.007	-0.004	0.0	-0.4	87.3	87.3	0.00
Line417	0.010	0.006	-0.010	-0.006	0.0	-0.7	87.3	87.3	0.00
Line420	0.346	0.213	-0.344	-0.213	1.2	0.3	96.7	96.4	0.37
Line421	0.108	0.067	-0.108	-0.067	0.0	0.0	96.7	96.7	0.01
Line427	0.036	0.022	-0.036	-0.022	0.0	0.0	96.7	96.7	0.00
Line603	0.036	0.022	-0.036	-0.022	0.0	-0.1	96.7	96.7	0.00
Line429	0.092	0.057	-0.092	-0.057	0.0	-0.1	96.4	96.4	0.01
Line431	0.252	0.156	-0.252	-0.156	0.1	0.0	96.4	96.4	0.03
Line433	0.252	0.156	-0.252	-0.156	0.6	-0.1	96.4	96.2	0.20
Line440	0.244	0.151	-0.244	-0.151	0.0	0.0	92.9	92.9	0.02
Line441	-1.957	-1.210	1.998	1.245	41.1	35.3	92.9	95.0	2.18
Line445	1.713	1.059	-1.708	-1.054	5.3	4.6	92.9	92.6	0.32
Line443	0.086	0.054	-0.086	-0.054	0.0	0.0	95.0	95.0	0.00
Line447	0.102	0.063	-0.102	-0.063	0.0	0.0	92.6	92.6	0.00
Line449	1.605	0.991	-1.593	-0.980	12.8	10.9	92.6	91.7	0.82
Line451	1.394	0.860	-1.392	-0.858	2.2	1.9	91.7	91.6	0.16
Line453	0.198	0.120	-0.198	-0.120	0.2	-0.2	91.7	91.6	0.12
Line455	0.007	0.004	-0.007	-0.004	0.0	0.0	91.6	91.6	0.00
Line457	0.191	0.116	-0.191	-0.116	0.1	-0.1	91.6	91.5	0.08
Line459	0.018	0.011	-0.018	-0.011	0.0	-0.1	91.5	91.5	0.00
Line461	0.173	0.105	-0.173	-0.105	0.2	-0.3	91.5	91.4	0.13
Line463	0.010	0.006	-0.010	-0.006	0.0	0.0	91.4	91.4	0.00
Line465	0.163	0.099	-0.163	-0.099	0.1	-0.1	91.4	91.4	0.04
Line467	0.028	0.017	-0.028	-0.017	0.0	-0.2	91.4	91.3	0.01
Line472	0.135	0.083	-0.135	-0.084	0.3	-0.6	91.4	91.2	0.20
Line469	0.010	0.006	-0.010	-0.006	0.0	-0.4	91.3	91.3	0.01
Line473	-0.071	-0.044	0.071	0.044	0.0	-0.2	91.1	91.2	0.02
Line478	2.820	1.761	-2.797	-1.741	23.1	20.0	94.5	93.7	0.86
Line479	-2.869	-1.791	2.913	1.830	44.2	38.4	94.5	96.2	1.62
Line481	0.055	0.034	-0.055	-0.034	0.0	-0.3	96.2	96.1	0.03

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line483	2.766	1.722	-2.757	-1.714	9.6	8.3	93.7	93.3	0.36
Line485	2.633	1.637	-2.625	-1.630	7.6	6.6	93.3	93.0	0.30
Line487	0.793	0.490	-0.791	-0.489	1.5	1.2	93.0	92.8	0.20
Line488	1.833	1.141	-1.817	-1.127	16.0	13.7	93.0	92.1	0.91
Line582	0.647	0.400	-0.646	-0.400	0.9	0.7	92.8	92.7	0.15
Line584	0.144	0.088	-0.144	-0.089	0.1	-0.2	92.8	92.8	0.06
Line490	1.384	0.858	-1.380	-0.856	3.3	2.8	92.1	91.9	0.25
Line492	0.508	0.315	-0.507	-0.314	0.2	0.1	91.9	91.8	0.04
Line494	0.873	0.541	-0.871	-0.540	1.6	1.3	91.9	91.7	0.19
Line496	0.227	0.140	-0.227	-0.140	0.0	0.0	91.7	91.7	0.01
Line498	0.645	0.399	-0.644	-0.399	0.6	0.4	91.7	91.6	0.09
Line500	0.340	0.211	-0.340	-0.211	0.0	0.0	91.6	91.6	0.01
Line508	0.304	0.188	-0.303	-0.188	0.1	0.0	91.6	91.6	0.04
Line502	0.155	0.096	-0.155	-0.096	0.0	0.0	91.5	91.5	0.02
Line506	-0.266	-0.165	0.266	0.165	0.2	0.0	91.5	91.6	0.07
Line586	0.126	0.077	-0.126	-0.078	0.1	-0.4	92.8	92.7	0.11
Line588	0.018	0.011	-0.018	-0.011	0.0	-0.2	92.7	92.7	0.01
Line589	0.107	0.066	-0.107	-0.067	0.0	-0.1	92.7	92.6	0.02
Line591	0.408	0.252	-0.408	-0.252	0.2	0.0	92.7	92.6	0.04
Line595	0.365	0.226	-0.365	-0.226	0.3	0.0	92.6	92.6	0.06
Line598	0.043	0.026	-0.043	-0.027	0.0	-0.4	92.6	92.6	0.03
Line596	0.365	0.226	-0.364	-0.225	0.7	0.3	92.6	92.4	0.21
Line639	1.170	0.720	-1.169	-0.720	0.6	0.5	91.6	91.5	0.06
Line640	-0.285	-0.176	0.285	0.176	0.0	0.0	91.5	91.5	0.01
Line641	0.885	0.543	-0.883	-0.542	1.2	1.0	91.5	91.4	0.14
Line642	-0.262	-0.162	0.262	0.162	0.1	0.0	91.3	91.4	0.05
Line643	0.622	0.380	-0.617	-0.377	4.7	3.4	91.4	90.6	0.77
Line644	-0.127	-0.079	0.127	0.079	0.0	0.0	90.6	90.6	0.01
Line645	-0.098	-0.061	0.099	0.061	0.1	-0.3	90.5	90.6	0.10
Line646	0.391	0.237	-0.391	-0.237	0.1	0.1	90.6	90.6	0.03
Line647	0.359	0.217	-0.358	-0.217	0.6	0.2	90.6	90.4	0.16
Line648	0.329	0.199	-0.329	-0.199	0.1	0.0	90.4	90.4	0.02
Line649	0.329	0.199	-0.329	-0.199	0.1	0.0	90.4	90.4	0.02
Line676	0.000	0.000	0.000	0.000	0.0	-0.1	90.4	90.4	0.00
Line650	0.313	0.189	-0.312	-0.189	0.6	0.2	90.4	90.2	0.18
Line651	0.005	0.003	-0.005	-0.003	0.0	-0.1	90.2	90.2	0.00
Line652	0.308	0.186	-0.308	-0.186	0.0	0.0	90.2	90.2	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
Line653	-0.016	-0.010	0.016	0.010	0.0	-0.1	90.2	90.2	0.00
Line654	-0.017	-0.010	0.017	0.010	0.0	-0.1	90.2	90.2	0.00
Line655	-0.016	-0.010	0.016	0.009	0.0	-0.5	90.1	90.2	0.01
Line656	-0.033	-0.020	0.033	0.020	0.0	-0.2	90.2	90.2	0.01
Line657	-0.049	-0.029	0.049	0.029	0.0	-0.1	90.2	90.2	0.01
Line658	0.259	0.157	-0.259	-0.157	0.3	0.0	90.2	90.1	0.13
Line659	-0.009	-0.006	0.009	0.005	0.0	-0.2	90.0	90.0	0.00
Line660	-0.022	-0.013	0.022	0.013	0.0	-0.1	90.0	90.1	0.00
Line661	0.237	0.144	-0.237	-0.144	0.3	0.0	90.1	89.9	0.15
Line662	0.211	0.128	-0.211	-0.128	0.1	0.0	89.9	89.9	0.05
Line663	-0.126	-0.078	0.126	0.078	0.0	0.0	89.8	89.9	0.01
Line664	0.085	0.050	-0.085	-0.050	0.0	-0.1	89.9	89.8	0.02
Line665	-0.018	-0.011	0.018	0.011	0.0	-0.3	89.8	89.8	0.01
Line666	-0.033	-0.020	0.034	0.020	0.0	-0.3	89.8	89.8	0.02
Line667	0.052	0.030	-0.052	-0.030	0.0	-0.1	89.8	89.8	0.01
Line668	-0.007	-0.004	0.007	0.004	0.0	-0.1	89.8	89.8	0.00
Line669	-0.016	-0.010	0.016	0.010	0.0	-0.4	89.8	89.8	0.01
Line670	0.036	0.021	-0.036	-0.021	0.0	-0.1	89.8	89.8	0.01
Line671	0.020	0.011	-0.020	-0.011	0.0	-0.1	89.8	89.8	0.00
Line672	-0.004	-0.002	0.004	0.001	0.0	-1.2	89.8	89.8	0.01
Line673	0.016	0.010	-0.016	-0.010	0.0	-0.1	89.8	89.8	0.00
					665.5	575.7			

Alert Summary Report

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

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus220	Bus	Under Voltage	33.000	kV	29.658	89.9	3-Phase
Bus222	Bus	Under Voltage	33.000	kV	29.46	89.3	3-Phase
Bus223	Bus	Under Voltage	33.000	kV	29.46	89.3	3-Phase
Bus224	Bus	Under Voltage	33.000	kV	29.46	89.3	3-Phase
Bus225	Bus	Under Voltage	33.000	kV	29.46	89.3	3-Phase
Bus226	Bus	Under Voltage	33.000	kV	29.46	89.3	3-Phase
Bus228	Bus	Under Voltage	33.000	kV	29.36	89.0	3-Phase
Bus229	Bus	Under Voltage	33.000	kV	29.36	89.0	3-Phase
Bus230	Bus	Under Voltage	33.000	kV	29.18	88.4	3-Phase
Bus231	Bus	Under Voltage	33.000	kV	29.18	88.4	3-Phase
Bus232	Bus	Under Voltage	33.000	kV	29.14	88.3	3-Phase
Bus233	Bus	Under Voltage	33.000	kV	28.98	87.8	3-Phase
Bus234	Bus	Under Voltage	33.000	kV	28.97	87.8	3-Phase
Bus235	Bus	Under Voltage	33.000	kV	28.96	87.8	3-Phase
Bus236	Bus	Under Voltage	33.000	kV	28.96	87.8	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus238	Bus	Under Voltage	33.000	kV	28.963	87.8	3-Phase
Bus239	Bus	Under Voltage	33.000	kV	28.96	87.8	3-Phase
Bus240	Bus	Under Voltage	33.000	kV	28.96	87.8	3-Phase
Bus241	Bus	Under Voltage	33.000	kV	28.94	87.7	3-Phase
Bus242	Bus	Under Voltage	33.000	kV	28.94	87.7	3-Phase
Bus243	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus244	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus245	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus246	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus248	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus249	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus251	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus255	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus256	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus257	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus259	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus261	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus264	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus266	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus268	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus270	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus272	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus273	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus274	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus275	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus276	Bus	Under Voltage	33.000	kV	28.93	87.7	3-Phase
Bus277	Bus	Under Voltage	33.000	kV	28.84	87.4	3-Phase
Bus278	Bus	Under Voltage	33.000	kV	28.56	86.5	3-Phase
Bus280	Bus	Under Voltage	33.000	kV	28.92	87.6	3-Phase
Bus282	Bus	Under Voltage	33.000	kV	28.90	87.6	3-Phase
Bus283	Bus	Under Voltage	33.000	kV	28.88	87.5	3-Phase
Bus284	Bus	Under Voltage	33.000	kV	28.88	87.5	3-Phase
Bus286	Bus	Under Voltage	33.000	kV	28.88	87.5	3-Phase
Bus287	Bus	Under Voltage	33.000	kV	28.88	87.5	3-Phase
Bus289	Bus	Under Voltage	33.000	kV	28.88	87.5	3-Phase
Bus290	Bus	Under Voltage	33.000	kV	28.86	87.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus291	Bus	Under Voltage	33.000	kV	28.863	87.5	3-Phase
Bus292	Bus	Under Voltage	33.000	kV	28.86	87.5	3-Phase
Bus294	Bus	Under Voltage	33.000	kV	28.86	87.5	3-Phase
Bus296	Bus	Under Voltage	33.000	kV	28.85	87.4	3-Phase
Bus297	Bus	Under Voltage	33.000	kV	28.84	87.4	3-Phase
Bus298	Bus	Under Voltage	33.000	kV	28.83	87.4	3-Phase
Bus299	Bus	Under Voltage	33.000	kV	28.83	87.4	3-Phase
Bus300	Bus	Under Voltage	33.000	kV	28.83	87.4	3-Phase
Bus302	Bus	Under Voltage	33.000	kV	28.83	87.4	3-Phase
Bus304	Bus	Under Voltage	33.000	kV	28.83	87.3	3-Phase
Bus306	Bus	Under Voltage	33.000	kV	28.82	87.3	3-Phase
Bus307	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus309	Bus	Under Voltage	33.000	kV	28.82	87.3	3-Phase
Bus311	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus312	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus313	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus314	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus316	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus318	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus320	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus322	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus324	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus326	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus328	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus330	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus331	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus333	Bus	Under Voltage	33.000	kV	28.80	87.3	3-Phase
Bus335	Bus	Under Voltage	33.000	kV	28.79	87.3	3-Phase
Bus337	Bus	Under Voltage	33.000	kV	28.79	87.3	3-Phase
Bus338	Bus	Under Voltage	33.000	kV	28.79	87.3	3-Phase
Bus340	Bus	Under Voltage	33.000	kV	28.79	87.3	3-Phase
Bus341	Bus	Under Voltage	33.000	kV	28.79	87.3	3-Phase
Bus4	Bus	Under Voltage	33.000	kV	29.14	88.3	3-Phase
Bus477	Bus	Under Voltage	33.000	kV	29.66	89.9	3-Phase
Bus539	Bus	Under Voltage	11.000	kV	9.89	89.9	3-Phase
Bus540	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase

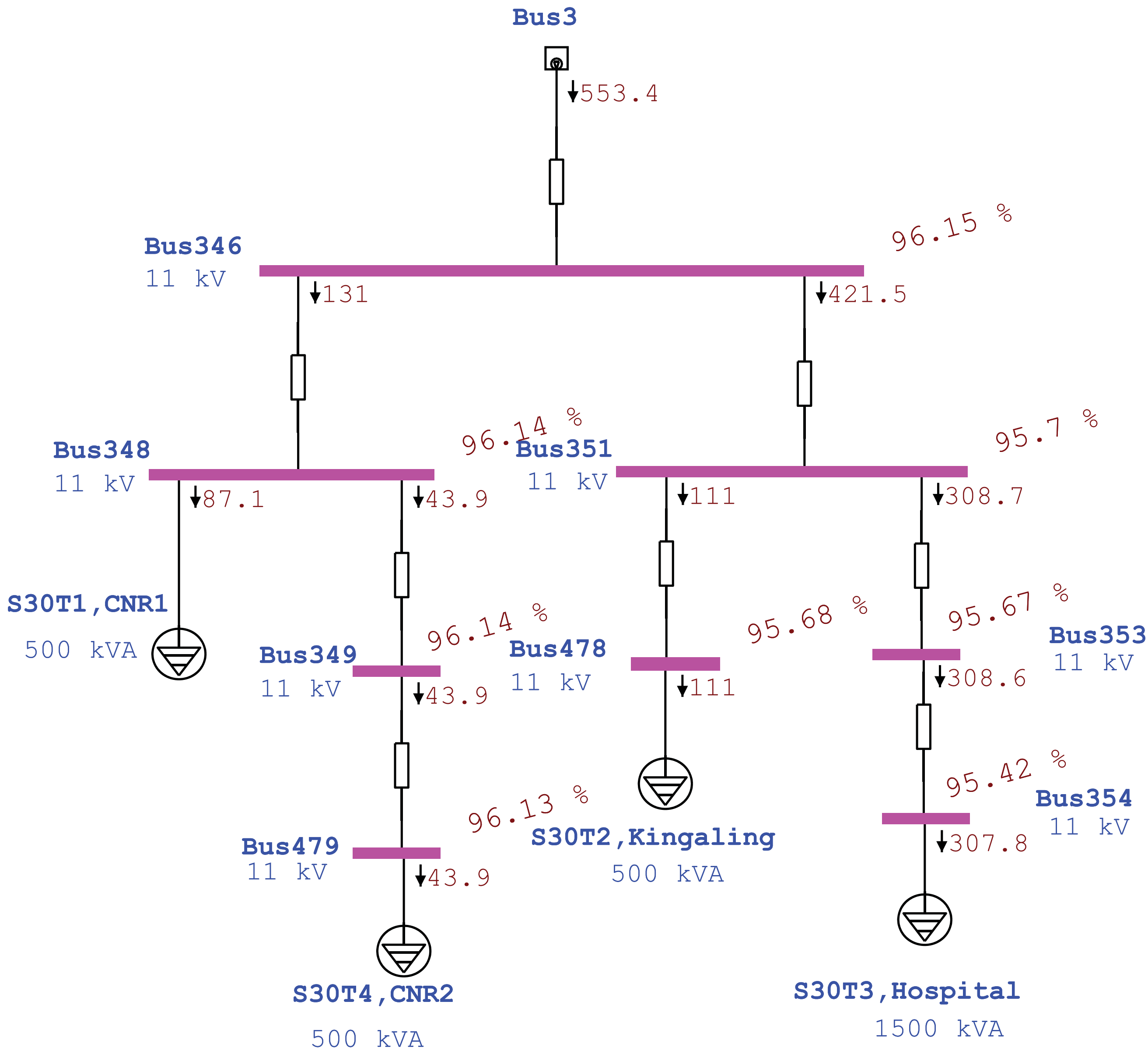
Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus541	Bus	Under Voltage	11.000	kV	9.884	89.9	3-Phase
Bus542	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus543	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus544	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus545	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus546	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus547	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus548	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus549	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus550	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus551	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase

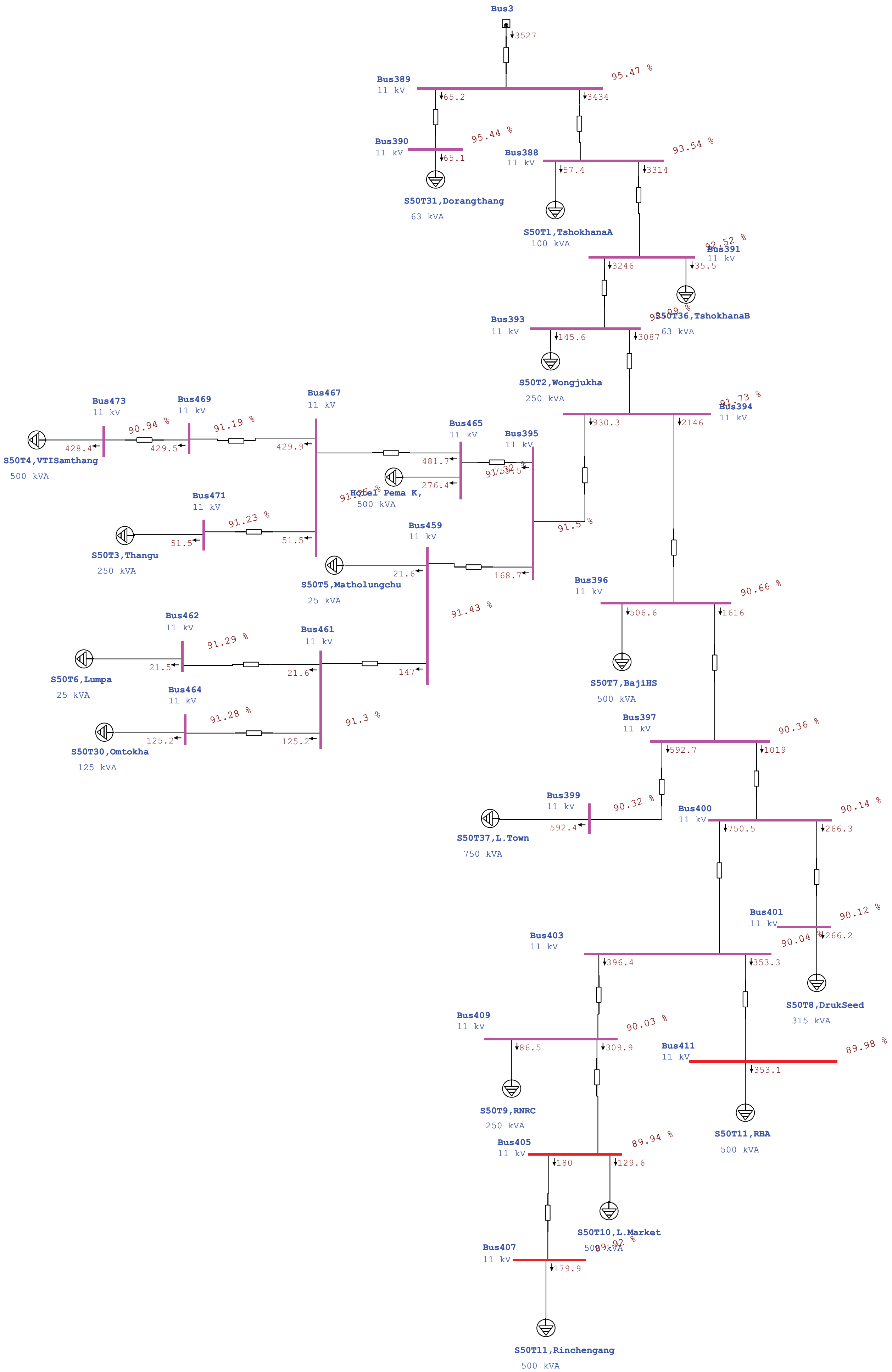
SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	11.626	7.796	13.998	83.05 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	11.626	7.796	13.998	83.05 Lagging
Total Motor Load:	2.565	1.697	3.076	83.40 Lagging
Total Static Load:	8.395	5.524	10.049	83.54 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.666	0.576		
System Mismatch:	0.000	0.000		

Number of Iterations: 3


Bus3
553.4
Bus346
11 kV
96.15 %
131
421.5
Bus348
11 kV
96.14 %
Bus351
11 kV
95.7 %
87.1
43.9
111
308.7
S30T1,CNR1
500 kVA
96.14 %
Bus349
11 kV
43.9
95.68 %
Bus478
11 kV
111
95.67 %
Bus353
11 kV
308.6
96.13 %
Bus479
11 kV
43.9
S30T2,Kingaling
500 kVA
95.42 %
Bus354
11 kV
307.8
S30T4,CNR2
500 kVA
S30T3,Hospital
1500 kVA

One-Line Diagram - OLV1=>11kV Feeder V (Load Flow Analysis)



Phobjikha

Project:		ETAP		Page:	1
Location:		16.1.1C		Date:	07-11-2019
Contract:				SN:	BHUTANPWR
Engineer:		Study Case:	2030 LFC	Revision:	Base
Filename:	Phobjikha			Config.:	Normal

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
Bus3	33.000										2.525	84.2	44.2	
Bus4	11.000										2.473	85.4	132.6	
Bus5	11.000		0.007	0.004	0.060	0.037					0.079	85.0	4.3	
Bus7	11.000				0.008	0.005					0.010	85.0	0.5	
Bus10	11.000		0.023	0.014	0.198	0.123					1.141	85.5	61.4	
Bus11	11.000										0.879	85.6	47.4	
Bus12	11.000		0.007	0.004	0.058	0.036					0.077	85.0	4.1	
Bus13	11.000		0.003	0.002	0.023	0.014					0.798	85.6	43.3	
Bus14	11.000										0.767	85.6	41.7	
Bus15	11.000		0.003	0.002	0.029	0.018					0.436	85.8	23.7	
Bus16	11.000		0.003	0.002	0.021	0.013					0.397	85.8	21.7	
Bus17	11.000		0.002	0.001	0.015	0.009					0.020	85.0	1.1	
Bus18	11.000										0.349	85.9	19.0	
Bus19	11.000		0.005	0.003	0.042	0.026					0.319	85.9	17.4	
Bus20	11.000		0.003	0.002	0.023	0.014					0.030	85.0	1.6	
Bus21	11.000		0.002	0.001	0.016	0.010					0.264	86.1	14.4	
Bus22	11.000		0.002	0.001	0.013	0.008					0.243	86.2	13.3	
Bus23	11.000		0.002	0.001	0.019	0.012					0.226	86.2	12.4	
Bus24	11.000		0.002	0.001	0.015	0.009					0.200	86.2	11.0	
Bus25	11.000		0.006	0.004	0.022	0.013					0.180	86.3	9.9	
Bus26	11.000		0.003	0.002	0.026	0.016					0.148	86.4	8.1	
Bus27	11.000										0.113	86.6	6.2	
Bus28	11.000		0.005	0.003	0.037	0.023					0.049	85.0	2.7	
Bus29	11.000										0.135	85.0	7.4	
Bus30	11.000		0.013	0.008	0.102	0.063					0.135	85.0	7.4	
Bus31	11.000										0.097	83.4	5.4	
Bus32	11.000		0.002	0.001	0.020	0.013					0.027	85.0	1.5	
Bus33	11.000		0.003	0.002	0.010	0.006					0.112	83.7	6.2	
Bus34	11.000										0.259	84.9	14.2	
Bus35	11.000		0.008	0.005	0.062	0.038					0.147	85.4	8.1	
Bus36	11.000		0.005	0.003	0.037	0.023					0.066	85.4	3.6	
Bus37	11.000		0.002	0.001	0.013	0.008					0.017	85.0	1.0	
Bus38	11.000										0.259	84.9	14.2	
Bus39	11.000										0.259	85.0	14.2	
Bus40	11.000		0.006	0.004	0.052	0.032					0.328	85.0	18.0	
Bus41	11.000										0.328	85.0	18.0	
Bus42	11.000										0.622	85.5	33.3	
Bus43	11.000		0.012	0.008	0.105	0.065					0.618	85.4	33.4	
Bus44	11.000		0.006	0.004	0.050	0.031					0.479	85.5	25.9	

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
Bus45	11.000										0.412	85.5	22.4	
Bus46	11.000		0.001	0.000	0.005	0.003					0.006	85.0	0.3	
Bus47	11.000		0.000	0.000	0.002	0.001					0.404	85.4	22.0	
Bus48	11.000										0.401	85.4	21.9	
Bus49	11.000		0.002	0.001	0.018	0.011					0.023	85.0	1.3	
Bus50	11.000										0.377	85.4	20.6	
Bus51	11.000		0.001	0.001	0.008	0.005					0.050	85.6	2.7	
Bus52	11.000										0.327	85.3	17.9	
Bus53	11.000		0.002	0.001	0.017	0.010					0.327	85.3	17.9	
Bus54	11.000										0.305	85.3	16.7	
Bus55	11.000										0.304	85.3	16.7	
Bus56	11.000										0.271	85.3	14.9	
Bus57	11.000		0.003	0.002	0.025	0.016					0.033	85.0	1.8	
Bus58	11.000		0.004	0.002	0.030	0.018					0.271	85.3	14.9	
Bus59	11.000										0.232	85.3	12.7	
Bus60	11.000										0.021	85.0	1.2	
Bus61	11.000		0.002	0.001	0.016	0.010					0.021	85.0	1.2	
Bus62	11.000										0.210	85.3	11.5	
Bus63	11.000		0.002	0.002	0.020	0.013					0.027	85.0	1.5	
Bus64	11.000		0.001	0.001	0.009	0.005					0.183	85.2	10.1	
Bus65	11.000		0.003	0.002	0.021	0.013					0.028	85.0	1.5	
Bus66	11.000		0.011	0.007	0.087	0.054					0.145	85.0	8.0	
Bus67	11.000		0.003	0.002	0.023	0.014					0.030	85.0	1.7	
Bus68	11.000										0.039	85.4	2.1	
Bus69	11.000		0.001	0.001	0.009	0.005					0.011	85.0	0.6	
Bus70	11.000										0.028	85.0	1.5	
Bus71	11.000		0.003	0.002	0.021	0.013					0.028	85.0	1.5	
Bus84	11.000										0.614	85.2	33.0	
Bus85	11.000		0.017	0.010	0.142	0.088					0.614	85.2	33.0	
Bus86	11.000		0.002	0.001	0.018	0.011					0.425	85.2	23.0	
Bus87	11.000		0.009	0.006	0.076	0.047					0.398	85.0	21.7	
Bus88	11.000		0.016	0.010	0.133	0.082					0.297	85.0	16.3	
Bus89	11.000		0.011	0.007	0.092	0.057					0.122	85.0	6.7	

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

Branch Loading Summary Report

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
Cable3	Cable	147.19	22.98	15.61					
Cable5	Cable	147.19	21.72	14.76					
Cable7	Cable	147.19	16.26	11.05					
Cable8	Cable	147.19	6.66	4.52					
Cable9	Cable	147.19	4.26	2.89					
Cable11	Cable	147.19	0.51	0.35					
Cable15	Cable	147.19	33.34	22.65					
Cable17	Cable	147.19	7.97	5.41					
Cable19	Cable	147.19	1.47	1.00					
Cable21	Cable	147.19	1.18	0.80					
Cable23	Cable	147.19	12.72	8.64					
Cable25	Cable	147.19	14.87	10.10					
Cable27	Cable	147.19	1.84	1.25					
Cable29	Cable	147.19	16.70	11.35					
Cable31	Cable	147.19	1.52	1.03					
Cable33	Cable	147.19	0.62	0.42					
Cable35	Cable	147.19	17.90	12.16					
Cable37	Cable	147.19	0.34	0.23					
Cable39	Cable	147.19	21.66	14.72					
Cable41	Cable	147.19	1.09	0.74					
Cable43	Cable	147.19	19.03	12.93					
Cable44	Cable	147.19	2.70	1.84					
Cable46	Cable	147.19	7.44	5.06					
Cable48	Cable	147.19	1.46	0.99					
Cable50	Cable	147.19	14.25	9.68					
Cable52	Cable	147.19	14.24	9.67					
Cable54	Cable	147.19	17.97	12.21					
T1	Transformer				2.500	1.263	50.5	1.236	49.5
T3	Transformer				2.500	1.263	50.5	1.236	49.5

* 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
T1	1.063	0.682	-1.056	-0.643	6.6	39.3	100.0	97.9	2.09
T3	1.063	0.682	-1.056	-0.643	6.6	39.3	100.0	97.9	2.09
Cable9	0.068	0.042	-0.067	-0.042	0.0	0.0	97.9	97.9	0.02
Cable11	0.008	0.005	-0.008	-0.005	0.0	0.0	97.9	97.9	0.00
Cable15	0.532	0.322	-0.532	-0.322	0.1	0.0	97.9	97.9	0.01
Line7	0.980	0.594	-0.975	-0.592	5.0	1.9	97.9	97.5	0.46
Line155	0.525	0.322	-0.523	-0.321	2.3	0.6	97.9	97.5	0.39
Line9	0.754	0.455	-0.752	-0.455	1.4	0.5	97.5	97.3	0.16
Line11	0.065	0.040	-0.065	-0.040	0.0	-0.2	97.3	97.3	0.02
Line13	0.687	0.414	-0.683	-0.413	4.3	1.4	97.3	96.7	0.56
Line15	0.657	0.397	-0.656	-0.397	1.0	0.3	96.7	96.6	0.13
Line17	0.375	0.224	-0.374	-0.224	0.2	0.0	96.6	96.6	0.04
Line70	0.281	0.173	-0.279	-0.173	2.7	-0.2	96.6	95.8	0.85
Cable39	0.342	0.204	-0.341	-0.204	1.1	0.2	96.6	96.3	0.25
Cable41	0.017	0.011	-0.017	-0.011	0.0	0.0	96.3	96.3	0.01
Cable43	0.300	0.178	-0.300	-0.178	0.3	0.1	96.3	96.2	0.08
Line25	0.275	0.163	-0.274	-0.163	0.5	0.0	96.2	96.1	0.17
Line27	0.025	0.015	-0.025	-0.016	0.0	-0.2	96.2	96.2	0.01
Line31	0.227	0.134	-0.227	-0.134	0.1	0.0	96.1	96.0	0.03
Line33	0.209	0.123	-0.209	-0.123	0.2	-0.1	96.0	96.0	0.07
Line35	0.195	0.114	-0.195	-0.114	0.2	-0.1	96.0	95.9	0.09
Line37	0.173	0.101	-0.173	-0.101	0.4	-0.4	95.9	95.6	0.22
Line39	0.156	0.091	-0.156	-0.091	0.3	-0.3	95.6	95.5	0.15
Line41	0.128	0.074	-0.127	-0.074	0.3	-0.5	95.5	95.3	0.18
Line43	0.098	0.056	-0.098	-0.056	0.1	-0.3	95.3	95.2	0.07
Cable44	0.042	0.026	-0.042	-0.026	0.0	0.0	95.2	95.2	0.01
Line45	0.056	0.031	-0.056	-0.031	0.0	-0.4	95.2	95.2	0.05
Cable46	0.115	0.071	-0.115	-0.071	0.1	0.0	95.2	95.2	0.04
Line51	-0.059	-0.040	0.059	0.040	0.0	-0.5	95.2	95.3	0.07
Cable48	0.023	0.014	-0.023	-0.014	0.0	0.0	95.3	95.3	0.01
Line55	-0.081	-0.054	0.081	0.053	0.0	-0.2	95.3	95.3	0.05
Line57	-0.094	-0.061	0.094	0.061	0.1	-0.3	95.3	95.4	0.07
Cable50	-0.220	-0.137	0.220	0.137	0.2	0.0	95.4	95.4	0.06
Line59	0.126	0.076	-0.126	-0.076	0.2	-0.5	95.4	95.2	0.17

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
Line62	0.056	0.034	-0.056	-0.034	0.1	-0.7	95.2	95.1	0.10
Line64	0.015	0.009	-0.015	-0.009	0.0	-0.6	95.1	95.1	0.02
Line66	-0.220	-0.137	0.221	0.137	0.6	-0.2	95.4	95.7	0.23
Cable52	-0.221	-0.137	0.221	0.137	0.2	0.0	95.7	95.7	0.06
Cable54	-0.279	-0.173	0.279	0.173	0.1	0.0	95.7	95.8	0.03
Line78	0.532	0.322	-0.528	-0.321	3.7	1.0	97.9	97.3	0.62
Line80	0.411	0.249	-0.409	-0.248	1.9	0.4	97.3	96.9	0.41
Line82	0.353	0.214	-0.352	-0.214	0.7	0.1	96.9	96.7	0.18
Cable37	0.005	0.003	-0.005	-0.003	0.0	0.0	96.7	96.7	0.00
Line84	0.347	0.210	-0.345	-0.210	1.3	0.1	96.7	96.4	0.32
Line87	0.343	0.209	-0.343	-0.209	0.5	0.0	96.4	96.2	0.12
Line89	0.323	0.196	-0.322	-0.196	1.2	0.1	96.2	95.9	0.33
Line91	0.020	0.012	-0.020	-0.012	0.0	0.0	96.2	96.2	0.00
Line93	0.043	0.026	-0.043	-0.026	0.0	-0.1	95.9	95.9	0.01
Line94	0.279	0.171	-0.279	-0.171	0.1	0.0	95.9	95.9	0.05
Line128	0.033	0.020	-0.033	-0.020	0.0	-0.3	95.9	95.9	0.02
Cable35	0.279	0.171	-0.279	-0.171	0.3	0.1	95.9	95.8	0.09
Cable29	0.260	0.159	-0.260	-0.159	0.2	0.0	95.8	95.7	0.07
Line100	0.260	0.159	-0.260	-0.159	0.2	0.0	95.7	95.6	0.07
Cable27	0.028	0.018	-0.028	-0.018	0.0	0.0	95.6	95.6	0.00
Line102	0.231	0.141	-0.231	-0.141	0.2	-0.1	95.6	95.6	0.08
Cable25	0.231	0.141	-0.231	-0.141	0.0	0.0	95.6	95.5	0.01
Cable23	0.198	0.121	-0.198	-0.121	0.0	0.0	95.5	95.5	0.01
Line5	0.179	0.110	-0.179	-0.110	0.2	-0.1	95.5	95.4	0.09
Line113	0.018	0.011	-0.018	-0.011	0.0	-0.2	95.5	95.5	0.01
Cable21	0.018	0.011	-0.018	-0.011	0.0	0.0	95.5	95.5	0.00
Cable19	0.023	0.014	-0.023	-0.014	0.0	0.0	95.4	95.4	0.01
Line120	0.156	0.096	-0.156	-0.096	0.2	-0.3	95.4	95.3	0.13
Cable17	0.123	0.076	-0.123	-0.076	0.0	0.0	95.3	95.3	0.02
Line122	0.024	0.014	-0.024	-0.015	0.0	-0.6	95.3	95.3	0.04
Line126	0.026	0.016	-0.026	-0.016	0.0	-0.2	95.3	95.3	0.01
Cable33	0.010	0.006	-0.010	-0.006	0.0	0.0	95.9	95.9	0.00
Line132	0.024	0.014	-0.024	-0.015	0.0	-0.4	95.9	95.9	0.02
Cable31	0.024	0.015	-0.024	-0.015	0.0	0.0	95.9	95.9	0.01
Line156	0.523	0.321	-0.523	-0.321	0.1	0.0	97.5	97.5	0.01
Cable3	0.364	0.223	-0.362	-0.222	1.8	0.4	97.5	97.1	0.40
Cable5	0.343	0.210	-0.338	-0.209	4.5	0.9	97.1	96.1	1.03

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Cable7	0.253	0.157	-0.253	-0.156	0.5	0.1	96.1	95.9	0.17
Cable8	0.103	0.064	-0.103	-0.064	0.1	0.0	95.9	95.8	0.08
					52.9	79.3			

Alert Summary Report

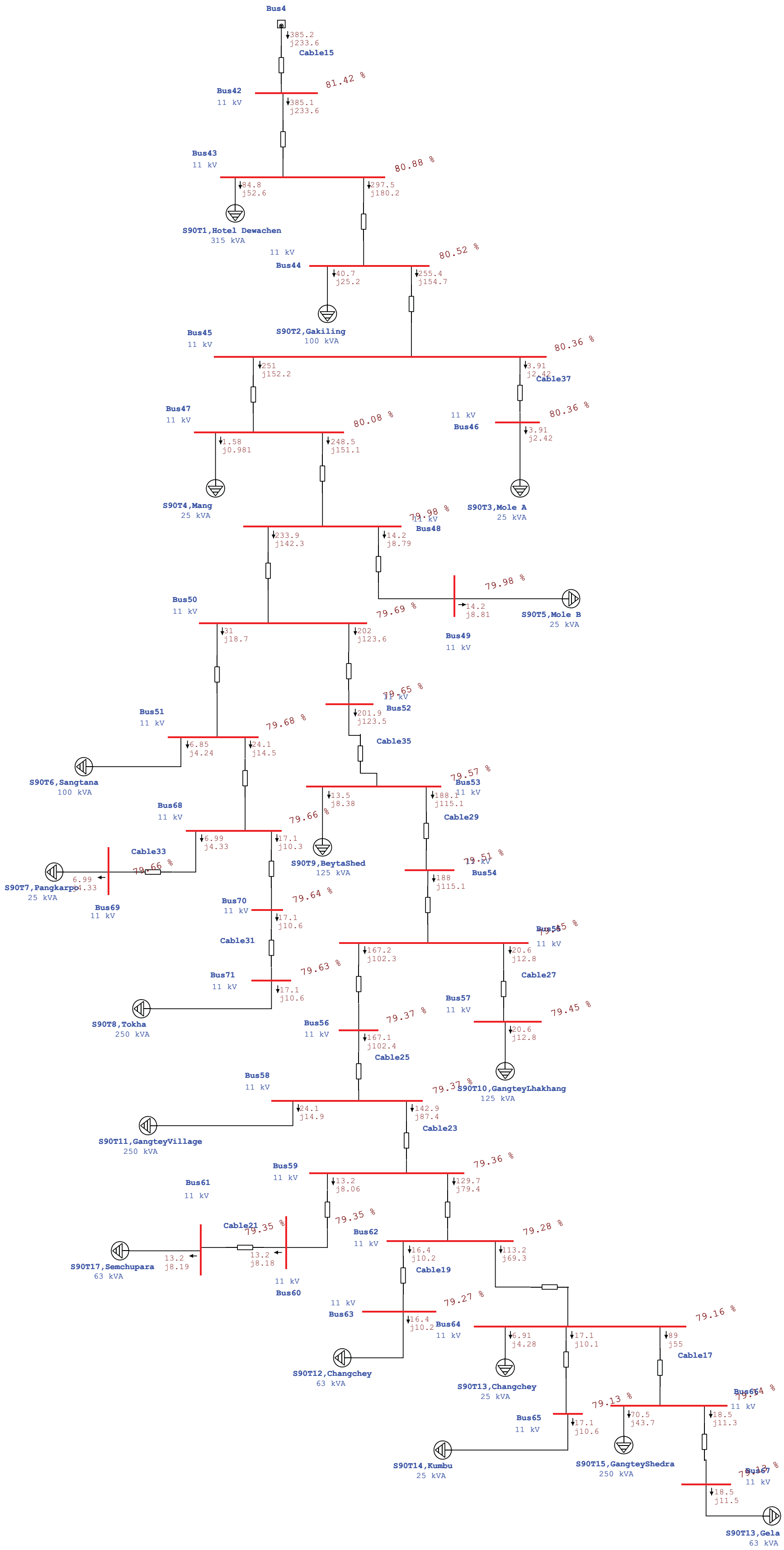
	% Alert Settings	
	Critical	**Marginal**
Loading		
Bus	100.0	95.0
Cable	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	110.0	105.0
UnderVoltage	90.0	95.0
Generator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

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

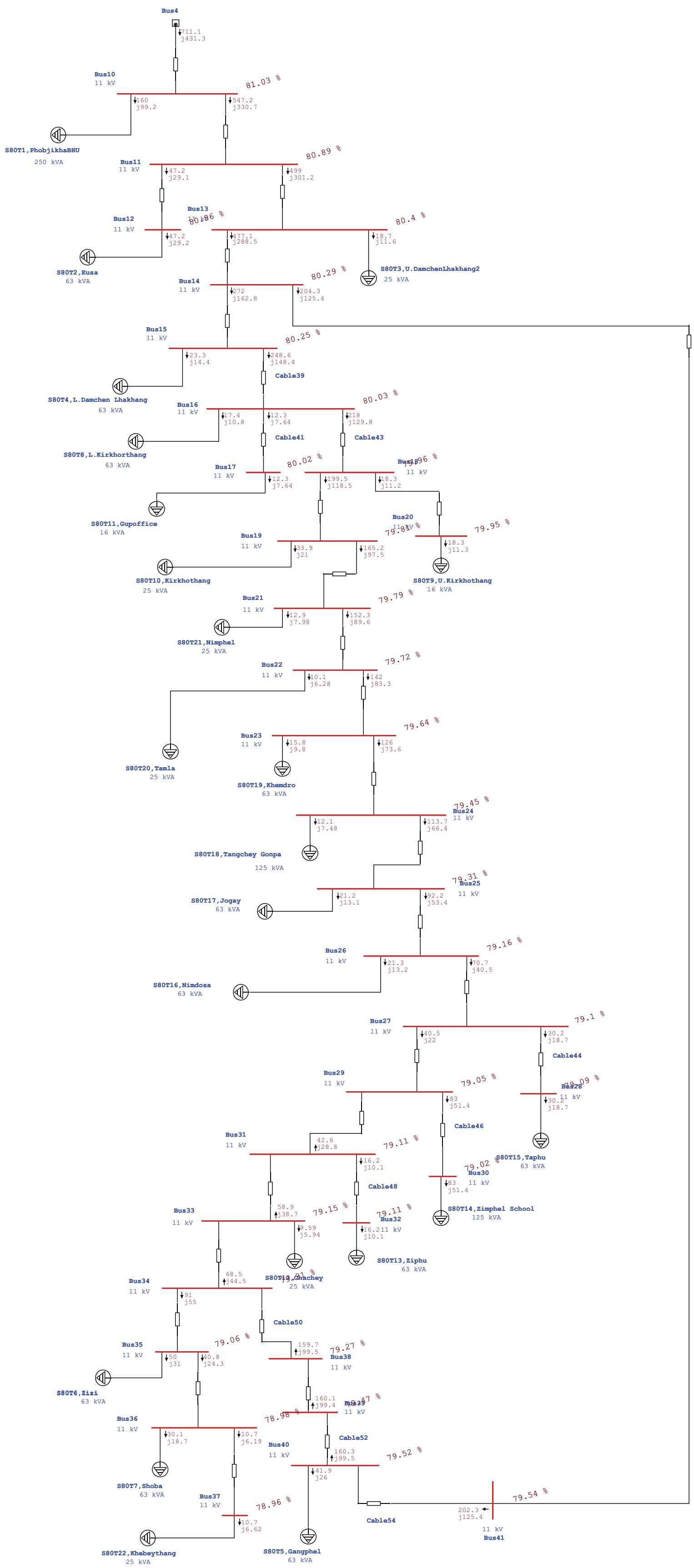
	MW	Mvar	MVA	% PF
Source (Swing Buses):	2.126	1.364	2.525	84.16 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	2.126	1.364	2.525	84.16 Lagging
Total Motor Load:	0.226	0.140	0.265	85.00 Lagging
Total Static Load:	1.847	1.145	2.173	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.053	0.079		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

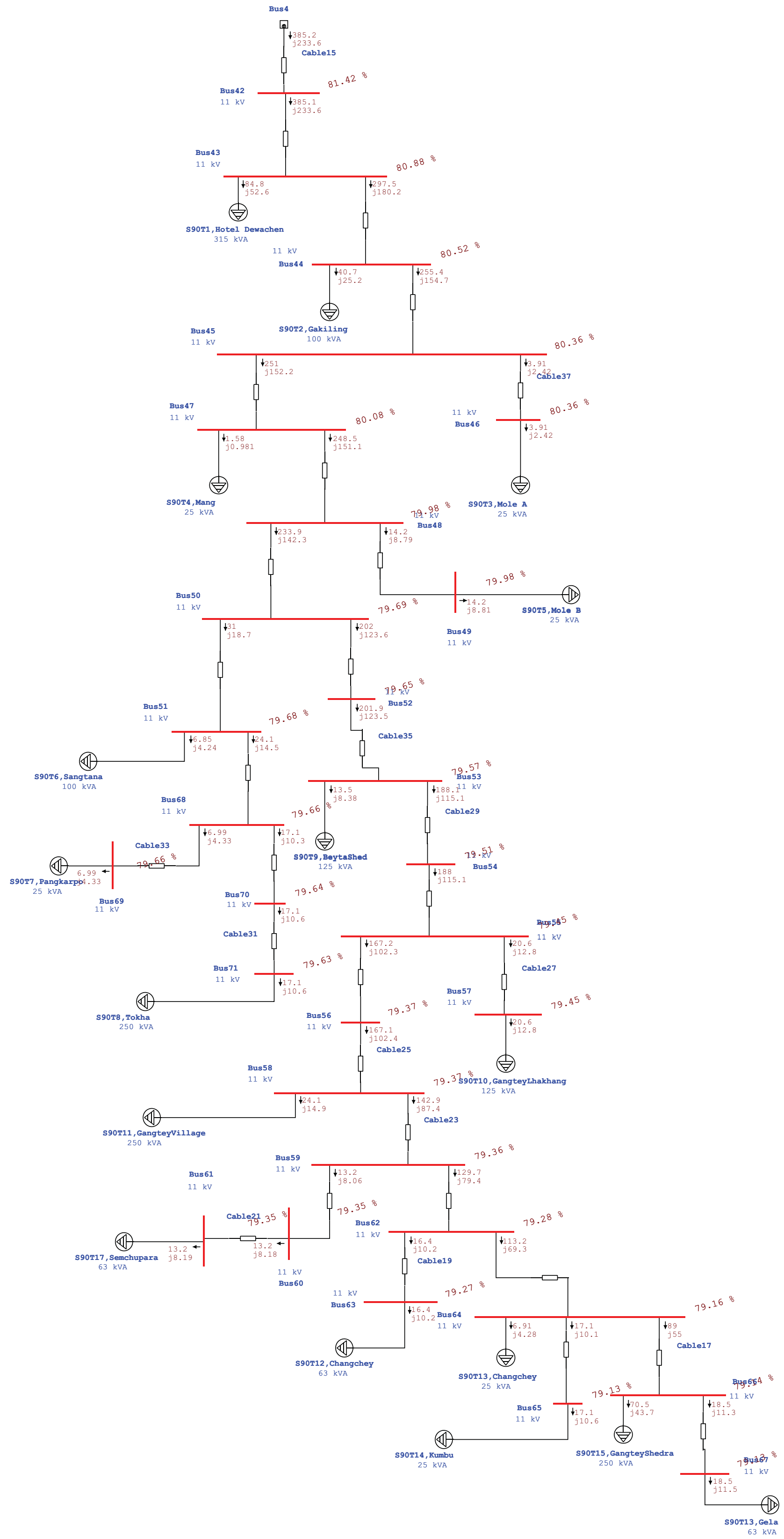
One-Line Diagram - OLV1=>S90 (Load Flow Analysis)

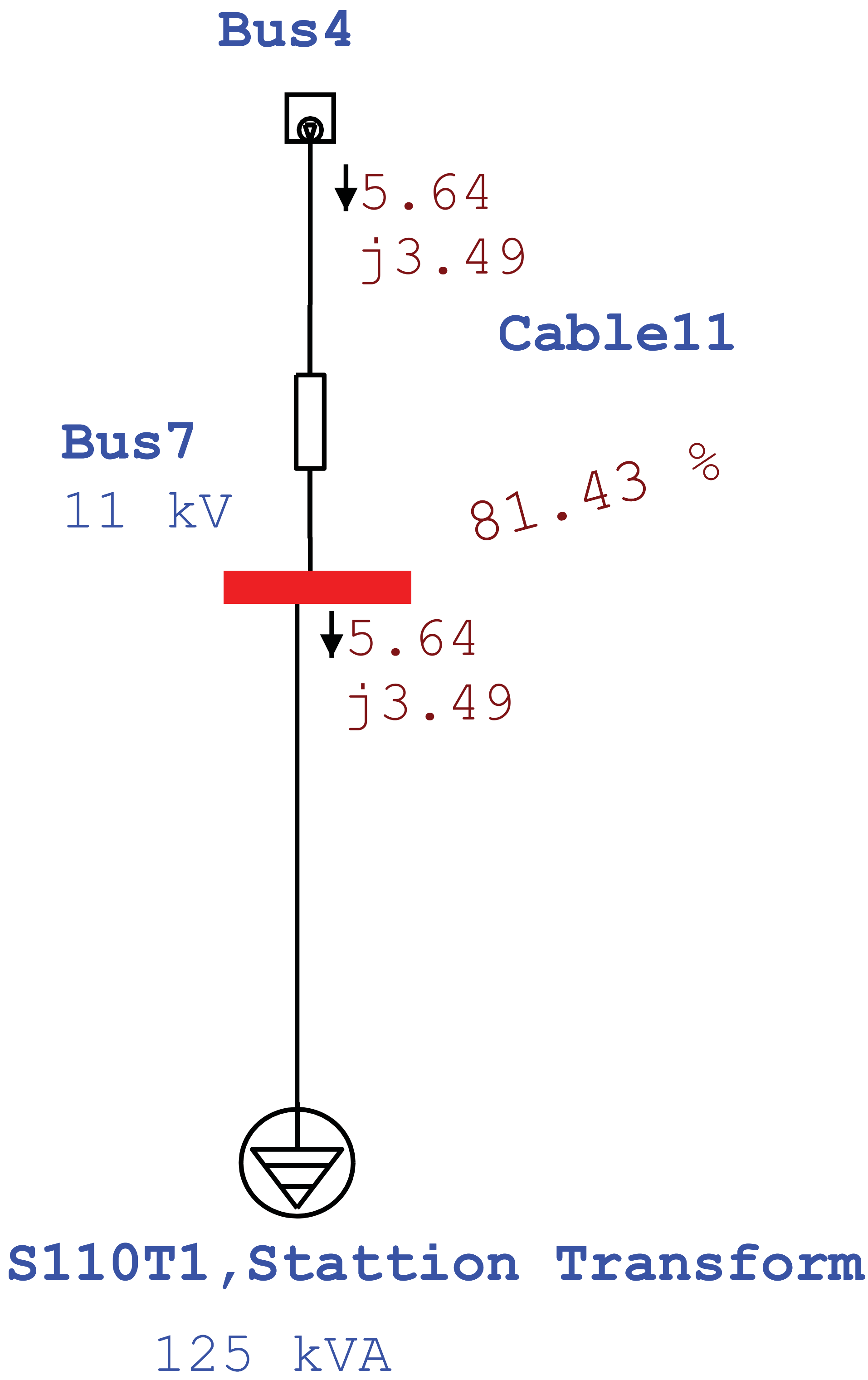


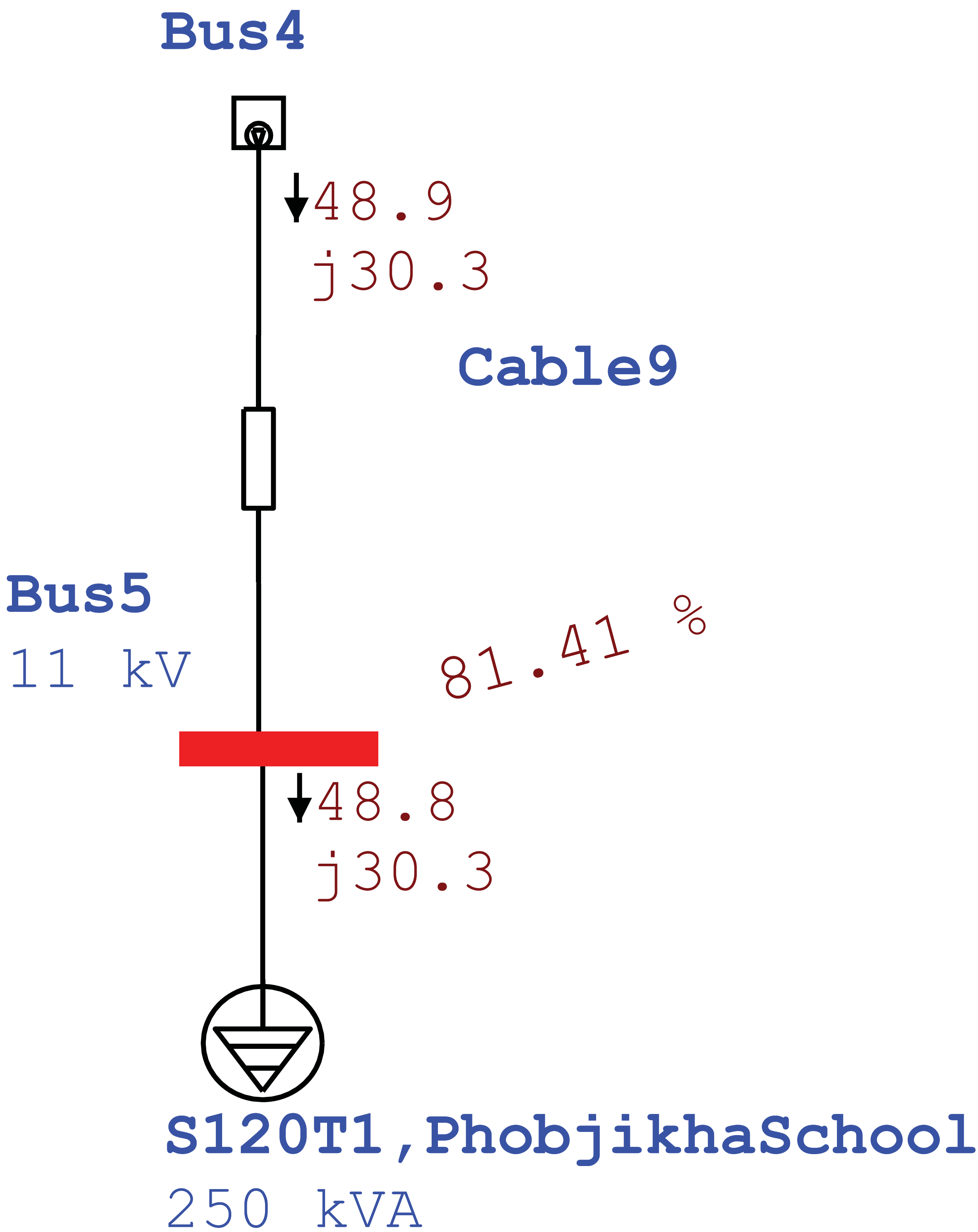
One-Line Diagram - OLV1=>S80 (Load Flow Analysis)



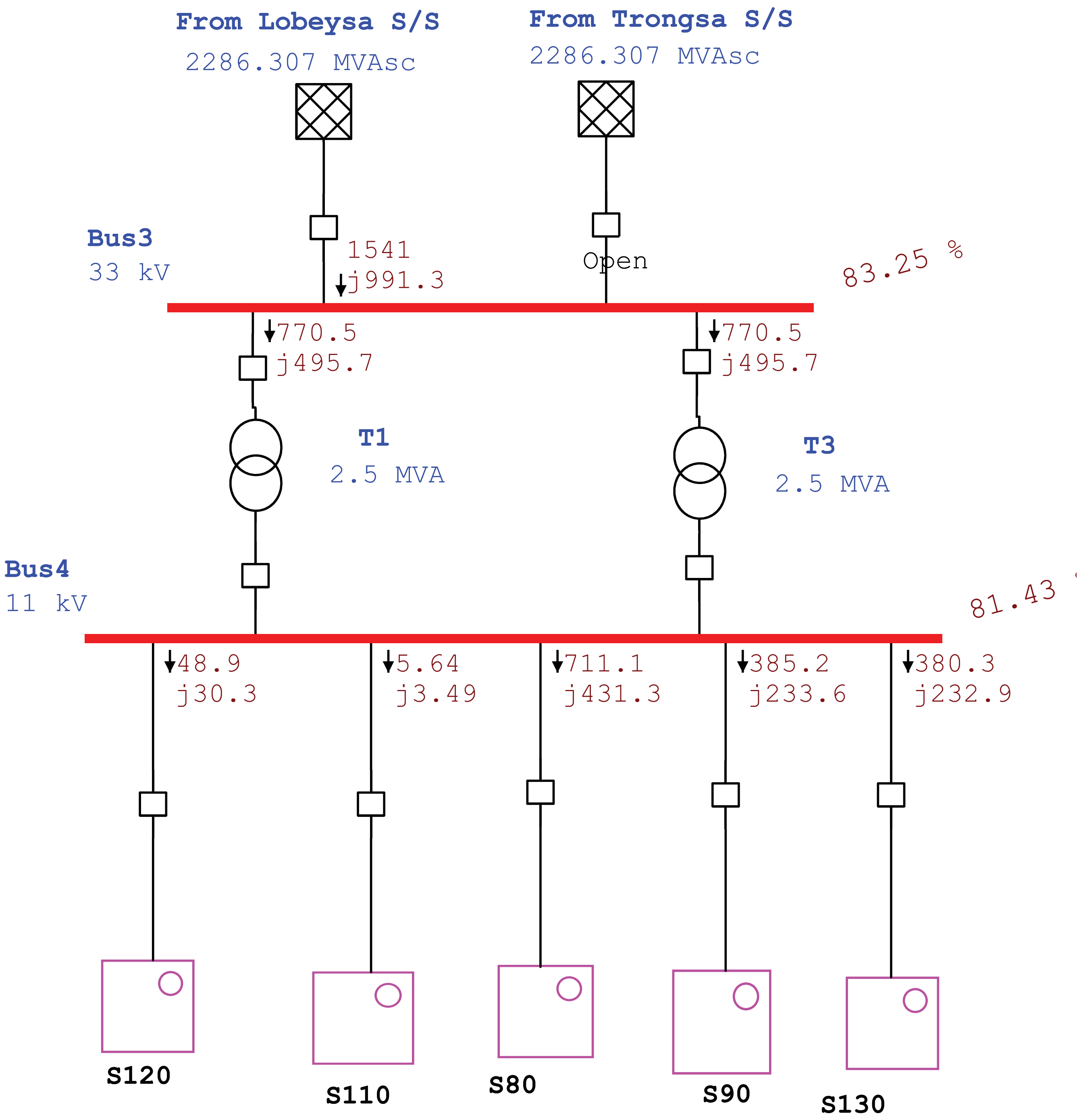
One-Line Diagram - OLV1=>S90 (Load Flow Analysis)




Bus4
5.64
j3.49
Cable11
Bus7
11 kV
81.43 %
5.64
j3.49
S110T1,Stattion Transform
125 kVA


Bus4
48.9
j30.3
Cable9
Bus5
11 kV
81.41 %
48.8
j30.3
S120T1,PhobjikhaSchool
250 kVA

One-Line Diagram - OLV1 (Load Flow Analysis)



Annexure 5: Feeder Wise Reliability Indices

Sl.No.	Year	Month	Reliability Indices	33 kV Khotokha/Phobjikha Feeder II	11kV Rinchengang Feeder III	11kV Gaselo Feeder IV	11kV Bajo Town Feeder V	11kV Hebesa Feeder I	11kV Jala Ula Feeder III	11kV Rurichu Feeder IV
1	2016	January	SAIFI	7.37	0.00	0.89	0.72	0.01	0.52	-
			SAIDI	8.17	0.00	0.24	0.16	0.48	0.11	-
2		February	SAIFI	5.96	0.00	0.54	0.72	0.01	0.26	-
			SAIDI	9.78	0.00	0.34	0.23	0.48	0.19	-
3		March	SAIFI	6.32	0.00	0.89	0.48	0.02	0.87	0.04
			SAIDI	2.45	0.00	0.46	2.56	0.06	2.58	0.06
4		April	SAIFI	10.16	0.00	2.68	-	-	0.35	0.02
			SAIDI	4.37	0.00	2.33	-	-	0.51	0.00
5		May	SAIFI	5.96	0.00	3.40	-	-	0.61	0.02
			SAIDI	3.48	-	1.62	-	-	0.40	0.01
6		June	SAIFI	12.26	0.00	3.03	1.67	-	0.26	0.06
			SAIDI	8.55	-	1.83	3.98	-	0.47	0.02
7		July	SAIFI	13.64	0.00	2.84	1.91	0.01	0.79	0.29
			SAIDI	14.61	0.00	1.98	18.47	0.03	1.47	0.21
8		August	SAIFI	8.78	-	2.84	0.72	-	0.35	0.02
			SAIDI	4.02	-	1.41	0.62	-	0.85	0.01
9		September	SAIFI	4.91	-	2.66	0.60	-	0.18	0.02
			SAIDI	2.40	-	2.18	2.17	-	0.18	0.01
10		October	SAIFI	6.66	-	2.13	-	-	0.17	-
			SAIDI	3.73	-	1.41	-	-	0.80	-
11		November	SAIFI	5.61	0.00	2.66	0.24	-	0.18	0.02
			SAIDI	3.35	0.00	1.57	0.18	-	0.06	0.02
12		December	SAIFI	2.80	-	1.24	0.95	-	0.18	-
			SAIDI	2.70	-	0.46	0.27	-	0.88	-
	Total		**SAIFI**	**90.42**	**0.00**	**25.81**	**7.99**	**0.05**	**4.70**	**0.49**
			SAIDI	**67.61**	**0.00**	**15.83**	**28.64**	**1.05**	**8.50**	**0.35**
1	2017	January	SAIFI	5.60	-	1.42	0.71	-	-	-
			SAIDI	2.13	-	1.31	0.44	-	0.01	-
2		February	SAIFI	4.20	0.00	0.53	0.47	-	0.27	-
			SAIDI	1.09	0.00	0.17	0.52	-	0.15	-
3		March	SAIFI	6.68	-	1.95	-	-	1.14	0.04
			SAIDI	3.09	-	1.75	-	-	0.75	0.01
4		April	SAIFI	0.23	0.00	0.15	0.07	0.01	0.14	-
			SAIDI	1.27	0.00	0.47	0.07	0.10	1.18	-
5		May	SAIFI	0.19	-	0.08	0.05	-	0.04	-
			SAIDI	2.95	-	0.21	0.06	-	0.03	-
6		June	SAIFI	0.69	0.01	0.53	0.23	0.01	0.18	0.01
			SAIDI	4.04	0.01	1.47	1.01	0.01	0.31	0.00
7		July	SAIFI	12.51	0.01	0.18	2.79	0.03	1.36	0.03
			SAIDI	10.15	0.18	0.62	1.07	0.04	1.59	0.02
8		August	SAIFI	12.80	0.01	0.18	2.11	0.04	0.73	0.03
			SAIDI	10.33	-	-	1.19	0.00	0.50	0.00
9		September	SAIFI	8.93	-	2.27	0.69	0.03	0.96	0.28
			SAIDI	5.74	-	0.99	0.23	0.02	0.91	0.31
10		October	SAIFI	8.46	-	1.25	0.71	-	1.06	0.10
			SAIDI	4.53	-	0.42	0.64	0.01	1.50	0.04
11		November	SAIFI	8.85	-	0.36	-	0.01	1.24	-
			SAIDI	4.24	0.00	0.59	-	0.01	0.64	-
12		December	SAIFI	2.47	-	1.43	0.71	0.01	0.35	0.08
			SAIDI	3.61	-	0.44	0.57	0.00	0.23	0.03
	Total		**SAIFI**	**71.62**	**0.03**	**10.33**	**8.54**	**0.15**	**7.46**	**0.58**
			SAIDI	**53.17**	**0.19**	**8.45**	**5.82**	**0.21**	**7.80**	**0.42**
1	2018	January	SAIFI	1.41	-	1.43	0.24	0.01	0.26	0.04
			SAIDI	0.23	-	1.75	0.08	0.03	0.02	0.02
2		February	SAIFI	6.33	-	2.14	0.71	0.01	0.26	-
			SAIDI	1.82	-	2.39	0.16	0.00	0.33	-
3		March	SAIFI	0.43	-	0.19	0.26	-	0.04	0.02
			SAIDI	1.61	-	0.14	0.44	-	0.07	0.01
4		April	SAIFI	0.23	-	0.18	0.07	0.02	0.15	0.03
			SAIDI	1.27	-	0.64	0.07	0.11	1.20	0.26
5		May	SAIFI	0.19	-	0.11	0.05	0.01	0.04	-
			SAIDI	2.95	-	0.27	0.06	0.02	0.03	-
6		June	SAIFI	0.09	-	0.07	0.05	0.01	0.04	0.03
			SAIDI	0.60	-	0.84	0.04	0.01	0.08	0.03
7		July	SAIFI	0.08	-	0.07	0.04	-	0.04	0.05
			SAIDI	1.92	-	0.39	0.13	-	0.57	0.14

Sl.No.	Year	Month	Reliability Indices	33 kV Khotokha/Phobjikha Feeder II	11kV Rinchengang Feeder III	11kV Gaselo Feeder IV	11kV Bajo Town Feeder V	11kV Hebesa Feeder I	11kV Jala Ula Feeder III	11kV Rurichu Feeder IV
8		August	SAIFI	0.15	0.01	0.03	0.07	0.02	0.20	0.07
			SAIDI	1.38	0.00	0.09	0.18	0.01	0.31	0.05
9		September	SAIFI	0.18	-	0.09	0.09	0.04	0.02	-
			SAIDI	2.13	-	1.59	0.76	0.07	0.07	-
10		October	SAIFI	0.12	0.00	0.04	-	-	0.01	-
			SAIDI	5.60	0.01	0.34	-	-	0.07	-
11		November	SAIFI	0.12	0.00	0.03	0.02	-	0.01	-
			SAIDI	2.08	0.00	0.13	0.50	-	0.09	-
12		December	SAIFI	0.06	0.00	0.02	0.02	0.01	0.10	0.02
			SAIDI	0.02	0.00	0.00	0.00	0.00	0.06	0.01
	Total		**SAIFI**	**9.40**	**0.02**	**4.41**	**1.59**	**0.12**	**1.17**	**0.26**
			SAIDI	**21.61**	**0.01**	**8.57**	**2.43**	**0.26**	**2.90**	**0.52**
	Overall total		**SAIFI**	**57.15**	**0.02**	**13.52**	**6.04**	**0.11**	**4.44**	**0.44**
			SAIDI	**47.47**	**0.07**	**10.95**	**12.30**	**0.51**	**6.40**	**0.43**
	Average		**SAIFI**	**11.67**						
			SAIDI	**11.16**						

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

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

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

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

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

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

Annexure-7: 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**