BHUTAN POWER CORPORATION LIMITED

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

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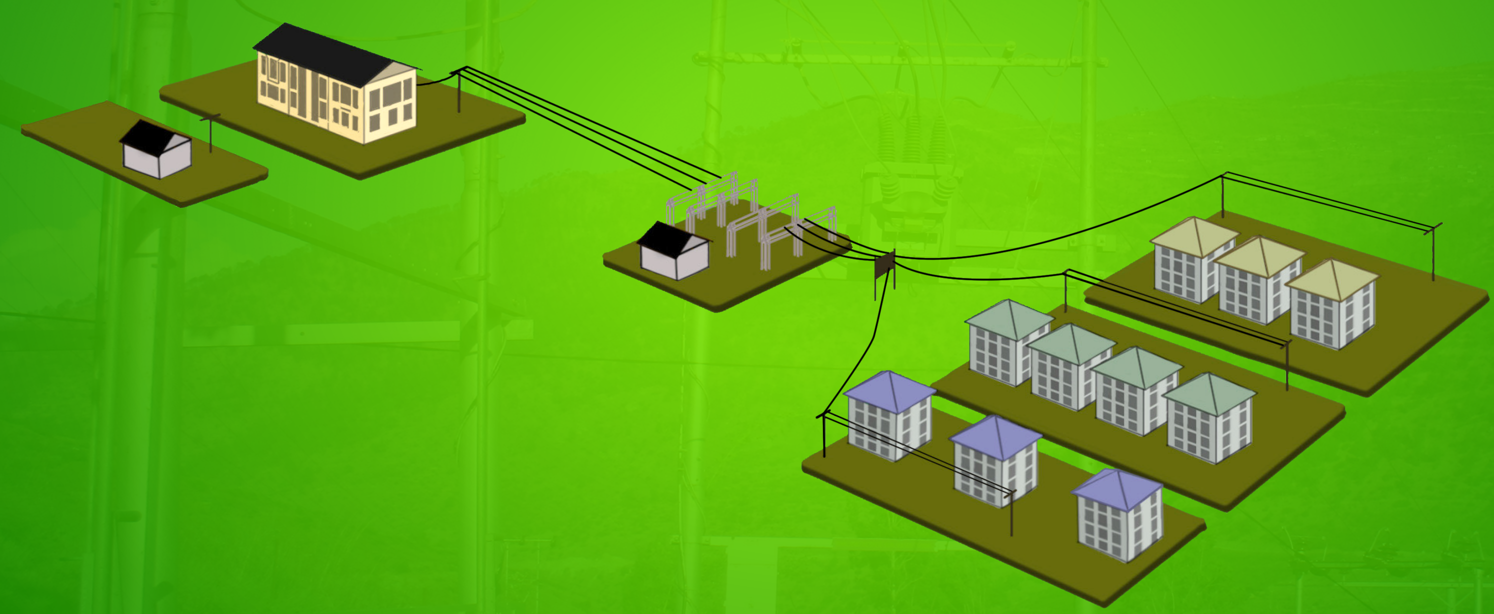
DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

PUNAKHA & GASA DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

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FOREWORD

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

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

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

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

(Sonam Tobjey)
Chief Executive Officer

Preparation, Review & Approval of the Document

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Approved by:	Board Tender & Technical Committee (BTTC), Bhutan Power Corporation Limited, Thimphu. (26th December, 2019 - 15th BTTC Meeting)	**Chairman, BTCC**

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Abbreviations

BPC: Bhutan Power Corporation Limited
ESD: Electricity Services Division
DSMP: Distribution System Master Plan
GIS: Geographical Information System
SLD: Single Line Diagram
ETAP: Electrical Transient and Analysis Program
IS: Indian Standard on Transformers
IEC: International 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.

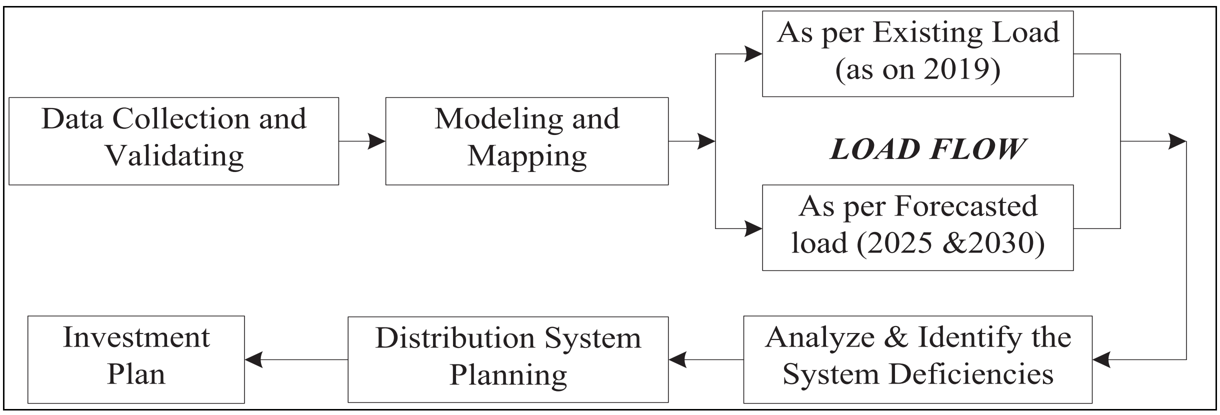


Figure 1: Block diagram for distribution system planning for thematic studies

5.1 Data Collection and Validation

In order to carry out the detailed studies with greater accuracy, complete and reliable data for 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 Modeling and Mapping

The feeder wise distribution lines and transformers were modeled and mapped in ETAP tool and the base case was developed for the existing distribution network. The technical parameters for the lines and transformers were considered based on IS 2026, IEC 60076 (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 of Punakha Dzongkhag

The power supply to eleven Gewogs and the three towns of Punakha Dzongkhag is 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 diagram is predominantly redial as shown in **Figure 2**. The power supply to all the customers of Gasa Dzongkhag is also fed from 33kV Feeder-I. The main source of electricity supply to Punakha, Wangdue and Gasa Dzongkhags is currently from Lobeysa substation.

The Lobeysa Substation has 66/33kV, 2x5 MVA and 66/11kV, 2x5 MVA as HV substations. Puanakha Dzongkhag has also 33/11kV, 2.5MVA MV substation at Khuruthang which is currently used as a switching station due to faulty 2.5MVA transformer.

The Lobeysa HV substation caters the power supply to Punakha, Gaza and Wangdue Dzongkhags through 33kV and 11kV feeders. With the commissioning of the 66/33kV, 2x5MVA Damji substation by the end of 2019, the Gasa load which is met from Lobeysa substation would be relieved and subsequently the quality and reliability of the power are anticipated to improve especially for Punakha and Gasa Dzongkhags.

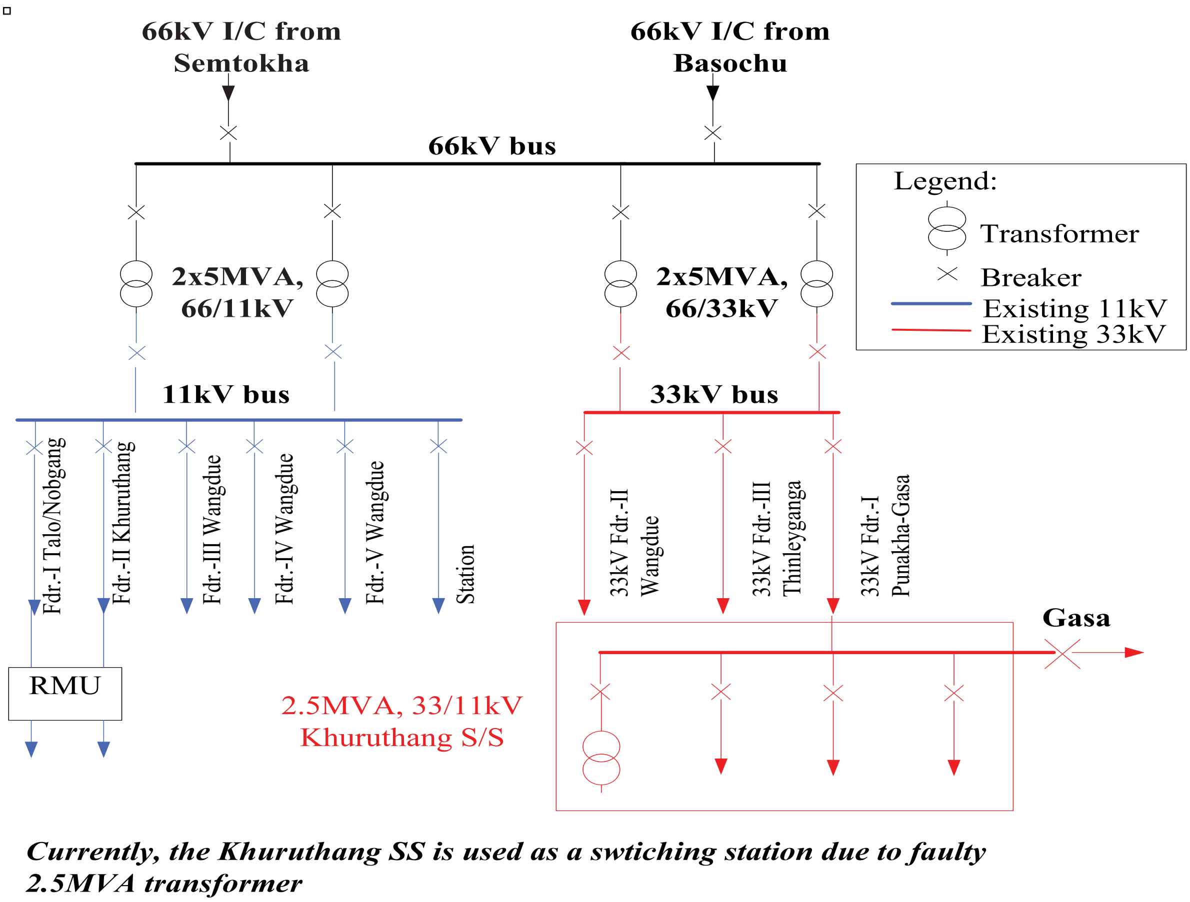


Figure 2: Electricity Distribution Schematic Diagram of Punakha Dzongkhag

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Details

Sl. No.	33 kV		11 kV		Total MV line		LV lines*		Total line length
	OH	UG	OH	UG	OH	UG	OH	UG	
1	210.22	0.00	39.36	0.20	249.59	0.20	353.31	2.50	605.60

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

The total MV line length is 249.79 km and the total LV line length is 355.81km. The ratio of LV to MV line length is 1.42 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 areas being through underground cables.

6.3 Distribution Transformers

The number of distribution transformers operated and maintained by the Dzongkhag 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	Total Installed Capacity (kVA)	Total Number of Customers
1	33 kV Feeder I	33/0.230kV	40	925	3833
		33/0.415kV	109	13266	
2	33kV Feeder III	33/0.230kV	0	0	884
		33/0.415kV	25	2458	
3	11kV Feeder I	11/0.230kV	3	42	1638
		11/0.415kV	22	5175	
4	11kV Feeder II	11/0.230kV	0	0	1777
		11/0.415kV	30	8085	
	Total		**229.00**	**29,951.00**	**8,132.00**

As of June 2019, there were 229 (203 BPC & 26 Private) transformers with a total installed capacity of 29,951 kVA. As evident from **Table 2,** the installed capacity of transformer per customer is 3.68 kVA as on June 2019. The installed transformers are generally large in capacity and few in number rather than small in capacity and more in numbers.

7. Analysis of the 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 total peak load of the four feeders of Punakha will increase from 7.64MW in 2019 to 10.05MW and 12.2MW in 2025 and 2030 respectively against the installed capacity of 20MVA (17MW @ 0.85pf) as tabulated in **Table 3**. Similarly, the peak power demand of Wangdue Dzongkhag is expected to increase from 9.87MW in 2019 to 13.51MW and 16.56MW in 2025 and 2030 respectively.

The total peak power requirement of the three Dzongkhags (Punakha, Wangdue and Gasa) would reach 23.55MW in 2025 and 28.76MW by 2030 exceeding the present installed capacity. Therefore, the load growth has to be properly monitored to take informed decision. Nevertheless, with the completion of Punatsangchu projects (scheduled to be completed by 2024-2025 for Puna-I and 2022 for Puna-II), some of the loads in Wangdue can be also catered from the 66/33/11kV, 2x12.5MVA Gewathang substation. Similarly, the 33/11kV, 5MVA MV substations each at the Dam Site and the Power House respectively would be available for utilization after the completion of the projects. Therefore, the power requirement for customers of Wangdue, Punakha and Gasa can be adequately met from Damji, Lobyesa and Gewathang substations subject to handing/taking over of the infrastructure.

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**
	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 only*

7.1.2 MV Substation

Currently, Punakha has 33/11kV, 2.5MVA substation at Khuruthang and is currently being operated as a switching station due to non-functioning of 2.5MVA transformer. With the revitalization of the substation, the load of Khuruthang town can be fed from the Khuruthang substation. Further, to meet the power requirement of Punakha and Wangdue Dzongkhags especially for the 11kV customers, it is necessary to up-grade the Khuruthang substation from 2.5MVA to 5MVA and also to ensure continuity of power supply should Lobeysa substation fails. In this scenario, Damji substation has to cater the power requirement of the Dzongkhags.

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 4** 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 4: Feeder Wise Peak Power Demand (2015-2019)

Sl. No.	Name of Feeder	Peak Consumption Pattern (MW)				
		2015	2016	2017	2018	2019
1	33kV Feeder-I (Punakha)	1.93	1.97	2.45	2.64	2.63
2	33kV Feeder-III (Thinleygang)	0.49	0.5	0.49	0.74	0.72
3	11kV Feeder-I (Talo/Nobgang)	1.6	1.8	2.1	1.76	2.4
4	11kV Feeder-II (Punakha)	1.47	1.48	1.8	2.24	1.89
	Total	**5.49**	**5.75**	**6.84**	**7.37**	**7.64**

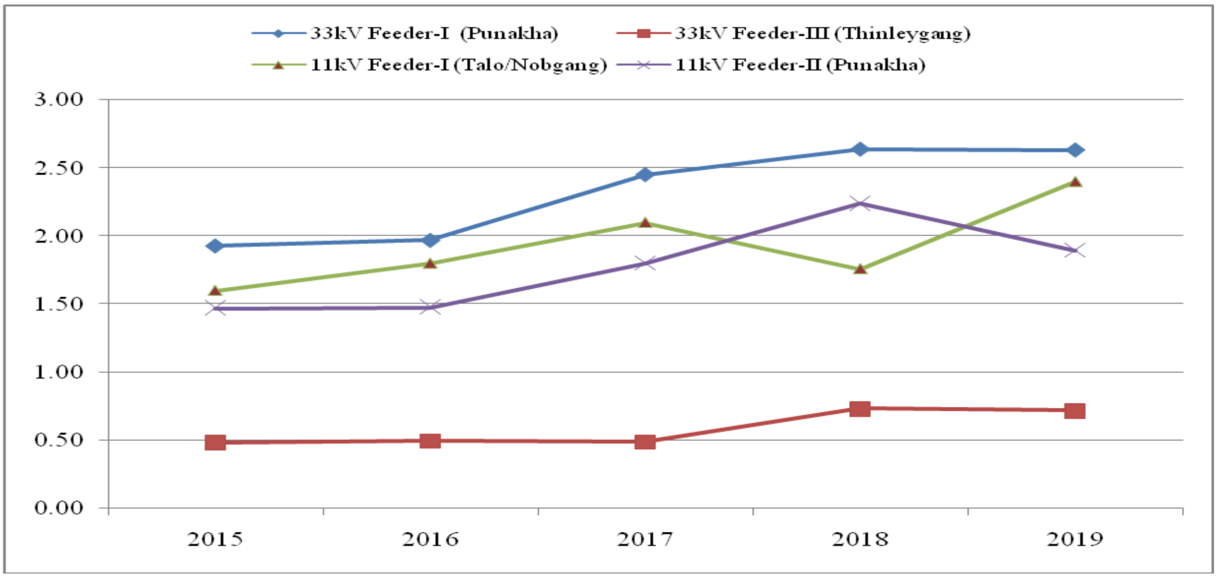


Figure 3:Plot for Feeder Wise Peak Power Demand

As can be inferred from **Figure 3,** the feeder wise peak load has grown steadily from 5.49MW to 7.64MW (2015-2019).

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 5.**

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.

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

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

The ampacity of all the feeders would be within the permissible range with the existing load however, the 11kV Talo/Nobgang feeder would exceed the thermal limit of the conductor marginally as it is forecasted to reach 3.71MW by 2030. As the 11kV Talo/Nobgang and Phuentshopelri are interconnected, the loads can be redistributed and power carrying capacity of the feeder is not expected to pose any significant issues. 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 2014-2019 has been considered to forecast the peak power demand for the next 10 years (2020-2030) as shown in **Table 6** 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.**

From **Table 6,** it is observed that the highest peak load (as on 2019) is 2.63MW for 33kV Feeder-I (Punakha-Gasa) which is expected to grow up to 3.45MW and 4.15MW by 2025 and 2030 respectively. Similarly, the highest peak load in case of the 11kV feeder is 2.40MW for Talo/Nobgang feeder and is expected to reach 3.04MW and 3.71MW by 2025 and 2030 respectively.

Table 6: Summary of Feeder Wise Loading Pattern of ESD, Punakha

Sl. No.	Feeder name	Circuit Length (km)	Total Transformer	Connected kVA	Total Forecasted Load Growth (MW)		
					2019	2025	2030
1	33 kV Feeder-I (Punakha-Gasa)	183.76	149	14191	2.63	3.45	4.15
2	33kV Feeder-III (Thinlaygang)	26.46	25	2458	0.72	0.99	1.22
3	11kV Feeder-I (Talo/Nobgang)	20.78	25	5217	2.4	3.04	3.71
4	11 kV Feeder-II (Phuntshopelri)	18.78	30	8085	1.89	2.56	3.12
	Total	**260**	**229**	**29951**	**7.64**	**10.05**	**12.2**

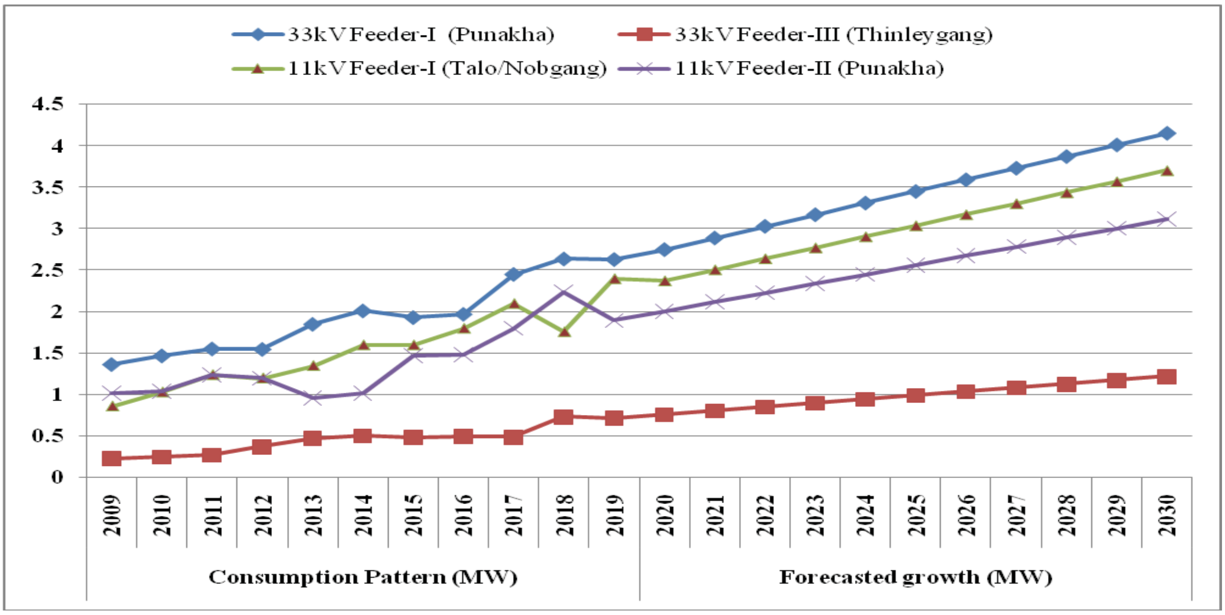


Figure 4: Plot of Feeder Wise Forecasted Peak Power Demand of ESD, Punakha

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 7**. 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 7: Feeders with Poor Voltage Profile (2019, 2025 and 2030)

Sl.No.	Name of Feeder	Conductor	Circuit Length (km)	End Voltage (kV)	% Variation	Load (MW)		
						2019	2025	2030
A	**2019**							
1	11 kV Feeder-II (Phuntshopelri)	D/R	18.78	10.23	7%	2.4	3.04	3.71
2	11kV Feeder-I (Talon/No gang)	D/R	20.78	10.36	6%	1.89	2.56	3.12
B	**2025**							
1	11 kV Feeder-II (Phuntshopelri)	D/R	18.78	9.36	15%	2.4	3.04	3.71
2	11kV Feeder-I (Talo/Nobgang)	D/R	20.78	9.84	11%	1.89	2.56	3.12
C	**2030**							
1	11 kV Feeder-II (Phuntshopelri)	D/R	18.78	9.02	18%	2.4	3.04	3.71
2	11kV Feeder-I (Talo/Nobgang)	D/R	20.78	9.60	13%	1.89	2.56	3.12

The 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 for 2025 & 2030. Details on each of the feeders with proposal for improving the voltage profile is as follows:

a) 11kV Feeder-I (Talo-Nobgang)

The Lobeysa-Talo-Nobgang feeder has a line length of 20.78 km with ACSR Dog and Rabbit conductors. Most of the loads connected to this feeder are rural customers and therefore, the connected loads are static/impedance load (90%) in nature. The simulation result shows that the voltage profile will be 11% and 13% in 2025 and 2030 respectively violating by small margin. However, only a small portion of the customers (those who are at the end of the feeder line) will be impacted. Furthermore, as the load considered for carrying out the technical evaluation is based on the annualized peak demand and not on the average load, the actual voltage profile would be within the permissible range of ±10%. Similarly, in the span of five years, the feeder will experience only 2% increase from the 11% voltage profile violation. Therefore, Talo-Nobgang feeder would be adequate to cater quality power to the customers.

b) 11kV Feeder-II (Phuntshopelri)

The Lobeysa-Phuntshopelri feeder has a line length of 18.78km with ACSR Dog and Rabbit conductors. This feeder caters the power supply to Khuruthang town, old Dzong areas and the rural customers. As there are no industries, the nature of load considered is static/impedance load (90%) in nature. The simulation result shows that the voltage profile will be 15% and 18% in 2025 and 2030 respectively significantly violating the voltage profile requirements. In order to improve the voltage profile, either some sections (preferably from source) of the line needs to be augmented (increase the size of the conductor) or need to reconfigure the sources and feeders. By proposing to this change, the source from Lobyesa to 33/11kV Khuruthang substation and utilizing the incremental tap of the PT, the voltage profile would be within the range as tabulated in **Table 9.**

c) 33kV Feeder-II (Gasa-Laya)

The section of Gasa-Laya line between Gasa to Panjokha via upper Laptsa experiences major power interruption due to thick vegetation and rugged geological topography. Whenever the area receives heavy snow fall during winter season aided by cold wind, the temperature of the conductors gets lowered thus shortening or contracting of lines. This in turn could snap the conductor and damaged the structures as a result of shortening if there was inadequate allowance left during the construction. Although, the distribution network to Laya was extended in 2016 through rural electrification project, the stretch still needs to be realigned as any interruption in this section would cut-off power supplies to 310 households of Laya. Therefore, it is proposed to realign the section of line (10.00km approximately) along the feeder road which is expected to not only improve the reliability but would increase the flexibility for the operation and maintenance of the line.

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 8**.

Table 8: Feeder Wise Voltage Improvement

Sl.No.	Name of Feeder	Before		After		Remarks
		Voltage (kV)	Voltage Profile %	Voltage (kV)	Voltage Profile %	
A	**2019**					
1	11 kV Feeder-II (Phuntshopelri)	10.23	7%	10.7	4.45%	Reconfiguration of sources and tap utilized
B	**2025**					
1	11 kV Feeder-II (Phuntshopelri)	9.36	15%	10.2	7.67%	
C	**2030**					
1	11 kV Feeder-II (Phuntshopelri)	9.02	18%	9.95	9.61%	

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 9** and as shown in **Figure 5.**

Table 9: Summary of Total Energy Loss (MU)

Sl. No.	Energy Requirement, Sales and Loss (MU)	2014	2015	2016	2017	2018	Average
1	Total Energy Requirement (MU)	17.11	17.96	18.90	19.72	21.33	19.01
2	Total Energy Sales (MU)	14.18	15.01	16.75	16.99	18.68	16.32
3	Total energy loss (MU)	2.93	2.96	2.15	2.73	2.66	2.68
4	Total Loss (%)	17.11%	16.46%	11.35%	13.84%	12.45%	14.24%

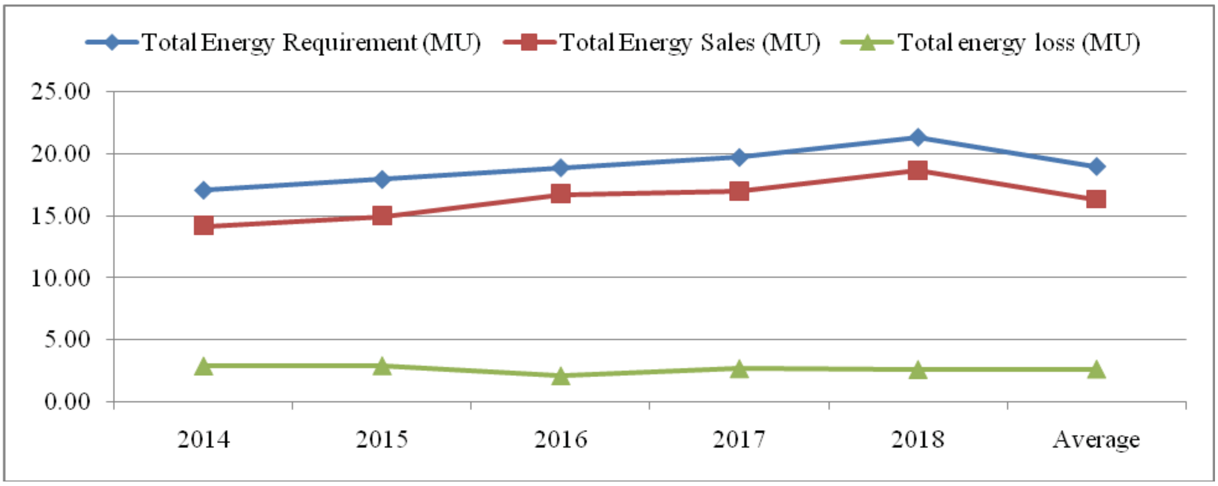


Figure 5: Total Energy Losses (MU) of ESD, Punakha

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 14.24% (2.68 million units on average) from 2014 to 2018. ESD, Punakha saw decrease in energy loss from 2014 to 2016 and dropped to 11.35% in 2016 while, in the following year the Division experienced marginal increase in the loss of energy (13.84%). This increase in the energy may be attributed to extension of distribution lines to the rural homes of Punakha and Gasa Dzongkhags. The loss profile is observed to be fluctuating and it is difficult to explicitly ascertain the reasons of fluctuations and therefore treated as random variations in nature for analysis purpose.

Table 10: Feeder Wise Energy Loss (in MU)

Sl. No.	Name of Feeder & Energy Loss in MU	Circuit Length (km)	2015	2016	2017	2018	Average	% Loss
1	33 kV Feeder-I (Punakha-Gasa)	183.76	1.39	1.01	1.29	1.25	1.24	6.71%
2	33kV Feeder-III (Thinlaygang)	26.46	0.32	0.23	0.3	0.29	0.28	1.55%
3	11kV Feeder-I (Talo/Nobgang)	20.78	0.6	0.43	0.55	0.54	0.53	2.87%
4	11 kV Feeder-II (Phuntshopelri)	18.78	0.65	0.47	0.6	0.58	0.57	3.11%
Total	**Total**	**249.78**	**2.96**	**2.15**	**2.73**	**2.66**	**2.62**	**14.24%**

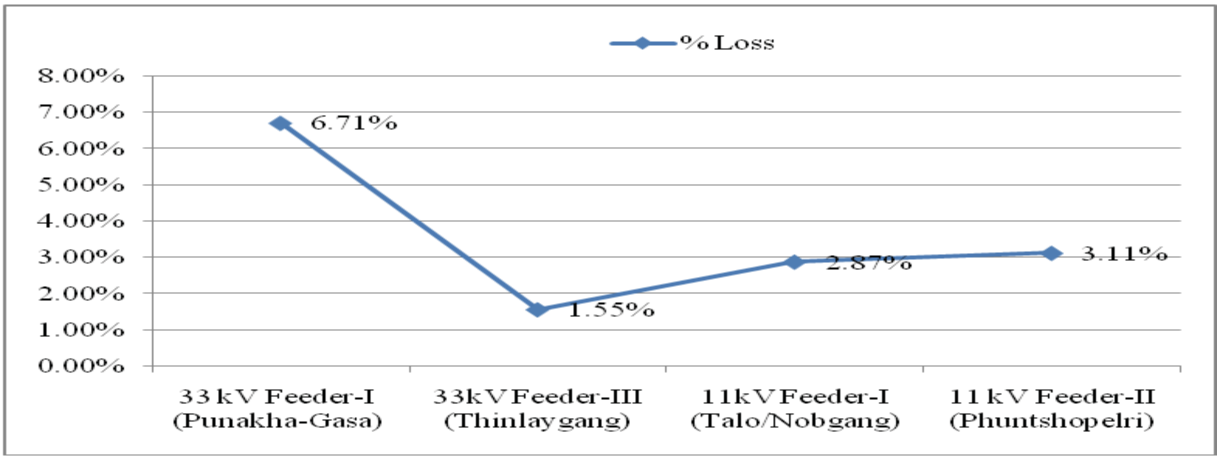


Figure 6: Feeder Wise Energy Losses (MU) of ESD, Punakha

As the feeder wise energy details were not available, the energy loss was redistributed to the feeders based on number of customers connected and circuit line length and accordingly the feeder wise energy loss was worked as shown in **Table 10** and **Figure 6.** It indicates that 33kV Feeder-I contributed to half the energy loss and has the longest circuit length. Addressing this feeder issue would considerably reduce the overall energy loss of the Dzongkhag.

The 11kV Feeder-II would require either some augmentation works or other contingency arrangements to reduce line losses and to improve the voltage profile. However, once the 33/11kV, 2.5 MVA substations is made operational, some of the 11kV Feeder-II load

(Khuruthang customers) can be fed from the outgoing 11kV feeder of 2.5MVA Khuruthang substation. This arrangement is expected to reduce the circuit length and the line loss and also contribute to the overall reliability improvement.

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 11** 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 and SAIDI compiled for 2017-2019 are 27.46 and 113.11 respectively which is exceptionally high.

Table 11: Feeder Wise Reliability Indices

Sl.No.	Year	Reliability Indices	33kV Feeder-I (Punakha-Gasa)	33kV Feeder-III (Thinleygang)	11 kV Feeder-I (Talo, Nobgang)	11 kV Feeder-II (Punakha)
1	2017	SAIFI	157.82	9.77	23.47	42.03
		SAIDI	131.41	17.05	48.53	27.14
2	2018	SAIFI	17.23	23.40	6.07	10.34
		SAIDI	4.01	35.69	5.52	7.25

Sl.No.	Year	Reliability Indices	33kV Feeder-I (Punakha-Gasa)	33kV Feeder-III (Thinleygang)	11 kV Feeder-I (Talo, Nobgang)	11 kV Feeder-II (Punakha)
3	2019	SAIFI	6.60	0.44	2.74	1.41
		SAIDI	4.14	0.42	1.17	0.46
	Total *	**SAIFI**	**9.63**	**9.56**	**3.53**	**4.74**
		SAIDI	**55.82**	**21.27**	**22.09**	**13.94**
Average Reliability Indices			**SAIFI**	**27.46**	**SAIDI**	**113.11**

**Reliability indices for last 2.5 years.*

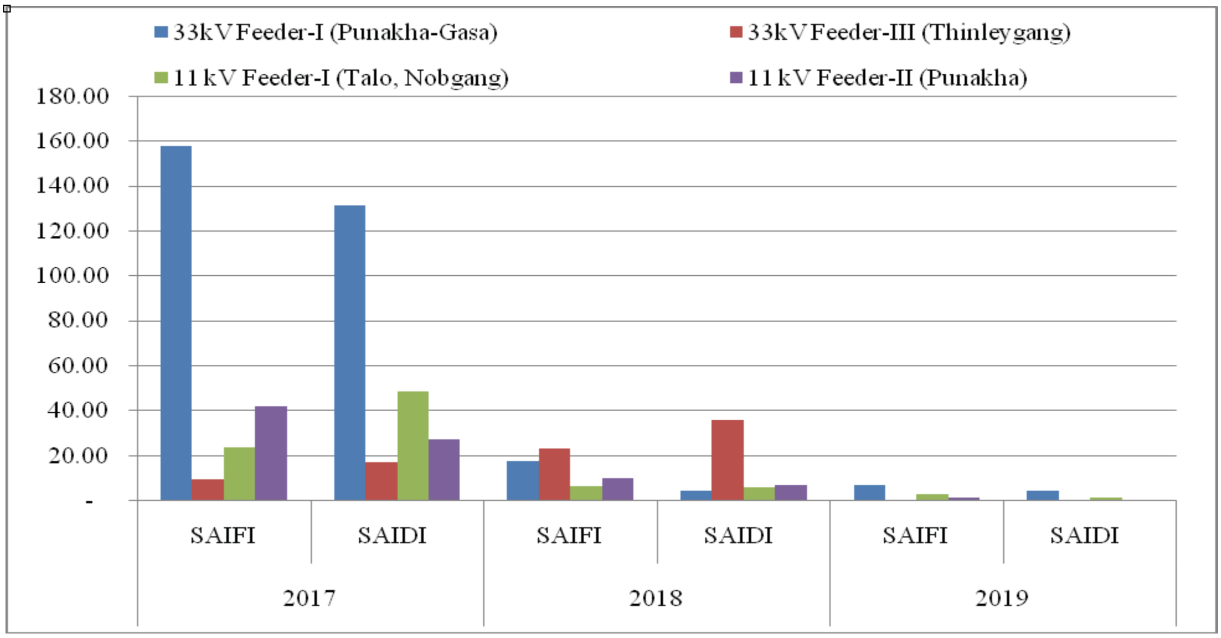
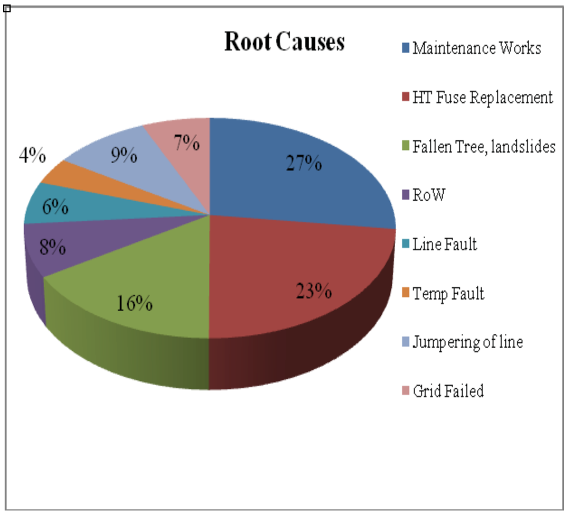


Figure 7: Feeder Wise Reliability Indices of ESD, Punakha

The above summary compiled from (2017-2019 data) indicates that the 33kV Feeder-I (Punakha-Gasa) and 33kV Feeder-III sustained more interruptions compared to the other feeders. It can also be noted that the reliability has significantly improved from 2017 to 2019 (i.e. SAIFI-233.09 to 11.19 and SAIDI-224.13 to 6.19 from 2017-2019). The causes of the power interruptions are attributed to scheduled maintenance works, HT fuse replacement, fallen trees, landslides, transient faults (temporary faults), line fault, grid failure etc. Scheduled maintenance and HT fuse replacement works contribute to half the interruptions.

Root Causes	Frequency	% Distribution
Maintenance Works	12.21	27%
HT Fuse Replacement	10.40	23%
Fallen Tree, landslides	7.18	16%
RoW	3.50	8%
Line Fault	2.84	6%
Temp Fault	1.81	4%
Jumpering of line	4.22	9%
Grid Failed	3.01	7%
Total	**32.96**	**100%**



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 Punakha-Gasa Feeder

The 33kV Feeder-I is the longest circuit (183.76km) with maximum number of customers (3,833.00 constituting 47% of the total customers) connected. The downstream customers (Gasa customers) connected to 33kV Feeder-I experiences interruptions because of local faults in addition to any other faults that occurs between Punakha and Lobeysa. The feeder recorded 9.63 and 55.82 (on average from 2017-2019) as SAIFI and SAIDI respectively. Some of the corrective and preventative measures proposed are as follows:

- Re-configuration of sources

With the commissioning of 66/33kV, 2x5MVA Damji substation by the end of 2019, the feeder will be sectionalized. The load can be directly fed from Damji substation reducing the overall feeder circuit length. The existing feeder can be sectionalized at Tashithang because of its inherent geographical advantages. This arrangement would reduce the detrimental ripple effect of the faults as any faults in the downstream feeders could be localized.

- Installation of additional smart switching devices

  The fault finding in the network is complicated by many new lines spurring from the existing one. Therefore, to reduce the downtime and to easily locate the fault instantly for isolation from healthy network, it is proposed to install more smart switching devices like ARCBs (1), Sectionalizers (10 no.) and FPIs (10 nos).

b) 33kV Thinleygang Feeder

The 33kV Feeder-III has circuit length of 26.46km with 884 customers connected to it. Some sections of the line are along the Punakha-Thimphu highway, while other passes through thick vegetation and rugged terrain where more faults are recorded. The feeder recorded 9.56 and 21.27 (on average from 2017-2019) as SAIFI and SAIDI respectively. Some of the corrective and preventative measures proposed are as follows:

- Installation of additional smart switching devices

  The fault finding in the network is complicated by many new lines spurring from the existing one. Therefore, to reduce the downtime and to easily locate the fault instantly for isolation from healthy network, it is proposed to be installed with additional smart switching devices like ARCBs (1), Sectionalizers (3 no.) and FPIs (3) nos).

7.2.2 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 68.02 km and the estimate for such conversion would require Nu. 11.79 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 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. Accordingly, the capacities of the transformers need to be up-graded and such proposal is tabulated in **Table 12**. The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Table 12: Forecasted Transformer Loading

Sl.No.	Name of Substation Location	Capacity (kVA)	Existing		2025		2030	
			Peak Load (kVA)	% Loading	Peak Load(kVA)	% Loading	Peak Load(kVA)	% Loading
1	Above Phuentshopelri Pala	100	60	60.00%	103.09	103.09%	124.01	124.01%
2	Eusakha	63	36.85	58.49%	63.32	100.50%	76.16	120.90%
3	Gumkarmo	100	129	129.00%	221.65	221.65%	266.63	266.63%
4	Gubji	30	22	73.33%	37.8	126.00%	45.47	151.57%
5	Samdingkha Town	30	18.6	62.00%	31.96	106.53%	38.44	128.15%
6	Amankora Resort	400	240	60.00%	412.38	103.09%	496.05	124.01%
7	Dompola Mushroom Factory	125	75	60.00%	128.87	103.09%	155.02	124.01%
8	Zhingkham resort	500	300	60.00%	515.47	103.09%	620.06	124.01%
9	Tashithang	63	37.8	60.00%	64.95	103.09%	78.13	124.01%
10	Khaylow	30	18	60.00%	30.93	103.09%	37.2	124.01%
11	Panekong	30	18	60.00%	30.93	103.09%	37.2	124.01%
12	Yemina	30	18	60.00%	30.93	103.09%	37.2	124.01%
13	Gasa Town	30	23.62	78.73%	40.59	135.28%	48.82	162.73%
14	Gasa BHU	30	19.77	65.90%	33.97	113.23%	40.86	136.21%
15	Gasa Dzong/Telecom	30	18	60.00%	30.93	103.09%	37.2	124.01%
16	Phulakha	30	18	60.00%	30.93	103.09%	37.2	124.01%
17	Tshachu Guest House	63	40.51	64.30%	69.61	110.49%	83.73	132.90%
18	Gamaluma	63	41.18	65.37%	62.39	99.03%	76.65	121.66%
19	Dhensa resort	500	300	60.00%	553.8	110.76%	675.13	135.03%

Sl.No.	Name of Substation Location	Capacity (kVA)	Existing		2025		2030	
			Peak Load (kVA)	% Loading	Peak Load(kVA)	% Loading	Peak Load(kVA)	% Loading
20	Sonamgang	63	39.91	63.35%	73.67	116.94%	89.81	142.56%
21	Jabchukarmo	16	9.6	60.00%	17.72	110.76%	21.6	135.03%
22	Kuenzangzhing resort	500	300	60.00%	553.8	110.76%	675.13	135.03%
23	Mitsena	500	305.35	61.07%	563.68	112.74%	687.17	137.43%
24	Zangdopelri Resort	315	189	60.00%	328.53	104.30%	399.88	126.95%
25	Animal Husbandary	63	37.8	60.00%	65.71	104.30%	79.98	126.95%
26	Chimipang	63	40.31	63.98%	70.07	111.22%	85.29	135.38%
27	Gumkarmo II	100	130	130.00%	225.97	225.97%	275.05	275.05%
28	YBM factory	100	60	60.00%	104.3	104.30%	126.95	126.95%
29	Lobeysa Transmission Station	125	75	60.00%	130.37	104.30%	158.68	126.95%

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 that arrangements be made for the up-gradation of 6 out of 29 transformers as tabulated in **Table 13**. However, cross-swapping the existing transformers prior to procurement of new transformers would mean that only 4 transformers have to be procured. However, the existing transformers of the urban areas need to be upgraded as forecasted.

Table 13: Proposed Lists of DTs Requiring Up-rating

Sl. No.	Name of Substation Location	Capacity (kVA)	Peak kVA	% Loading	Proposed kVA	Adjustment/New
	List of Transformers for 2019					
1	Gumkarmo II	100	130	130.00%	500	New
	List of Transformers for 2025					
1	Eusakha	63	63.32	100.50%	250	New
	List of Transformers for 2030					
1	Animal Husbandary	63	79.98	126.95%	250	New
2	Samdingkha Town	30	38.44	128.15%	100	Adjustment-Gumkarmo
3	Chimipang	63	85.29	135.38%	500	New

Sl. No.	Name of Substation Location	Capacity (kVA)	Peak kVA	% Loading	Proposed kVA	Adjustment/New
4	Gubji	30	45.47	151.57%	63	Adjustment-Eusakha
	Total Transformers required to up-grade				**6**	
	Extra Transformers	63	2	**2030-**		**Check with the nearest ESDs for adjustment**
		30	2	**2030-**		
	Total extra		**4**			

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 14,** 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	Unit	Qty	Cap. Date	No. of Years put to Use	Serial Number
1	Lower Laptsakha, STP Make,11/0.415kV,63kVA	NO	1	7/1/1993	26.52	TCB03-23
2	Sapsokha, Uttam make,11/0.400kV,315kVA	NO	1	7/1/1989	30.52	15229
3	Sonamgang, STP make,11/0.420kV,63kVA	NO	1	7/1/1989	30.52	2011-02/33
4	Above Palace, Marson's make,11/0.420kV,100kVA	NO	1	7/1/1989	30.52	2026
5	Ritsa, Marson's make,11/0.400kV,160kVA	NO	1	7/1/1989	30.52	75593
6	Zomlingthang, Uttam make,11/0.415kV,250kVA	NO	1	7/1/1989	30.52	17643
7	Haviding, Gec make,11/0.400kV,100kVA.	NO	1	7/1/1976	43.53	22414 O/B

Sl.No.	Name of Location	Unit	Qty	Cap. Date	No. of Years put to Use	Serial Number
8	Punakha HS School, Stan Make,11/0.433kV,125kVA	NO	1	7/1/1988	31.52	S/3638
9	Chang Jongkha,Kilsr Make,11/0.433kV,125kVA	NO	1	7/1/1994	25.52	94CD-003/02
10	Changyul, Stanelee make,11/0.433kv,160kVA	NO	1	7/1/1988	31.52	4233
11	Phuentshopelri, Marosn's make,11/0.400kV,250kVA	NO	1	7/1/1989	30.52	75589
12	Lower Talo, Stanelee make,11/0.433kV,63kVA	NO	1	7/1/1989	30.52	3520
	Total number of transformers		**12**			

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-8.**

There are 39 single phase transformers in the Dzongkhag and the estimate for up-grading all the single to three-phase transformers would require Nu. 8.20 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

Khuruthang, Lobeysa and Punakha Dzong areas fall within the urban areas of the Dzongkhag. With the restriction of town expansion in the Dzong areas, many developmental activities are centered in Khuruthang and Lobeysa towns.

The Parliament approved urban boundary of Punakha which has an area of 685 acres (2.77 sq. km) and the Thromde falls under Guma Gewog as per the PHCB. Within Thromde area, there are four (4) schools including one private school namely Khuruthang Technical Training Institute, Lekshed Jungney Shedra near the Punakha Dzong, Punakha Hospital, Punakha Training Centre for Technical-Medical Staff in the Punakha old town and Ugyen Academy. Financial Institutions such as BDBL, BOB and BNB are institutionalized at Khuruthang town. Other institutions and corporations such as RICBL, BOC, BPC and RSTA including municipality office are located within the Khuruthang town.

As per the Punakha Structure Plan Vol-1 2016-2035, there are three LAPs identified for Punakha Dzongkhag viz., LAP 1- Dzong area, LAP 2- Punakha Old Town and LAP 3- Khuruthang Town and lately LAP 4- Lobeysa town has also been proposed.

a) LAP 1- Dzong Area

The Dzong area comprises of Dzong, Lhakhangs, Shoedras, Lingkana Palace and crematorium ground. Almost all the administrative offices are located inside the Dzong with minimal nearby residential structures.

Figure 8: LAP-I (Dzong Area)

i. **Existing Distribution Network**

Currently there are three 500 kVA transformers installed in the vicinity of the Dzong (Thangzona, Lingkana and Dzong substations) with total transformation capacity of 1500kVA. Since, there are no plans for residential structures nor any commercial activities, the existing installed capacities would be adequate to cater the load till 2030.

ii. **Augmentation of the Distribution Network**

The existing area with OH lines need to be converted to UG system to preserve the aesthetic outlook of the area and safety point of view.

b) LAP 2-Punakha Old Town

The steep area facing Punakha Dzong has been designed as the Scattered Settlement Zone. This precinct takes over 77.81 acres comprising 8% of the thromde area. This also would be predominantly residential neighborhood with permissible plot coverage of 20%. The population projections using average livable spaces was computed to arrive at the total number of housing units in each zone and then multiplied by the average resident population or household size which was determined to be 5 members in the socio-economic. The projected residence of the area will be 7,845 in 2035 compared to 5,781 in 2015.

Figure 9: Porposed LAP-2 (Punakha Old Town)

i. Existing Distribtution Network

Punakha old town is fed by 11kV feeder-II from Lobeysa substation. The feeder is constructed with ACSR Rabbit and Dog, HV ABC and AAAC. There are 2 transformers at Punakha Old Town catering the entire zone, namely, Babegang (250kVA) and Punakha Old Town USS (750kVA). Babegang and Punakha Old Town transformer cater to 151 customers and 295 customers respectively as of today.

ii. Augmentation of Transformer Capacities

The total power requirement for LAP-2 including the Lobeysa town is around 2.00MW. Based on the infrastructure developmental activities in the town and the existing feeder peak load of the area, the two prevailing transformers will not be adequate to cater the load by 2030. Therefore, the construction of 11/0.415kV, 1000kVA in Punakha Old Town is proposed to meet the projected power requirement.

c) **LAP-3: Khuruthang Town**

According to projections carried out for Khuruthang and Guma Gewog using the PHCB data, the total population for these places are projected to increase to 8,929 in 2025 and 10,048 in 2030. Khuruthang town is proposed to be the main commercial area under Punakha Dzongkhag and many infrastructure developmental activities are also expected in the area. The statistics on the completed structure and empty plots available and tabulated in **Table 15** indicates that the town would require additional power in the near future.

Table 15: Statistics on Completed Structure and Empty Plots Available in Khuruthang Town

Sl. No.	Place	Completed Structure	Empty Plot	Remarks
1	Core Town	85	41	Structures are B+G+3 and G+2
2	Institute and leased	23	2	G+2
3	Extended Town	3	33	The construction numbers may increase as the LAP isn't validated yet

i. Existing Distribution Network

Presently, there are 11/0.415kV, 1000kVA USS and 250kVA transformers installed in the area. Another, 1000kVA USS is earmarked to be installed at TTI. The total reserved capacity of 2.25 MVA would be adequate to cater the load till 2030. With the proposal to revive the existing 33/11kV, 2.5MVA Khuruthang substation and up-grade the capacity to 5MVA, load for Khuruthang town can adequately met from Khuruthang substation and accordingly reduce the load of 11kV feeders terminating from Lobeysa substation. Further, with Damji substation commissioned by the end of 2019, there will be source contingency in place.

Should, power supply from Lobyesa get interrupted; it can be arranged from Damji by LILO arrangement through Khuruthang substation.

ii. Augmentation of Distribution Network

The 33kV feeder-I can be interconnected with Damji substation and Khuruthang substation at Khuruthang. Therefore, installation of new CB panels, 2 each for 33kV and 11kV at Khuruthang substation is required. The underground cables were initially laid (direct burial system) without proper collaboration with the stakeholders. This in turn has resulted in serious interruptions to the power supply due to third party damages which could have been the result of uncoordinated construction activities. The Dzongkhag administration has designed LAPs with a provision to construct the footpath along the road with trenches for utility services like electricity and telecommunications. Therefore, to enhance the safety to the populace, provide better asset management, operate and maintain conveniently and to improve the aesthetics of the town, it is proposed to convert existing overhead distribution network with UG cable system for 11kV HT and LT network.

The blue markings on the map in **Figure 11** represents the route for the footpath where the cable trenches can be constructed alongside the road. Total of 2.00km LT cable has to be laid to convert the existing overhead line to UG system. Similarly, the existing 0.60km HT overhead line constructed alongside the road leading to Punakha Dzong need to be converted to UG system.

d) LAP-4: Lobeysa Town

Although the LAP-4 which is for Lobeysa town was not proposed in the Structural Plan of Punakha, the Dzongkhag officials have intimidated that sooner or later, the LAP for Lobeysa town would be also developed. Therefore, to keep abreast with new initiatives, it is recommended that BPC to plan and outlay the electrical distribution system for the area.

i. Existing Distribution Network

Lobeysa town is currently fed from 11kV feeder I with 11/0.415kV, 500kVA substation installed at the center of the town for 510 customers which are mostly the commercial customers. Similarly, for the outskirt customers of the town; 11/0.415kV, 500kVA transformer distributes the power supply. Although, the plots are not assigned, it is anticipated that there will be increasing demand in the power requirement due to construction of two mega projects downstream the Punatsangchu river.

Figure 10: Layout Plan for Cable Trenches in Khuruthang Town

ii. Augmentation of the Distribution Network

Anticipating that the Lobeysa town would be growing fast, following augmentation works would be necessary to meet the load demand:

1) Upgradation of 11/0.415kV, 500kVA to 1000kVA at Mitsena town; and
2) Conversion of OH LT network to UG system.

Figure 11: Existing Distribution Network of Khuruthang Town

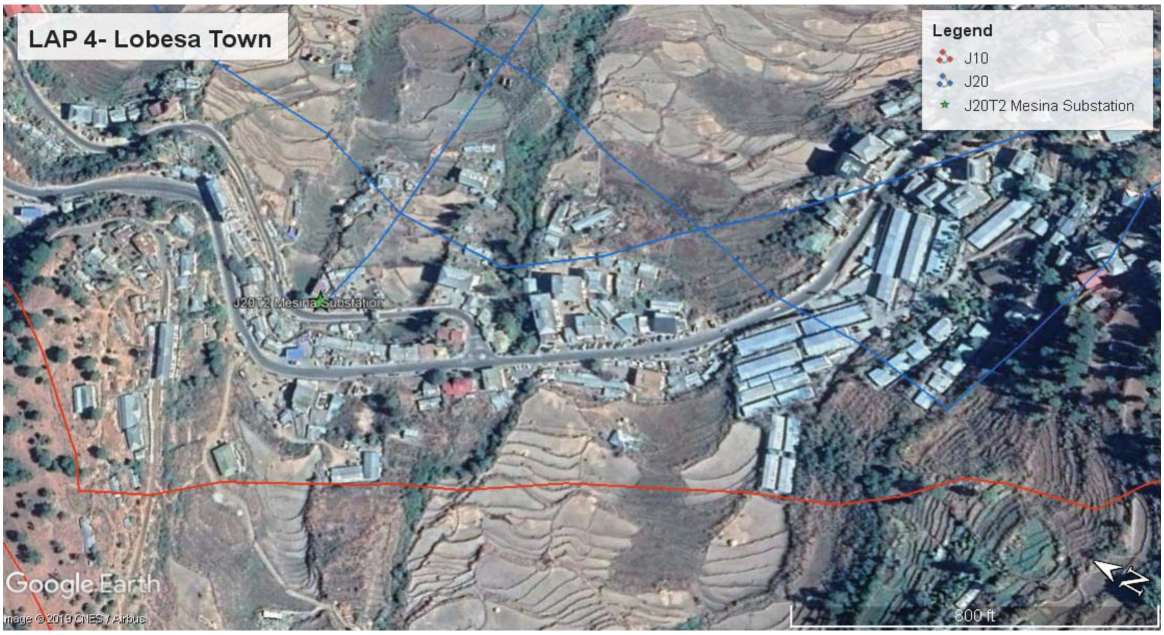


Figure 12: Distribution Network of Lobeysa Town

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 Substation

As detailed in **Section 7.1.1,** the total peak power requirement of the two Dzongkhags would reach 23.55MW in 2025 and 28.76MW by 2030 hence, surpassing the installed transformation capacity. Although some of the load of Lobeysa substation can be relived after commissioning of Damji substation, the existing installed capacity will still 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, the 2x12.5MVA Gewathang HV substation can be utilized thereby addressing the source constraint.

8.1.2 MV Substations

As detailed in **Section 7.1.2**, it would be necessary to revive the existing 2.5MVA 33/11kV transformer and up-grade the Khuruthang substation to meet the power requirement of 11kV network of Punakha Dzongkhags should Lobeysa substation experience contingency event.

Table 16: Proposed up-rating of MV substation

Sl.No.	Name of Substation	Source Capacity		Forecasted Load (MW)		
		Existing	Proposed	2019	2025	2030
1	33/11kV Khuruthang SS	2.5	5	3.35	4.44	5.37

8.2 MV and LV Lines

a) Major power interruption on 33kV Feeder-I (Punakha-Gasa) occurs between Tashithang and Rimchu as the stretch passes through thick vegetation and rugged terrain. Therefore, to improve the reliability and maximize the revenue generation, it is proposed to realign this stretch of line.

b) Construction of 1.5km MV with AAAC line in new Gasa town.

c) Conversion of MV bare conductor to UG system at Dzong (0.85km) and Lobyesa (2.00km) town. This is being proposed to enhance the safety of the general public of the area and to improve the aesthetic view of the area.

d) Conversion of LT ABC to UG system at old Dzong (1.50km) area (including the Palace and Dzong), Khuruthang and Lobyesa (2.50km) towns. This is being proposed to enhance the safety of the general public of the area and to maintain the aesthetic of the area intact.

e) As detailed in **Section 7.2.1**, it is proposed to realign section of Gasa-Laya line (10.00km approximately) along the existing feeder road and this reconfiguration of line is expected to improve the reliability and would be convenient to the crew for the operation and maintenance of the line.

f) There is a proposal to provide electricity to additional 40 households of Laya which can be done through LT extension. Therefore, it is proposed to extend LT line to various areas of Laya.

g) Replacement of LV ABC 4x50 sq. mm with LV ABC 4x90 sq. mm at Gasa old town. The load of Gasa is expected to grow with implementation of new Gasa town plan. The existing LV network was constructed in 2006 without any altitude correction factor. The detrimental effects of the gaps combined with exposure of cable to the extreme cold weather has huge bearing and deterioration of the cable insulation. Therefore, to adequately cater the power supply and to replace the partially damaged cable, it is proposed to re-size the existing LV ABC to 4X95 sq. mm (0.7km) incorporating the necessary additional standard like altitude correction factor and provisioning adequate expansion and contraction allowances for the conductors during the extreme weather conditions.

8.3 Distribution Transformers

As listed in **Section 7.3.1,** the transformers need to be up-graded either by procuring or by cross-swapping the required capacities. As per the findings, 4 DTs would be required to be procured which has been worked out based on the likelihood of load growth of the areas and inculcating the fair judgment of the field offices.

Table 17: List of Distribution Transformers which needs to be Up-Graded

Sl. No.	Name of Substation Location	Capacity (kVA)	Peak kVA	% Loading	Proposed kVA	Adjustment/New
	List of Transformers for 2019					
1	Gumkarmo II	100	130	130.00%	500	New
	List of Transformers for 2025					
1	Eusakha	63	63.32	100.50%	250	New
	List of Transformers for 2030					
1	Animal Husbandary	63	79.98	126.95%	250	New
2	Samdingkha Town	30	38.44	128.15%	100	Adjustment-Gumkarmo
3	Chimipang	63	85.29	135.38%	500	New
4	Gubji	30	45.47	151.57%	63	Adjustment-Eusakha
	Total Transformers required to up-grade				**6**	
	Extra Transformers	63	2	2025-2030		Check with the nearest ESDs for adjustment
		30	2	2025-2030		
	Total extra		**4**			

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 Feeder-III are the most susceptible feeders. Therefore, additional preventive and corrective measure for these feeders need to be put in place. 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 18** and **Figure 13** 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.

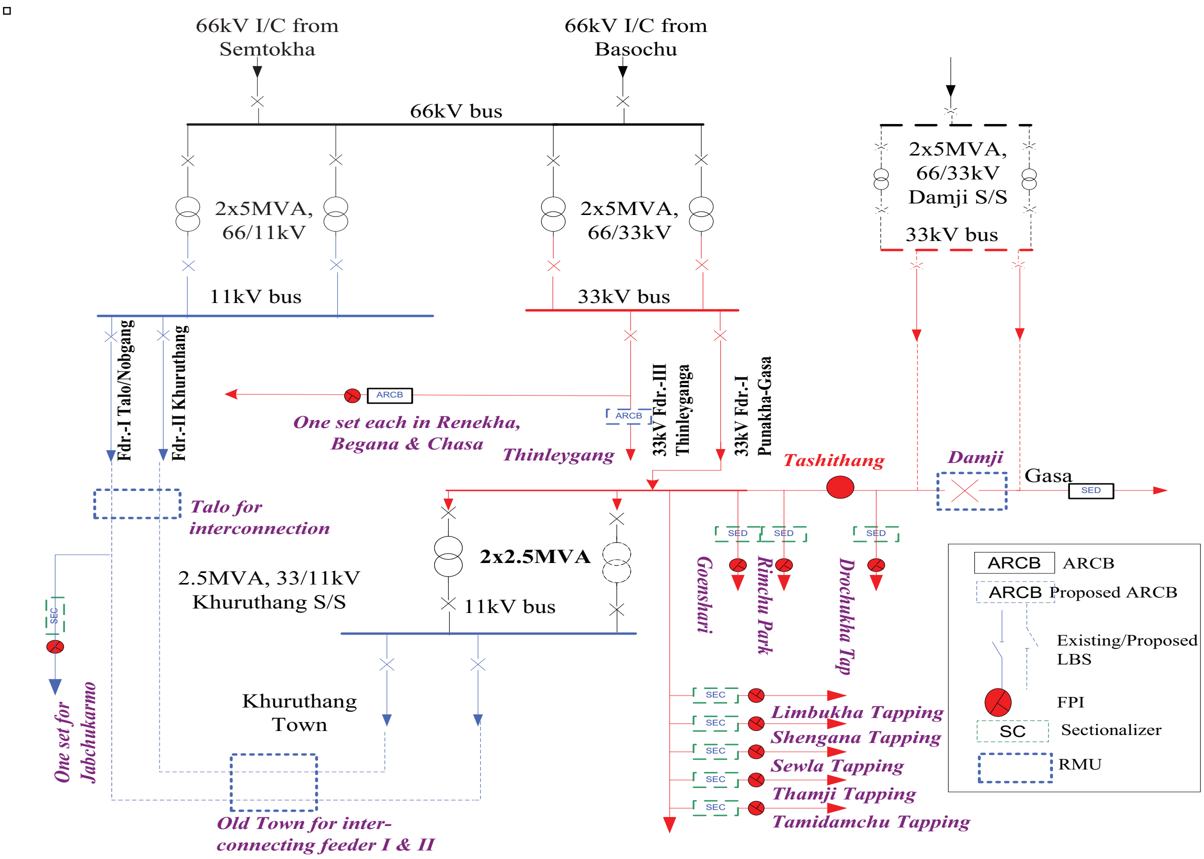


Figure 13: Proposed Switching Equipment for Distribution Network

Table 18: Existing and Proposed Switching Equipment

Sl.No.	Name of Feeder	ARCBs		Sectionalizers		FPIs	
		Exist	Prop	Exist	Prop	Exist	Prop
1	33 kV Feeder 1(Punakha-Gasa Feeder)	3	1		10		10
2	33kV Feeder III (Thinleygang)		1		3		3
3	11kV Feeder I (Talo, Nobgang)				1		1
4	11kV Feeder II (Punakha)						
	Total	**3**	**2**	**0**	**14**	**0**	**14**

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 14.**

The matrix gives us the basis on the prioritization of the investments to be made in the ten-year schedule as every activity cannot be carried out at a time. The activities which have to be carried out due to load growth, developmental activities and retrofitting of obsolete/defective 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).

How important is the task?

Highly Important	Action: Do First **I**	Action: Do Next **II**
Important	**Action: Do Later III**	No Action: Don't Do **IV**
	More Urgent	**Urgent**

How urgent is the task?

Figure 14: Priority Matrix

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

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 19** as an investment plan. The cost estimates have been worked out based on the BPC ESR-2015 and annual inflation is cumulatively applied to arrive the actual investment cost for the following years.

In the span of next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Punakha Dzongkhag is Nu. 112.91 million (Nu. 11.29 million per year).

Table 19: Yearly Investment Plans (2020-2030)

Sl. No.	Activities	Investment Plan (Nu. In Million)											Total
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
1	Installation of LBS (33kV & 11kV)	0.53											**0.53**
2	Re-alignment of 33kV line from Tashithang to Rimchu	1.14	-										**1.14**
3	Laying of UG cable in and around Khuruthang town	3.32	-										**3.32**
4	Replacement of LV ABC 4x50sq.mm line with LV ABC 4x95sq.mm at Gasa old town (0.7km)	0.35	-										**0.35**
5	Construction of 0.8km MV AAAC line for new Town, Gasa	0.90											**0.90**
6	Construction of 0.7km of LT line (UG) for Gasa new town			2.30									**2.30**
7	Installation of 500kVA transformer at Gasa new town	1.21											**1.21**
8	Extension of LT line at Laya (40 HH)	2.33		-									**2.33**
9	Replacement of 500kVA transformer with 1000 kVA at Lobeysa Town			1.50									**1.50**
10	RE Fill-in	1.90	1.80	1.50	1.50	2.00	2.00	2.00	2.00	2.00	2.00	2.00	**20.70**
11	Construction of 33kV Substation with additional 2.5 MVA transformer at existing Khuru Control Room					20.00							**20.00**
12	Construction of 1000kVA USS at Punakha Old Town						3.50						**3.50**
13	Construction of 750kVA USS at Khuruthang Town									3.20			**3.20**
14	Conversion of HT bare conductor to UG cable in Dzong area, .85km HT and 1.5km LT										3.00	3.00	**6.00**
15	Conversion of 2km HT bare conductor and 2.5km LT ABC cable to UG cable at Lobesa Town										4.00	4.00	**8.00**
16	Installation of 2 nos. of 33kV ARCB					1.50	1.50						**3.00**

Sl. No.	Activities	Investment Plan (Nu. In Million)											Total
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
17	Installation of 2 nos. of 11kV RMU								1.50			1.50	**3.00**
18	Installation of 1 no. of 33kV RMU							1.80					**1.80**
19	Upgradation of Gumkarmo Substation from 100 to 500kVA		0.70										**0.70**
20	Upgradation of Animal Husb Substation from 63 to 250 kVA										1.00		**1.00**
21	Upgradation of Esakha substation from 63 to 250kVA transformer				1.00								**1.00**
22	Upgradation of Samdingkha Town substation from 30 to 125kVA transformer												**-**
23	Upgradation of Chimipang substation from 63 to 500kVA transformer							1.50					**1.50**
24	Upgradation of Gubji substation from 30 to 63kVA transformer												**-**
25	Installation of 3 nos. of 125 kVA at Laya (rural)									1.00	1.00	1.00	**3.00**
26	Conversion of single to three-phase line			1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	**11.79**
27	Replacement of single by three phase transformers			0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	**8.19**
28	Replacement of 500kVA transformer for Chortenningpo		1.77										**1.77**
29	Installation of 125 kVA transformer at Lakhu		1.18										**1.18**
	Total	**11.68**	**5.45**	**7.52**	**4.72**	**25.72**	**9.22**	**7.52**	**5.72**	**8.42**	**13.22**	**13.72**	**112.91**

10. Conclusion

Based on the inputs from ESD Punakha, 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. Recommendations

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	1) 2x12.5 Gewathang substation The existing HV substation would be adequate provided the Punatsangchu projects are completed on schedule and Gewathang HV substation can be used to cater to some of the Wangdue's loads. 2) 66/33kV Damji substation Having dedicated 33kV lines for Punakha and Gasa from Damji substation would mean independent sources and any faults in one Dzongkhag will not have impact to other. Sectionalizing of 33kV Feeder-I will reduce the line losses attributed to shorter circuit line length.
2	MV Substations	1) 33/11kV Khuruthang substation With the revivable of 33/11kV, 2.5 MVA transformer, main Khuruthang town can be fed from this substation and rest of the customers from Lobeysa 11kV Feeder-II. This alternate arrangement will ensure that Khuruthang town will have dedicated power supply with increased reliability. Technical losses arising from this line can be reduced. Further, 11kV Feeder-II and the outgoing 11kV feeder from 33/11kV substation can be looped for redundancy purpose. 2) 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. It can cater some of the 11kV loads of Wangdue thereby relieving the Lobeysa substation.
B. MV Feeders		

Sl. No.	Parameters	Recommendations
1	Punakha-Damji & Damji-Gasa Lines	Independent 33kV lines for Punakha and Gasa would be advisable to be tapped from Damji and terminate to the existing 33kV Feeder-I. With this arrangement, both the Dzongkhags would have two sources at a time which will not only improve the reliability but also reduce line losses (due to reduction of line length).
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 Transformer	As reflected in Section 7.3.1 of this report, it is proposed to regularly monitor the loading pattern especially of the urban transformers. It is desired to load the transformers less than 85% 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.

Sl. No.	Parameters	Recommendations
		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 Punakha should carry out the studies on LV network including the DTs. Nevertheless, with the entire distribution network captured in the GIS and ISU, the system studies should be carried out including the LV network in the future.
4	Customer Mapping	One of the important parameters required especially for reaffirming the capability of the DTs is by examining customer growth patterns. Therefore, it is recommended to consistently update the customers via customer mapping process carried out annually.
5	Right of Way	RoW should be maintained as per the DDCS 2016. However, increased frequency of RoW clearing in the problematic sections of the line and in fast growth sub-tropical forest is recommended.
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

Sl. No.	Parameters	Recommendations
		(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 & 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 out based on assumptions of likely scenarios. Therefore, actual activities should be incorporated 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: Distribution Transformer loading
Annexure-8: Material Cost of three phase (3Φ) Transformers

13. References

1. The FWPL and CPL from TD, BPC as of 2018.
2. BPC Power Data Book 2018.
3. BPC Distribution Design and Construction Standards (DDCS)-2016.
4. BPC Smart Grid Master Plan (2019-2027).
5. BPC National Transmission Grid Master Plan (2020 & 2030).
6. BPC Operation and Maintenance Manual for Distribution System (2012).
7. BPC Corporate Strategic Plan (2019-2030).
8. Population and Housing Census of Bhutan 2019.
9. The Structural Plan (2004-2027) for every Dzongkhag.
10. 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) 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.
		c) Balanced Load Flow	
		d) Limitations of No. of buses (1000)	
2	Data	a) No recorded data (reliability & energy) on the out-going feeders of MV SS	a) Feeder Meters could be install for outgoing feeders of MV substations to record actual data (reliability & energy)
		b) Peak Load data of DTs which were recorded manually may be inaccurate due to timing and number of DTs.	b) In order to get the accurate Transformer Load Management (TLM)/loading, it is proposed to install DT meters which could also have additional features to capture other required information.
		c) No proper feeder and DT wise Customer Mapping recorded	c) Customer Information System (CIS) of the feeder/DT would enable to have proper TLM and replacement framework.
3	Manpower	a) Resource gap in terms of trained (ETAP) and adequate engineers (numbers)	a) Due to lesser number of trained engineers in the relevant fields (software), engineers from other areas were involved.

12. Annexures

Annexure-1: MV Line Details and Single Line Diagram

MV line detials

Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
11 kV Feeder I	66/33/11kV Lobeysa SS	11	Mixed	Trunk Line	ACSR Dog, 100 sq mm	Gantry	J40H18	1.11	Substation to Mitsena tapping	Mitsena Tapping
				Spur line 1	ACSR Rabbit, 50 sq mm	J40H18	J40H335	0.25	Mitsena	Mitsena SS
				Trunk Line	ACSR Dog, 100 sq. mm	J40H18	J40H24	0.41	Mitsen Tapping to Drupchu tapping	Drupchu Tapping
				Spur line 2	ACSR Rabbit, 50 sq. mm	J40H24	J40H332	0.17	Drupchu Resort	Drupchu Resort SS
				Spur line 3	ACSR Dog, 100 sq. mm	J40H24	J40H25	0.06	Drupchu tapping to Sopsokha tapping	Sopsokha Tapping
				Spur line 4	ACSR Rabbit, 50 sq. mm	J40H25	J40H26	0.05	Sopsokha	Sopsokha SS
				Trunk Line	ACSR Dog, 100 sq. mm	J40H25	J40H60	2.00	Sopsokha tapping to Khuruthang Tapping	Khuruthang tapping
				Spur line 5	ACSR Rabbit, 50 sq. mm	J40H60	J40H67	0.40	Khuruthnag tapping	Kuenzangzhing Resort tapping
				Spur line 6	ACSR Rabbit, 50 sq. mm	J40H67	J40H261	0.04	Kuenzangzhing Resort	Kuenzangzhing SS
				Spur line 7	ACSR Rabbit, 50 sq. mm	J40H67	J40H68	0.10	Sonamgang overhead	Sonamgang
				Spur line 9	ACSR Rabbit, 50 sq. mm	J40H72	J40H91	1.02	Khuruthang	Khuruthang GO
				Trunk Line	ACSR Dog, 100 sq. mm	J40H60	J40H107	0.81	Khuruthang Tapping to Lower Laptsakha Tapping	Lower Laptsakha tapping
				Spur Line 11	ACSR Rabbit, 50 sq. mm	J40H107	J40H110	0.14	Lower Laptsakha tapping	Lower Laptsakha SS
				Spur Line 12	ACSR Dog, 100 sq. mm	J40H107	J40H139	1.70	Lower Laptsakha Tapping to Lunakha tapping	Lunakha Tapping
				Spur Line 13	ACSR Rabbit, 50 sq. mm	J40H139	J40H185	0.78	Lunakha Tapping	Gangthramo tapping
				Spur Line 14	ACSR Rabbit, 50 sq. mm	J40H185	J40H213	0.39	Gangthramo	Gangthramo SS
				Trunk line	ACSR Rabbit, 50 sq. mm	J40H185	J40H239	2.30	Gangthramo tapping to Lunakha	lunakha Tapping
				Spur line 15	ACSR Rabbit, 50 sq. mm	J40H239	J40H242	0.19	Lunakha Tapping	Lunakha SS
				Spur line	ACSR Rabbit, 50 sq. mm	J40H239	J40H260	1.00	Lunakha Tapping	Pachakha SS
				Spur line 16	ACSR Rabbit, 50 sq. mm	J40H239	J40H329	3.48	Pachakha SS	Jabchukarmo SS
				Trunk Line	ACSR Dog, 100 sq. mm	J40H139	J40H165	1.50	Lunakha Tapping to lower Talo tapping	Lower Talo Tapping
				Spur line 17	ACSR Rabbit, 50 sq. mm	J40H165	J40H167	0.18	Lower talo	Lower Talo SS
				Trunk line	ACSR Dog, 100 sq. mm	J40H165	J40H176	0.62	Lower talo Tapping	Upper Talo SS
				Trunk Line	ACSR Dog, 100 sq. mm	J40H176	J40H288	2.00	Upper Talo SS	Pangserpo SS
				Spur line 19	xlpe 3x300 sq. mm	Khuru SS	Khuru Power Transformer	0.09	Khuru SS	Khuru Power Transformer
								20.78		
11 kV Feeder II	66/33/11kV Lobeysa SS	11	Mixed	Trunk Line	UG 150sq.mm	S/S	Gantry	0.06	Lobeysa S/S	Gantry
				Trunk Line	ACSR Dog, 100 sq.mm	Gantry	J20H004	0.22	Gantry	PWD Tapping
				Spur line 1	ACSR Dog, 100 sq.mm	J20H004	J20H006	0.16	PWD Tapping	PWD S/S
				Trunk Line	ACSR Dog, 100 sq.mm	J20H004	J20H020	0.80	PWD Tapping	Baywakha Tapping
				Spur line 2	ACSR Rabbit, 50 sq.mm	J20H020	J20H231	0.93	Baywakha Tapping	Royal Pump S/S
				Trunk Line	ACSR Dog, 100 sq.mm	J20H020	J20H043	1.74	Baywakha Tapping	Nobthang Tapping
				Spur line 3	ACSR Rabbit, 50 sq.mm	J20H043	J20H233	0.19	Nobthang Tapping	Nobthang S/S

Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
				Trunk Line	ACSR Dog, 100 sq.mm	J20H043	J20H044	0.13	Nobthang Tapping	YBM Tapping
				Spur line 4	ACSR Rabbit, 50 sq.mm	J20H044	J20H234	0.05	YBM Tapping	YBM S/S
				Trunk Line	ACSR Dog, 100 sq.mm	J20H044	J20H059	1.04	YBM Tapping	Zangdopelri Tapping
				Spur line 5	ACSR squirrel 25 sq.mm	J20H059	J20H240	0.25	Zangdopelri Tapping	Zangdopelri S/S
				Trunk Line	ACSR Dog, 100 sq.mm	J20H059	J20H065	0.68	Zangdopelri Tapping	RMU Tapping
				Spur line 6	AAAC, 49.5 sq.mm	J20H065	J20H241	0.04	RMU Tapping	RMU
				Trunk Line	ACSR Dog, 100 sq.mm	J20H065	J20H068	0.31	RMU Tapping	Gumkarmo Tapping
				Spur line 7	ACSR Rabbit, 50 sq.mm	J20H068	J20H242	0.26	Khuru Resort Tapping	Khuru S/S
				Trunk Line	ACSR Dog, 100 sq.mm	J20H068	J20H069	0.06	Gumkarmo Tapping	HV ABC Start
				Trunk Line	HV ABC, 3x50 sq.mm	J20H069	J20H071	0.08	HV ABC Start	Hi-Tech Tapping
				Trunk Line	HV ABC, 3x50 sq.mm	J20H071	J20H093	0.71	Hi-Tech Tapping	Khuru RMU
				Spur line 9	ACSR Dog, 100 sq.mm	J20H093	J20H298	4.62	Khuru RMU	Thangzona Tapping
				Spur line 10	ACSR Dog, 100 sq.mm	J20H298	J20H299	0.09	Thangzona Tapping	Thangzona S/S
				Spur line 11	ACSR Dog, 100 sq.mm	J20H298	J20H303	0.30	Thangzona Tapping	Changyul Tapping
				Spur line 12	AAAC, 49.5 sq.mm	J20H303	J20H333	0.25	Changyul Tapping	Changyul S/S
				Spur line 13	ACSR Dog, 100 sq.mm	J20H303	J20H328	1.59	Changyul Tapping	Sonagasa S/S
				Trunk Line	ACSR Rabbit, 50 sq.mm	J20H093	J20H114	1.00	Khuru RMU	Veterinary Tapping
				Spur line 14	AAAC, 49.5 sq.mm	J20H114	J20H334	0.02	Veterinary Tapping	Veterinary S/S
				Trunk Line	AAAC, 49.5 sq.mm	J20H114	J20H126	1.00	Veterinary Tapping	Changjokha Tapping
				Spur line 15	AAAC, 49.5 sq.mm	J20H126	J20H340	0.40	Changjokha Tapping	Changjokha S/S
				Trunk Line	AAAC, 49.5 sq.mm	J20H130	J20H140	0.75	Dzong Tapping	Old town tapping
				Spur line 17	AAAC, 49.5 sq.mm	J20H140	J20H357	0.43	Old town tapping	Logodama S/S
				Trunk Line	AAAC, 49.5 sq.mm	J20H140	J20H147	0.57	Old town tapping	Babegang tapping
				Spur line 18	AAAC, 49.5 sq.mm	J20H147	J20H148	0.05	Babegang tapping	Babegang S/S
								18.78		
33kV Feeder I	66/33/11 kV Lobeysa SS	33	overhead	Trunk Line	ACSR Wolf, 150 sq.mm	S/S	J10H073	4.60	Lobeysa S/S	Shegana/Sdongkha Tapping
				Spur line 1	ACSR Dog, 100 sq.mm	J10H073	J10H373	0.77	Shegana Tapping	Gumkarmo Tapping
				Spur line 2	ACSR Dog, 100 sq.mm	J10H373	J10H374	0.06	Gumkarmo Tapping	Gumkarmo SS
				Spur line 3	ACSR Dog, 100 sq.mm	J10H373	J10H383	0.51	Gumkarmo Tapping	Limbukha Tapping
				Spur line 4	ACSR Dog, 100 sq.mm	J10H383	J10H653	2.08	Limbukha Tapping	Monk RC tapping
				Spur line 5	ACSR Rabbit, 50 sq.mm	J10H653	J10H1576	1.56	Monk RC tapping	Monk RC SS
				Spur line 6	ACSR Dog, 100 sq.mm	J10H653	J10H659	0.64	Monk RC tapping	Napchi Tapping
				Spur line 7	ACSR Rabbit, 50 sq.mm	J10H660	J10H674	1.25	Napchi Tapping	Napchi SS
				Spur line 8	ACSR Rabbit, 50 sq.mm	J10H660	J10H722	3.46	Napchi Tapping	Pangna SS
				Spur line 9	ACSR Dog, 100 sq.mm	J10H383	J10H456	4.85	Limbukha Tapping	Tashidingkha Tapping

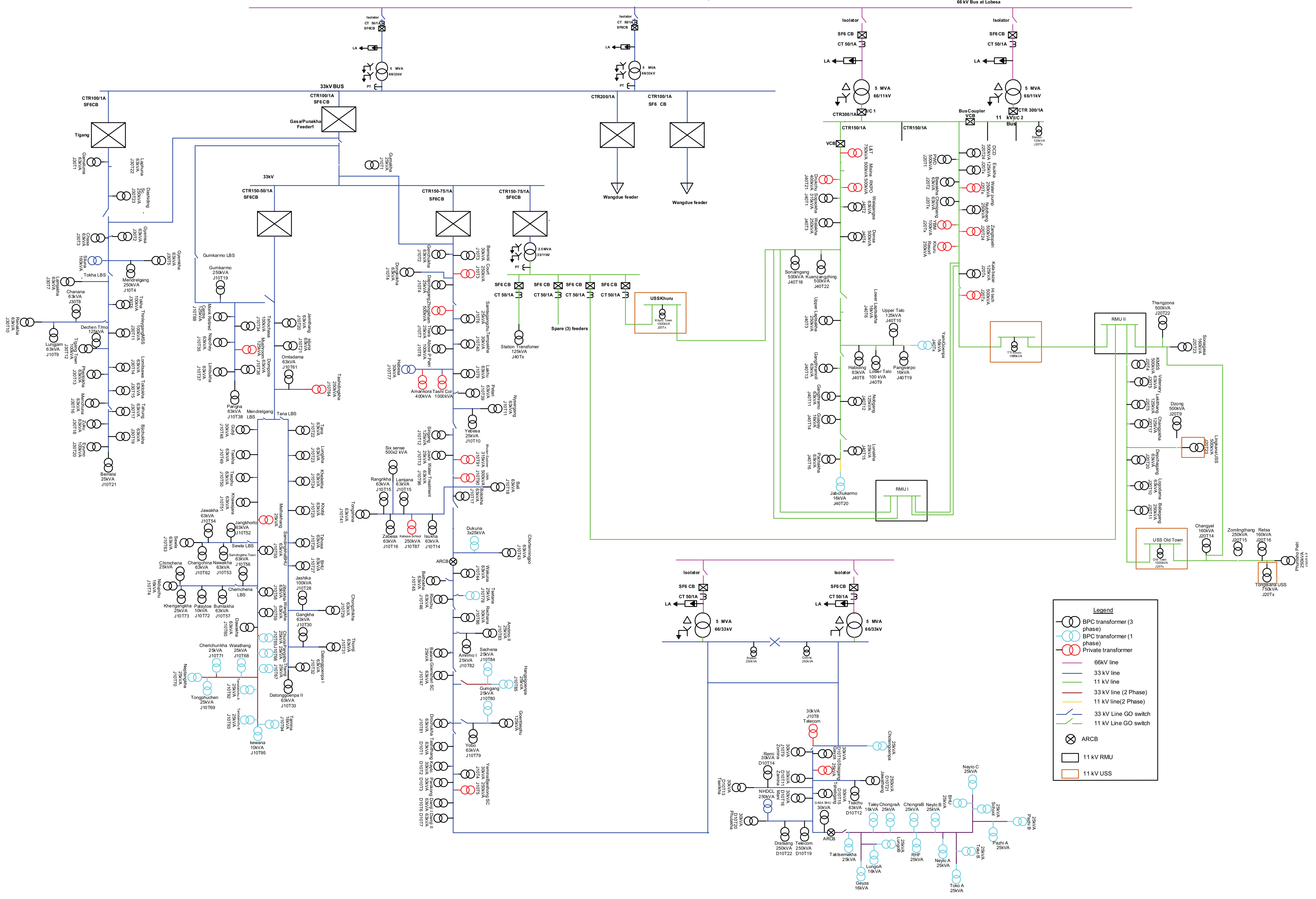
Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
				Spur line 10	ACSR Rabbit, 50 sq.mm	J10H456	J10H1286	1.11	Tashidingkha Tapping	Tashidingkha SS
				Spur line 11	ACSR Dog, 100 sq.mm	J10H456	J10H461	0.39	Tashidingkha Tapping	Shegana Tapping
				Spur line 12	ACSR Dog, 100 sq.mm	J10H461	J10H476	1.09	Shegana Tapping	Lungkha Tapping
				Spur line 13	ACSR Dog, 100 sq.mm	J10H476	J10H480	0.29	Lungkha Tapping	Lungkha SS
				Spur line 14	ACSR Dog, 100 sq.mm	J10H476	J10H490	0.69	Lungkha Tapping	Khelekha Tapping
				Spur line 15	ACSR Dog, 100 sq.mm	J10H490	J10H494	0.31	Khelekha Tapping	Khelekha SS
				Spur line 16	ACSR Dog, 100 sq.mm	J10H490	J10H516	1.52	Khelekha Tapping	Khobji Tapping
				Spur line 17	ACSR Dog, 100 sq.mm	J10H516	J10H517	0.04	Khobji Tapping	Khobji SS
				Spur line 18	ACSR Dog, 100 sq.mm	J10H516	J10H532	0.96	Khobji Tapping	Tshosa Tapping
				Spur line 19	ACSR Dog, 100 sq.mm	J10H532	J10H534	0.13	Tshosa Tapping	Tshosa SS
				Spur line 20	ACSR Dog, 100 sq.mm	J10H532	J10H544	0.71	Tshosa Tapping	Shegana BHU Tapping
				Spur line 21	ACSR Dog, 100 sq.mm	J10H544	J10H545	0.06	Shegana BHU Tapping	Shegana BHU SS
				Spur line 22	ACSR Dog, 100 sq.mm	J10H544	J10H554	0.56	Shegana BHU Tapping	Chongzhikha Tapping
				Spur line 23	ACSR Dog, 100 sq.mm	J10H554	J10H568	1.05	Chongzhikha Tapping	Chongzhikha SS
				Spur line 24	ACSR Dog, 100 sq.mm	J10H554	J10H575	0.50	Chongzhikha Tapping	Dadogoenpa Tapping
				Spur line 25	ACSR Rabbit, 50 sq.mm	J10H575	J10H626	1.99	Dadogoenpa Tapping	Dadogoenpa SS
				Spur line 26	ACSR Dog, 100 sq.mm	J10H575	J10H594	1.25	Dadogoenpa Tapping	Thomji SS
				Spur line 27	ACSR Dog, 100 sq.mm	J10H461	J10H1033	1.00	Shegana Tapping	Gubji Tapping
				Spur line 28	ACSR Rabbit, 50 sq.mm	J10H1033	J10H1036	0.15	Gubji Tapping	Gubji SS
				Spur line 29	ACSR Dog, 100 sq.mm	J10H1033	J10H1065	2.06	Gubji Tapping	Tshephu Tapping
				Spur line 30	ACSR Rabbit, 50 sq.mm	J10H1065	J10H1087	1.60	Tshephu Tapping	Tshephu SS
				Spur line 31	ACSR Dog, 100 sq.mm	J10H1065	J10H1120	2.10	Tshephu Tapping	Sewla Goenpa Tapping
				Spur line 32	ACSR Rabbit, 50 sq.mm	J10H1120	J10H1270	6.39	Sewla Goenpa Tapping	Sewla Goenpa SS
				Spur line 33	ACSR Dog, 100 sq.mm	J10H1120	J10H1157	0.69	Sewla Goenpa Tapping	Nidupchu tapping
				Spur line 34	ACSR Rabbit, 50 sq.mm	J10H1157	J10H1410	3.34	Nidupchu tapping	Kerigangkha tapping
				Spur line 35	ACSR Rabbit, 50 sq.mm	J10H1410	J10H1418	0.86	Kerigangkha tapping	Kerigangkha ss
				Spur line 36	ACSR Rabbit, 50 sq.mm	J10H1410	J10H1434	1.76	Kerigangkha tapping	Nidupchu lhakhang SS
				Spur line 37	ACSR Rabbit, 50 sq.mm	J10H1157	J10H1182	0.42	Nidupchu tapping	Bjibjokha Tapping
				Spur line 38	ACSR Rabbit, 50 sq.mm	J10H1182	J10H1184	0.13	Bjibjokha Tapping	Bjibjokha SS
				Spur line 39	ACSR Rabbit, 50 sq.mm	J10H1182	J10H1187	0.16	Bjibjokha Tapping	Wangkha Tapping
				Spur line 40	ACSR Rabbit, 50 sq.mm	J10H1187	J10H1198	0.72	Wangkha Tapping	Wangkha SS
				Spur line 41	ACSR Rabbit, 50 sq.mm	J10H1187	J10H1333	4.48	Wangkha Tapping	Pangsho Tapping
				Spur line 42	ACSR Rabbit, 50 sq.mm	J10H1333	J10H1337	0.22	Pangsho Tapping	Pangsho SS
				Spur line 43	ACSR Rabbit, 50 sq.mm	J10H1333	J10H1346	0.95	Pangsho Tapping	Kewana Tapping
				Spur line 44	ACSR Rabbit, 50 sq.mm	J10H1346	J10H1670	6.32	Kewana Tapping	Kewana SS

Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
				Spur line 45	ACSR Rabbit, 50 sq.mm	J10H1346	J10H1354	0.76	Kewana Tapping	Cherichungkha Tapping
				Spur line 46	ACSR Rabbit, 50 sq.mm	J10H1354	J10H1383	0.94	Cherichungkha Tapping	Cherichungkha SS
				Spur line 47	ACSR Rabbit, 50 sq.mm	J10H1354	J10H1372	1.27	Cherichungkha Tapping	Neptengkha SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H073	J10H090	1.17	Shegana Tapping	Khuru CR Tapping
				Spur line 51	ACSR Rabbit, 50 sq.mm	J10H1438	J10H389	0.36	TT SS	Before Tashidingkha Tapping
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H090	J10H094	0.23	Khuru CR Tapping	Genchukha Tapping
				Spur line 52	ACSR Dog, 100 sq.mm	J10H094	J10H110	1.11	Genchukha Tapping	Genchukha SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H094	J10H139	2.25	Genchukha Tapping	Dongkokha Tappinng
				Spur line 53	ACSR Rabbit, 50 sq.mm	J10H139	J10H160	1.33	Dongkokha Tappinng	Dongkokha SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H139	J10H188	2.08	Dongkokha Tappinng	Tempakha Tapping
				spur line 54	ACSR Rabbit, 50 sq.mm	J10H188	J10H761	1.32	Tempakha Tapping	Tempakha SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H188	J10H249	4.89	Tempakha Tapping	Amankora Tapping
				Spur line 55	ACSR Rabbit, 50 sq.mm	J10H249	J10H362	0.67	Amankora Tapping	Habesa Tapping
				Spur line 56	ACSR Rabbit, 50 sq.mm	J10H362	J10H1441	0.21	Habesa Tapping	Habesa SS
				Spur line 57	XLPE Aluminium cable, 3x150sq. Mm	J10H362	J10T76 P1	0.16	Habesa Tapping	Amankora SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H249	J10H257	0.46	Amankora Tapping	Peltari Tapping
				Spur line 58	ACSR Rabbit, 50 sq.mm	J10H257	J10H744	1.67	Peltari Tapping	Peltari SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H257	J10H265	0.70	Peltari Tapping	Nyezergang Tapping
				Spur line 59	ACSR Wolf, 150 sq.mm	J10H265	J10H275	0.74	Nyezergang Tapping	Nyezergang SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H265	J10H295	1.66	Nyezergang Tapping	Sirigang Tapping
				Spur line 60	ACSR Wolf, 150 sq.mm	J10H295	J10H299	0.24	Sirigang Tapping	Sirigang SS
				Trunk Line	ACSR Wolf, 150 sq.mm	J10H295	J10H307	0.47	Sirigang Tapping	Explore Bhutan Tapping
				Spur line 61	ACSR Rabbit, 50 sq.mm	J10H307	J10T91 P1	0.43	Explore Bhutan Tapping	Explore Bhutan SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H307	J10H1593	0.23	Explore Bhutan Tapping	Kabesa Water Treatment Tapping
				Spur line 62	ACSR Rabbit, 50 sq.mm	J10H1593	J10H1671	0.03	Kabesa Water Treatment Tapping	Kabesa Water Treatment SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H1671	J10H316	0.42	Kabesa Water Treatment Tapping	Bali Tapping
				Spur line 63	ACSR Rabbit, 50 sq.mm	J10H316	J10H355	0.93	Bali Tapping	Bali SS
				Spur line 64	ACSR Rabbit, 50 sq.mm	J10H316	J10H327	0.53	Bali Tapping	Kabesa School Tapping
				Spur line 65	ACSR Rabbit, 50 sq.mm	J10H327	J10H1546	0.11	Kabesa School Tapping	Kabesa School SS
				Spur line 66	ACSR Rabbit, 50 sq.mm	J10H327	J10H799	4.31	Kabesa School Tapping	Tongshina SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H316	J10H808	0.64	Bali Tapping	Chortenningpo Tapping
				Spur line 67	ACSR Rabbit, 50 sq.mm	J10H808	J10H822	0.98	Chortenningpo Tapping	Chortenningpo SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H808	J10H850	1.81	Chortenningpo Tapping	Betikha Tapping
				Spur line 68	ACSR Dog, 100 sq.mm	J10H850	J10H869	1.33	Betikha Tapping	Betikha SS

Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
				Trunk Line	ACSR Dog, 100 sq.mm	J10H850	J10H872	0.21	Betikha Tapping	Tsetena Tapping
				Spur line 69	ACSR Rabbit, 50 sq.mm	J10H872	J10H1457A	1.44	Tsetena Tapping	Tsetena SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H872	J10H1490	5.84	Tsetena Tapping	Amrimo Tapping
				Spur line 70	AAAC, 49.5 sq.mm	J10H1490	J10H1504	1.32	Amrimo Tapping	Amrimo I SS
				Spur line 71	AAAC, 49.5 sq.mm	J10H1502	J10H1511	0.61	Amrimo I Tapping	Amrimo II
				Trunk Line	ACSR Dog, 100 sq.mm	J10H1490	J10H981	2.18	Amrimo Tapping	Nangsigoenpa Tapping
				Spur line 72	AAAC, 49.5 sq.mm	J10H981	J10H1544	3.44	Nangsigoenpa Tapping	Nangsigoenpa SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H981	J10H1004	2.46	Nangsigoenpa Tapping	Drochukha Tapping
				Spur line 73	AAAC, 49.5 sq.mm	J10H1004	J10H1489	0.59	Drochukha Tapping	Drochukha SS
				Spur line 74	AAAC, 49.5 sq.mm	J10H1004	J10H1472	1.34	Drochukha Tapping	Yobo SS
				Spur line 75	AAAC, 49.5 sq.mm	J10H1471	J10H1480	0.99	Gumgang tapping	Gumgang SS
				Trunk Line	ACSR Dog, 100 sq.mm	J10H1004	D10H015	2.78	Drochukha Tapping	Before Khaylow Tapping
				Trunk Line	AAAC, 100 sq.mm	D10H015	D10H045	2.20	Before Khaylow Tapping	Kukuzam
				Spur line 76	ACSR Dog, 100 sq.mm	D10H045	D10H052	0.63	Kukuzam	Yemina Tapping
				Spur line 77	ACSR Dog, 100 sq.mm	D10H052	D10H068	1.79	Yemina Tapping	Yemina SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H052	D10H345	5.88	Yemina Tapping	Bjishong Tapping
				Spur line 78	ACSR Dog, 100 sq.mm	D10H345	D10H114	0.19	Bjishong Tapping	Bjishong SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H345	D10H170	5.21	Bjishong Tapping	After Gayza SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H225	D10H234	0.81	Before Tsachu Tapping	Tsachu Tapping
				Spur line 79	ACSR Rabbit, 50 sq. mm	D10H234	D10H350	1.84	Tsachu Tapping	Tsachu SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H234	D10H254	0.88	Tsachu Tapping	Remi Tapping
				Spur line 80	ACSR Rabbit, 50 sq. mm	D10H254	D10H271	1.63	Remi Tapping	Remi SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H254	D10H280	0.71	Remi Tapping	Tshebgang SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H276	D10H290	0.68	Tshebgang Tappinng	Phulakha Tapping
				Spur line 81	ACSR Rabbit, 50 sq. mm	D10H290	D10H299	0.41	Phulakha Tapping	Phulakha SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H290	D10H293	0.27	Phulakha Tapping	Bazar SS
				Trunk Line	ACSR Dog, 100 sq.mm	D10H292	D10H295	0.15	Bazar Tapping	BHU SS
				Spur line 78	AAAC, 49.5 sq.mm	J10H1472	Goentsephu	1.16	Yobo SS	Goentsephu
				Spur line	ACSR Rabbit, 50 sq. mm	J10H1428	Chimchena	1.95	Nidupchu Tapping	Chimchena
				Trunk Line	AAAC, 49.5 sq.mm	J10H295	J10H508	22.00	BHU SS	Talay Taaping
				Spur line	AAAC, 49.5 sq.mm	J10H508	J10H535	5.49	Talay Taaping	Pazhi SS
				Trunk Line	AAAC, 49.5 sq.mm	J10H508	J10H551	1.83	Talay Taaping	Lungo Tapping
				Spur line	AAAC, 49.5 sq.mm	J10H551	J10H564	0.66	Lungo Tapping	Lungo SS
				Trunk Line	AAAC, 49.5 sq.mm	J10H551	J10H560	1.97	Lungo Tapping	Gayza SS
								183.76		

Name of Feeder	Source	Voltage Level (kV)	UG/Overhead or Mixed	Line	Size of Conductor (sq.mm)	First GPS code	Final GPS code	Line length (km)	Location	Termination Point
33kV feeder III	66/33/11 kV Lobeysa SS	33	overhead	Trunk Line	ACSR Dog, 100 sq.mm	J30H001	J30H014	0.97	Lobeysa SS	Gamaluma Tapping
				Spur line 1	ACSR Dog, 100 sq.mm	J30H014	J30H018	0.34	Gamaluma Tapping	Gamaluma SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H014	J30H025	0.68	Gamaluma Tapping	Laphuna Tapping
				Spur line 2	ACSR Rabbit, 50 sq.mm	J30H025	J30H350	0.06	Laphuna Tapping	Laphuna SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H025	J30H026	0.21	Laphuna Tapping	Dashiding School Tapping
				Spur line 3	ACSR Rabbit, 50 sq.mm	J30H026	J30H363	0.52	Dashiding School Tapping	Dashiding SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H026	J30H062	2.94	Dashiding School Tapping	Gemsa Tapping
				Spur line 4	ACSR Dog, 100 sq.mm	J30H062	J30H080	1.11	Gemsa Tapping	Gemsa SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H062	J30H110	2.21	Gemsa Tapping	Siluna Tapping
				Spur line 6	ACSR Dog, 100 sq.mm	J30H110	J30H138	1.65	Siluna Tapping	Gemkha SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H110	J30H155	1.10	Siluna Tapping	Tokha Tapping
				Spur line 7	ACSR Dog, 100 sq.mm	J30H155	J30H156	0.04	Tokha Tapping	Tokha SS
				Spur line 8	ACSR Dog, 100 sq.mm	J30H155	J30H169	0.97	Tokha Tapping	Lamjakha SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H155	J30H237	1.45	Tokha Tapping	Thinleygang Town Tapping
				Spur line 9	ACSR Dog, 100 sq.mm	J30H170	J30H192	1.19	Chandana Tapping	Chandana SS
				Spur line 10	ACSR Dog, 100 sq.mm	J30H185	J30H215	1.75	Renekha Tapping	Renekha SS
				Spur line 11	ACSR Dog, 100 sq.mm	J30H237	J30H240	0.16	Thinleygang Town Tapping	Thinleygang Town SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H237	J30H256	1.08	Thinleygang Town Tapping	Lumitsawa Tapping
				Spur line 12	ACSR Dog, 100 sq.mm	J30H256	J30H269	0.40	Lumitsawa Tapping	Lumitsawa SS
				Spur line 13	ACSR Dog, 100 sq.mm	J30H256	J30H263	0.49	Lumitsawa Tapping	Phentokha SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H256	J30H286	1.43	Lumitsawa Tapping	Menchuna Tapping
				Spur line 14	ACSR Dog, 100 sq.mm	J30H286	J30H304	1.14	Menchuna Tapping	Menchuna SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H286	J30H314	0.93	Menchuna Tapping	Tahong Tapping
				Spur line 15	ACSR Dog, 100 sq.mm	J30H314	J30H317	0.29	Tahong Tapping	Tahong SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H314	J30H319	0.28	Tahong Tapping	Zeku Tapping
				Spur line 16	ACSR Dog, 100 sq.mm	J30H319	J30H323	0.21	Zeku Tapping	Zeku SS
				Trunk Line	ACSR Dog, 100 sq.mm	J30H319	J30H349	2.86	Zeku Tapping	Bemsisi SS
								26.46		
Total								**249.79**		

Distribution Network of ESD, Punakha



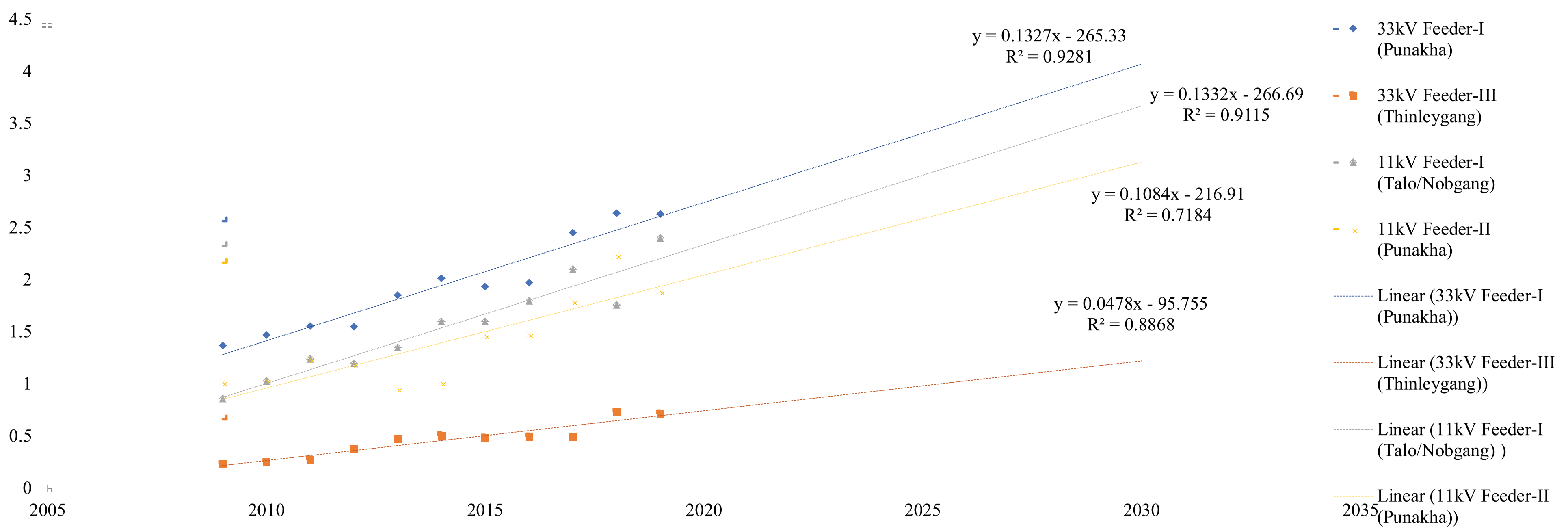
Annexure-2: IS 2026, IEC 60076 (Technical parameters for Distribution Lines and Transformers)

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 Punakha Dzongkhag

Sl. No.	Name of Feeder	Consumption Pattern (MW)											Forecasted growth (MW)										
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	33kV Feeder-I (Punakha)	1.367	1.471	1.555	1.55	1.85	2.01	1.93	1.97	2.45	2.64	2.63	2.75	2.89	3.03	3.17	3.31	3.45	3.59	3.73	3.87	4.01	4.15
2	33kV Feeder-III (Thinleygang)	0.232	0.254	0.276	0.38	0.48	0.51	0.49	0.50	0.49	0.74	0.72	0.76	0.81	0.86	0.90	0.95	0.99	1.04	1.08	1.13	1.18	1.22
3	11kV Feeder-I (Talo/Nobgang)	0.86	1.03	1.24	1.20	1.35	1.60	1.60	1.80	2.10	1.76	2.40	2.37	2.51	2.64	2.77	2.91	3.04	3.17	3.31	3.44	3.57	3.71
4	11kV Feeder-II (Punakha)	1.02	1.04	1.24	1.20	0.96	1.02	1.47	1.48	1.80	2.24	1.89	2.01	2.12	2.23	2.34	2.45	2.56	2.67	2.79	2.90	3.01	3.12
	Total	**3.479**	**3.795**	**4.311**	**4.33**	**4.64**	**5.14**	**5.49**	**5.75**	**6.84**	**7.37**	**7.64**	**7.89**	**8.32**	**8.75**	**9.19**	**9.62**	**10.05**	**10.48**	**10.91**	**11.34**	**11.77**	**12.20**



Load forecast methodology

1. Load Forecast

1.1 Type of Load Forecast and Power System Planning

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

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

a) Time
  - Hours of the day (day or night)
  - Day of the week (weekdays or weekend)
  - Time of the year (winter or summer season)

b) Weather conditions (temperature and humidity)

c) Type of customers (residential, commercial, industries etc.)

d) Population

e) Economic indicators (per capita income, Gross Domestic Product (GDP) etc.)

f) Prices of the electricity

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

1.2 Methods of Load (LTLF) Forecast

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

1.2.1 Trend Analysis

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

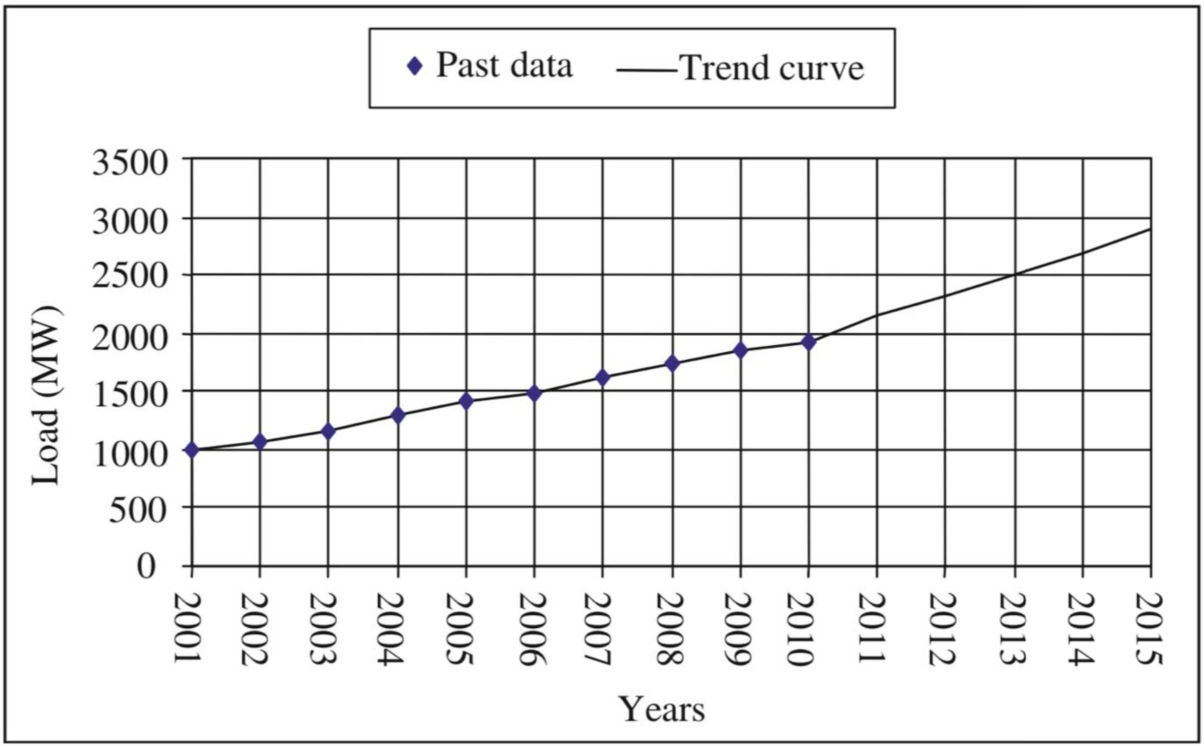


Figure 1: Typical trend curve[1]

1.2.2 Economic Modelling

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

1.2.3 End-use Analysis

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

1.2.4 Hybrid Analysis

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

1.3 Trend Line Analysis

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

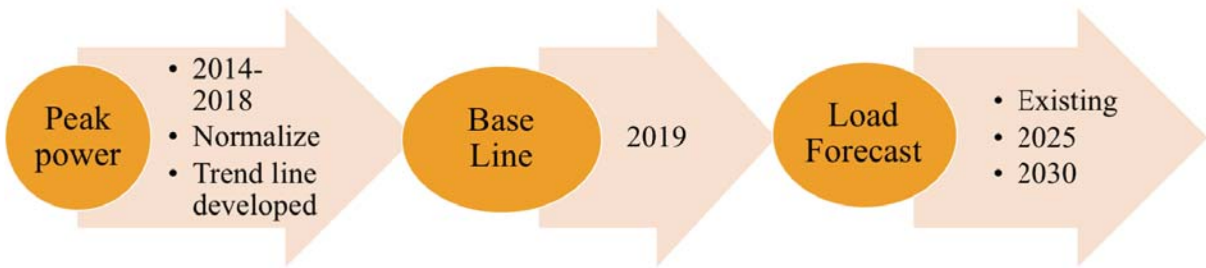


Figure 2: Flow diagram for load forecast

1.3.1 Normalizing the Data

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

Table 1: Actual power data of Punakha Dzongkhag

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

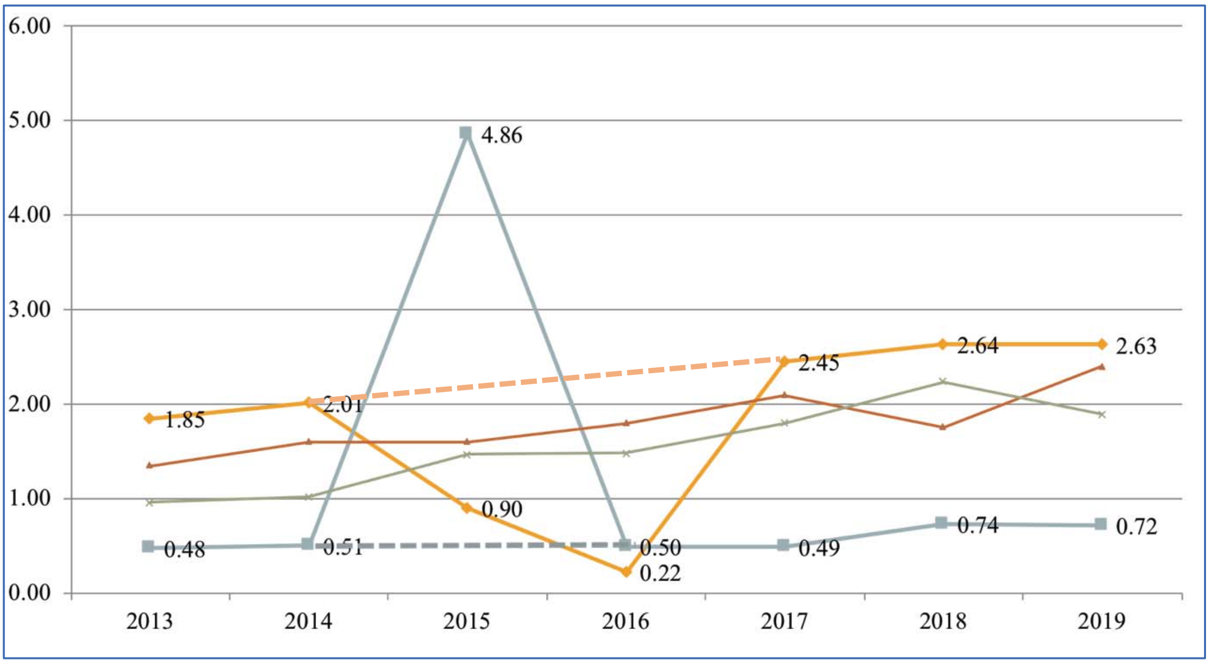


Figure 3: Actual data of Punakha Dzongkhag

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

Where:
x is the normalized data

x_1 and x_2 is the data for two years

Table 2: Normalized power data of Punakha Dzongkhag

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

1.3.2 Trend Line and Load Forecast

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

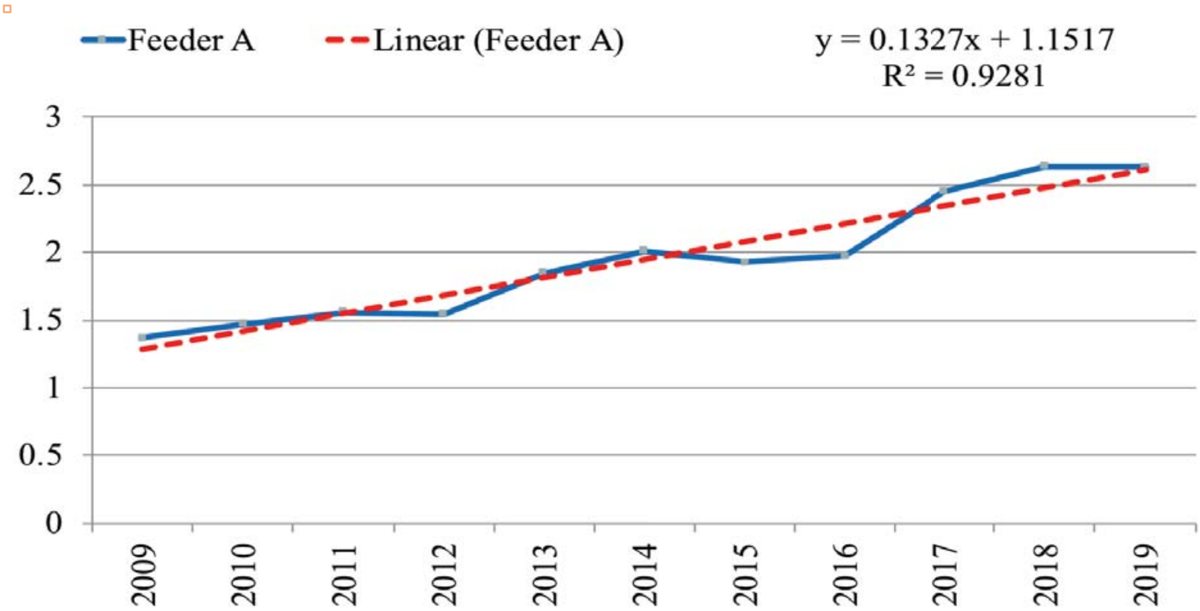


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$$y = ax + b$$

Where:

y is the dependent variable or forecasted load
a is the slope which is the average change in y for every increment of x (increase in year).
It also gives x is the independent variable or time in year
b is the intercept which is the predicted value of y when x is zero (time is zero)

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

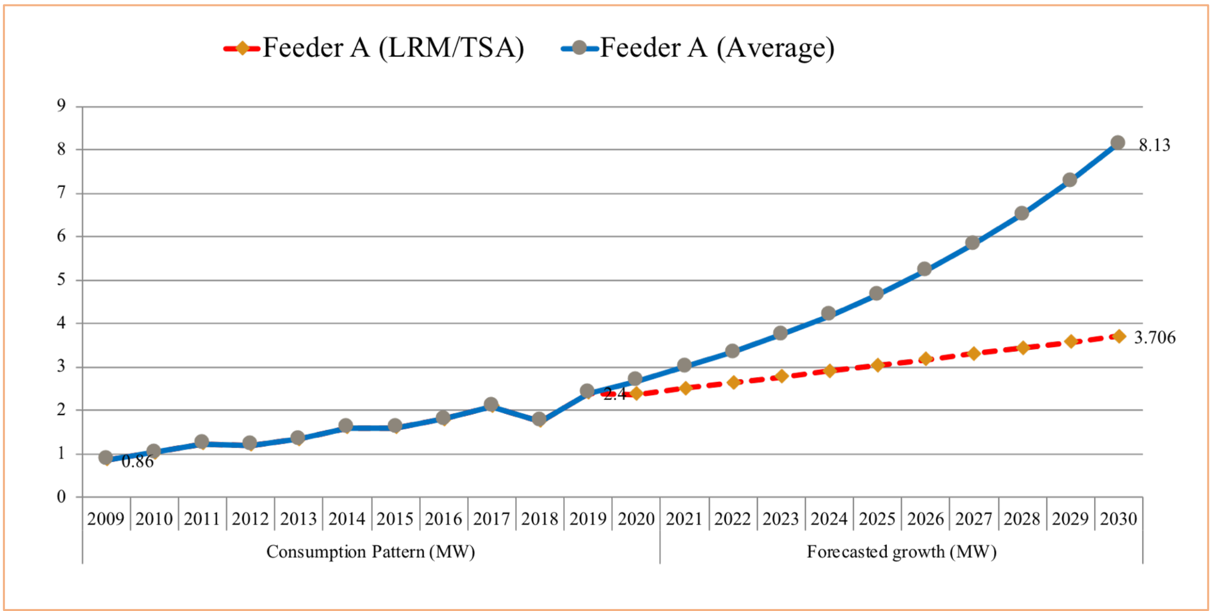


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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

2.1 ETAP Software

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

2.2 Load Flow Analysis (ETAP)

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

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

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

2.2.1 Creating the Library

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

a) Transmission Cable

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

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

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

c) Set Loading and Generation Categories.

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

2.2.2 Network Modelling and Load Flow Analysis

a) Draw Distribution Network (SLD).

b) Enter the height=8 and spacing =1.25 in the Transmission line table.

c) Enter the electrical parameters (kW, kVA, kV, etc.) ratings for power sources, transformers, line type, bus kV and loading details.

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

2.3 Consideration/Assumptions made while simulating in ETAP software

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

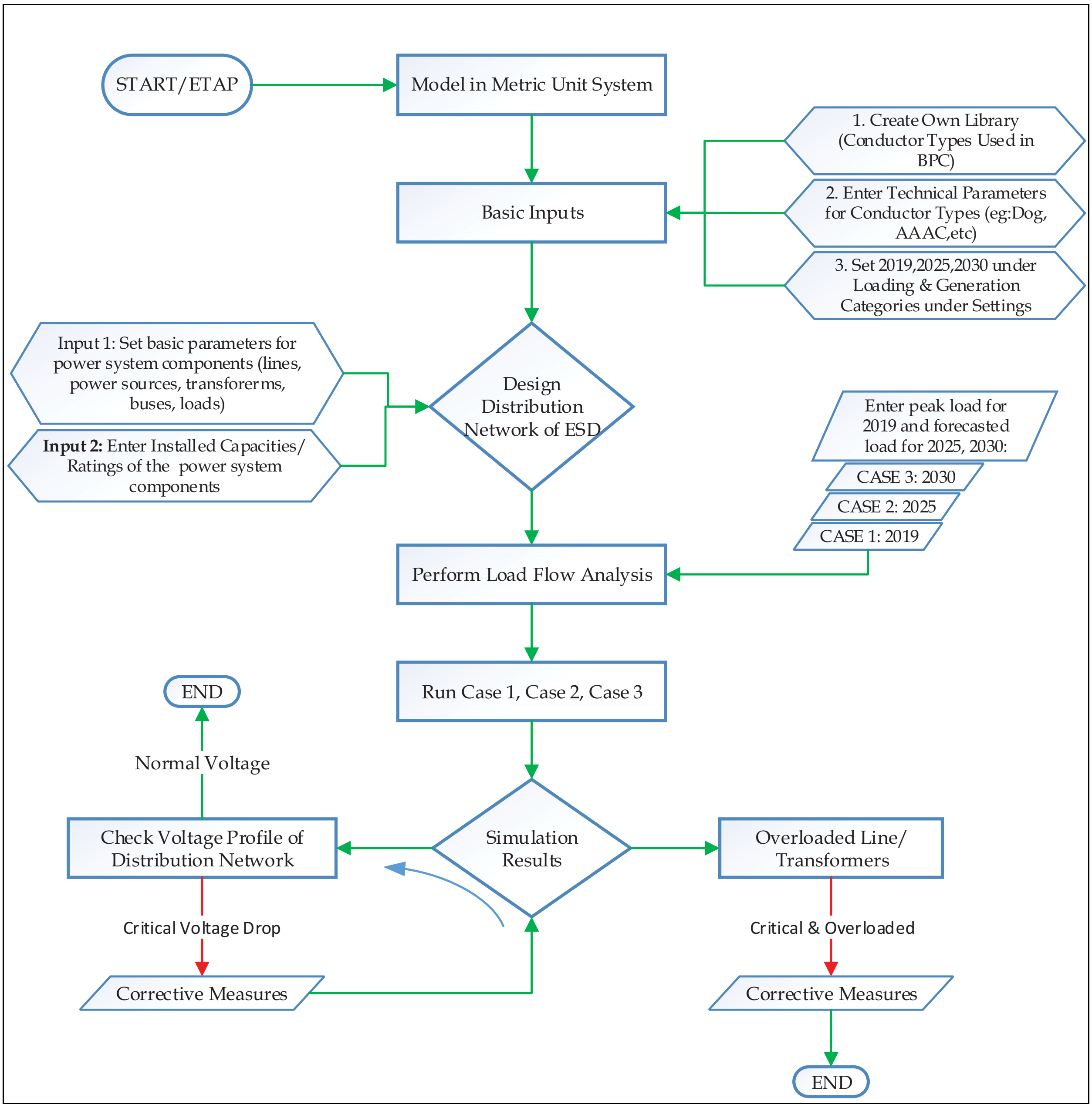


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

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

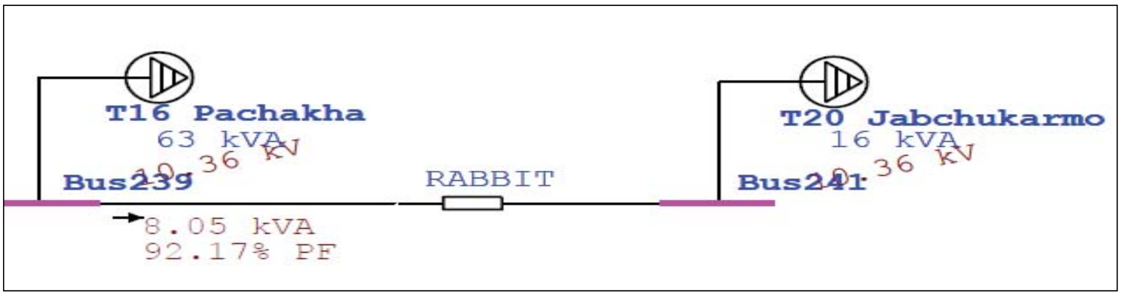
[2]http://sites.utexas.edu/sos/guided/inferential/numeric/bivariate/cor/: dated September 29, 2020

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

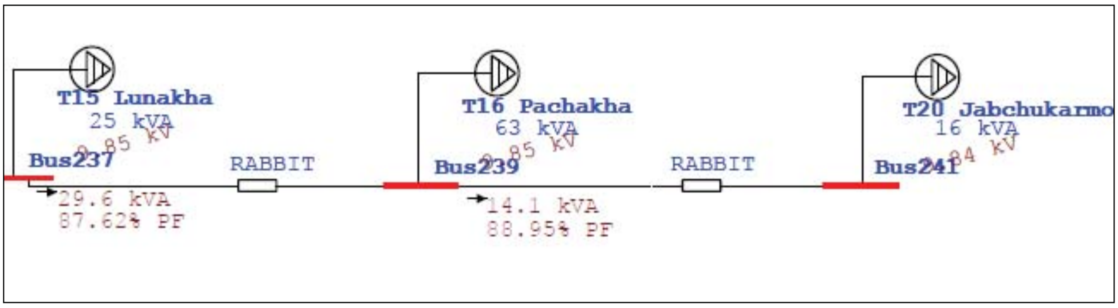
Annexure 4: The Simulation Results

1) 11kV Feeder-I (Talo-Nobgang)

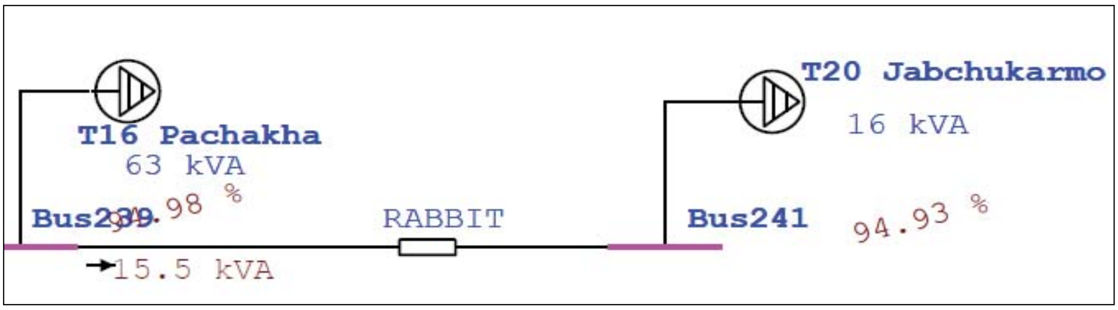
2019 Result



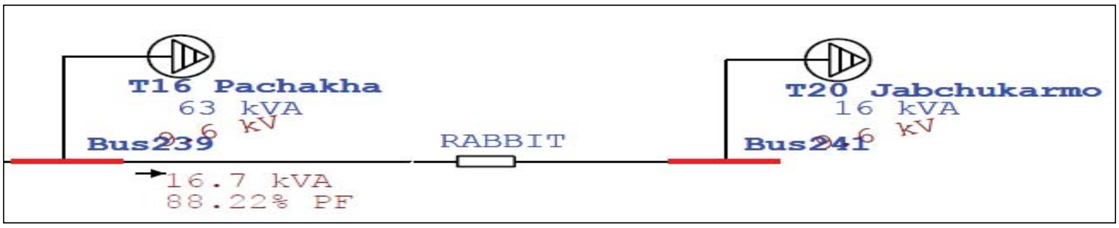
2025 (Before improvement)



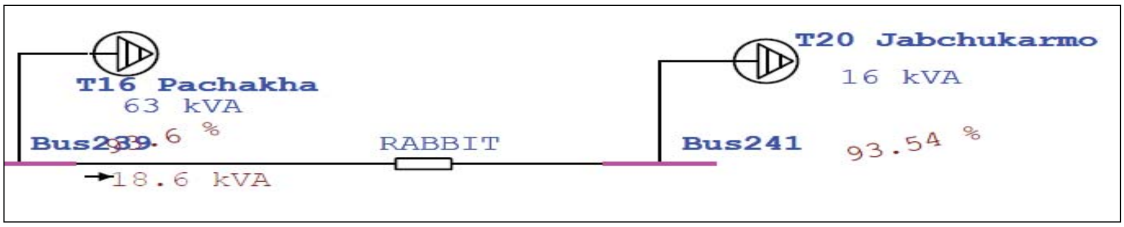
2025 (After improvement by reconfiguring the sources)



2030 (Before improvement)

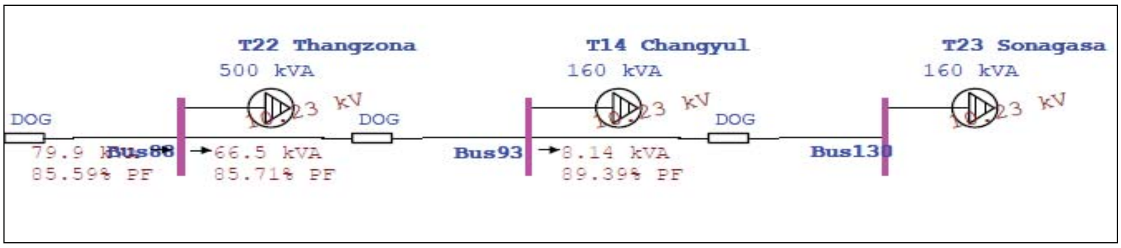


2030 (After improvement by reconfiguring the source)

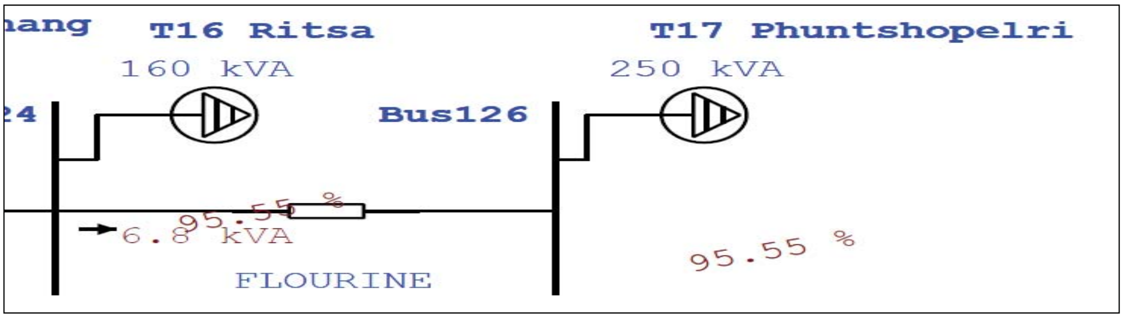


2) 11kV Feeder-II (Phuentshopelri)

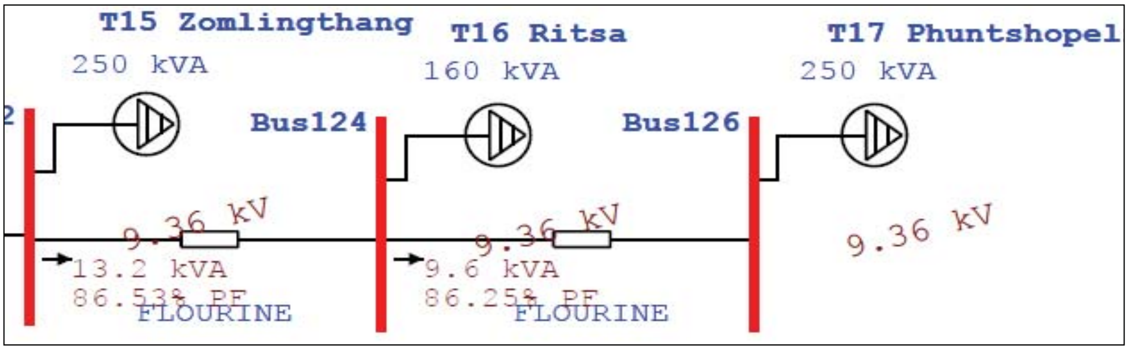
2019



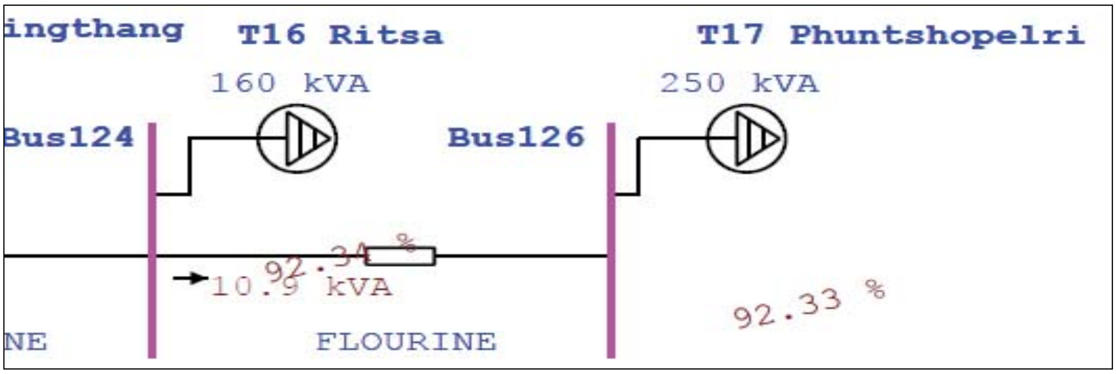
2019 (After improvement by reconfiguring the source)



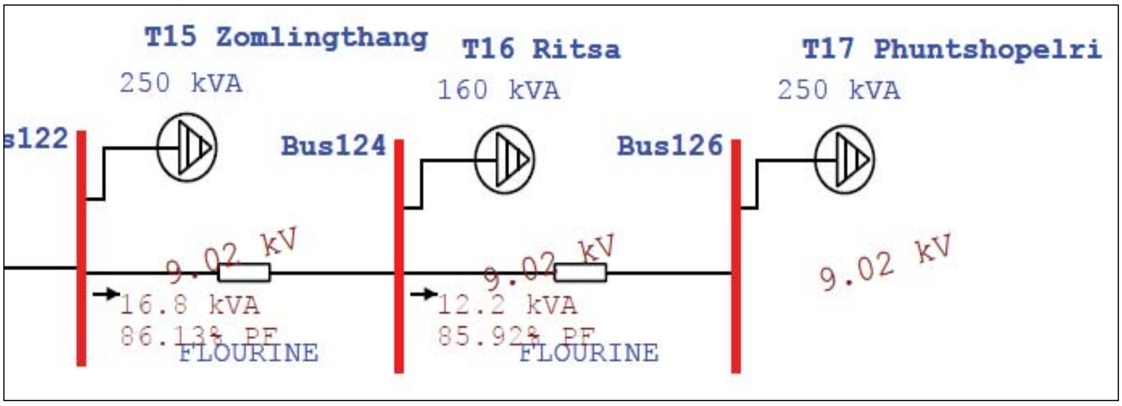
2025 (Before improvement)



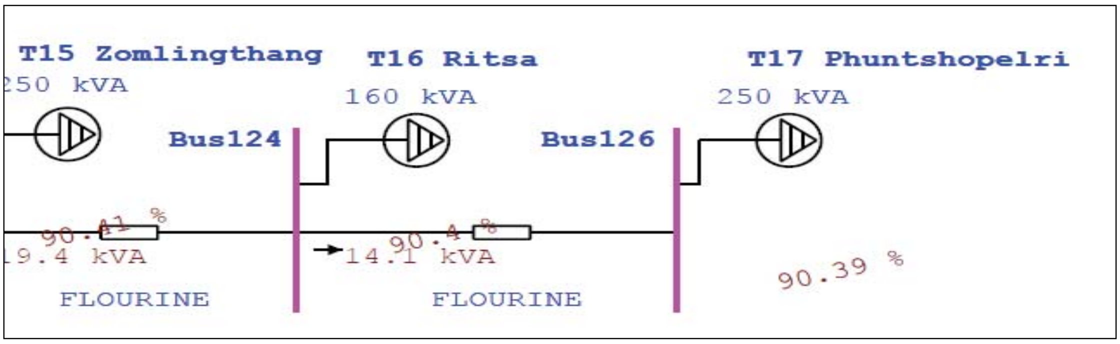
2025 (After improvement by reconfiguring the source)



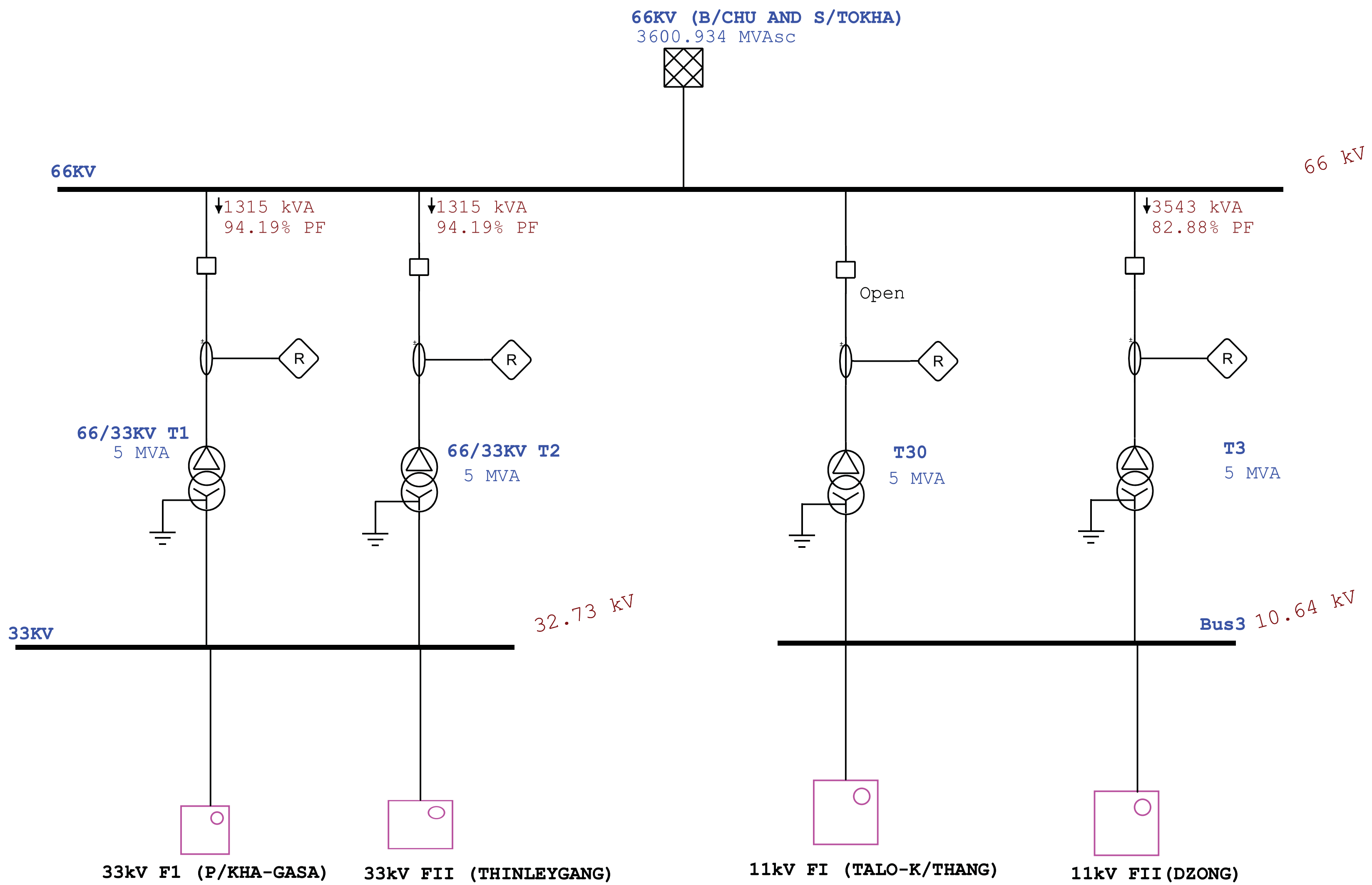
2030 (Before improvement)



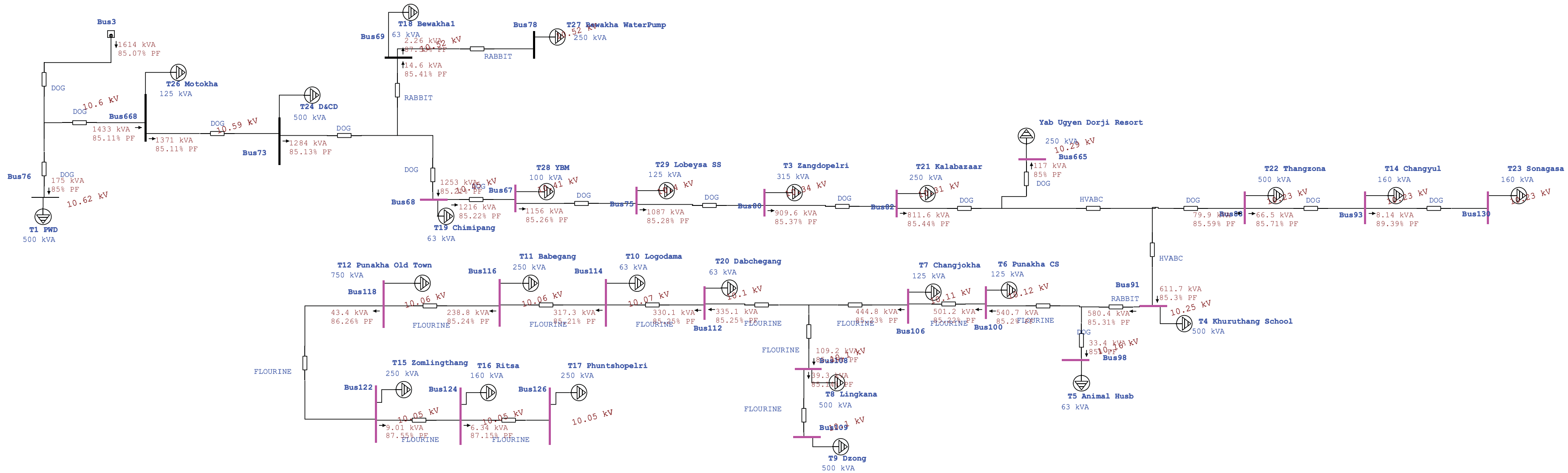
2030 (After improvement by reconfiguring the source)



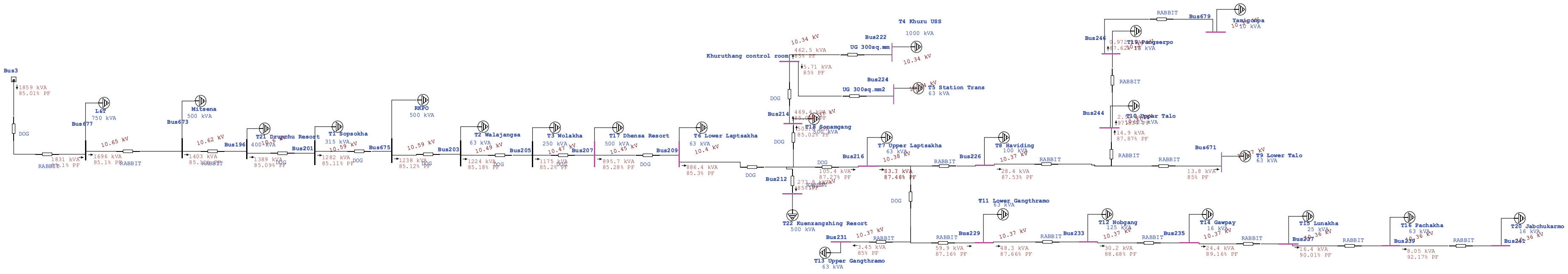
One-Line Diagram - ESD PUNAKHA (LF 2019) (Load Flow Analysis)



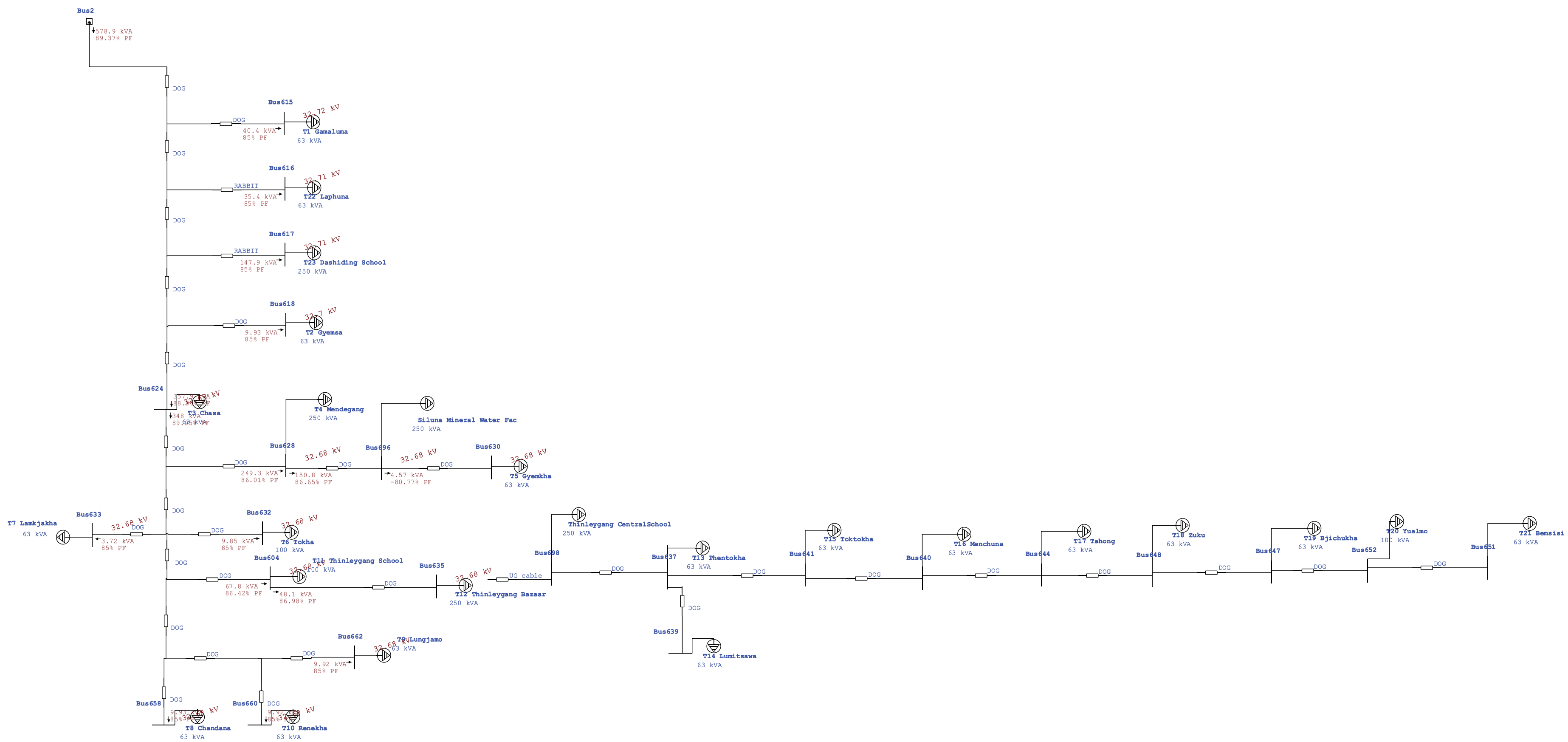
One-Line Diagram - OLV1=>11kV FEEDER II (Load Flow Analysis)



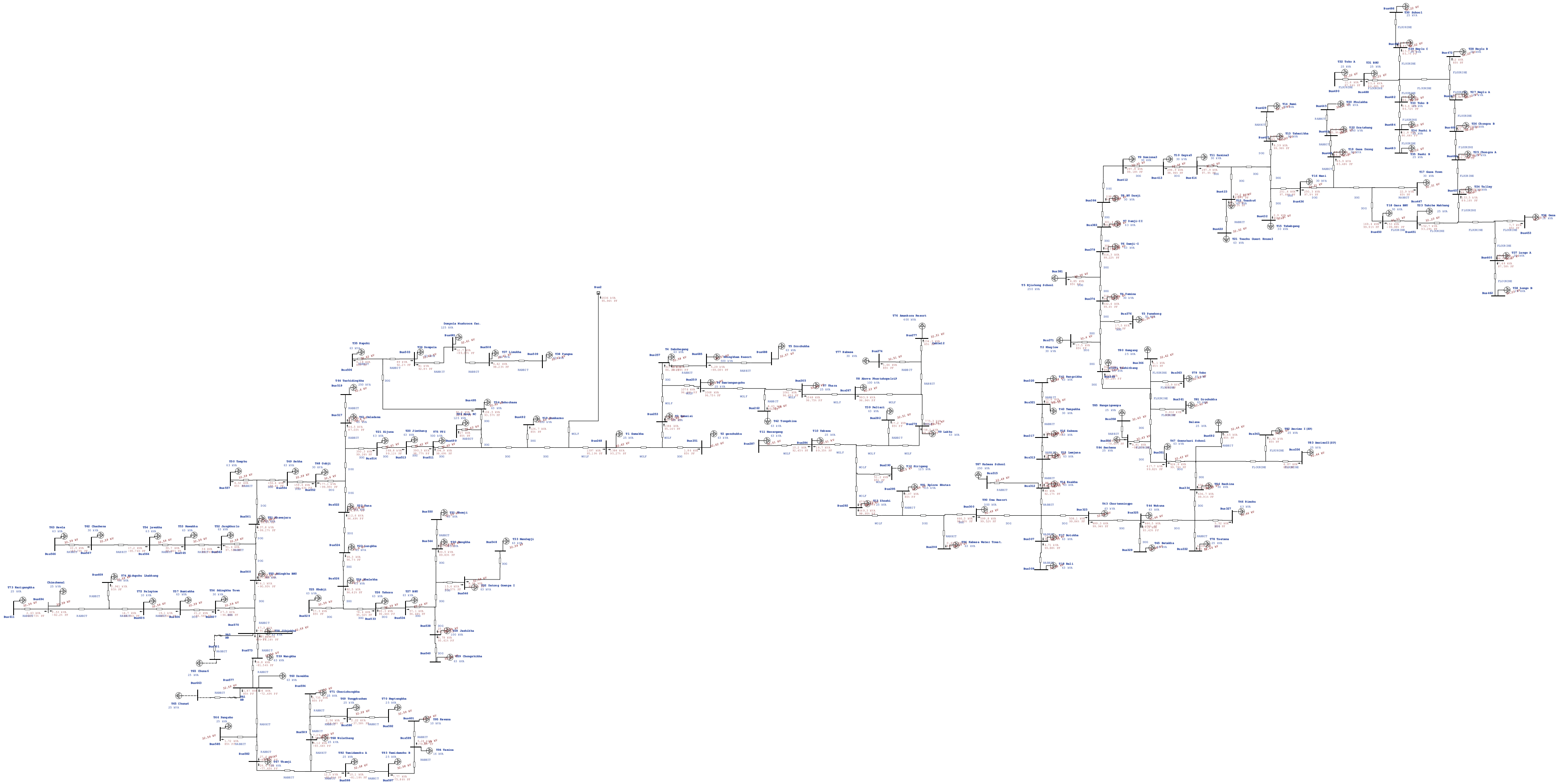
One-Line Diagram - OLV1=>11kV FEEDER I (Load Flow Analysis)



One-Line Diagram - OLV1=>33kV feeder III (Load Flow Analysis)



One-Line Diagram - OLV1=>33kV Feeder I (Load Flow Analysis)



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										4.494	90.5	39.3	
Bus2	33.000										2.611	94.7	46.1	
Bus3	11.000										1.859	85.0	99.3	
Bus196	11.000		0.002	0.001	0.008	0.005					1.401	85.1	76.3	
Bus199	11.000										1.835	85.1	99.3	
Bus201	11.000		0.019	0.012	0.072	0.044					1.388	85.1	75.7	
Bus203	11.000		0.001	0.000	0.003	0.002					1.228	85.2	67.5	
Bus205	11.000		0.009	0.005	0.031	0.019					1.221	85.2	67.3	
Bus207	11.000		0.051	0.032	0.184	0.114					1.172	85.2	64.8	
Bus209	11.000		0.001	0.001	0.003	0.002					0.892	85.3	49.5	
Bus211	11.000										0.885	85.3	49.2	
Bus212	11.000		0.051	0.032	0.182	0.113					0.274	85.0	15.2	
Bus214	11.000		0.007	0.004	0.024	0.015					0.506	85.0	28.2	
Bus216	11.000		0.002	0.001	0.006	0.004					0.105	87.3	5.9	
Bus222	11.000		0.087	0.054	0.306	0.190					0.462	85.0	25.8	
Bus224	11.000		0.001	0.001	0.004	0.002					0.006	85.0	0.3	
Bus226	11.000		0.001	0.001	0.004	0.002					0.034	87.1	1.9	
Bus227	11.000										0.063	87.2	3.5	
Bus229	11.000		0.008	0.005	0.002	0.001					0.060	87.2	3.3	
Bus231	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus233	11.000		0.003	0.002	0.012	0.007					0.048	87.4	2.7	
Bus235	11.000		0.001	0.001	0.004	0.002					0.030	88.4	1.7	
Bus237	11.000		0.002	0.001	0.005	0.003					0.025	88.4	1.4	
Bus239	11.000		0.006	0.004	0.001	0.001					0.017	88.7	0.9	
Bus241	11.000		0.002	0.001	0.006	0.004					0.009	85.0	0.5	
Bus243	11.000										0.029	86.9	1.6	
Bus244	11.000		0.002	0.001	0.008	0.005					0.015	87.9	0.8	
Bus246	11.000		0.000	0.000	0.001	0.001					0.003	85.9	0.2	
Bus247	33.000										2.038	95.8	36.1	
Bus248	33.000		0.002	0.001	0.009	0.006					1.397	95.2	24.7	
Bus251	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus252	33.000										1.385	95.2	24.5	
Bus253	33.000		0.000	0.000	0.001	0.001					1.384	95.1	24.5	
Bus255	33.000										1.383	95.0	24.5	
Bus257	33.000		0.004	0.002	0.015	0.009					0.318	86.1	5.6	
Bus259	33.000		0.001	0.001	0.006	0.004					1.076	96.7	19.1	
Bus262	33.000		0.001	0.001	0.006	0.004					0.009	85.0	0.2	
Bus263	33.000										1.068	96.7	18.9	
Bus265	33.000		0.002	0.002	0.009	0.006					1.061	96.7	18.8	

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
Bus267	33.000		0.010	0.006	0.040	0.025					1.050	96.5	18.6	
Bus269	33.000										0.995	96.8	17.7	
Bus274	33.000		0.000	0.000	0.001	0.001					0.001	85.0	-	
Bus275	33.000										0.230	87.1	4.1	
Bus277	33.000		0.041	0.025	0.158	0.098					0.234	85.0	4.2	
Bus279	33.000		0.003	0.002	0.012	0.008					0.775	98.3	13.8	
Bus280	33.000										0.758	98.5	13.5	
Bus282	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus284	33.000		0.001	0.001	0.006	0.004					0.019	89.3	0.3	
Bus285	33.000										0.743	98.5	13.2	
Bus287	33.000		0.002	0.001	0.007	0.005					0.011	85.0	0.2	
Bus288	33.000										0.726	98.4	12.9	
Bus290	33.000		0.009	0.006	0.035	0.021					0.051	85.0	0.9	
Bus292	33.000		0.002	0.001	0.007	0.005					0.679	98.9	12.1	
Bus293	33.000										0.669	98.9	11.9	
Bus295	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus296	33.000										0.667	98.9	11.8	
Bus298	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus300	33.000		0.013	0.008	0.049	0.031					0.666	98.9	11.8	
Bus305	33.000										0.600	99.5	10.7	
Bus307	33.000		0.002	0.001	0.009	0.005					0.017	91.2	0.3	
Bus309	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus312	33.000		0.006	0.004	0.024	0.015					0.080	92.2	1.4	
Bus313	33.000		0.003	0.002	0.013	0.008					0.043	95.8	0.8	
Bus315	33.000		0.000	0.000	0.002	0.001					0.002	85.0	-	
Bus317	33.000		0.002	0.001	0.009	0.006					0.026	96.2	0.5	
Bus320	33.000		0.002	0.001	0.009	0.006					0.014	85.0	0.2	
Bus321	33.000		0.000	0.000	0.002	0.001					0.014	97.6	0.3	
Bus323	33.000		0.004	0.002	0.015	0.009					0.508	99.8	9.0	
Bus325	33.000		0.006	0.004	0.022	0.014					0.489	99.9	8.7	
Bus327	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus329	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus330	33.000										0.445	100.0	7.9	
Bus332	33.000		0.001	0.001	0.004	0.003					0.006	85.0	0.1	
Bus334	33.000		0.000	0.000	0.001	-					0.435	99.9	7.7	
Bus336	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus338	33.000										0.434	99.9	7.7	
Bus341	33.000										0.007	97.5	0.1	
Bus343	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus351	33.000		0.001	0.001	0.005	0.003					0.425	99.8	7.6	
Bus354	33.000										0.418	99.7	7.4	
Bus356	33.000		0.001	0.000	0.003	0.002					0.009	91.6	0.2	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus358	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus359	33.000										0.410	99.5	7.3	
Bus361	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus363	33.000		0.002	0.001	0.009	0.005					0.013	85.0	0.2	
Bus364	33.000										0.017	92.0	0.3	
Bus366	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus368	33.000		0.006	0.004	0.025	0.015					0.395	99.3	7.0	
Bus369	33.000										0.362	99.6	6.5	
Bus371	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus372	33.000										0.347	99.6	6.2	
Bus374	33.000		0.003	0.002	0.012	0.007					0.332	99.6	5.9	
Bus376	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus378	33.000										0.318	99.2	5.7	
Bus379	33.000		0.001	0.001	0.006	0.004					0.314	99.2	5.6	
Bus381	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus383	33.000		0.001	0.001	0.004	0.003					0.307	99.2	5.5	
Bus384	33.000		0.001	0.000	0.003	0.002					0.302	99.2	5.4	
Bus412	33.000		0.000	0.000	0.000	-					0.298	99.2	5.3	
Bus413	33.000		0.000	0.000	0.001	0.001					0.299	98.9	5.3	
Bus414	33.000		0.000	0.000	0.002	0.001					0.300	97.8	5.4	
Bus422	33.000		0.007	0.004	0.026	0.016					0.039	85.0	0.7	
Bus423	33.000		0.000	0.000	0.001	0.001					0.040	87.7	0.7	
Bus424	33.000										0.298	97.9	5.3	
Bus425	33.000										0.262	98.2	4.7	
Bus427	33.000		0.001	0.001	0.004	0.003					0.009	92.2	0.2	
Bus429	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus430	33.000										0.254	98.0	4.5	
Bus432	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus436	33.000		0.000	0.000	0.001	-					0.251	97.9	4.5	
Bus438	33.000										0.190	99.5	3.4	
Bus439	33.000										0.250	97.9	4.5	
Bus442	33.000		0.006	0.003	0.021	0.013					0.049	85.3	0.9	
Bus443	33.000		0.003	0.002	0.012	0.007					0.066	85.5	1.2	
Bus445	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus447	33.000		0.004	0.002	0.015	0.010					0.023	85.0	0.4	
Bus450	33.000		0.003	0.002	0.013	0.008					0.170	99.8	3.0	
Bus451	33.000		0.002	0.001	0.008	0.005					0.165	92.8	2.9	
Bus453	33.000		0.001	0.001	0.005	0.003					0.008	85.0	0.1	
Bus455	33.000										0.154	92.6	2.8	
Bus457	33.000		0.001	0.001	0.005	0.003					0.134	89.2	2.4	
Bus458	33.000										0.025	94.3	0.4	
Bus460	33.000		0.002	0.001	0.008	0.005					0.020	86.0	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
Bus462	33.000		0.001	0.001	0.005	0.003					0.008	85.0	0.1	
Bus464	33.000		0.002	0.001	0.008	0.005					0.129	87.5	2.3	
Bus466	33.000		0.002	0.001	0.008	0.005					0.117	87.6	2.1	
Bus467	33.000		0.002	0.001	0.008	0.005					0.105	87.6	1.9	
Bus472	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus473	33.000										0.094	87.1	1.7	
Bus478	33.000										0.082	86.9	1.5	
Bus480	33.000		0.002	0.001	0.008	0.005					0.024	85.7	0.4	
Bus482	33.000		0.002	0.001	0.008	0.005					0.036	86.1	0.6	
Bus483	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus484	33.000		0.002	0.001	0.008	0.005					0.024	85.8	0.4	
Bus486	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus488	33.000		0.002	0.001	0.008	0.005					0.024	86.5	0.4	
Bus490	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus492	33.000		0.022	0.014	0.086	0.053					0.127	85.0	2.2	
Bus493	33.000										0.642	96.6	11.4	
Bus495	33.000		0.002	0.001	0.008	0.005					0.105	93.6	1.8	
Bus496	33.000										0.523	98.1	9.2	
Bus497	33.000										0.129	93.9	2.3	
Bus499	33.000		0.005	0.003	0.018	0.011					0.027	85.0	0.5	
Bus503	33.000		0.001	0.001	0.005	0.003					0.089	92.2	1.6	
Bus504	33.000										0.093	94.0	1.6	
Bus506	33.000		0.001	0.001	0.004	0.003					0.006	85.0	0.1	
Bus508	33.000		0.001	0.001	0.005	0.003					0.014	92.7	0.2	
Bus509	33.000		0.001	0.001	0.005	0.003					0.007	85.0	0.1	
Bus511	33.000		0.001	0.001	0.003	0.002					0.398	98.6	7.0	
Bus513	33.000		0.004	0.003	0.016	0.010					0.393	98.7	7.0	
Bus514	33.000		0.004	0.002	0.014	0.009					0.372	98.8	6.6	
Bus515	33.000										0.354	98.8	6.3	
Bus517	33.000		0.004	0.003	0.016	0.010					0.044	87.0	0.8	
Bus519	33.000		0.004	0.002	0.015	0.009					0.022	85.0	0.4	
Bus520	33.000										0.314	99.1	5.6	
Bus522	33.000		0.005	0.003	0.018	0.011					0.139	94.9	2.5	
Bus524	33.000		0.003	0.002	0.010	0.006					0.114	95.7	2.0	
Bus526	33.000		0.001	0.001	0.005	0.003					0.100	95.8	1.8	
Bus527	33.000										0.094	94.8	1.7	
Bus529	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus533	33.000		0.002	0.001	0.009	0.006					0.078	95.0	1.4	
Bus534	33.000		0.002	0.001	0.006	0.004					0.066	95.4	1.2	
Bus535	33.000										0.058	95.6	1.0	
Bus538	33.000		0.003	0.002	0.011	0.007					0.025	89.3	0.4	
Bus540	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus543	33.000										0.034	96.3	0.6	
Bus544	33.000		0.002	0.001	0.007	0.004					0.020	89.8	0.4	
Bus546	33.000		0.001	0.001	0.005	0.003					0.016	90.6	0.3	
Bus548	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus550	33.000		0.002	0.001	0.008	0.005					0.011	85.0	0.2	
Bus552	33.000		0.004	0.002	0.015	0.009					0.180	99.7	3.2	
Bus554	33.000		0.001	0.001	0.004	0.003					0.162	99.6	2.9	
Bus555	33.000										0.156	99.8	2.8	
Bus557	33.000		0.001	0.000	0.003	0.002					0.004	85.0	0.1	
Bus560	33.000		0.004	0.002	0.014	0.009					0.094	94.9	1.7	
Bus561	33.000		0.003	0.002	0.010	0.006					0.153	99.5	2.7	
Bus562	33.000										0.140	99.1	2.5	
Bus563	33.000		0.003	0.002	0.011	0.007					0.051	97.5	0.9	
Bus564	33.000		0.003	0.002	0.011	0.007					0.032	96.1	0.6	
Bus565	33.000		0.001	0.001	0.004	0.003					0.036	99.1	0.6	
Bus566	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus567	33.000		0.001	0.001	0.005	0.003					0.017	97.6	0.3	
Bus570	33.000		0.002	0.001	0.008	0.005					0.051	89.3	0.9	
Bus571	33.000										0.077	93.4	1.4	
Bus573	33.000		0.001	0.000	0.003	0.002					0.042	84.4	0.7	
Bus577	33.000		0.001	0.001	0.006	0.003					0.039	80.4	0.7	
Bus582	33.000		0.001	0.000	0.002	0.001					0.029	81.1	0.5	
Bus583	33.000										0.030	81.1	0.5	
Bus585	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus587	33.000										0.026	78.2	0.5	
Bus588	33.000										0.006	47.8	0.1	
Bus589	33.000		0.001	0.001	0.004	0.003					0.011	78.7	0.2	
Bus590	33.000		0.000	0.000	0.001	0.001					0.003	74.4	0.1	
Bus592	33.000		0.000	0.000	0.001	-					0.001	85.0	-	
Bus594	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus597	33.000		0.000	0.000	0.002	0.001					0.010	85.0	0.2	
Bus598	33.000		0.001	0.000	0.003	0.002					0.013	89.7	0.2	
Bus599	33.000		0.000	0.000	0.001	0.001					0.007	88.0	0.1	
Bus601	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus602	33.000										0.091	91.8	1.6	
Bus604	33.000		0.003	0.002	0.013	0.008					0.068	86.4	1.2	
Bus605	33.000		0.000	0.000	0.000	-					0.015	20.2	0.3	
Bus606	33.000		0.001	0.001	0.006	0.004					0.021	48.0	0.4	
Bus607	33.000		0.003	0.002	0.012	0.008					0.032	81.2	0.6	
Bus608	33.000										0.013	23.0	0.2	
Bus609	33.000		0.000	0.000	0.001	-					0.001	85.0	-	
Bus611	33.000		0.000	0.000	0.000	-					0.001	85.0	-	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus614	33.000										0.580	89.1	10.2	
Bus615	33.000		0.007	0.004	0.027	0.017					0.040	85.0	0.7	
Bus616	33.000		0.006	0.004	0.024	0.015					0.035	85.0	0.6	
Bus617	33.000		0.026	0.016	0.100	0.062					0.148	85.0	2.6	
Bus618	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus619	33.000										0.541	89.2	9.6	
Bus620	33.000										0.507	89.4	8.9	
Bus621	33.000										0.364	89.7	6.4	
Bus624	33.000		0.002	0.001	0.007	0.004					0.358	88.9	6.3	
Bus626	33.000										0.350	88.6	6.2	
Bus628	33.000		0.017	0.011	0.067	0.041					0.249	86.0	4.4	
Bus630	33.000		0.001	0.000	0.003	0.002					0.004	85.0	0.1	
Bus631	33.000										0.104	91.8	1.8	
Bus632	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus633	33.000		0.001	0.000	0.003	0.002					0.004	85.0	0.1	
Bus635	33.000		0.009	0.005	0.033	0.021					0.049	85.0	0.9	
Bus654	33.000										0.027	95.2	0.5	
Bus656	33.000										0.019	91.1	0.3	
Bus658	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus660	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus662	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus671	11.000		0.003	0.002	0.009	0.006					0.014	85.0	0.8	
Bus673	11.000		0.052	0.032	0.193	0.120					1.692	85.1	92.0	
Bus675	11.000		0.008	0.005	0.028	0.018					1.281	85.1	69.8	
Bus677	11.000		0.024	0.015	0.091	0.056					1.831	85.1	99.3	
Bus679	11.000		0.000	0.000	0.001	-					0.001	85.0	0.1	
Bus681	33.000		0.013	0.008	0.050	0.031					0.085	88.9	1.5	
Bus685	33.000		0.051	0.032	0.199	0.123					0.298	85.5	5.3	
Bus688	33.000		0.001	0.001	0.004	0.003					0.006	85.0	0.1	
Bus692	33.000		0.001	0.000	0.002	0.002					0.004	85.0	0.1	
Bus694	33.000		0.000	0.000	0.001	0.001					0.003	66.4	0.1	
Bus696	33.000		0.102	0.063	0.025	0.015					0.153	85.7	2.7	
Khuruthang control room	11.000										0.468	85.0	26.1	

* 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	%
Cable12	Cable	301.98	4.16	1.38					
UG 300sq.mm	Cable	338.03	25.82	7.64					
UG 300sq.mm2	Cable	338.03	0.32	0.09					
T1	Transformer				5.000	1.316	26.3	1.305	26.1
T3	Transformer				5.000	1.891	37.8	1.859	37.2
T27	Transformer				5.000	1.316	26.3	1.305	26.1

* 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	1.239	0.443	-1.236	-0.418	2.9	24.6	100.0	99.2	0.82
T3	1.587	1.030	-1.581	-0.979	6.0	50.8	100.0	98.3	1.71
T27	1.239	0.443	-1.236	-0.418	2.9	24.6	100.0	99.2	0.82
Line178	1.956	0.577	-1.951	-0.588	4.2	-10.7	99.2	98.9	0.28
Line571	0.517	0.260	-0.517	-0.263	0.1	-3.3	99.2	99.2	0.03
Line129	1.581	0.979	-1.562	-0.963	18.6	15.6	98.3	97.0	1.29
Line130	1.182	0.730	-1.182	-0.729	0.8	0.6	96.4	96.3	0.07
Line634	-1.192	-0.736	1.194	0.737	2.4	1.1	96.4	96.6	0.18
Line131	1.562	0.963	-1.558	-0.962	4.0	1.8	97.0	96.8	0.23
Line636	1.091	0.673	-1.090	-0.672	0.7	0.5	96.3	96.2	0.06
Line134	-1.046	-0.643	1.054	0.650	8.3	6.7	95.4	96.2	0.84
Line136	1.042	0.641	-1.040	-0.639	2.0	1.7	95.4	95.2	0.21
Line138	1.001	0.615	-0.999	-0.613	2.1	1.7	95.2	95.0	0.22
Line140	0.764	0.468	-0.761	-0.465	3.3	2.5	95.0	94.5	0.46
Line142	0.756	0.463	-0.755	-0.462	0.9	0.7	94.5	94.4	0.12
Line144	0.233	0.144	-0.233	-0.144	0.0	0.0	94.4	94.4	0.01
Line147	0.430	0.267	-0.430	-0.266	0.4	0.2	94.4	94.3	0.10
Line149	0.092	0.051	-0.092	-0.051	0.0	-0.3	94.4	94.3	0.05
Line151	0.399	0.247	-0.398	-0.247	1.1	0.5	94.3	94.0	0.28
Line156	0.029	0.016	-0.029	-0.017	0.0	-0.3	94.3	94.3	0.02
Line158	0.055	0.031	-0.055	-0.031	0.0	-0.3	94.3	94.3	0.03
UG 300sq.mm	-0.393	-0.244	0.393	0.244	0.0	0.0	94.0	94.0	0.01
UG 300sq.mm2	-0.005	-0.003	0.005	0.003	0.0	0.0	94.0	94.0	0.00
Line173	0.025	0.014	-0.025	-0.014	0.0	-0.4	94.3	94.3	0.03
Line160	0.052	0.029	-0.052	-0.029	0.0	-0.1	94.3	94.3	0.02
Line162	0.003	0.002	-0.003	-0.002	0.0	-0.1	94.3	94.3	0.00
line	0.042	0.023	-0.042	-0.024	0.0	-0.3	94.3	94.2	0.04
Line165	0.027	0.014	-0.027	-0.014	0.0	-0.2	94.2	94.2	0.02
Line167	0.022	0.011	-0.022	-0.011	0.0	-0.4	94.2	94.2	0.02
Line169	0.015	0.007	-0.015	-0.008	0.0	-0.5	94.2	94.2	0.02
Line171	0.007	0.003	-0.007	-0.005	0.0	-1.5	94.2	94.2	0.03
Line175	0.013	0.007	-0.013	-0.007	0.0	-0.2	94.3	94.3	0.01
Line632	0.012	0.007	-0.012	-0.007	0.0	-0.1	94.3	94.3	0.00
Line177	0.002	0.001	-0.002	-0.001	0.0	-0.9	94.3	94.3	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
Line640	0.001	0.000	-0.001	-0.001	0.0	-0.1	94.3	94.3	0.00
Line180	1.331	0.425	-1.330	-0.428	0.4	-2.9	98.9	98.9	0.04
Line182	0.621	0.162	-0.621	-0.165	0.1	-2.6	98.9	98.9	0.02
Line184	1.318	0.421	-1.318	-0.422	0.2	-1.4	98.9	98.8	0.02
Line186	-0.002	-0.001	0.002	-0.003	0.0	-3.8	98.8	98.8	0.00
Line187	1.317	0.425	-1.317	-0.426	0.2	-1.2	98.8	98.8	0.02
Line189	1.315	0.425	-1.315	-0.431	0.8	-5.6	98.8	98.7	0.08
Line191	0.273	0.161	-0.273	-0.162	0.0	-0.3	98.7	98.7	0.00
Line193	1.041	0.270	-1.041	-0.275	0.4	-4.8	98.7	98.7	0.05
Line195	0.255	0.150	-0.255	-0.154	0.1	-3.9	98.7	98.7	0.03
Line197	1.033	0.270	-1.033	-0.272	0.2	-1.9	98.7	98.7	0.02
Line199	-0.007	-0.005	0.007	0.000	0.0	-4.3	98.7	98.7	0.00
Line201	1.026	0.272	-1.026	-0.272	0.0	-0.4	98.7	98.7	0.00
Line203	1.014	0.265	-1.013	-0.275	0.8	-10.0	98.7	98.6	0.09
Line206	0.963	0.244	-0.963	-0.250	0.4	-5.6	98.6	98.5	0.05
Line209	0.200	0.111	-0.200	-0.113	0.0	-2.1	98.5	98.5	0.01
Line215	0.763	0.139	-0.762	-0.140	0.1	-1.4	98.5	98.5	0.01
Line211	-0.001	-0.001	0.001	0.000	0.0	-0.7	98.5	98.5	0.00
Cable12	0.199	0.113	-0.199	-0.123	0.0	-10.7	98.5	98.5	0.00
Line217	0.747	0.131	-0.747	-0.131	0.0	-0.2	98.5	98.5	0.00
Line219	0.732	0.127	-0.732	-0.129	0.1	-2.4	98.5	98.5	0.01
Line221	0.015	0.004	-0.015	-0.009	0.0	-5.4	98.5	98.5	0.00
Line223	-0.017	-0.008	0.017	0.008	0.0	-0.7	98.5	98.5	0.00
Line225	0.009	0.004	-0.009	-0.006	0.0	-2.0	98.5	98.5	0.00
Line227	0.715	0.122	-0.715	-0.127	0.2	-5.7	98.5	98.5	0.03
Line229	0.672	0.101	-0.672	-0.102	0.0	-1.0	98.5	98.5	0.01
Line231	0.044	0.026	-0.044	-0.027	0.0	-0.9	98.5	98.5	0.00
Line233	0.662	0.097	-0.662	-0.097	0.0	-0.6	98.5	98.5	0.00
Line235	0.660	0.096	-0.660	-0.097	0.0	-0.8	98.5	98.5	0.01
Line237	0.003	0.001	-0.003	-0.002	0.0	-0.9	98.5	98.5	0.00
Line239	0.659	0.097	-0.659	-0.097	0.0	-0.3	98.5	98.5	0.00
Line241	0.001	0.000	-0.001	0.000	0.0	-0.1	98.5	98.5	0.00
Line243	0.597	0.059	-0.597	-0.060	0.0	-1.1	98.5	98.4	0.01
Line246	0.016	0.007	-0.016	-0.007	0.0	-0.3	98.4	98.4	0.00
Line254	0.074	0.030	-0.074	-0.031	0.0	-1.4	98.4	98.4	0.00
Line264	0.507	0.023	-0.507	-0.029	0.2	-5.4	98.4	98.4	0.03
Line248	0.005	0.000	-0.005	-0.003	0.0	-2.7	98.4	98.4	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line251	0.041	0.011	-0.041	-0.012	0.0	-1.0	98.4	98.4	0.00
Line256	0.002	0.001	-0.002	-0.001	0.0	-0.4	98.4	98.4	0.00
Line252	0.025	0.002	-0.025	-0.007	0.0	-4.2	98.4	98.4	0.00
Line261	0.014	-0.001	-0.014	-0.003	0.0	-3.6	98.4	98.4	0.00
Line262	-0.011	-0.007	0.011	0.002	0.0	-5.4	98.4	98.4	0.00
Line266	0.489	0.017	-0.489	-0.024	0.2	-6.7	98.4	98.4	0.04
Line268	0.444	0.001	-0.444	-0.001	0.0	-0.7	98.4	98.4	0.00
Line270	0.016	0.006	-0.016	-0.010	0.0	-3.8	98.4	98.4	0.00
Line274	-0.005	-0.003	0.005	-0.004	0.0	-6.9	98.4	98.4	0.00
Line272	0.005	-0.001	-0.005	-0.003	0.0	-4.7	98.4	98.4	0.00
Line276	0.435	0.007	-0.434	-0.018	0.3	-11.6	98.4	98.3	0.06
Line280	0.434	0.018	-0.434	-0.019	0.0	-1.2	98.3	98.3	0.01
Line278	-0.004	-0.003	0.004	0.001	0.0	-1.9	98.3	98.3	0.00
Line282	0.007	-0.002	-0.007	-0.002	0.0	-3.4	98.3	98.3	0.00
Line294	0.424	0.023	-0.424	-0.029	0.1	-6.0	98.3	98.3	0.03
Line648	0.003	-0.002	-0.003	-0.002	0.0	-4.2	98.3	98.3	0.00
Line286	0.002	0.001	-0.002	-0.002	0.0	-0.7	98.3	98.3	0.00
Line296	0.417	0.025	-0.417	-0.026	0.0	-1.3	98.3	98.3	0.01
Line298	0.009	-0.006	-0.009	0.001	0.0	-4.2	98.3	98.3	0.00
Line301	0.408	0.032	-0.408	-0.040	0.2	-8.3	98.3	98.2	0.04
Line300	0.005	-0.004	-0.005	-0.003	0.0	-6.9	98.3	98.3	0.00
Line304	0.001	-0.002	-0.001	0.000	0.0	-1.9	98.2	98.2	0.00
Line306	0.015	0.002	-0.015	-0.006	0.0	-4.0	98.2	98.2	0.00
Line312	0.392	0.040	-0.392	-0.047	0.1	-7.6	98.2	98.2	0.04
Line308	-0.011	-0.007	0.011	0.007	0.0	-0.3	98.2	98.2	0.00
Line310	0.004	0.000	-0.004	-0.003	0.0	-3.1	98.2	98.2	0.00
Line314	0.361	0.028	-0.361	-0.030	0.0	-2.5	98.2	98.2	0.01
Line316	0.015	0.007	-0.015	-0.009	0.0	-2.3	98.2	98.2	0.00
Line318	0.346	0.024	-0.346	-0.032	0.1	-8.4	98.2	98.1	0.03
Line320	0.331	0.029	-0.331	-0.030	0.0	-0.8	98.1	98.1	0.00
Line322	0.015	0.003	-0.015	-0.009	0.0	-6.1	98.1	98.1	0.00
Line324	0.316	0.020	-0.316	-0.040	0.2	-19.3	98.1	98.1	0.07
Line325	0.312	0.038	-0.312	-0.039	0.0	-1.4	98.1	98.1	0.01
Line327	0.004	0.002	-0.004	-0.003	0.0	-0.7	98.1	98.1	0.00
Line329	0.305	0.035	-0.305	-0.038	0.0	-3.1	98.1	98.1	0.01
Line330	0.299	0.035	-0.299	-0.037	0.0	-2.6	98.1	98.0	0.01
Line340	0.296	0.035	-0.296	-0.038	0.0	-3.2	98.0	98.0	0.01

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line359	0.295	0.038	-0.295	-0.044	0.1	-5.6	98.0	98.0	0.02
Line360	0.294	0.043	-0.294	-0.062	0.2	-19.3	98.0	97.9	0.07
Line361	0.292	0.061	-0.292	-0.061	0.0	-0.2	97.9	97.9	0.00
Line368	-0.033	-0.021	0.033	0.018	0.0	-2.5	97.9	97.9	0.00
Line367	-0.035	-0.019	0.035	0.016	0.0	-3.5	97.9	97.9	0.00
Line364	0.257	0.045	-0.257	-0.048	0.0	-3.0	97.9	97.9	0.01
Line365	0.008	0.000	-0.008	0.000	0.0	-0.6	97.9	97.9	0.00
Line370	0.249	0.049	-0.249	-0.050	0.0	-1.3	97.9	97.9	0.00
Line372	0.003	-0.003	-0.003	-0.002	0.0	-5.0	97.9	97.9	0.00
Line374	0.002	0.000	-0.002	-0.002	0.0	-1.1	97.9	97.9	0.00
Line376	0.246	0.050	-0.246	-0.052	0.0	-1.9	97.9	97.9	0.01
Line380	0.245	0.051	-0.245	-0.052	0.0	-0.4	97.9	97.9	0.00
Line381	-0.189	-0.018	0.189	0.018	0.0	-0.6	97.9	97.9	0.00
Line390	0.019	0.012	-0.019	-0.012	0.0	-0.2	97.9	97.9	0.00
Line392	0.169	0.007	-0.169	-0.007	0.0	-0.5	97.9	97.9	0.00
Line386	0.056	0.034	-0.056	-0.034	0.0	-0.4	97.9	97.9	0.00
Line385	-0.042	-0.025	0.042	0.025	0.0	-0.4	97.9	97.9	0.00
Line388	0.015	0.009	-0.015	-0.009	0.0	-0.4	97.9	97.9	0.00
Line395	0.153	-0.003	-0.153	-0.061	0.4	-64.4	97.9	97.7	0.24
Line398	0.142	0.055	-0.142	-0.058	0.0	-2.9	97.7	97.7	0.01
Line405	-0.007	-0.004	0.007	-0.002	0.0	-6.1	97.7	97.7	0.00
Line402	0.023	0.000	-0.023	-0.006	0.0	-5.7	97.7	97.7	0.00
Line403	0.119	0.057	-0.119	-0.060	0.0	-3.0	97.7	97.7	0.01
Line411	0.113	0.056	-0.112	-0.062	0.0	-5.8	97.7	97.6	0.02
Line407	0.017	0.008	-0.017	-0.010	0.0	-1.7	97.7	97.7	0.00
Line409	0.007	0.004	-0.007	-0.004	0.0	-0.4	97.7	97.7	0.00
Line415	0.102	0.056	-0.102	-0.056	0.0	-0.4	97.6	97.6	0.00
Line416	0.092	0.050	-0.092	-0.051	0.0	-0.8	97.6	97.6	0.00
Line425	0.082	0.044	-0.082	-0.046	0.0	-1.7	97.6	97.6	0.00
Line427	-0.010	-0.006	0.010	0.006	0.0	-0.4	97.6	97.6	0.00
Line429	0.072	0.040	-0.072	-0.041	0.0	-0.7	97.6	97.6	0.00
Line431	0.031	0.018	-0.031	-0.018	0.0	-0.4	97.6	97.6	0.00
Line433	0.020	0.012	-0.020	-0.012	0.0	-0.8	97.6	97.6	0.00
Line441	0.020	0.011	-0.020	-0.012	0.0	-0.4	97.6	97.6	0.00
Line439	0.010	0.006	-0.010	-0.006	0.0	-0.4	97.6	97.6	0.00
Line437	0.020	0.012	-0.020	-0.012	0.0	-0.5	97.6	97.6	0.00
Line436	-0.010	-0.006	0.010	0.006	0.0	-0.4	97.6	97.6	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
Line443	0.010	0.006	-0.010	-0.006	0.0	-0.8	97.6	97.6	0.00
Line445	-0.108	-0.067	0.108	0.067	0.0	-0.2	98.9	98.9	0.00
Line447	0.513	0.098	-0.513	-0.100	0.1	-1.7	98.9	98.9	0.01
Line451	-0.098	-0.037	0.098	0.035	0.0	-1.7	98.8	98.9	0.00
Line455	0.087	0.030	-0.087	-0.031	0.0	-0.5	98.8	98.8	0.00
Line449	0.121	0.037	-0.121	-0.044	0.0	-7.2	98.9	98.9	0.01
Line464	0.392	0.063	-0.392	-0.066	0.1	-2.9	98.9	98.8	0.01
Line453	0.023	0.009	-0.023	-0.014	0.0	-5.1	98.9	98.8	0.00
Line457	-0.082	-0.034	0.082	0.032	0.0	-2.7	98.8	98.8	0.01
Line642	0.075	0.030	-0.075	-0.037	0.0	-6.8	98.8	98.8	0.01
Line459	0.005	-0.001	-0.005	-0.003	0.0	-4.1	98.8	98.8	0.00
Line461	-0.013	-0.005	0.013	-0.002	0.0	-6.8	98.8	98.8	0.00
Line462	0.006	0.001	-0.006	-0.004	0.0	-2.7	98.8	98.8	0.00
Line466	0.388	0.063	-0.388	-0.064	0.0	-0.3	98.8	98.8	0.00
Line467	0.368	0.051	-0.368	-0.056	0.1	-5.1	98.8	98.8	0.02
Line469	0.350	0.045	-0.350	-0.055	0.1	-9.6	98.8	98.8	0.04
Line471	0.039	0.020	-0.039	-0.022	0.0	-1.6	98.8	98.8	0.00
Line477	0.311	0.034	-0.311	-0.036	0.0	-1.3	98.8	98.8	0.01
Line475	0.019	0.010	-0.019	-0.012	0.0	-2.1	98.8	98.8	0.00
Line479	0.132	0.043	-0.132	-0.044	0.0	-1.2	98.8	98.8	0.00
Line481	0.179	-0.007	-0.179	0.004	0.0	-3.4	98.8	98.8	0.01
Line483	0.109	0.030	-0.109	-0.033	0.0	-3.5	98.8	98.8	0.01
Line485	0.096	0.025	-0.096	-0.029	0.0	-3.5	98.8	98.8	0.00
Line487	0.089	0.025	-0.089	-0.030	0.0	-5.3	98.8	98.8	0.01
Line489	0.015	0.009	-0.015	-0.009	0.0	-0.1	98.8	98.8	0.00
Line494	0.075	0.021	-0.075	-0.024	0.0	-3.6	98.8	98.8	0.00
Line495	0.063	0.017	-0.063	-0.020	0.0	-2.6	98.8	98.8	0.00
Line496	0.055	0.015	-0.055	-0.017	0.0	-1.9	98.8	98.8	0.00
Line499	0.023	0.010	-0.023	-0.011	0.0	-1.0	98.8	98.8	0.00
Line506	0.033	0.007	-0.033	-0.009	0.0	-2.5	98.8	98.8	0.00
Line501	0.008	0.003	-0.008	-0.005	0.0	-2.6	98.8	98.8	0.00
Line507	0.018	0.007	-0.018	-0.009	0.0	-1.8	98.8	98.7	0.00
Line509	0.014	0.002	-0.014	-0.007	0.0	-4.7	98.8	98.7	0.00
Line505	0.009	0.003	-0.009	-0.006	0.0	-2.4	98.7	98.7	0.00
Line511	0.008	0.003	-0.008	-0.005	0.0	-2.1	98.7	98.7	0.00
Line513	0.161	-0.015	-0.161	0.011	0.0	-3.4	98.8	98.8	0.01
Line515	0.156	-0.015	-0.156	0.011	0.0	-3.7	98.8	98.8	0.01

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line517	0.004	-0.003	-0.004	-0.002	0.0	-5.2	98.8	98.8	0.00
Line520	0.152	-0.008	-0.152	0.007	0.0	-0.8	98.8	98.8	0.00
Line521	-0.089	0.019	0.089	-0.019	0.0	-0.4	98.7	98.7	0.00
Line531	0.072	-0.029	-0.072	0.028	0.0	-1.9	98.7	98.7	0.00
Line522	0.139	-0.015	-0.139	0.009	0.0	-6.5	98.8	98.7	0.01
Line524	0.050	0.010	-0.050	-0.011	0.0	-1.1	98.7	98.7	0.00
Line526	0.036	0.003	-0.036	-0.005	0.0	-2.2	98.7	98.7	0.00
Line525	-0.031	-0.004	0.031	0.002	0.0	-2.3	98.7	98.7	0.00
Line528	0.016	-0.005	-0.016	-0.003	0.0	-8.0	98.7	98.7	0.00
Line527	-0.010	-0.007	0.010	-0.001	0.0	-7.2	98.7	98.7	0.00
Line532	0.035	-0.023	-0.035	0.020	0.0	-2.9	98.7	98.7	0.00
Line534	-0.046	0.017	0.046	-0.018	0.0	-1.8	98.7	98.7	0.00
Line566	0.026	-0.009	-0.026	0.009	0.0	-0.2	98.7	98.7	0.00
Line538	0.032	-0.022	-0.032	0.019	0.0	-3.4	98.7	98.7	0.00
Line544	0.025	-0.023	-0.025	0.018	0.0	-5.9	98.7	98.7	0.00
Line543	-0.023	0.015	0.023	-0.018	0.0	-2.7	98.7	98.7	0.00
Line547	0.020	-0.017	-0.020	0.016	0.0	-0.4	98.7	98.7	0.00
Line546	0.001	0.000	-0.001	-0.001	0.0	-0.7	98.7	98.7	0.00
Line550	0.009	-0.004	-0.009	0.003	0.0	-1.1	98.7	98.7	0.00
Line558	0.012	-0.012	-0.012	0.004	0.0	-8.4	98.7	98.7	0.00
Line548	0.001	-0.003	-0.001	0.000	0.0	-3.1	98.7	98.7	0.00
Line549	-0.003	0.005	0.003	-0.007	0.0	-1.3	98.7	98.7	0.00
Line552	0.002	-0.003	-0.002	0.001	0.0	-1.5	98.7	98.7	0.00
Line554	0.001	-0.002	-0.001	-0.001	0.0	-2.6	98.7	98.7	0.00
Line557	-0.008	0.004	0.008	-0.006	0.0	-2.2	98.7	98.7	0.00
Line560	0.006	-0.005	-0.006	0.002	0.0	-3.0	98.7	98.7	0.00
Line559	0.004	-0.003	-0.004	-0.003	0.0	-5.8	98.7	98.7	0.00
Line562	-0.084	-0.036	0.084	0.036	0.0	-0.1	99.0	99.0	0.00
Line569	0.059	0.031	-0.059	-0.034	0.0	-3.3	99.0	99.0	0.00
Line613	0.025	0.005	-0.025	-0.008	0.0	-2.7	99.0	99.0	0.00
Line594	0.042	0.024	-0.042	-0.026	0.0	-2.2	99.0	99.0	0.00
Line564	-0.003	0.014	0.003	-0.019	0.0	-4.5	98.7	98.7	0.00
Line568	0.003	-0.014	-0.003	0.012	0.0	-2.2	98.7	98.7	0.00
Line565	-0.010	0.014	0.010	-0.019	0.0	-4.3	98.7	98.7	0.00
Line567	0.001	-0.005	-0.001	0.000	0.0	-5.7	98.7	98.7	0.00
Line646	0.002	-0.007	-0.002	0.001	0.0	-5.5	98.7	98.7	0.00
Line570	-0.001	0.000	0.001	-0.002	0.0	-2.7	98.7	98.7	0.00

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line572	0.483	0.243	-0.483	-0.245	0.1	-2.3	99.2	99.1	0.02
Line573	0.034	0.020	-0.034	-0.021	0.0	-1.2	99.2	99.2	0.00
Line574	-0.030	-0.019	0.030	0.018	0.0	-0.2	99.1	99.1	0.00
Line575	-0.126	-0.078	0.126	0.076	0.0	-1.7	99.1	99.1	0.01
Line576	-0.008	-0.005	0.008	0.001	0.0	-3.9	99.1	99.1	0.00
Line577	0.453	0.227	-0.453	-0.227	0.0	-0.7	99.1	99.1	0.01
Line578	0.327	0.151	-0.327	-0.161	0.1	-10.1	99.1	99.1	0.05
Line581	0.318	0.160	-0.318	-0.164	0.1	-3.6	99.1	99.1	0.02
Line584	0.310	0.158	-0.310	-0.162	0.1	-4.0	99.1	99.0	0.02
Line586	0.214	0.126	-0.214	-0.127	0.0	-0.7	99.0	99.0	0.00
Line589	0.095	0.036	-0.095	-0.040	0.0	-3.8	99.0	99.0	0.01
Line650	0.131	0.075	-0.131	-0.076	0.0	-0.7	99.0	99.0	0.00
Line588	-0.004	-0.002	0.004	-0.003	0.0	-5.0	99.0	99.0	0.00
Line590	0.008	0.005	-0.008	-0.005	0.0	-0.1	99.0	99.0	0.00
Line591	0.003	-0.001	-0.003	-0.002	0.0	-3.4	99.0	99.0	0.00
Line615	0.017	0.004	-0.017	-0.008	0.0	-3.3	99.0	99.0	0.00
Line617	0.008	0.004	-0.008	-0.005	0.0	-1.4	99.0	99.0	0.00
Line619	0.008	0.003	-0.008	-0.005	0.0	-2.7	99.0	99.0	0.00
Line621	0.008	0.005	-0.008	-0.005	0.0	-0.1	99.0	99.0	0.00
Line638	-1.439	-0.889	1.443	0.890	3.5	1.6	96.6	96.8	0.22
Line644	0.005	-0.001	-0.005	-0.003	0.0	-4.0	98.7	98.7	0.00
					71.4	-559.7			

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	

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus207	Bus	Under Voltage	11.000	kV	10.447	95.0	3-Phase
Bus209	Bus	Under Voltage	11.000	kV	10.40	94.5	3-Phase
Bus211	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus212	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus214	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus216	Bus	Under Voltage	11.000	kV	10.38	94.3	3-Phase
Bus222	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
Bus224	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
Bus226	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus227	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus229	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus231	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus233	Bus	Under Voltage	11.000	kV	10.37	94.2	3-Phase
Bus235	Bus	Under Voltage	11.000	kV	10.37	94.2	3-Phase
Bus237	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase

Marginal Report

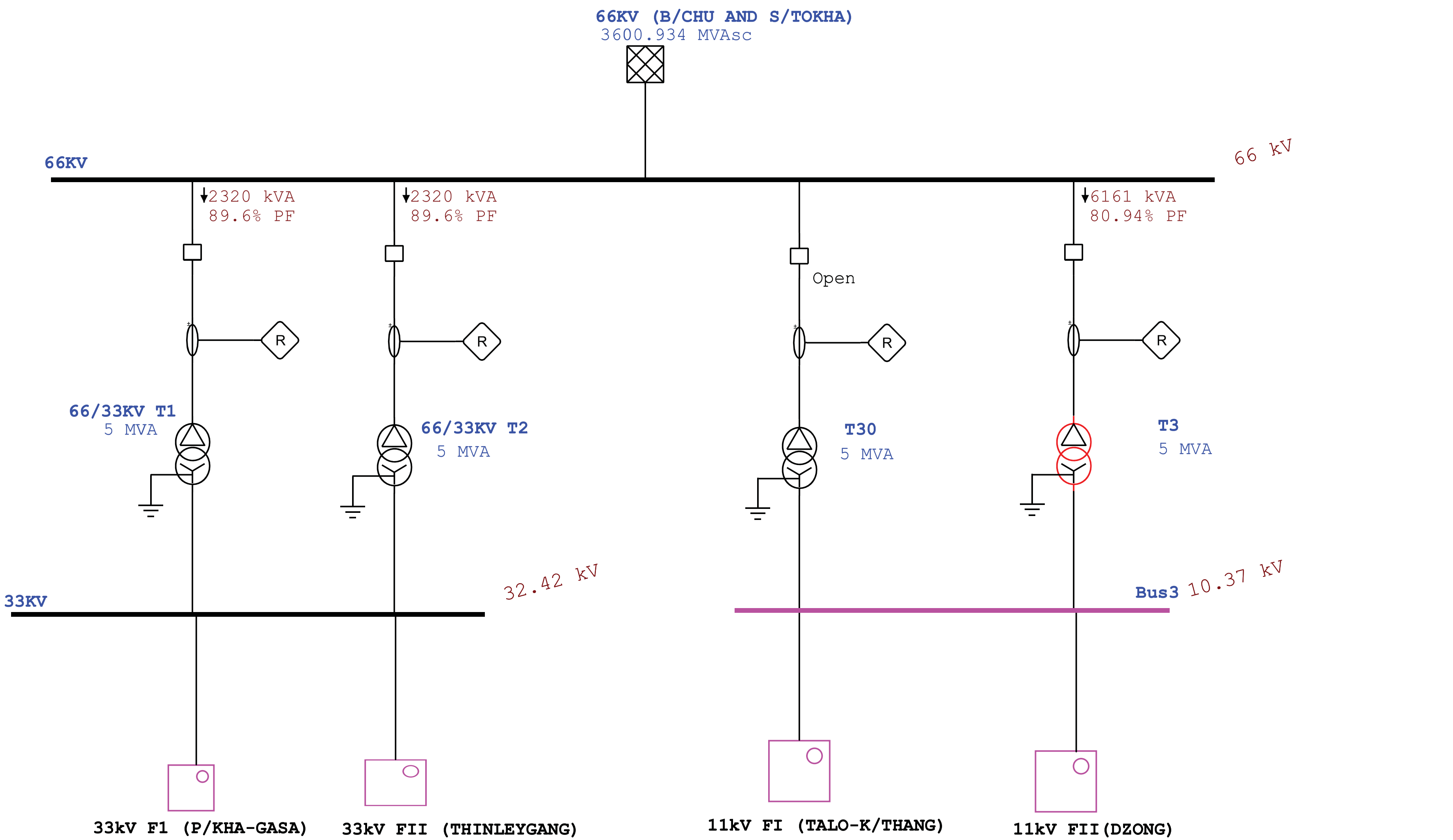
Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus239	Bus	Under Voltage	11.000	kV	10.360	94.2	3-Phase
Bus241	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase
Bus243	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus244	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus246	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus671	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Bus679	Bus	Under Voltage	11.000	kV	10.37	94.3	3-Phase
Khuruthang control room	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	4.065	1.915	4.494	90.46 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	4.065	1.915	4.494	90.46 Lagging
Total Motor Load:	0.922	0.571	1.085	85.00 Lagging
Total Static Load:	3.072	1.904	3.614	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.071	-0.560		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

One-Line Diagram - ESD PUNAKHA (LF 2019) (Load Flow Analysis) Time Horizon-2025



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										8.022	86.9	70.2	
Bus2	33.000										4.563	90.8	81.3	
Bus3	11.000										3.289	84.7	178.2	
Bus196	11.000		0.003	0.002	0.012	0.007					2.432	84.8	136.6	
Bus199	11.000										3.211	84.9	178.2	
Bus201	11.000		0.036	0.022	0.125	0.077					2.411	84.8	135.6	
Bus203	11.000		0.001	0.001	0.005	0.003					2.112	85.0	120.9	
Bus205	11.000		0.016	0.010	0.052	0.033					2.097	85.0	120.5	
Bus207	11.000		0.094	0.058	0.312	0.193					2.008	85.0	115.9	
Bus209	11.000		0.002	0.001	0.006	0.003					1.516	85.1	88.3	
Bus211	11.000										1.504	85.1	87.8	
Bus212	11.000		0.093	0.058	0.302	0.187					0.465	85.0	27.2	
Bus214	11.000		0.013	0.008	0.041	0.025					0.854	85.0	50.0	
Bus216	11.000		0.003	0.002	0.010	0.006					0.183	86.2	10.7	
Bus222	11.000		0.158	0.098	0.503	0.312					0.778	85.0	45.8	
Bus224	11.000		0.002	0.001	0.005	0.003					0.008	85.0	0.5	
Bus226	11.000		0.002	0.001	0.006	0.004					0.058	86.2	3.4	
Bus227	11.000										0.110	86.2	6.5	
Bus229	11.000		0.015	0.009	0.003	0.002					0.105	86.1	6.1	
Bus231	11.000		0.001	0.001	0.003	0.002					0.005	85.0	0.3	
Bus233	11.000		0.006	0.004	0.020	0.012					0.084	86.3	4.9	
Bus235	11.000		0.002	0.001	0.006	0.004					0.054	86.8	3.1	
Bus237	11.000		0.003	0.002	0.009	0.006					0.044	86.8	2.6	
Bus239	11.000		0.011	0.007	0.002	0.001					0.030	86.9	1.7	
Bus241	11.000		0.003	0.002	0.010	0.006					0.015	85.0	0.9	
Bus243	11.000										0.049	86.0	2.9	
Bus244	11.000		0.004	0.003	0.014	0.008					0.025	86.6	1.5	
Bus246	11.000		0.001	0.000	0.002	0.001					0.005	85.5	0.3	
Bus247	33.000										3.611	91.5	64.7	
Bus248	33.000		0.004	0.003	0.016	0.010					2.464	91.1	44.2	
Bus251	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus252	33.000										2.441	91.1	43.8	
Bus253	33.000		0.000	0.000	0.002	0.001					2.439	91.1	43.7	
Bus255	33.000										2.435	91.0	43.8	
Bus257	33.000		0.006	0.004	0.024	0.015					0.541	85.6	9.7	
Bus259	33.000		0.003	0.002	0.010	0.006					1.899	92.2	34.2	
Bus262	33.000		0.003	0.002	0.010	0.006					0.014	85.0	0.3	
Bus263	33.000										1.885	92.2	33.9	
Bus265	33.000		0.004	0.003	0.016	0.010					1.873	92.2	33.7	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus267	33.000		0.018	0.011	0.067	0.041					1.850	92.1	33.4	
Bus269	33.000										1.753	92.4	31.6	
Bus274	33.000		0.000	0.000	0.002	0.001					0.003	85.0	-	
Bus275	33.000										0.393	86.2	7.1	
Bus277	33.000		0.071	0.044	0.266	0.165					0.396	85.0	7.1	
Bus279	33.000		0.006	0.003	0.021	0.013					1.366	93.7	24.6	
Bus280	33.000										1.335	93.9	24.1	
Bus282	33.000		0.005	0.003	0.019	0.012					0.029	85.0	0.5	
Bus284	33.000		0.003	0.002	0.010	0.006					0.032	87.5	0.6	
Bus285	33.000										1.309	93.8	23.6	
Bus287	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus288	33.000										1.278	93.8	23.1	
Bus290	33.000		0.015	0.009	0.057	0.036					0.086	85.0	1.5	
Bus292	33.000		0.003	0.002	0.012	0.008					1.195	94.3	21.6	
Bus293	33.000										1.177	94.4	21.3	
Bus295	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus296	33.000										1.175	94.4	21.2	
Bus298	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus300	33.000		0.021	0.013	0.080	0.049					1.174	94.3	21.2	
Bus305	33.000										1.059	95.1	19.1	
Bus307	33.000		0.004	0.002	0.015	0.009					0.030	88.7	0.5	
Bus309	33.000		0.002	0.001	0.006	0.004					0.009	85.0	0.2	
Bus312	33.000		0.011	0.007	0.041	0.025					0.141	89.2	2.6	
Bus313	33.000		0.006	0.004	0.022	0.013					0.077	91.6	1.4	
Bus315	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus317	33.000		0.004	0.003	0.016	0.010					0.047	92.3	0.8	
Bus320	33.000		0.004	0.003	0.015	0.009					0.023	85.0	0.4	
Bus321	33.000		0.001	0.001	0.003	0.002					0.025	93.1	0.5	
Bus323	33.000		0.007	0.004	0.024	0.015					0.892	95.8	16.1	
Bus325	33.000		0.010	0.006	0.038	0.023					0.858	95.9	15.5	
Bus327	33.000		0.002	0.001	0.006	0.004					0.010	85.0	0.2	
Bus329	33.000		0.006	0.004	0.022	0.013					0.032	85.0	0.6	
Bus330	33.000										0.774	96.5	14.0	
Bus332	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus334	33.000		0.000	0.000	0.001	0.001					0.760	96.0	13.8	
Bus336	33.000		0.001	0.001	0.006	0.003					0.008	85.0	0.1	
Bus338	33.000										0.759	95.9	13.8	
Bus341	33.000										0.012	93.1	0.2	
Bus343	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus351	33.000		0.002	0.001	0.009	0.005					0.745	95.6	13.5	
Bus354	33.000										0.733	95.6	13.3	
Bus356	33.000		0.001	0.001	0.005	0.003					0.015	96.7	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
Bus358	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus359	33.000										0.721	95.1	13.1	
Bus361	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus363	33.000		0.004	0.002	0.014	0.009					0.021	85.0	0.4	
Bus364	33.000										0.029	89.7	0.5	
Bus366	33.000		0.002	0.001	0.006	0.004					0.009	85.0	0.2	
Bus368	33.000		0.011	0.007	0.041	0.026					0.695	94.8	12.6	
Bus369	33.000										0.636	95.4	11.6	
Bus371	33.000		0.005	0.003	0.020	0.012					0.029	85.0	0.5	
Bus372	33.000										0.610	95.2	11.1	
Bus374	33.000		0.005	0.003	0.020	0.012					0.584	95.3	10.6	
Bus376	33.000		0.005	0.003	0.020	0.012					0.029	85.0	0.5	
Bus378	33.000										0.560	94.7	10.2	
Bus379	33.000		0.003	0.002	0.010	0.006					0.552	94.7	10.1	
Bus381	33.000		0.002	0.001	0.006	0.004					0.009	85.0	0.2	
Bus383	33.000		0.002	0.001	0.007	0.004					0.538	94.7	9.8	
Bus384	33.000		0.001	0.001	0.005	0.003					0.529	94.7	9.6	
Bus412	33.000		0.000	0.000	0.001	-					0.523	94.7	9.5	
Bus413	33.000		0.001	0.000	0.002	0.001					0.524	94.4	9.6	
Bus414	33.000		0.001	0.000	0.003	0.002					0.527	93.3	9.6	
Bus422	33.000		0.012	0.007	0.044	0.027					0.065	85.0	1.2	
Bus423	33.000		0.000	0.000	0.002	0.001					0.066	86.6	1.2	
Bus424	33.000										0.523	93.3	9.6	
Bus425	33.000										0.459	93.7	8.4	
Bus427	33.000		0.002	0.001	0.008	0.005					0.015	91.8	0.3	
Bus429	33.000		0.001	0.001	0.003	0.002					0.005	85.0	0.1	
Bus430	33.000										0.446	93.4	8.1	
Bus432	33.000		0.001	0.001	0.003	0.002					0.004	85.0	0.1	
Bus436	33.000		0.000	0.000	0.001	0.001					0.442	93.3	8.1	
Bus438	33.000										0.332	95.2	6.1	
Bus439	33.000										0.441	93.3	8.1	
Bus442	33.000		0.010	0.006	0.036	0.022					0.083	85.2	1.5	
Bus443	33.000		0.005	0.003	0.019	0.012					0.111	85.3	2.0	
Bus445	33.000		0.005	0.003	0.019	0.012					0.029	85.0	0.5	
Bus447	33.000		0.007	0.004	0.025	0.016					0.038	85.0	0.7	
Bus450	33.000		0.006	0.004	0.021	0.013					0.295	96.0	5.4	
Bus451	33.000		0.004	0.002	0.013	0.008					0.285	89.6	5.2	
Bus453	33.000		0.002	0.001	0.009	0.005					0.013	85.0	0.2	
Bus455	33.000										0.266	89.5	4.9	
Bus457	33.000		0.002	0.001	0.009	0.005					0.228	87.4	4.2	
Bus458	33.000										0.042	92.2	0.8	
Bus460	33.000		0.004	0.002	0.013	0.008					0.033	85.6	0.6	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus462	33.000		0.002	0.001	0.009	0.005					0.013	85.0	0.2	
Bus464	33.000		0.004	0.002	0.013	0.008					0.218	86.4	4.0	
Bus466	33.000		0.004	0.002	0.013	0.008					0.198	86.5	3.6	
Bus467	33.000		0.004	0.002	0.013	0.008					0.178	86.5	3.3	
Bus472	33.000		0.004	0.002	0.013	0.008					0.020	85.0	0.4	
Bus473	33.000										0.159	86.2	2.9	
Bus478	33.000										0.139	86.1	2.6	
Bus480	33.000		0.004	0.002	0.013	0.008					0.040	85.4	0.7	
Bus482	33.000		0.004	0.002	0.013	0.008					0.060	85.7	1.1	
Bus483	33.000		0.004	0.002	0.013	0.008					0.020	85.0	0.4	
Bus484	33.000		0.004	0.002	0.013	0.008					0.040	85.5	0.7	
Bus486	33.000		0.004	0.002	0.013	0.008					0.020	85.0	0.4	
Bus488	33.000		0.004	0.002	0.013	0.008					0.040	85.8	0.7	
Bus490	33.000		0.004	0.002	0.013	0.008					0.020	85.0	0.4	
Bus492	33.000		0.038	0.024	0.145	0.090					0.216	85.0	3.9	
Bus493	33.000										1.147	92.3	20.6	
Bus495	33.000		0.004	0.002	0.014	0.009					0.185	90.1	3.3	
Bus496	33.000										0.935	93.5	16.8	
Bus497	33.000										0.227	90.3	4.1	
Bus499	33.000		0.008	0.005	0.031	0.019					0.046	85.0	0.8	
Bus503	33.000		0.002	0.001	0.009	0.006					0.156	89.3	2.8	
Bus504	33.000										0.164	90.6	2.9	
Bus506	33.000		0.002	0.001	0.007	0.005					0.011	85.0	0.2	
Bus508	33.000		0.002	0.001	0.009	0.005					0.024	89.5	0.4	
Bus509	33.000		0.002	0.001	0.009	0.005					0.013	85.0	0.2	
Bus511	33.000		0.002	0.001	0.006	0.004					0.712	94.0	12.8	
Bus513	33.000		0.007	0.004	0.027	0.017					0.703	94.1	12.6	
Bus514	33.000		0.006	0.004	0.024	0.015					0.664	94.3	11.9	
Bus515	33.000										0.633	94.2	11.4	
Bus517	33.000		0.007	0.004	0.027	0.017					0.077	86.2	1.4	
Bus519	33.000		0.007	0.004	0.026	0.016					0.038	85.0	0.7	
Bus520	33.000										0.558	94.9	10.0	
Bus522	33.000		0.008	0.005	0.031	0.019					0.247	91.0	4.4	
Bus524	33.000		0.004	0.003	0.017	0.011					0.203	91.5	3.6	
Bus526	33.000		0.002	0.002	0.009	0.006					0.179	91.6	3.2	
Bus527	33.000										0.167	91.0	3.0	
Bus529	33.000		0.005	0.003	0.020	0.012					0.029	85.0	0.5	
Bus533	33.000		0.004	0.003	0.016	0.010					0.140	91.1	2.5	
Bus534	33.000		0.003	0.002	0.011	0.007					0.118	91.3	2.1	
Bus535	33.000										0.103	91.5	1.8	
Bus538	33.000		0.005	0.003	0.019	0.012					0.043	87.5	0.8	
Bus540	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					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus543	33.000										0.061	92.0	1.1	
Bus544	33.000		0.003	0.002	0.012	0.008					0.036	87.8	0.6	
Bus546	33.000		0.002	0.001	0.008	0.005					0.028	88.2	0.5	
Bus548	33.000		0.003	0.002	0.011	0.007					0.017	85.0	0.3	
Bus550	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus552	33.000		0.006	0.004	0.025	0.015					0.315	96.9	5.6	
Bus554	33.000		0.002	0.001	0.007	0.004					0.281	97.6	5.0	
Bus555	33.000										0.272	97.5	4.9	
Bus557	33.000		0.001	0.001	0.005	0.003					0.008	85.0	0.1	
Bus560	33.000		0.006	0.004	0.023	0.014					0.152	99.0	2.7	
Bus561	33.000		0.005	0.003	0.017	0.011					0.266	97.3	4.8	
Bus562	33.000										0.242	97.5	4.4	
Bus563	33.000		0.005	0.003	0.019	0.012					0.092	93.0	1.7	
Bus564	33.000		0.005	0.003	0.019	0.012					0.054	94.9	1.0	
Bus565	33.000		0.002	0.001	0.007	0.005					0.064	94.7	1.2	
Bus566	33.000		0.004	0.002	0.014	0.009					0.021	85.0	0.4	
Bus567	33.000		0.002	0.001	0.008	0.005					0.029	93.9	0.5	
Bus570	33.000		0.004	0.002	0.014	0.009					0.078	99.0	1.4	
Bus571	33.000										0.122	99.9	2.2	
Bus573	33.000		0.001	0.001	0.005	0.003					0.060	99.1	1.1	
Bus577	33.000		0.002	0.001	0.009	0.006					0.054	97.6	1.0	
Bus582	33.000		0.001	0.001	0.004	0.002					0.040	98.4	0.7	
Bus583	33.000										0.042	98.6	0.8	
Bus585	33.000		0.000	0.000	0.002	0.001					0.003	85.0	-	
Bus587	33.000										0.035	98.1	0.6	
Bus588	33.000										0.006	77.9	0.1	
Bus589	33.000		0.002	0.001	0.007	0.005					0.015	92.6	0.3	
Bus590	33.000		0.001	0.000	0.002	0.001					0.004	91.2	0.1	
Bus592	33.000		0.000	0.000	0.001	0.001					0.001	85.0	-	
Bus594	33.000		0.000	0.000	0.001	-					0.001	85.0	-	
Bus597	33.000		0.001	0.001	0.003	0.002					0.014	98.6	0.3	
Bus598	33.000		0.001	0.001	0.005	0.003					0.021	98.2	0.4	
Bus599	33.000		0.001	0.000	0.002	0.001					0.010	98.3	0.2	
Bus601	33.000		0.001	0.001	0.006	0.003					0.008	85.0	0.1	
Bus602	33.000										0.148	89.3	2.7	
Bus604	33.000		0.005	0.003	0.021	0.013					0.107	85.9	1.9	
Bus605	33.000		0.000	0.000	0.000	-					0.014	40.2	0.2	
Bus606	33.000		0.003	0.002	0.010	0.006					0.025	73.9	0.4	
Bus607	33.000		0.005	0.003	0.021	0.013					0.047	93.9	0.9	
Bus608	33.000										0.012	45.8	0.2	
Bus609	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus611	33.000		0.000	0.000	0.001	0.001					0.001	85.0	-	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus614	33.000										0.943	87.6	16.8	
Bus615	33.000		0.011	0.007	0.044	0.027					0.065	85.0	1.2	
Bus616	33.000		0.010	0.006	0.038	0.024					0.056	85.0	1.0	
Bus617	33.000		0.041	0.026	0.159	0.098					0.235	85.0	4.2	
Bus618	33.000		0.003	0.002	0.011	0.007					0.016	85.0	0.3	
Bus619	33.000										0.879	87.6	15.7	
Bus620	33.000										0.823	87.7	14.7	
Bus621	33.000										0.593	87.9	10.6	
Bus624	33.000		0.003	0.002	0.011	0.007					0.581	87.4	10.4	
Bus626	33.000										0.567	87.2	10.1	
Bus628	33.000		0.028	0.017	0.106	0.066					0.402	85.6	7.2	
Bus630	33.000		0.001	0.001	0.005	0.003					0.007	85.0	0.1	
Bus631	33.000										0.168	89.6	3.0	
Bus632	33.000		0.003	0.002	0.010	0.006					0.015	85.0	0.3	
Bus633	33.000		0.001	0.001	0.004	0.002					0.005	85.0	0.1	
Bus635	33.000		0.014	0.008	0.052	0.032					0.077	85.0	1.4	
Bus654	33.000										0.044	91.7	0.8	
Bus656	33.000										0.030	88.8	0.5	
Bus658	33.000		0.003	0.002	0.011	0.007					0.016	85.0	0.3	
Bus660	33.000		0.003	0.002	0.011	0.007					0.016	85.0	0.3	
Bus662	33.000		0.003	0.002	0.011	0.007					0.016	85.0	0.3	
Bus671	11.000		0.005	0.003	0.015	0.009					0.023	85.0	1.4	
Bus673	11.000		0.095	0.059	0.335	0.208					2.946	84.9	164.9	
Bus675	11.000		0.014	0.008	0.047	0.029					2.219	84.8	124.9	
Bus677	11.000		0.045	0.028	0.158	0.098					3.197	84.9	178.2	
Bus679	11.000		0.000	0.000	0.001	0.001					0.002	85.0	0.1	
Bus681	33.000		0.022	0.014	0.084	0.052					0.146	87.7	2.6	
Bus685	33.000		0.088	0.055	0.335	0.208					0.506	85.3	9.1	
Bus688	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus692	33.000		0.001	0.001	0.004	0.003					0.006	85.0	0.1	
Bus694	33.000		0.001	0.000	0.002	0.001					0.004	89.8	0.1	
Bus696	33.000		0.165	0.102	0.040	0.025					0.245	85.6	4.4	
Khuruthang control room	11.000										0.786	85.0	46.3	

* 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	%
Cable12	Cable	301.98	7.15	2.37					
UG 300sq.mm	Cable	338.03	45.77	13.54					
UG 300sq.mm2	Cable	338.03	0.50	0.15					
T1	Transformer				5.000	2.323	46.5	2.281	45.6
T3	Transformer				5.000	3.395	67.9	3.289	65.8
T27	Transformer				5.000	2.323	46.5	2.281	45.6

* 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	2.081	1.032	-2.072	-0.955	9.0	76.6	100.0	98.2	1.77
T3	2.807	1.910	-2.788	-1.746	19.3	163.7	100.0	96.9	3.11
T27	2.081	1.032	-2.072	-0.955	9.0	76.6	100.0	98.2	1.77
Line178	3.318	1.459	-3.304	-1.455	13.7	3.1	98.2	97.7	0.55
Line571	0.826	0.452	-0.825	-0.455	0.3	-3.0	98.2	98.2	0.04
Line129	2.788	1.746	-2.728	-1.694	59.9	51.5	96.9	94.6	2.31
Line130	2.048	1.278	-2.045	-1.276	2.5	2.1	93.5	93.3	0.12
Line634	-2.063	-1.287	2.071	1.291	7.6	3.5	93.5	93.8	0.32
Line131	2.728	1.694	-2.715	-1.688	13.0	6.0	94.6	94.2	0.42
Line636	1.884	1.176	-1.882	-1.174	2.1	1.8	93.3	93.2	0.12
Line134	-1.795	-1.114	1.821	1.137	26.5	22.7	91.7	93.2	1.51
Line136	1.789	1.110	-1.782	-1.104	6.5	5.6	91.7	91.3	0.37
Line138	1.714	1.062	-1.707	-1.056	6.7	5.7	91.3	90.9	0.40
Line140	1.301	0.805	-1.291	-0.796	10.5	8.9	90.9	90.1	0.82
Line142	1.283	0.791	-1.280	-0.789	2.8	2.4	90.1	89.9	0.22
Line144	0.396	0.245	-0.396	-0.245	0.1	0.0	89.9	89.9	0.02
Line147	0.727	0.451	-0.726	-0.450	1.3	1.0	89.9	89.7	0.18
Line149	0.158	0.092	-0.158	-0.093	0.2	-0.2	89.9	89.8	0.10
Line151	0.672	0.417	-0.668	-0.414	3.3	2.5	89.7	89.2	0.50
Line156	0.050	0.029	-0.050	-0.029	0.0	-0.2	89.8	89.8	0.04
Line158	0.095	0.056	-0.095	-0.056	0.0	-0.3	89.8	89.7	0.05
UG 300sq.mm	-0.661	-0.410	0.661	0.410	0.2	0.1	89.2	89.2	0.02
UG 300sq.mm2	-0.007	-0.004	0.007	0.004	0.0	0.0	89.2	89.2	0.00
Line173	0.042	0.025	-0.042	-0.025	0.0	-0.4	89.8	89.7	0.05
Line160	0.091	0.053	-0.090	-0.053	0.0	-0.1	89.7	89.7	0.04
Line162	0.005	0.003	-0.005	-0.003	0.0	-0.1	89.7	89.7	0.00
line	0.072	0.042	-0.072	-0.042	0.1	-0.3	89.7	89.6	0.07
Line165	0.046	0.026	-0.046	-0.027	0.0	-0.2	89.6	89.6	0.03
Line167	0.038	0.021	-0.038	-0.022	0.0	-0.4	89.6	89.6	0.05
Line169	0.026	0.014	-0.026	-0.015	0.0	-0.5	89.6	89.5	0.04
Line171	0.013	0.006	-0.013	-0.008	0.0	-1.3	89.5	89.5	0.05
Line175	0.022	0.013	-0.022	-0.013	0.0	-0.2	89.7	89.7	0.01
Line632	0.020	0.012	-0.020	-0.012	0.0	-0.1	89.7	89.7	0.00
Line177	0.004	0.002	-0.004	-0.003	0.0	-0.9	89.7	89.7	0.01

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line640	0.002	0.001	-0.002	-0.001	0.0	-0.1	89.7	89.7	0.00
Line180	2.246	1.015	-2.244	-1.017	1.3	-1.5	97.7	97.6	0.08
Line182	1.059	0.440	-1.058	-0.442	0.4	-2.3	97.7	97.6	0.04
Line184	2.224	1.005	-2.224	-1.005	0.6	-0.7	97.6	97.6	0.04
Line186	-0.003	-0.002	0.003	-0.002	0.0	-3.7	97.6	97.6	0.00
Line187	2.221	1.007	-2.221	-1.008	0.5	-0.6	97.6	97.5	0.03
Line189	2.219	1.007	-2.216	-1.010	2.5	-3.0	97.5	97.4	0.15
Line191	0.463	0.279	-0.463	-0.279	0.0	-0.3	97.4	97.4	0.00
Line193	1.753	0.731	-1.752	-0.734	1.2	-3.5	97.4	97.3	0.09
Line195	0.432	0.260	-0.432	-0.264	0.2	-3.7	97.4	97.3	0.05
Line197	1.740	0.727	-1.739	-0.728	0.5	-1.4	97.3	97.2	0.04
Line199	-0.012	-0.008	0.012	0.003	0.0	-4.2	97.2	97.2	0.00
Line201	1.727	0.725	-1.727	-0.725	0.1	-0.3	97.2	97.2	0.01
Line203	1.707	0.713	-1.704	-0.720	2.4	-7.3	97.2	97.0	0.19
Line206	1.620	0.668	-1.619	-0.672	1.2	-4.2	97.0	97.0	0.10
Line209	0.339	0.197	-0.339	-0.199	0.1	-2.1	97.0	96.9	0.02
Line215	1.280	0.475	-1.280	-0.476	0.2	-1.2	97.0	96.9	0.02
Line211	-0.002	-0.001	0.002	0.001	0.0	-0.7	96.9	96.9	0.00
Cable12	0.336	0.198	-0.336	-0.209	0.0	-10.3	96.9	96.9	0.00
Line217	1.253	0.460	-1.253	-0.460	0.0	-0.1	96.9	96.9	0.00
Line219	1.229	0.450	-1.229	-0.452	0.3	-2.1	96.9	96.9	0.03
Line221	0.024	0.010	-0.024	-0.015	0.0	-5.2	96.9	96.9	0.00
Line223	-0.028	-0.016	0.028	0.015	0.0	-0.6	96.9	96.9	0.00
Line225	0.016	0.008	-0.016	-0.010	0.0	-1.9	96.9	96.9	0.00
Line227	1.200	0.437	-1.200	-0.442	0.6	-4.9	96.9	96.8	0.07
Line229	1.127	0.398	-1.127	-0.399	0.1	-0.9	96.8	96.8	0.01
Line231	0.073	0.044	-0.073	-0.045	0.0	-0.8	96.8	96.8	0.00
Line233	1.111	0.389	-1.111	-0.389	0.1	-0.5	96.8	96.8	0.01
Line235	1.109	0.389	-1.108	-0.389	0.1	-0.6	96.8	96.8	0.01
Line237	0.003	0.001	-0.003	-0.002	0.0	-0.8	96.8	96.8	0.00
Line239	1.108	0.389	-1.108	-0.389	0.0	-0.2	96.8	96.8	0.00
Line241	0.001	0.000	-0.001	0.000	0.0	-0.1	96.8	96.8	0.00
Line243	1.007	0.327	-1.007	-0.328	0.1	-1.0	96.8	96.8	0.02
Line246	0.026	0.014	-0.026	-0.014	0.0	-0.3	96.8	96.8	0.00
Line254	0.126	0.063	-0.126	-0.064	0.0	-1.3	96.8	96.8	0.00
Line264	0.855	0.252	-0.854	-0.257	0.5	-4.9	96.8	96.7	0.07
Line248	0.008	0.002	-0.008	-0.005	0.0	-2.6	96.8	96.8	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
Line251	0.070	0.030	-0.070	-0.031	0.0	-1.0	96.8	96.8	0.00
Line256	0.004	0.002	-0.004	-0.003	0.0	-0.4	96.8	96.8	0.00
Line252	0.043	0.014	-0.043	-0.018	0.0	-4.1	96.8	96.8	0.00
Line261	0.023	0.006	-0.023	-0.009	0.0	-3.5	96.8	96.8	0.00
Line262	-0.019	-0.012	0.019	0.007	0.0	-5.2	96.8	96.8	0.00
Line266	0.823	0.237	-0.822	-0.244	0.6	-6.2	96.7	96.6	0.08
Line268	0.747	0.201	-0.747	-0.201	0.0	-0.6	96.6	96.6	0.01
Line270	0.027	0.013	-0.027	-0.017	0.0	-3.7	96.6	96.6	0.00
Line274	-0.008	-0.005	0.008	-0.002	0.0	-6.6	96.6	96.6	0.00
Line272	0.009	0.001	-0.009	-0.005	0.0	-4.5	96.6	96.6	0.00
Line276	0.731	0.202	-0.730	-0.213	0.8	-10.7	96.6	96.5	0.12
Line280	0.729	0.212	-0.728	-0.213	0.1	-1.1	96.5	96.5	0.01
Line278	-0.007	-0.004	0.007	0.003	0.0	-1.8	96.5	96.5	0.00
Line282	0.011	0.001	-0.011	-0.004	0.0	-3.3	96.5	96.5	0.00
Line294	0.712	0.213	-0.712	-0.219	0.4	-5.6	96.5	96.4	0.06
Line648	0.005	-0.001	-0.005	-0.003	0.0	-4.0	96.5	96.5	0.00
Line286	0.004	0.002	-0.004	-0.002	0.0	-0.7	96.5	96.5	0.00
Line296	0.701	0.212	-0.701	-0.213	0.1	-1.2	96.4	96.4	0.01
Line298	0.015	-0.002	-0.015	-0.002	0.0	-4.0	96.4	96.4	0.00
Line301	0.686	0.214	-0.685	-0.222	0.5	-7.6	96.4	96.3	0.08
Line300	0.008	-0.001	-0.008	-0.005	0.0	-6.6	96.4	96.4	0.00
Line304	0.001	-0.001	-0.001	0.000	0.0	-1.8	96.3	96.3	0.00
Line306	0.026	0.009	-0.026	-0.013	0.0	-3.8	96.3	96.3	0.00
Line312	0.659	0.215	-0.659	-0.222	0.4	-7.0	96.3	96.3	0.07
Line308	-0.018	-0.011	0.018	0.011	0.0	-0.2	96.3	96.3	0.00
Line310	0.007	0.002	-0.007	-0.005	0.0	-3.0	96.3	96.3	0.00
Line314	0.607	0.189	-0.606	-0.192	0.1	-2.3	96.3	96.2	0.02
Line316	0.025	0.013	-0.025	-0.015	0.0	-2.2	96.2	96.2	0.00
Line318	0.581	0.178	-0.581	-0.186	0.4	-7.9	96.2	96.2	0.07
Line320	0.556	0.177	-0.556	-0.177	0.0	-0.7	96.2	96.2	0.01
Line322	0.025	0.010	-0.025	-0.015	0.0	-5.9	96.2	96.2	0.00
Line324	0.531	0.162	-0.530	-0.180	0.7	-18.1	96.2	96.0	0.15
Line325	0.523	0.176	-0.522	-0.177	0.1	-1.3	96.0	96.0	0.01
Line327	0.008	0.004	-0.008	-0.005	0.0	-0.6	96.0	96.0	0.00
Line329	0.510	0.169	-0.510	-0.172	0.1	-2.9	96.0	96.0	0.02
Line330	0.501	0.167	-0.501	-0.169	0.1	-2.5	96.0	96.0	0.02
Line340	0.495	0.166	-0.495	-0.169	0.1	-3.0	96.0	95.9	0.02

Branch ID	From-To Bus Flow MW	From-To Bus Flow Mvar	To-From Bus Flow MW	To-From Bus Flow Mvar	Losses kW	Losses kvar	% Bus Voltage From	% Bus Voltage To	Vd % Drop in Vmag
Line359	0.494	0.168	-0.494	-0.173	0.2	-5.2	95.9	95.9	0.04
Line360	0.492	0.172	-0.491	-0.190	0.6	-18.1	95.9	95.7	0.14
Line361	0.488	0.188	-0.488	-0.188	0.0	-0.2	95.7	95.7	0.00
Line368	-0.055	-0.034	0.055	0.032	0.0	-2.4	95.7	95.7	0.00
Line367	-0.057	-0.033	0.057	0.030	0.0	-3.3	95.7	95.7	0.00
Line364	0.430	0.158	-0.430	-0.161	0.1	-2.8	95.7	95.7	0.02
Line365	0.014	0.003	-0.014	-0.004	0.0	-0.6	95.7	95.7	0.00
Line370	0.416	0.158	-0.416	-0.159	0.0	-1.2	95.7	95.7	0.01
Line372	0.004	-0.002	-0.004	-0.003	0.0	-4.8	95.7	95.7	0.00
Line374	0.004	0.001	-0.004	-0.002	0.0	-1.1	95.7	95.7	0.00
Line376	0.412	0.158	-0.412	-0.159	0.0	-1.8	95.7	95.7	0.01
Line380	0.411	0.159	-0.411	-0.159	0.0	-0.4	95.7	95.7	0.00
Line381	-0.316	-0.102	0.316	0.101	0.0	-0.6	95.7	95.7	0.00
Line390	0.032	0.020	-0.032	-0.020	0.0	-0.2	95.7	95.7	0.00
Line392	0.284	0.082	-0.284	-0.082	0.0	-0.5	95.7	95.7	0.00
Line386	0.095	0.058	-0.095	-0.058	0.0	-0.4	95.7	95.7	0.00
Line385	-0.070	-0.043	0.070	0.043	0.0	-0.3	95.7	95.7	0.00
Line388	0.025	0.015	-0.025	-0.015	0.0	-0.3	95.7	95.7	0.00
Line395	0.256	0.066	-0.255	-0.127	1.1	-60.9	95.7	95.3	0.45
Line398	0.238	0.116	-0.238	-0.119	0.0	-2.8	95.3	95.2	0.02
Line405	-0.011	-0.007	0.011	0.001	0.0	-5.8	95.2	95.2	0.00
Line402	0.039	0.011	-0.039	-0.016	0.0	-5.5	95.2	95.2	0.01
Line403	0.199	0.108	-0.199	-0.111	0.0	-2.9	95.2	95.2	0.02
Line411	0.188	0.104	-0.188	-0.109	0.1	-5.5	95.2	95.2	0.03
Line407	0.028	0.015	-0.028	-0.017	0.0	-1.6	95.2	95.2	0.00
Line409	0.011	0.006	-0.011	-0.007	0.0	-0.4	95.2	95.2	0.00
Line415	0.171	0.099	-0.171	-0.099	0.0	-0.4	95.2	95.2	0.00
Line416	0.154	0.089	-0.154	-0.089	0.0	-0.7	95.2	95.2	0.00
Line425	0.137	0.079	-0.137	-0.080	0.0	-1.6	95.2	95.2	0.01
Line427	-0.017	-0.011	0.017	0.010	0.0	-0.3	95.2	95.2	0.00
Line429	0.120	0.070	-0.120	-0.071	0.0	-0.6	95.2	95.2	0.00
Line431	0.051	0.031	-0.051	-0.031	0.0	-0.4	95.2	95.2	0.00
Line433	0.034	0.020	-0.034	-0.021	0.0	-0.7	95.2	95.2	0.00
Line441	0.034	0.020	-0.034	-0.020	0.0	-0.4	95.2	95.2	0.00
Line439	0.017	0.010	-0.017	-0.011	0.0	-0.4	95.2	95.2	0.00
Line437	0.034	0.020	-0.034	-0.021	0.0	-0.5	95.2	95.2	0.00
Line436	-0.017	-0.011	0.017	0.010	0.0	-0.4	95.2	95.2	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
Line443	0.017	0.010	-0.017	-0.011	0.0	-0.8	95.2	95.2	0.00
Line445	-0.183	-0.114	0.183	0.113	0.0	-0.2	97.6	97.6	0.00
Line447	0.875	0.329	-0.875	-0.331	0.2	-1.6	97.6	97.6	0.02
Line451	-0.167	-0.080	0.167	0.078	0.0	-1.7	97.6	97.6	0.00
Line455	0.148	0.069	-0.148	-0.069	0.0	-0.5	97.6	97.6	0.00
Line449	0.205	0.091	-0.205	-0.098	0.0	-7.0	97.6	97.6	0.02
Line464	0.669	0.240	-0.669	-0.243	0.2	-2.7	97.6	97.6	0.03
Line453	0.039	0.019	-0.039	-0.024	0.0	-4.9	97.6	97.6	0.01
Line457	-0.139	-0.070	0.139	0.068	0.0	-2.6	97.6	97.6	0.01
Line642	0.128	0.063	-0.128	-0.070	0.0	-6.7	97.6	97.5	0.03
Line459	0.009	0.002	-0.009	-0.006	0.0	-4.0	97.6	97.6	0.00
Line461	-0.022	-0.011	0.022	0.004	0.0	-6.7	97.5	97.5	0.00
Line462	0.011	0.004	-0.011	-0.007	0.0	-2.6	97.5	97.5	0.00
Line466	0.661	0.238	-0.661	-0.238	0.0	-0.3	97.6	97.6	0.00
Line467	0.627	0.217	-0.626	-0.221	0.3	-4.8	97.6	97.5	0.05
Line469	0.596	0.203	-0.596	-0.212	0.4	-9.0	97.5	97.4	0.08
Line471	0.067	0.038	-0.067	-0.039	0.0	-1.5	97.4	97.4	0.00
Line477	0.529	0.174	-0.529	-0.175	0.0	-1.3	97.4	97.4	0.01
Line475	0.033	0.018	-0.033	-0.020	0.0	-2.0	97.4	97.4	0.00
Line479	0.224	0.101	-0.224	-0.102	0.0	-1.2	97.4	97.4	0.00
Line481	0.305	0.074	-0.305	-0.077	0.0	-3.3	97.4	97.4	0.01
Line483	0.185	0.078	-0.185	-0.082	0.0	-3.4	97.4	97.4	0.01
Line485	0.164	0.068	-0.164	-0.072	0.0	-3.4	97.4	97.4	0.01
Line487	0.152	0.064	-0.152	-0.069	0.0	-5.1	97.4	97.4	0.01
Line489	0.025	0.015	-0.025	-0.015	0.0	-0.1	97.4	97.4	0.00
Line494	0.127	0.054	-0.127	-0.058	0.0	-3.5	97.4	97.4	0.01
Line495	0.107	0.045	-0.107	-0.048	0.0	-2.5	97.4	97.4	0.00
Line496	0.094	0.040	-0.094	-0.042	0.0	-1.9	97.4	97.4	0.00
Line499	0.038	0.020	-0.038	-0.021	0.0	-1.0	97.4	97.4	0.00
Line506	0.056	0.021	-0.056	-0.024	0.0	-2.4	97.4	97.4	0.00
Line501	0.014	0.006	-0.014	-0.009	0.0	-2.6	97.4	97.4	0.00
Line507	0.031	0.015	-0.031	-0.017	0.0	-1.7	97.4	97.4	0.00
Line509	0.025	0.009	-0.025	-0.013	0.0	-4.6	97.4	97.4	0.00
Line505	0.016	0.008	-0.016	-0.010	0.0	-2.3	97.4	97.4	0.00
Line511	0.014	0.007	-0.014	-0.009	0.0	-2.1	97.4	97.4	0.00
Line513	0.274	0.058	-0.274	-0.062	0.0	-3.3	97.4	97.4	0.01
Line515	0.265	0.056	-0.265	-0.060	0.0	-3.6	97.4	97.4	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
Line517	0.007	-0.001	-0.007	-0.004	0.0	-5.0	97.4	97.4	0.00
Line520	0.258	0.061	-0.258	-0.061	0.0	-0.7	97.4	97.4	0.00
Line521	-0.151	-0.022	0.151	0.021	0.0	-0.4	97.4	97.4	0.00
Line531	0.122	0.004	-0.122	-0.005	0.0	-1.8	97.4	97.4	0.00
Line522	0.236	0.048	-0.236	-0.054	0.0	-6.3	97.4	97.4	0.02
Line524	0.085	0.033	-0.085	-0.034	0.0	-1.1	97.4	97.4	0.00
Line526	0.061	0.019	-0.061	-0.021	0.0	-2.2	97.4	97.4	0.00
Line525	-0.052	-0.017	0.052	0.015	0.0	-2.2	97.4	97.4	0.00
Line528	0.027	0.002	-0.027	-0.010	0.0	-7.8	97.4	97.4	0.01
Line527	-0.017	-0.011	0.017	0.004	0.0	-7.0	97.4	97.4	0.00
Line532	0.059	-0.007	-0.059	0.004	0.0	-2.8	97.4	97.4	0.00
Line534	-0.077	-0.004	0.077	0.002	0.0	-1.7	97.4	97.4	0.00
Line566	0.044	0.003	-0.044	-0.003	0.0	-0.2	97.4	97.4	0.00
Line538	0.053	-0.008	-0.053	0.005	0.0	-3.3	97.4	97.4	0.00
Line544	0.041	-0.012	-0.041	0.006	0.0	-5.7	97.4	97.4	0.01
Line543	-0.039	0.004	0.039	-0.007	0.0	-2.6	97.4	97.4	0.00
Line547	0.035	-0.007	-0.035	0.007	0.0	-0.4	97.4	97.4	0.00
Line546	0.002	0.001	-0.002	-0.001	0.0	-0.7	97.4	97.4	0.00
Line550	0.014	-0.001	-0.014	-0.001	0.0	-1.1	97.4	97.4	0.00
Line558	0.020	-0.006	-0.020	-0.002	0.0	-8.2	97.4	97.3	0.00
Line548	0.001	-0.002	-0.001	-0.001	0.0	-3.0	97.4	97.4	0.00
Line549	-0.005	0.004	0.005	-0.005	0.0	-1.3	97.4	97.4	0.00
Line552	0.004	-0.002	-0.004	0.000	0.0	-1.5	97.4	97.4	0.00
Line554	0.001	-0.002	-0.001	-0.001	0.0	-2.5	97.4	97.4	0.00
Line557	-0.014	0.000	0.014	-0.002	0.0	-2.2	97.3	97.3	0.00
Line560	0.010	-0.002	-0.010	-0.001	0.0	-2.9	97.3	97.3	0.00
Line559	0.007	-0.001	-0.007	-0.004	0.0	-5.6	97.3	97.3	0.00
Line562	-0.133	-0.067	0.133	0.067	0.0	-0.1	98.0	98.0	0.00
Line569	0.092	0.052	-0.092	-0.055	0.0	-3.2	98.0	98.0	0.01
Line613	0.040	0.015	-0.040	-0.018	0.0	-2.7	98.0	98.0	0.00
Line594	0.066	0.039	-0.066	-0.041	0.0	-2.1	98.0	98.0	0.00
Line564	-0.005	0.012	0.005	-0.017	0.0	-4.4	97.4	97.4	0.00
Line568	0.005	-0.012	-0.005	0.010	0.0	-2.2	97.4	97.4	0.00
Line565	-0.018	0.009	0.018	-0.013	0.0	-4.2	97.4	97.4	0.00
Line567	0.001	-0.005	-0.001	-0.001	0.0	-5.5	97.4	97.4	0.00
Line646	0.004	-0.006	-0.004	0.000	0.0	-5.4	97.4	97.4	0.00
Line570	-0.001	-0.001	0.001	-0.002	0.0	-2.7	97.4	97.4	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
Line572	0.770	0.422	-0.770	-0.424	0.2	-2.1	98.2	98.2	0.03
Line573	0.055	0.033	-0.055	-0.034	0.0	-1.1	98.2	98.2	0.00
Line574	-0.048	-0.030	0.048	0.029	0.0	-0.2	98.2	98.2	0.00
Line575	-0.200	-0.124	0.200	0.122	0.0	-1.7	98.1	98.1	0.01
Line576	-0.013	-0.008	0.013	0.005	0.0	-3.8	98.1	98.1	0.00
Line577	0.722	0.395	-0.722	-0.396	0.1	-0.7	98.2	98.1	0.01
Line578	0.522	0.273	-0.522	-0.283	0.4	-9.7	98.1	98.1	0.09
Line581	0.508	0.278	-0.508	-0.282	0.1	-3.5	98.1	98.0	0.03
Line584	0.495	0.274	-0.494	-0.277	0.1	-3.8	98.0	98.0	0.03
Line586	0.344	0.207	-0.344	-0.208	0.0	-0.7	98.0	98.0	0.00
Line589	0.150	0.070	-0.150	-0.074	0.0	-3.7	98.0	98.0	0.01
Line650	0.210	0.125	-0.210	-0.125	0.0	-0.7	98.0	98.0	0.00
Line588	-0.006	-0.004	0.006	-0.001	0.0	-4.9	98.0	98.0	0.00
Line590	0.013	0.008	-0.013	-0.008	0.0	-0.1	98.0	98.0	0.00
Line591	0.005	0.000	-0.005	-0.003	0.0	-3.3	98.0	98.0	0.00
Line615	0.027	0.011	-0.027	-0.014	0.0	-3.3	98.0	98.0	0.00
Line617	0.013	0.007	-0.013	-0.008	0.0	-1.4	98.0	98.0	0.00
Line619	0.013	0.006	-0.013	-0.008	0.0	-2.7	98.0	98.0	0.00
Line621	0.013	0.008	-0.013	-0.008	0.0	-0.1	98.0	98.0	0.00
Line638	-2.501	-1.557	2.512	1.563	11.1	5.2	93.8	94.2	0.39
Line644	0.009	0.002	-0.009	-0.005	0.0	-3.9	97.3	97.3	0.00
					228.3	-203.5			

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
Bus211	Bus	Under Voltage	11.000	kV	9.888	89.9	3-Phase
Bus212	Bus	Under Voltage	11.000	kV	9.89	89.9	3-Phase
Bus214	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus216	Bus	Under Voltage	11.000	kV	9.88	89.8	3-Phase
Bus222	Bus	Under Voltage	11.000	kV	9.81	89.2	3-Phase
Bus224	Bus	Under Voltage	11.000	kV	9.81	89.2	3-Phase
Bus226	Bus	Under Voltage	11.000	kV	9.87	89.8	3-Phase
Bus227	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus229	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus231	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus233	Bus	Under Voltage	11.000	kV	9.86	89.6	3-Phase
Bus235	Bus	Under Voltage	11.000	kV	9.86	89.6	3-Phase
Bus237	Bus	Under Voltage	11.000	kV	9.85	89.6	3-Phase
Bus239	Bus	Under Voltage	11.000	kV	9.85	89.5	3-Phase
Bus241	Bus	Under Voltage	11.000	kV	9.84	89.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus243	Bus	Under Voltage	11.000	kV	9.868	89.7	3-Phase
Bus244	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus246	Bus	Under Voltage	11.000	kV	9.86	89.7	3-Phase
Bus671	Bus	Under Voltage	11.000	kV	9.87	89.7	3-Phase
Bus679	Bus	Under Voltage	11.000	kV	9.86	89.7	3-Phase
Khuruthang control room	Bus	Under Voltage	11.000	kV	9.81	89.2	3-Phase

Marginal Report

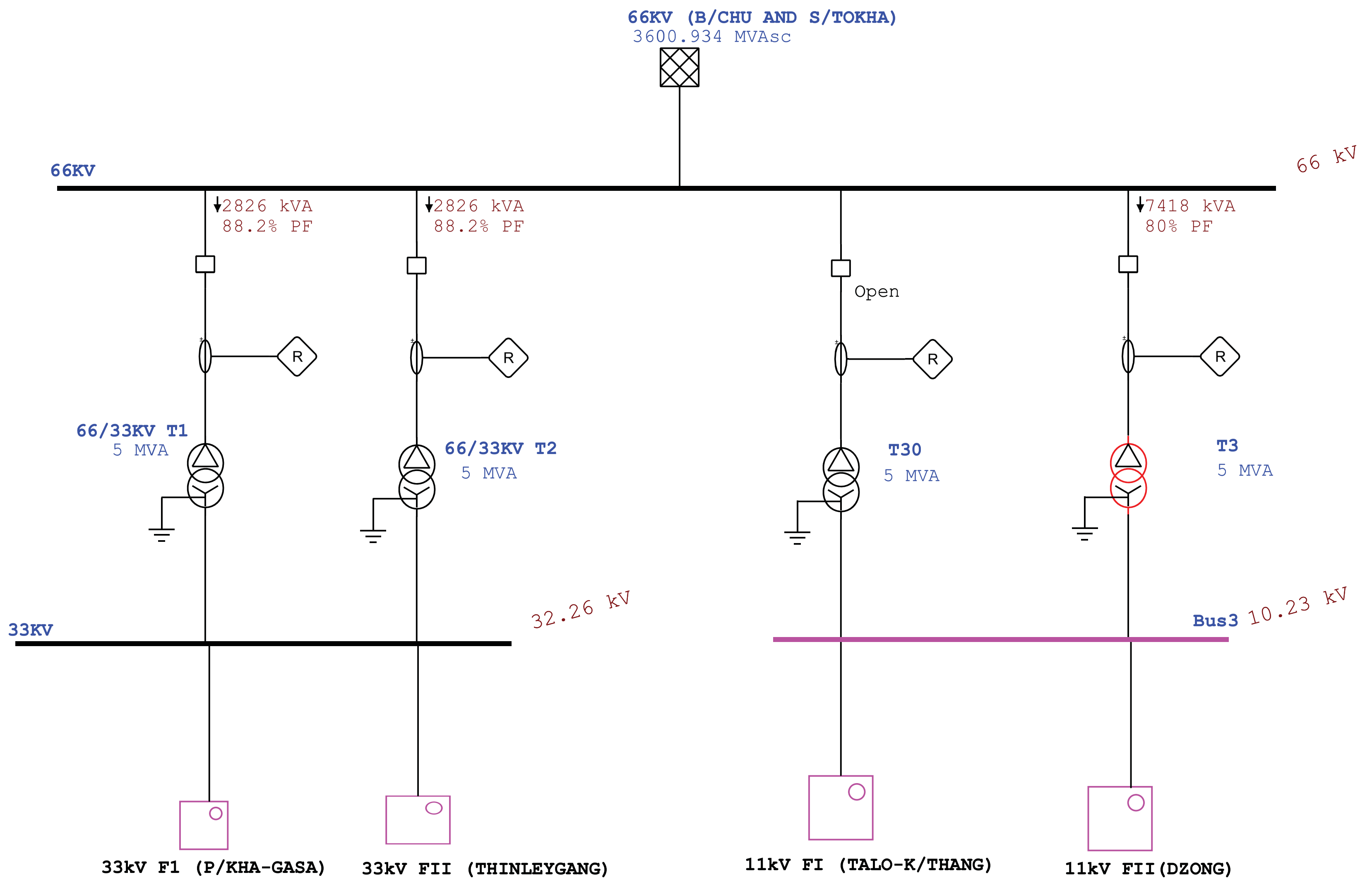
Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus196	Bus	Under Voltage	11.000	kV	10.280	93.5	3-Phase
Bus199	Bus	Under Voltage	11.000	kV	10.40	94.6	3-Phase
Bus201	Bus	Under Voltage	11.000	kV	10.27	93.3	3-Phase
Bus203	Bus	Under Voltage	11.000	kV	10.09	91.7	3-Phase
Bus205	Bus	Under Voltage	11.000	kV	10.05	91.3	3-Phase
Bus207	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus209	Bus	Under Voltage	11.000	kV	9.91	90.1	3-Phase
Bus673	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
Bus675	Bus	Under Voltage	11.000	kV	10.25	93.2	3-Phase
Bus677	Bus	Under Voltage	11.000	kV	10.36	94.2	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	6.968	3.974	8.022	86.87 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	6.968	3.974	8.022	86.87 Lagging
Total Motor Load:	1.611	0.999	1.896	85.00 Lagging
Total Static Load:	5.129	3.178	6.034	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.228	-0.204		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

One-Line Diagram - ESD PUNAKHA (LF 2019) (Load Flow Analysis) Time Horizon-2030



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										9.746	85.8	85.3	
Bus2	33.000										5.530	89.7	99.0	
Bus3	11.000										3.949	84.6	215.4	
Bus196	11.000		0.004	0.003	0.014	0.009					2.898	84.7	165.2	
Bus199	11.000										3.835	84.9	215.4	
Bus201	11.000		0.044	0.027	0.148	0.092					2.872	84.8	164.0	
Bus203	11.000		0.002	0.001	0.005	0.003					2.504	84.9	146.1	
Bus205	11.000		0.020	0.012	0.063	0.039					2.484	84.9	145.7	
Bus207	11.000		0.115	0.071	0.364	0.225					2.374	85.0	140.0	
Bus209	11.000		0.002	0.001	0.006	0.004					1.791	85.1	106.8	
Bus211	11.000										1.776	85.1	106.2	
Bus212	11.000		0.114	0.071	0.351	0.217					0.547	85.0	32.7	
Bus214	11.000		0.015	0.009	0.047	0.029					1.011	85.0	60.6	
Bus216	11.000		0.004	0.002	0.011	0.007					0.216	86.0	12.9	
Bus222	11.000		0.194	0.120	0.585	0.363					0.917	85.0	55.4	
Bus224	11.000		0.003	0.002	0.009	0.006					0.015	85.0	0.9	
Bus226	11.000		0.002	0.001	0.007	0.005					0.068	85.9	4.1	
Bus227	11.000										0.131	86.0	7.8	
Bus229	11.000		0.018	0.011	0.003	0.002					0.125	85.9	7.5	
Bus231	11.000		0.001	0.001	0.004	0.002					0.006	85.0	0.4	
Bus233	11.000		0.008	0.005	0.023	0.014					0.100	86.0	6.0	
Bus235	11.000		0.002	0.002	0.008	0.005					0.063	86.5	3.8	
Bus237	11.000		0.003	0.002	0.011	0.007					0.051	86.5	3.1	
Bus239	11.000		0.013	0.008	0.003	0.002					0.035	86.6	2.1	
Bus241	11.000		0.004	0.002	0.011	0.007					0.017	85.0	1.0	
Bus243	11.000										0.057	85.9	3.4	
Bus244	11.000		0.005	0.003	0.016	0.010					0.030	86.3	1.8	
Bus246	11.000		0.001	0.000	0.002	0.001					0.006	85.4	0.3	
Bus247	33.000										4.347	90.4	78.3	
Bus248	33.000		0.005	0.003	0.019	0.012					2.963	90.0	53.5	
Bus251	33.000		0.001	0.000	0.002	0.001					0.004	85.0	0.1	
Bus252	33.000										2.935	90.0	53.0	
Bus253	33.000		0.001	0.000	0.002	0.001					2.932	90.0	52.9	
Bus255	33.000										2.926	90.0	52.9	
Bus257	33.000		0.008	0.005	0.029	0.018					0.644	85.5	11.6	
Bus259	33.000		0.003	0.002	0.012	0.007					2.286	91.0	41.4	
Bus262	33.000		0.003	0.002	0.012	0.007					0.017	85.0	0.3	
Bus263	33.000										2.268	91.0	41.1	
Bus265	33.000		0.005	0.003	0.019	0.012					2.253	91.0	40.8	

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
Bus267	33.000		0.021	0.013	0.079	0.049					2.224	90.9	40.4	
Bus269	33.000										2.107	91.1	38.3	
Bus274	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus275	33.000										0.467	86.0	8.5	
Bus277	33.000		0.085	0.053	0.314	0.195					0.470	85.0	8.5	
Bus279	33.000		0.007	0.004	0.025	0.015					1.645	92.3	29.9	
Bus280	33.000										1.608	92.5	29.3	
Bus282	33.000		0.006	0.004	0.023	0.014					0.034	85.0	0.6	
Bus284	33.000		0.003	0.002	0.011	0.007					0.039	87.1	0.7	
Bus285	33.000										1.576	92.4	28.7	
Bus287	33.000		0.004	0.003	0.015	0.009					0.022	85.0	0.4	
Bus288	33.000										1.539	92.4	28.0	
Bus290	33.000		0.018	0.011	0.068	0.042					0.102	85.0	1.9	
Bus292	33.000		0.004	0.002	0.015	0.009					1.439	92.8	26.2	
Bus293	33.000										1.417	92.9	25.8	
Bus295	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus296	33.000										1.415	92.9	25.8	
Bus298	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus300	33.000		0.026	0.016	0.094	0.058					1.414	92.9	25.8	
Bus305	33.000										1.276	93.6	23.3	
Bus307	33.000		0.005	0.003	0.018	0.011					0.036	88.0	0.7	
Bus309	33.000		0.002	0.001	0.007	0.004					0.011	85.0	0.2	
Bus312	33.000		0.013	0.008	0.048	0.030					0.170	88.5	3.1	
Bus313	33.000		0.007	0.004	0.026	0.016					0.092	90.6	1.7	
Bus315	33.000		0.001	0.001	0.005	0.003					0.007	85.0	0.1	
Bus317	33.000		0.005	0.003	0.018	0.011					0.056	91.2	1.0	
Bus320	33.000		0.005	0.003	0.018	0.011					0.027	85.0	0.5	
Bus321	33.000		0.001	0.001	0.004	0.002					0.030	91.8	0.5	
Bus323	33.000		0.008	0.005	0.029	0.018					1.074	94.2	19.6	
Bus325	33.000		0.012	0.008	0.044	0.028					1.033	94.3	18.9	
Bus327	33.000		0.002	0.001	0.007	0.005					0.011	85.0	0.2	
Bus329	33.000		0.007	0.004	0.026	0.016					0.038	85.0	0.7	
Bus330	33.000										0.932	94.9	17.0	
Bus332	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus334	33.000		0.000	0.000	0.001	0.001					0.915	94.4	16.7	
Bus336	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus338	33.000										0.913	94.4	16.7	
Bus341	33.000										0.014	91.8	0.3	
Bus343	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus351	33.000		0.003	0.002	0.011	0.007					0.896	94.0	16.4	
Bus354	33.000										0.880	94.1	16.1	
Bus356	33.000		0.002	0.001	0.006	0.004					0.018	96.7	0.3	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus358	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus359	33.000										0.867	93.6	15.9	
Bus361	33.000		0.000	0.000	0.000	-					0.001	85.0	-	
Bus363	33.000		0.005	0.003	0.017	0.011					0.026	85.0	0.5	
Bus364	33.000										0.034	88.9	0.6	
Bus366	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus368	33.000		0.013	0.008	0.049	0.030					0.835	93.3	15.3	
Bus369	33.000										0.764	93.8	14.0	
Bus371	33.000		0.006	0.004	0.023	0.014					0.035	85.0	0.6	
Bus372	33.000										0.733	93.7	13.5	
Bus374	33.000		0.006	0.004	0.023	0.014					0.701	93.7	12.9	
Bus376	33.000		0.006	0.004	0.023	0.014					0.035	85.0	0.6	
Bus378	33.000										0.672	93.2	12.4	
Bus379	33.000		0.003	0.002	0.012	0.007					0.661	93.2	12.2	
Bus381	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus383	33.000		0.002	0.001	0.008	0.005					0.645	93.3	11.9	
Bus384	33.000		0.001	0.001	0.005	0.003					0.635	93.3	11.7	
Bus412	33.000		0.000	0.000	0.001	0.001					0.628	93.2	11.6	
Bus413	33.000		0.001	0.000	0.002	0.001					0.628	92.9	11.6	
Bus414	33.000		0.001	0.001	0.003	0.002					0.630	92.0	11.6	
Bus422	33.000		0.014	0.009	0.051	0.032					0.077	85.0	1.4	
Bus423	33.000		0.001	0.000	0.002	0.001					0.079	86.3	1.5	
Bus424	33.000										0.626	92.0	11.6	
Bus425	33.000										0.550	92.3	10.2	
Bus427	33.000		0.002	0.002	0.009	0.006					0.018	91.9	0.3	
Bus429	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus430	33.000										0.533	92.1	9.9	
Bus432	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus436	33.000		0.000	0.000	0.001	0.001					0.529	92.0	9.8	
Bus438	33.000										0.396	93.7	7.3	
Bus439	33.000										0.527	92.0	9.7	
Bus442	33.000		0.012	0.007	0.043	0.026					0.098	85.1	1.8	
Bus443	33.000		0.006	0.004	0.023	0.014					0.133	85.2	2.5	
Bus445	33.000		0.006	0.004	0.023	0.014					0.034	85.0	0.6	
Bus447	33.000		0.008	0.005	0.030	0.019					0.045	85.0	0.8	
Bus450	33.000		0.007	0.004	0.025	0.016					0.352	94.5	6.5	
Bus451	33.000		0.004	0.003	0.016	0.010					0.337	88.8	6.3	
Bus453	33.000		0.003	0.002	0.010	0.006					0.015	85.0	0.3	
Bus455	33.000										0.315	88.8	5.9	
Bus457	33.000		0.003	0.002	0.010	0.006					0.268	87.0	5.0	
Bus458	33.000										0.050	91.1	0.9	
Bus460	33.000		0.004	0.003	0.016	0.010					0.038	85.5	0.7	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus462	33.000		0.003	0.002	0.010	0.006					0.015	85.0	0.3	
Bus464	33.000		0.004	0.003	0.016	0.010					0.256	86.2	4.8	
Bus466	33.000		0.004	0.003	0.016	0.010					0.232	86.3	4.3	
Bus467	33.000		0.004	0.003	0.016	0.010					0.209	86.2	3.9	
Bus472	33.000		0.004	0.003	0.016	0.010					0.024	85.0	0.4	
Bus473	33.000										0.186	86.0	3.5	
Bus478	33.000										0.163	85.9	3.0	
Bus480	33.000		0.004	0.003	0.016	0.010					0.047	85.3	0.9	
Bus482	33.000		0.004	0.003	0.016	0.010					0.070	85.5	1.3	
Bus483	33.000		0.004	0.003	0.016	0.010					0.024	85.0	0.4	
Bus484	33.000		0.004	0.003	0.016	0.010					0.047	85.4	0.9	
Bus486	33.000		0.004	0.003	0.016	0.010					0.024	85.0	0.4	
Bus488	33.000		0.004	0.003	0.016	0.010					0.047	85.7	0.9	
Bus490	33.000		0.004	0.003	0.016	0.010					0.024	85.0	0.4	
Bus492	33.000		0.046	0.028	0.172	0.107					0.256	85.0	4.6	
Bus493	33.000										1.383	91.1	24.9	
Bus495	33.000		0.004	0.003	0.017	0.010					0.223	89.3	4.0	
Bus496	33.000										1.129	92.2	20.4	
Bus497	33.000										0.274	89.4	4.9	
Bus499	33.000		0.010	0.006	0.037	0.023					0.055	85.0	1.0	
Bus503	33.000		0.003	0.002	0.011	0.007					0.188	88.5	3.4	
Bus504	33.000										0.198	89.7	3.6	
Bus506	33.000		0.002	0.001	0.009	0.005					0.013	85.0	0.2	
Bus508	33.000		0.003	0.002	0.010	0.006					0.029	88.7	0.5	
Bus509	33.000		0.003	0.002	0.010	0.006					0.015	85.0	0.3	
Bus511	33.000		0.002	0.001	0.006	0.004					0.859	92.6	15.5	
Bus513	33.000		0.009	0.005	0.032	0.020					0.850	92.7	15.3	
Bus514	33.000		0.007	0.005	0.028	0.017					0.804	92.9	14.5	
Bus515	33.000										0.765	92.8	13.8	
Bus517	33.000		0.008	0.005	0.032	0.020					0.094	85.9	1.7	
Bus519	33.000		0.009	0.005	0.032	0.020					0.047	85.0	0.9	
Bus520	33.000										0.674	93.5	12.2	
Bus522	33.000		0.010	0.006	0.037	0.023					0.297	90.0	5.4	
Bus524	33.000		0.005	0.003	0.020	0.013					0.244	90.5	4.4	
Bus526	33.000		0.003	0.002	0.011	0.007					0.215	90.6	3.9	
Bus527	33.000										0.201	90.0	3.6	
Bus529	33.000		0.006	0.004	0.023	0.014					0.035	85.0	0.6	
Bus533	33.000		0.005	0.003	0.019	0.012					0.168	90.1	3.0	
Bus534	33.000		0.003	0.002	0.012	0.008					0.141	90.3	2.5	
Bus535	33.000										0.123	90.4	2.2	
Bus538	33.000		0.006	0.004	0.022	0.014					0.052	87.1	0.9	
Bus540	33.000		0.004	0.002	0.013	0.008					0.020	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
Bus543	33.000										0.073	90.8	1.3	
Bus544	33.000		0.004	0.002	0.014	0.009					0.042	87.3	0.8	
Bus546	33.000		0.003	0.002	0.010	0.006					0.034	87.6	0.6	
Bus548	33.000		0.004	0.002	0.014	0.008					0.020	85.0	0.4	
Bus550	33.000		0.004	0.002	0.015	0.009					0.022	85.0	0.4	
Bus552	33.000		0.008	0.005	0.029	0.018					0.380	95.3	6.9	
Bus554	33.000		0.002	0.001	0.008	0.005					0.339	96.0	6.1	
Bus555	33.000										0.328	96.0	5.9	
Bus557	33.000		0.002	0.001	0.006	0.004					0.010	85.0	0.2	
Bus560	33.000		0.007	0.005	0.027	0.017					0.184	97.5	3.3	
Bus561	33.000		0.006	0.003	0.021	0.013					0.320	95.7	5.8	
Bus562	33.000										0.292	95.9	5.3	
Bus563	33.000		0.006	0.004	0.023	0.014					0.110	91.8	2.0	
Bus564	33.000		0.006	0.004	0.022	0.014					0.065	93.4	1.2	
Bus565	33.000		0.002	0.001	0.008	0.005					0.077	93.3	1.4	
Bus566	33.000		0.004	0.003	0.016	0.010					0.024	85.0	0.4	
Bus567	33.000		0.002	0.002	0.009	0.006					0.035	92.6	0.6	
Bus570	33.000		0.004	0.003	0.017	0.010					0.093	98.9	1.7	
Bus571	33.000										0.147	99.0	2.7	
Bus573	33.000		0.002	0.001	0.006	0.004					0.071	99.8	1.3	
Bus577	33.000		0.003	0.002	0.011	0.007					0.064	99.1	1.2	
Bus582	33.000		0.001	0.001	0.004	0.003					0.047	99.7	0.8	
Bus583	33.000										0.050	99.9	0.9	
Bus585	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus587	33.000										0.042	99.6	0.8	
Bus588	33.000										0.007	88.9	0.1	
Bus589	33.000		0.002	0.001	0.009	0.006					0.019	92.7	0.3	
Bus590	33.000		0.001	0.000	0.002	0.001					0.005	92.7	0.1	
Bus592	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus594	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus597	33.000		0.001	0.001	0.004	0.002					0.017	98.5	0.3	
Bus598	33.000		0.002	0.001	0.006	0.004					0.025	98.2	0.4	
Bus599	33.000		0.001	0.000	0.003	0.002					0.012	98.3	0.2	
Bus601	33.000		0.002	0.001	0.007	0.004					0.010	85.0	0.2	
Bus602	33.000										0.185	88.5	3.3	
Bus604	33.000		0.007	0.004	0.026	0.016					0.133	85.7	2.4	
Bus605	33.000		0.000	0.000	0.000	-					0.013	47.2	0.2	
Bus606	33.000		0.003	0.002	0.012	0.007					0.027	80.3	0.5	
Bus607	33.000		0.007	0.004	0.025	0.015					0.056	93.9	1.0	
Bus608	33.000										0.011	53.7	0.2	
Bus609	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus611	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus614	33.000										1.163	87.1	20.8	
Bus615	33.000		0.014	0.009	0.053	0.033					0.079	85.0	1.4	
Bus616	33.000		0.012	0.008	0.046	0.029					0.069	85.0	1.2	
Bus617	33.000		0.051	0.032	0.194	0.121					0.289	85.0	5.2	
Bus618	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus619	33.000										1.086	87.1	19.5	
Bus620	33.000										1.018	87.2	18.2	
Bus621	33.000										0.734	87.3	13.2	
Bus624	33.000		0.003	0.002	0.013	0.008					0.718	87.0	12.9	
Bus626	33.000										0.700	86.8	12.6	
Bus628	33.000		0.034	0.021	0.129	0.080					0.494	85.5	8.9	
Bus630	33.000		0.001	0.001	0.005	0.003					0.008	85.0	0.1	
Bus631	33.000										0.209	88.8	3.8	
Bus632	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus633	33.000		0.001	0.001	0.004	0.003					0.007	85.0	0.1	
Bus635	33.000		0.017	0.011	0.065	0.040					0.096	85.0	1.7	
Bus654	33.000										0.055	90.5	1.0	
Bus656	33.000										0.037	88.1	0.7	
Bus658	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus660	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus662	33.000		0.003	0.002	0.013	0.008					0.019	85.0	0.3	
Bus671	11.000		0.006	0.004	0.017	0.011					0.027	85.0	1.6	
Bus673	11.000		0.116	0.072	0.398	0.247					3.516	84.8	199.6	
Bus675	11.000		0.017	0.011	0.057	0.035					2.642	84.7	151.1	
Bus677	11.000		0.054	0.033	0.185	0.115					3.814	84.9	215.4	
Bus679	11.000		0.000	0.000	0.001	0.001					0.002	85.0	0.1	
Bus681	33.000		0.027	0.016	0.100	0.062					0.175	87.3	3.2	
Bus685	33.000		0.106	0.066	0.397	0.246					0.602	85.3	10.9	
Bus688	33.000		0.002	0.001	0.008	0.005					0.012	85.0	0.2	
Bus692	33.000		0.001	0.001	0.005	0.003					0.007	85.0	0.1	
Bus694	33.000		0.001	0.000	0.002	0.001					0.005	92.1	0.1	
Bus696	33.000		0.204	0.126	0.048	0.030					0.303	85.6	5.4	
Khuruthang control room	11.000										0.932	85.0	56.3	

* 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	%
Cable12	Cable	301.98	8.55	2.83					
UG 300sq.mm	Cable	338.03	55.37	16.38					
UG 300sq.mm2	Cable	338.03	0.89	0.26					
T1	Transformer				5.000	2.829	56.6	2.765	55.3
T3	Transformer				5.000	4.104	82.1	3.949	79.0
T27	Transformer				5.000	2.829	56.6	2.765	55.3

* 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	2.495	1.334	-2.481	-1.220	13.4	113.7	100.0	97.7	2.25
T3	3.371	2.342	-3.343	-2.102	28.1	239.3	100.0	96.2	3.79
T27	2.495	1.334	-2.481	-1.220	13.4	113.7	100.0	97.7	2.25
Line178	3.949	1.871	-3.929	-1.859	20.1	12.5	97.7	97.1	0.68
Line571	1.014	0.569	-1.013	-0.572	0.5	-2.8	97.7	97.7	0.06
Line129	3.343	2.102	-3.255	-2.027	87.5	75.6	96.2	93.4	2.79
Line130	2.438	1.527	-2.434	-1.524	3.6	3.1	92.1	91.9	0.15
Line634	-2.456	-1.539	2.467	1.544	11.2	5.2	92.1	92.4	0.39
Line131	3.255	2.027	-3.236	-2.018	19.0	8.9	93.4	92.9	0.51
Line636	2.242	1.405	-2.239	-1.403	3.1	2.6	91.9	91.8	0.14
Line134	-2.126	-1.323	2.165	1.357	38.7	33.4	89.9	91.8	1.82
Line136	2.119	1.319	-2.110	-1.311	9.5	8.3	89.9	89.5	0.45
Line138	2.028	1.260	-2.018	-1.251	9.8	8.4	89.5	89.0	0.48
Line140	1.539	0.955	-1.524	-0.942	15.4	13.2	89.0	88.0	0.99
Line142	1.516	0.936	-1.512	-0.933	4.1	3.5	88.0	87.7	0.27
Line144	0.465	0.288	-0.465	-0.288	0.1	0.0	87.7	87.7	0.02
Line147	0.861	0.535	-0.859	-0.533	2.0	1.6	87.7	87.5	0.22
Line149	0.186	0.110	-0.186	-0.110	0.2	-0.1	87.7	87.6	0.12
Line151	0.797	0.495	-0.792	-0.491	4.9	3.9	87.5	86.9	0.60
Line156	0.058	0.034	-0.058	-0.035	0.0	-0.2	87.6	87.6	0.05
Line158	0.113	0.067	-0.112	-0.067	0.1	-0.2	87.6	87.6	0.06
UG 300sq.mm	-0.779	-0.483	0.779	0.483	0.2	0.2	86.9	86.9	0.03
UG 300sq.mm2	-0.012	-0.008	0.012	0.008	0.0	0.0	86.9	86.9	0.00
Line173	0.049	0.029	-0.049	-0.029	0.0	-0.3	87.6	87.5	0.06
Line160	0.107	0.064	-0.107	-0.064	0.1	-0.1	87.6	87.5	0.05
Line162	0.005	0.003	-0.005	-0.003	0.0	-0.1	87.6	87.6	0.00
line	0.086	0.051	-0.086	-0.051	0.1	-0.3	87.5	87.4	0.09
Line165	0.055	0.032	-0.055	-0.032	0.0	-0.2	87.4	87.4	0.03
Line167	0.045	0.026	-0.045	-0.026	0.0	-0.4	87.4	87.3	0.06
Line169	0.031	0.017	-0.031	-0.018	0.0	-0.4	87.3	87.3	0.05
Line171	0.015	0.008	-0.015	-0.009	0.0	-1.3	87.3	87.2	0.06
Line175	0.026	0.015	-0.026	-0.015	0.0	-0.2	87.5	87.5	0.02
Line632	0.023	0.014	-0.023	-0.014	0.0	-0.1	87.5	87.5	0.00
Line177	0.005	0.002	-0.005	-0.003	0.0	-0.8	87.5	87.5	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
Line640	0.002	0.001	-0.002	-0.001	0.0	-0.1	87.5	87.5	0.00
Line180	2.669	1.291	-2.667	-1.291	1.9	-0.6	97.1	97.0	0.10
Line182	1.260	0.568	-1.260	-0.570	0.6	-2.1	97.1	97.0	0.05
Line184	2.643	1.276	-2.642	-1.277	0.9	-0.3	97.0	96.9	0.05
Line186	-0.003	-0.002	0.003	-0.002	0.0	-3.7	96.9	96.9	0.00
Line187	2.639	1.278	-2.639	-1.279	0.8	-0.2	96.9	96.9	0.04
Line189	2.636	1.277	-2.632	-1.278	3.7	-1.2	96.9	96.7	0.19
Line191	0.551	0.333	-0.551	-0.334	0.0	-0.3	96.7	96.7	0.00
Line193	2.082	0.945	-2.080	-0.948	1.8	-2.6	96.7	96.6	0.11
Line195	0.514	0.311	-0.513	-0.314	0.3	-3.6	96.7	96.6	0.06
Line197	2.065	0.939	-2.065	-0.940	0.7	-1.0	96.6	96.5	0.05
Line199	-0.015	-0.009	0.015	0.005	0.0	-4.1	96.5	96.5	0.00
Line201	2.050	0.935	-2.050	-0.935	0.1	-0.2	96.5	96.5	0.01
Line203	2.026	0.920	-2.023	-0.926	3.6	-5.5	96.5	96.3	0.23
Line206	1.922	0.864	-1.921	-0.867	1.8	-3.3	96.3	96.2	0.12
Line209	0.402	0.236	-0.402	-0.238	0.1	-2.0	96.2	96.1	0.03
Line215	1.519	0.631	-1.518	-0.632	0.3	-1.0	96.2	96.2	0.02
Line211	-0.003	-0.002	0.003	0.001	0.0	-0.6	96.1	96.1	0.00
Cable12	0.399	0.237	-0.399	-0.247	0.0	-10.2	96.1	96.1	0.00
Line217	1.487	0.612	-1.487	-0.612	0.0	-0.1	96.2	96.1	0.00
Line219	1.457	0.599	-1.457	-0.601	0.4	-1.8	96.1	96.1	0.04
Line221	0.029	0.013	-0.029	-0.018	0.0	-5.1	96.1	96.1	0.00
Line223	-0.034	-0.019	0.034	0.018	0.0	-0.6	96.1	96.1	0.00
Line225	0.019	0.010	-0.019	-0.012	0.0	-1.9	96.1	96.1	0.00
Line227	1.423	0.583	-1.422	-0.587	0.9	-4.4	96.1	96.0	0.09
Line229	1.336	0.534	-1.336	-0.535	0.1	-0.8	96.0	96.0	0.01
Line231	0.087	0.053	-0.087	-0.054	0.0	-0.8	96.0	96.0	0.00
Line233	1.317	0.523	-1.317	-0.524	0.1	-0.5	96.0	96.0	0.01
Line235	1.315	0.523	-1.314	-0.524	0.2	-0.6	96.0	96.0	0.02
Line237	0.003	0.001	-0.003	-0.002	0.0	-0.8	96.0	96.0	0.00
Line239	1.314	0.524	-1.314	-0.524	0.1	-0.2	96.0	96.0	0.01
Line241	0.001	0.000	-0.001	0.000	0.0	-0.1	96.0	96.0	0.00
Line243	1.194	0.450	-1.194	-0.451	0.2	-0.9	96.0	96.0	0.02
Line246	0.032	0.017	-0.032	-0.017	0.0	-0.3	96.0	96.0	0.00
Line254	0.150	0.078	-0.150	-0.079	0.0	-1.3	96.0	96.0	0.01
Line264	1.012	0.356	-1.011	-0.360	0.8	-4.6	96.0	95.9	0.08
Line248	0.009	0.003	-0.009	-0.006	0.0	-2.6	96.0	96.0	0.00

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line251	0.083	0.038	-0.083	-0.039	0.0	-1.0	96.0	96.0	0.00
Line256	0.006	0.003	-0.006	-0.004	0.0	-0.4	96.0	96.0	0.00
Line252	0.051	0.019	-0.051	-0.023	0.0	-4.0	96.0	95.9	0.01
Line261	0.028	0.009	-0.028	-0.012	0.0	-3.4	95.9	95.9	0.00
Line262	-0.023	-0.014	0.023	0.009	0.0	-5.2	95.9	95.9	0.00
Line266	0.975	0.338	-0.974	-0.344	0.9	-5.8	95.9	95.8	0.10
Line268	0.885	0.292	-0.885	-0.293	0.1	-0.6	95.8	95.8	0.01
Line270	0.033	0.016	-0.033	-0.020	0.0	-3.6	95.8	95.8	0.00
Line274	-0.010	-0.006	0.010	-0.001	0.0	-6.5	95.8	95.8	0.00
Line272	0.010	0.002	-0.010	-0.006	0.0	-4.4	95.8	95.8	0.00
Line276	0.865	0.291	-0.864	-0.302	1.2	-10.2	95.8	95.6	0.15
Line280	0.862	0.301	-0.862	-0.302	0.1	-1.1	95.6	95.6	0.02
Line278	-0.008	-0.005	0.008	0.003	0.0	-1.8	95.6	95.6	0.00
Line282	0.013	0.002	-0.013	-0.006	0.0	-3.3	95.6	95.6	0.00
Line294	0.843	0.299	-0.842	-0.305	0.6	-5.3	95.6	95.5	0.08
Line648	0.006	0.000	-0.006	-0.004	0.0	-4.0	95.6	95.6	0.00
Line286	0.005	0.002	-0.005	-0.003	0.0	-0.7	95.6	95.6	0.00
Line296	0.829	0.296	-0.829	-0.298	0.1	-1.1	95.5	95.5	0.02
Line298	0.017	0.000	-0.017	-0.004	0.0	-3.9	95.5	95.5	0.00
Line301	0.811	0.297	-0.811	-0.305	0.7	-7.3	95.5	95.4	0.10
Line300	0.010	0.000	-0.010	-0.006	0.0	-6.5	95.5	95.5	0.00
Line304	0.000	-0.001	0.000	0.000	0.0	-1.8	95.4	95.4	0.00
Line306	0.031	0.012	-0.031	-0.016	0.0	-3.7	95.4	95.4	0.00
Line312	0.780	0.294	-0.779	-0.301	0.6	-6.7	95.4	95.3	0.09
Line308	-0.022	-0.014	0.022	0.013	0.0	-0.2	95.4	95.4	0.00
Line310	0.009	0.002	-0.009	-0.005	0.0	-2.9	95.4	95.4	0.00
Line314	0.717	0.262	-0.717	-0.264	0.2	-2.2	95.3	95.3	0.03
Line316	0.030	0.016	-0.030	-0.018	0.0	-2.2	95.3	95.3	0.00
Line318	0.687	0.248	-0.687	-0.256	0.5	-7.5	95.3	95.2	0.09
Line320	0.657	0.243	-0.657	-0.244	0.0	-0.7	95.2	95.2	0.01
Line322	0.029	0.013	-0.029	-0.018	0.0	-5.8	95.2	95.2	0.00
Line324	0.628	0.226	-0.627	-0.243	1.1	-17.4	95.2	95.0	0.19
Line325	0.617	0.238	-0.617	-0.239	0.1	-1.3	95.0	95.0	0.01
Line327	0.010	0.005	-0.010	-0.006	0.0	-0.6	95.0	95.0	0.00
Line329	0.602	0.230	-0.602	-0.233	0.2	-2.8	95.0	95.0	0.03
Line330	0.592	0.226	-0.592	-0.229	0.1	-2.4	95.0	94.9	0.02
Line340	0.585	0.225	-0.585	-0.228	0.2	-2.9	94.9	94.9	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
Line359	0.584	0.227	-0.584	-0.232	0.3	-5.0	94.9	94.9	0.05
Line360	0.581	0.230	-0.580	-0.247	0.9	-17.4	94.9	94.7	0.18
Line361	0.576	0.245	-0.576	-0.245	0.0	-0.2	94.7	94.7	0.00
Line368	-0.066	-0.041	0.066	0.038	0.0	-2.3	94.7	94.7	0.01
Line367	-0.068	-0.040	0.068	0.037	0.0	-3.3	94.7	94.7	0.00
Line364	0.508	0.209	-0.508	-0.211	0.1	-2.8	94.7	94.7	0.02
Line365	0.017	0.005	-0.017	-0.006	0.0	-0.6	94.7	94.7	0.00
Line370	0.491	0.206	-0.491	-0.208	0.0	-1.2	94.7	94.6	0.01
Line372	0.005	-0.001	-0.005	-0.003	0.0	-4.6	94.7	94.7	0.00
Line374	0.005	0.002	-0.005	-0.003	0.0	-1.1	94.6	94.6	0.00
Line376	0.486	0.206	-0.486	-0.207	0.1	-1.7	94.6	94.6	0.01
Line380	0.484	0.206	-0.484	-0.207	0.0	-0.4	94.6	94.6	0.00
Line381	-0.371	-0.138	0.371	0.138	0.0	-0.6	94.6	94.6	0.00
Line390	0.038	0.024	-0.038	-0.024	0.0	-0.2	94.6	94.6	0.00
Line392	0.333	0.115	-0.333	-0.115	0.0	-0.5	94.6	94.6	0.00
Line386	0.113	0.069	-0.113	-0.069	0.0	-0.4	94.6	94.6	0.00
Line385	-0.084	-0.052	0.084	0.051	0.0	-0.3	94.6	94.6	0.00
Line388	0.029	0.018	-0.029	-0.018	0.0	-0.3	94.6	94.6	0.00
Line395	0.301	0.095	-0.299	-0.155	1.6	-59.2	94.6	94.1	0.54
Line398	0.279	0.142	-0.279	-0.145	0.1	-2.7	94.1	94.1	0.02
Line405	-0.013	-0.008	0.013	0.002	0.0	-5.6	94.1	94.1	0.00
Line402	0.046	0.015	-0.046	-0.021	0.0	-5.3	94.1	94.1	0.01
Line403	0.233	0.129	-0.233	-0.132	0.1	-2.8	94.1	94.0	0.02
Line411	0.221	0.124	-0.220	-0.130	0.1	-5.3	94.0	94.0	0.04
Line407	0.033	0.018	-0.033	-0.020	0.0	-1.6	94.1	94.1	0.00
Line409	0.013	0.008	-0.013	-0.008	0.0	-0.4	94.1	94.1	0.00
Line415	0.200	0.117	-0.200	-0.118	0.0	-0.4	94.0	94.0	0.00
Line416	0.180	0.105	-0.180	-0.106	0.0	-0.7	94.0	94.0	0.00
Line425	0.160	0.093	-0.160	-0.095	0.0	-1.6	94.0	94.0	0.01
Line427	-0.020	-0.012	0.020	0.012	0.0	-0.3	94.0	94.0	0.00
Line429	0.140	0.083	-0.140	-0.084	0.0	-0.6	94.0	94.0	0.00
Line431	0.060	0.036	-0.060	-0.036	0.0	-0.3	94.0	94.0	0.00
Line433	0.040	0.024	-0.040	-0.024	0.0	-0.7	94.0	94.0	0.00
Line441	0.040	0.024	-0.040	-0.024	0.0	-0.3	94.0	94.0	0.00
Line439	0.020	0.012	-0.020	-0.012	0.0	-0.3	94.0	94.0	0.00
Line437	0.040	0.024	-0.040	-0.024	0.0	-0.5	94.0	94.0	0.00
Line436	-0.020	-0.012	0.020	0.012	0.0	-0.4	94.0	94.0	0.00

	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
Branch ID	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line443	0.020	0.012	-0.020	-0.012	0.0	-0.7	94.0	94.0	0.00
Line445	-0.218	-0.135	0.218	0.135	0.0	-0.2	97.0	97.0	0.00
Line447	1.042	0.435	-1.042	-0.437	0.3	-1.5	97.0	97.0	0.03
Line451	-0.199	-0.100	0.199	0.099	0.0	-1.6	97.0	97.0	0.01
Line455	0.177	0.087	-0.177	-0.088	0.0	-0.5	97.0	96.9	0.00
Line449	0.245	0.116	-0.245	-0.123	0.1	-6.9	97.0	97.0	0.03
Line464	0.796	0.321	-0.796	-0.324	0.2	-2.6	97.0	96.9	0.04
Line453	0.047	0.024	-0.047	-0.029	0.0	-4.9	97.0	96.9	0.01
Line457	-0.166	-0.087	0.166	0.085	0.0	-2.6	96.9	96.9	0.01
Line642	0.152	0.079	-0.152	-0.085	0.0	-6.6	96.9	96.9	0.03
Line459	0.011	0.003	-0.011	-0.007	0.0	-4.0	96.9	96.9	0.00
Line461	-0.026	-0.013	0.026	0.007	0.0	-6.6	96.9	96.9	0.00
Line462	0.013	0.005	-0.013	-0.008	0.0	-2.6	96.9	96.9	0.00
Line466	0.788	0.319	-0.788	-0.319	0.0	-0.3	96.9	96.9	0.00
Line467	0.747	0.294	-0.747	-0.298	0.4	-4.6	96.9	96.9	0.06
Line469	0.711	0.276	-0.710	-0.285	0.6	-8.7	96.9	96.8	0.10
Line471	0.081	0.046	-0.081	-0.048	0.0	-1.5	96.8	96.8	0.00
Line477	0.630	0.239	-0.630	-0.240	0.1	-1.2	96.8	96.8	0.01
Line475	0.040	0.023	-0.040	-0.025	0.0	-2.0	96.8	96.8	0.00
Line479	0.268	0.128	-0.268	-0.130	0.0	-1.1	96.8	96.8	0.01
Line481	0.362	0.111	-0.362	-0.115	0.1	-3.2	96.8	96.8	0.02
Line483	0.221	0.101	-0.221	-0.104	0.0	-3.4	96.8	96.8	0.01
Line485	0.195	0.088	-0.195	-0.091	0.0	-3.3	96.8	96.7	0.01
Line487	0.181	0.082	-0.181	-0.088	0.0	-5.1	96.7	96.7	0.02
Line489	0.029	0.018	-0.029	-0.018	0.0	-0.1	96.7	96.7	0.00
Line494	0.151	0.069	-0.151	-0.073	0.0	-3.4	96.7	96.7	0.01
Line495	0.127	0.058	-0.127	-0.061	0.0	-2.5	96.7	96.7	0.01
Line496	0.111	0.051	-0.111	-0.053	0.0	-1.9	96.7	96.7	0.00
Line499	0.045	0.024	-0.045	-0.025	0.0	-0.9	96.7	96.7	0.00
Line506	0.067	0.028	-0.067	-0.031	0.0	-2.4	96.7	96.7	0.00
Line501	0.017	0.008	-0.017	-0.010	0.0	-2.5	96.7	96.7	0.00
Line507	0.037	0.019	-0.037	-0.021	0.0	-1.7	96.7	96.7	0.00
Line509	0.029	0.012	-0.029	-0.016	0.0	-4.6	96.7	96.7	0.00
Line505	0.019	0.009	-0.019	-0.012	0.0	-2.3	96.7	96.7	0.00
Line511	0.017	0.009	-0.017	-0.011	0.0	-2.1	96.7	96.7	0.00
Line513	0.325	0.092	-0.325	-0.095	0.0	-3.3	96.8	96.7	0.02
Line515	0.315	0.089	-0.315	-0.092	0.0	-3.5	96.7	96.7	0.02

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line517	0.008	0.000	-0.008	-0.005	0.0	-5.0	96.7	96.7	0.00
Line520	0.307	0.092	-0.307	-0.093	0.0	-0.7	96.7	96.7	0.00
Line521	-0.180	-0.041	0.180	0.040	0.0	-0.4	96.7	96.7	0.00
Line531	0.145	0.019	-0.145	-0.021	0.0	-1.8	96.7	96.7	0.00
Line522	0.280	0.076	-0.280	-0.083	0.1	-6.2	96.7	96.7	0.03
Line524	0.101	0.042	-0.101	-0.044	0.0	-1.1	96.7	96.7	0.00
Line526	0.072	0.026	-0.072	-0.028	0.0	-2.1	96.7	96.7	0.00
Line525	-0.061	-0.023	0.061	0.021	0.0	-2.2	96.7	96.7	0.00
Line528	0.033	0.006	-0.033	-0.013	0.0	-7.7	96.7	96.7	0.01
Line527	-0.021	-0.013	0.021	0.006	0.0	-6.9	96.7	96.7	0.00
Line532	0.071	0.001	-0.071	-0.004	0.0	-2.8	96.7	96.7	0.00
Line534	-0.092	-0.014	0.092	0.012	0.0	-1.7	96.7	96.7	0.00
Line566	0.053	0.009	-0.053	-0.009	0.0	-0.2	96.7	96.7	0.00
Line538	0.063	-0.001	-0.063	-0.002	0.0	-3.3	96.7	96.7	0.01
Line544	0.050	-0.006	-0.050	0.001	0.0	-5.6	96.7	96.7	0.01
Line543	-0.047	-0.001	0.047	-0.002	0.0	-2.6	96.7	96.7	0.00
Line547	0.041	-0.003	-0.041	0.002	0.0	-0.4	96.7	96.7	0.00
Line546	0.003	0.001	-0.003	-0.002	0.0	-0.7	96.7	96.7	0.00
Line550	0.017	0.002	-0.017	-0.003	0.0	-1.1	96.7	96.7	0.00
Line558	0.024	-0.004	-0.024	-0.004	0.0	-8.1	96.7	96.7	0.00
Line548	0.001	-0.002	-0.001	-0.001	0.0	-2.9	96.7	96.7	0.00
Line549	-0.006	0.003	0.006	-0.004	0.0	-1.3	96.7	96.7	0.00
Line552	0.005	-0.001	-0.005	0.000	0.0	-1.5	96.7	96.7	0.00
Line554	0.002	-0.001	-0.002	-0.001	0.0	-2.5	96.7	96.7	0.00
Line557	-0.017	-0.002	0.017	0.000	0.0	-2.2	96.7	96.7	0.00
Line560	0.012	-0.001	-0.012	-0.002	0.0	-2.8	96.7	96.7	0.00
Line559	0.008	0.000	-0.008	-0.005	0.0	-5.5	96.7	96.7	0.00
Line562	-0.164	-0.086	0.164	0.086	0.0	-0.1	97.4	97.4	0.00
Line569	0.114	0.065	-0.114	-0.069	0.0	-3.2	97.4	97.4	0.01
Line613	0.049	0.021	-0.049	-0.023	0.0	-2.6	97.4	97.4	0.00
Line594	0.082	0.048	-0.082	-0.051	0.0	-2.1	97.4	97.4	0.00
Line564	-0.006	0.012	0.006	-0.016	0.0	-4.3	96.7	96.7	0.00
Line568	0.006	-0.012	-0.006	0.010	0.0	-2.1	96.7	96.7	0.00
Line565	-0.021	0.006	0.021	-0.011	0.0	-4.1	96.7	96.7	0.00
Line567	0.002	-0.004	-0.002	-0.001	0.0	-5.5	96.7	96.7	0.00
Line646	0.004	-0.005	-0.004	0.000	0.0	-5.3	96.7	96.7	0.00
Line570	-0.001	-0.001	0.001	-0.002	0.0	-2.6	96.7	96.7	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
Line572	0.946	0.532	-0.946	-0.534	0.3	-2.0	97.7	97.7	0.04
Line573	0.067	0.040	-0.067	-0.042	0.0	-1.1	97.7	97.7	0.00
Line574	-0.058	-0.036	0.058	0.036	0.0	-0.2	97.7	97.7	0.00
Line575	-0.245	-0.152	0.245	0.150	0.0	-1.6	97.6	97.6	0.01
Line576	-0.016	-0.010	0.016	0.006	0.0	-3.8	97.5	97.5	0.00
Line577	0.887	0.498	-0.887	-0.499	0.1	-0.6	97.7	97.6	0.01
Line578	0.642	0.348	-0.641	-0.358	0.6	-9.4	97.6	97.5	0.11
Line581	0.625	0.351	-0.624	-0.354	0.2	-3.4	97.5	97.5	0.04
Line584	0.608	0.344	-0.608	-0.348	0.2	-3.7	97.5	97.5	0.04
Line586	0.422	0.255	-0.422	-0.256	0.0	-0.7	97.5	97.5	0.01
Line589	0.186	0.092	-0.185	-0.096	0.0	-3.7	97.5	97.4	0.01
Line650	0.259	0.155	-0.259	-0.156	0.0	-0.7	97.5	97.4	0.00
Line588	-0.007	-0.004	0.007	-0.001	0.0	-4.8	97.4	97.4	0.00
Line590	0.016	0.010	-0.016	-0.010	0.0	-0.1	97.4	97.4	0.00
Line591	0.006	0.000	-0.006	-0.004	0.0	-3.3	97.4	97.4	0.00
Line615	0.033	0.014	-0.033	-0.018	0.0	-3.2	97.4	97.4	0.00
Line617	0.016	0.009	-0.016	-0.010	0.0	-1.4	97.4	97.4	0.00
Line619	0.016	0.008	-0.016	-0.010	0.0	-2.6	97.4	97.4	0.00
Line621	0.016	0.010	-0.016	-0.010	0.0	-0.1	97.4	97.4	0.00
Line638	-2.982	-1.863	2.998	1.870	16.3	7.6	92.4	92.9	0.47
Line644	0.010	0.002	-0.010	-0.006	0.0	-3.8	96.6	96.6	0.00
					334.6	35.6			

Alert Summary Report

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

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus203	Bus	Under Voltage	11.000	kV	9.893	89.9	3-Phase
Bus205	Bus	Under Voltage	11.000	kV	9.84	89.5	3-Phase
Bus207	Bus	Under Voltage	11.000	kV	9.79	89.0	3-Phase
Bus209	Bus	Under Voltage	11.000	kV	9.68	88.0	3-Phase
Bus211	Bus	Under Voltage	11.000	kV	9.65	87.7	3-Phase
Bus212	Bus	Under Voltage	11.000	kV	9.65	87.7	3-Phase
Bus214	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus216	Bus	Under Voltage	11.000	kV	9.64	87.6	3-Phase
Bus222	Bus	Under Voltage	11.000	kV	9.56	86.9	3-Phase
Bus224	Bus	Under Voltage	11.000	kV	9.56	86.9	3-Phase
Bus226	Bus	Under Voltage	11.000	kV	9.63	87.6	3-Phase
Bus227	Bus	Under Voltage	11.000	kV	9.63	87.6	3-Phase
Bus229	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus231	Bus	Under Voltage	11.000	kV	9.63	87.6	3-Phase
Bus233	Bus	Under Voltage	11.000	kV	9.62	87.4	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus235	Bus	Under Voltage	11.000	kV	9.613	87.4	3-Phase
Bus237	Bus	Under Voltage	11.000	kV	9.61	87.3	3-Phase
Bus239	Bus	Under Voltage	11.000	kV	9.60	87.3	3-Phase
Bus241	Bus	Under Voltage	11.000	kV	9.60	87.2	3-Phase
Bus243	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus244	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus246	Bus	Under Voltage	11.000	kV	9.62	87.5	3-Phase
Bus671	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus679	Bus	Under Voltage	11.000	kV	9.62	87.5	3-Phase
Khuruthang control room	Bus	Under Voltage	11.000	kV	9.56	86.9	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus196	Bus	Under Voltage	11.000	kV	10.126	92.1	3-Phase
Bus199	Bus	Under Voltage	11.000	kV	10.28	93.4	3-Phase
Bus201	Bus	Under Voltage	11.000	kV	10.11	91.9	3-Phase
Bus379	Bus	Under Voltage	33.000	kV	31.35	95.0	3-Phase
Bus383	Bus	Under Voltage	33.000	kV	31.34	95.0	3-Phase
Bus384	Bus	Under Voltage	33.000	kV	31.33	94.9	3-Phase
Bus412	Bus	Under Voltage	33.000	kV	31.32	94.9	3-Phase
Bus413	Bus	Under Voltage	33.000	kV	31.30	94.9	3-Phase
Bus414	Bus	Under Voltage	33.000	kV	31.25	94.7	3-Phase
Bus422	Bus	Under Voltage	33.000	kV	31.24	94.7	3-Phase
Bus423	Bus	Under Voltage	33.000	kV	31.24	94.7	3-Phase
Bus424	Bus	Under Voltage	33.000	kV	31.25	94.7	3-Phase
Bus425	Bus	Under Voltage	33.000	kV	31.24	94.7	3-Phase
Bus427	Bus	Under Voltage	33.000	kV	31.24	94.7	3-Phase
Bus429	Bus	Under Voltage	33.000	kV	31.24	94.7	3-Phase
Bus430	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus432	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus436	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus438	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus439	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus442	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus443	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus445	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus447	Bus	Under Voltage	33.000	kV	31.227	94.6	3-Phase
Bus450	Bus	Under Voltage	33.000	kV	31.23	94.6	3-Phase
Bus451	Bus	Under Voltage	33.000	kV	31.05	94.1	3-Phase
Bus453	Bus	Under Voltage	33.000	kV	31.04	94.1	3-Phase
Bus455	Bus	Under Voltage	33.000	kV	31.04	94.1	3-Phase
Bus457	Bus	Under Voltage	33.000	kV	31.03	94.0	3-Phase
Bus458	Bus	Under Voltage	33.000	kV	31.04	94.1	3-Phase
Bus460	Bus	Under Voltage	33.000	kV	31.04	94.1	3-Phase
Bus462	Bus	Under Voltage	33.000	kV	31.04	94.1	3-Phase
Bus464	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus466	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus467	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus472	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus473	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus478	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus480	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus482	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus483	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus484	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus486	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus488	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus490	Bus	Under Voltage	33.000	kV	31.02	94.0	3-Phase
Bus673	Bus	Under Voltage	11.000	kV	10.17	92.4	3-Phase
Bus675	Bus	Under Voltage	11.000	kV	10.09	91.8	3-Phase
Bus677	Bus	Under Voltage	11.000	kV	10.22	92.9	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	8.360	5.010	9.746	85.78 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	8.360	5.010	9.746	85.78 Lagging
Total Motor Load:	1.959	1.214	2.305	85.00 Lagging
Total Static Load:	6.067	3.760	7.137	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.335	0.036		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure 5: Feeder Wise Reliability Indices

Sl.No.	Year	Month	Reliability Indices	33kV Feeder-I (Punakha-Gasa)	33kV Feeder-III (Thinleygang)	11 kV Feeder-I (Talo, Nobgang)	11 kV Feeder-II (Punakha)	Remarks
1	2017	January	SAIFI	3.00	-	-	6.00	
			SAIDI	8.91	-	-	5.75	
2		February	SAIFI	9.31	1.00	-	3.00	
			SAIDI	13.31	1.40	-	0.63	
3		March	SAIFI	15.00	1.00	1.00	1.00	
			SAIDI	7.45	0.10	0.10	0.10	
4		April	SAIFI	15.00	2.00	4.00	3.00	
			SAIDI	13.42	1.05	2.02	0.77	
5		May	SAIFI	18.00	-	2.00	7.00	
			SAIDI	12.96	-	0.70	2.75	
6		June	SAIFI	19.00	1.00	7.00	11.00	
			SAIDI	18.29	12.37	41.28	12.01	
7		July	SAIFI	34.00	1.00	2.00	7.00	
			SAIDI	31.11	0.82	0.35	3.36	
8		August	SAIFI	23.70	2.00	4.00	1.87	
			SAIDI	16.42	0.56	1.61	0.50	
9		September	SAIFI	14.68	0.99	2.00	0.54	
			SAIDI	6.38	0.35	1.43	0.09	
10		October	SAIFI	1.88	0.11	0.44	1.08	
			SAIDI	2.09	0.12	0.40	0.21	
11		November	SAIFI	3.29	0.55	0.88	0.27	
			SAIDI	0.81	0.23	0.62	0.88	
12		December	SAIFI	0.94	0.11	0.15	0.27	
			SAIDI	0.26	0.05	0.01	0.09	
	Total		**SAIFI**	**157.82**	**9.77**	**23.47**	**42.03**	
			SAIDI	**131.41**	**17.05**	**48.53**	**27.14**	
1	2018	January	SAIFI	0.47	0.11	0.73	1.36	
			SAIDI	0.10	0.08	0.41	0.59	
2		February	SAIFI	0.47	0.67	0.30	2.46	
			SAIDI	0.28	3.08	0.33	1.24	
3		March	SAIFI	13.00	-	-	-	
			SAIDI	2.26	-	-	-	
4		April	SAIFI		3.49		0.27	
			SAIDI		14.86		0.11	
5		May	SAIFI		1.17	0.15	0.67	
			SAIDI		0.47	0.08	0.82	
6		June	SAIFI		4.66	1.50		
			SAIDI		2.22	2.41		

Sl.No.	Year	Month	Reliability Indices	33kV Feeder-I (Punakha-Gasa)	33kV Feeder-III (Thinleygang)	11 kV Feeder-I (Talo, Nobgang)	11 kV Feeder-II (Punakha)	Remarks
7		July	SAIFI		12.19	0.72	0.55	
			SAIDI		14.21	0.38	0.12	
8		August	SAIFI	0.47	0.34	0.83	0.85	
			SAIDI	0.22	0.24	0.25	0.87	
9		September	SAIFI	0.94	0.22	1.43	1.39	
			SAIDI	0.66	0.22	0.80	0.68	
10		October	SAIFI	-	0.34	0.14	0.84	
			SAIDI	-	0.05	0.16	1.05	
11		November	SAIFI	0.47	0.11	-	0.28	
			SAIDI	0.11	0.24	-	0.10	
12		December	SAIFI	1.41	0.11	0.28	1.67	
			SAIDI	0.37	0.02	0.70	1.67	
	Total		**SAIFI**	**17.23**	**23.40**	**6.07**	**10.34**	
			SAIDI	**4.01**	**35.69**	**5.52**	**7.25**	
1	2019	January	SAIFI	0.94		0.72	0.56	
			SAIDI	0.23		0.41	0.08	
2		February	SAIFI	0.94			0.20	
			SAIDI	1.06			0.07	
3		March	SAIFI			0.82	0.22	
			SAIDI			0.41	0.05	
4		April	SAIFI	-	-	0.41	-	
			SAIDI	-	-	0.11	-	
5		May	SAIFI	1.88	-	0.40	0.22	
			SAIDI	1.71	-	0.11	0.22	
6		June	SAIFI	2.84	0.44	0.40	0.22	
			SAIDI	1.15	0.42	0.13	0.04	
	Total		**SAIFI**	**6.60**	**0.44**	**2.74**	**1.41**	
			SAIDI	**4.14**	**0.42**	**1.17**	**0.46**	
	Overall total		**SAIFI**	**24.09**	**23.89**	**8.83**	**11.84**	
			SAIDI	**139.55**	**53.16**	**55.21**	**34.85**	

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

Sl. No	Name of ESDs	11kV 1Φ Line (km)	33kV 1Φ Line (km)	Total 1Φ Line (km)
6	Mongar	0	0	0
7	Paro	24.772	14.937	39.709
8	Pemagatshel	0	31.705	31.705
9	Punakha	9.62	58.4	68.02
10	S/Jongkhar	0	93.672	93.672
11	Samtse	31.913	6.897	38.81
12	Sarpang	11.8862	14.299	26.1852
13	Trashigang	3.954	8.047	12.001
14	Trashiyangtse	0	28.36	28.36
15	Thimphu	5.93	0	5.93
16	Trongsa	0	5.383	5.383
17	Tsirang	0	21.756	21.756
18	Wangdue	1.01	29.7	30.71
19	Zhemgang	0	66.785	66.785
TOTAL		**136.32446**	**579.6086**	**715.93306**

Annexure 7: Distribution Transformer Loading

Sl.No.	Name of substation location	Capacity (kVA)	Existing		2025		2030	
			Peak Load (kVA)	% Loading	Peak Load(kVA)	% Loading	Peak Load(kVA)	% Loading
1	Above Phuentshopelri Palace	100	60	60.00%	103.09	103.09%	124.01	124.01%
2	Eusakha	63	36.85	58.49%	63.32	100.50%	76.16	120.90%
3	Gumkarmo	100	129	129.00%	221.65	221.65%	266.63	266.63%
4	Gubji	30	22	73.33%	37.8	126.00%	45.47	151.57%
5	Samdingkha Town	30	18.6	62.00%	31.96	106.53%	38.44	128.15%
6	Amankora Resort	400	240	60.00%	412.38	103.09%	496.05	124.01%
7	Dompola Mushroom Factory	125	75	60.00%	128.87	103.09%	155.02	124.01%
8	Zhingkham resort	500	300	60.00%	515.47	103.09%	620.06	124.01%
9	Tashithang	63	37.8	60.00%	64.95	103.09%	78.13	124.01%
10	Khaylow	30	18	60.00%	30.93	103.09%	37.2	124.01%
11	Panekong	30	18	60.00%	30.93	103.09%	37.2	124.01%
12	Yemina	30	18	60.00%	30.93	103.09%	37.2	124.01%
13	Gasa Town	30	23.62	78.73%	40.59	135.28%	48.82	162.73%
14	Gasa BHU	30	19.77	65.90%	33.97	113.23%	40.86	136.21%
15	Gasa Dzong/Telecom	30	18	60.00%	30.93	103.09%	37.2	124.01%
16	Punakha	30	18	60.00%	30.93	103.09%	37.2	124.01%
17	Tshachu Guest House	63	40.51	64.30%	69.61	110.49%	83.73	132.90%
18	Gamaluma	63	41.18	65.37%	62.39	99.03%	76.65	121.66%
19	Dhensa resort	500	300	60.00%	553.8	110.76%	675.13	135.03%
20	Sonamgang	63	39.91	63.35%	73.67	116.94%	89.81	142.56%
21	Jabchukarmo	16	9.6	60.00%	17.72	110.76%	21.6	135.03%
22	Kuenzangzhing resort	500	300	60.00%	553.8	110.76%	675.13	135.03%
23	Mitsena	500	305.35	61.07%	563.68	112.74%	687.17	137.43%
24	Zangdopelri Resort	315	189	60.00%	328.53	104.30%	399.88	126.95%
25	Animal Husbandary	63	37.8	60.00%	65.71	104.30%	79.98	126.95%
26	Chimipang	63	40.31	63.98%	70.07	111.22%	85.29	135.38%
27	Gumkarmo II	100	130	130.00%	225.97	225.97%	275.05	275.05%
28	YBM factory	100	60	60.00%	104.3	104.30%	126.95	126.95%
29	Lobeysa Transmission Station	125	75	60.00%	130.37	104.30%	158.68	126.95%

Annexure-8: Material Cost of three phase (3Φ) Transformers

Sl. No	Name of ESDs	Cost for replacement of single phase transformers and distribution boards with three phase		Total cost in Nu.
		11 kV transformers	33 kV transformers	
		Cost in Nu.	Cost in Nu.	
1	Bumthang	421,565.09	132,535.04	554,100.14
2	Chukhha	956,241.73	9,144,917.99	10,101,159.72
3	Dagana	–	6,361,682.08	6,361,682.08
4	Haa	–	3,048,306.00	3,048,306.00
5	Lhuntse	731,506.19	8,747,312.86	9,478,819.05
6	Mongar	182,876.55	4,108,586.34	4,291,462.89
7	Paro	836,897.46	1,060,280.35	1,897,177.81
8	Pemagatshel	91,438.27	6,759,287.21	6,850,725.48
9	Punakha	274,314.82	4,771,261.56	5,045,576.38
10	S/Jongkhar	–	15,506,600.07	15,506,600.07
11	Samtse	6,674,993.95	4,241,121.39	10,916,115.34
12	Sarpang	2,053,501.01	3,445,911.13	5,499,412.14
13	Trashi Gang	906,662.46	4,903,796.60	5,810,459.06
14	Trashiyangtse	–	4,638,726.52	4,638,726.52
15	Thimphu	723,785.91	–	723,785.91
16	Trongsa	91,438.27	3,445,911.13	3,537,349.40
17	Tsirang	–	5,168,866.69	5,168,866.69
18	Wangdue	182,876.55	1,457,885.48	1,640,762.02
19	Zhemgang	105,391.27	11,928,153.90	12,033,545.17
	TOTAL	**14,233,489.55**	**98,871,142.33**	**113,104,631.87**

Here the existing single phase transformers and distribution boards were replaced by three phase system, therefore the estimation includes the cost of three phase transformers and distribution boards.In line with Distribution Design and Construction Standard (DDCS) 2015, the transformer capacities according to voltage level are standardized as shown below:

33 kV System		11 kV System	
3 Φ	**1Φ**	**3 Φ**	**1Φ**
25 kVA	25 kVA, 16 kVA	25 kVA, 16 kVA	25 kVA,16 kVA, 10 kVA

Therefore, during the estimation, on 33 kV system, the cost of 25 kVA transformers was taken for 10 kVA and 16 kVA transformers and for 11 kV system, the cost of 16 kVA transformers was taken for 10 kVA ratings. The total cost for replacing the 1-phase transformers under whole ESD including transportation cost (Nu. 2.6 million) and labor cost (Nu. 70 million) is Nu. 186 million. Therefore, the total cost under this option will amount to Nu. 283 million.

11 kV & 33 kV Single Phase Transformers used under each ESD

Sl. No	Name of ESDs	TRANSFORMERS (Nos.)					
		11/0.240 kV			33/0.240 kV		
		10 kVA	16kVA	25kVA	10 kVA	16kVA	25kVA
1	Bumthang	–	–	4	–	1	–
2	Chukhha	2	5	3	19	31	19
3	Dagana	–	–	–	4	43	1
4	Haa	–	–	–	8	13	2
5	Lhuntse	3	5	–	3	19	44
6	Mongar		2	–	12	17	2
7	Paro	5	3	1	6	2	–
8	Pemagatshel	–	1	–	4	8	39
9	Punakha	1	2	–	2	5	29
10	S/Jongkhar	–	–	–	18	24	75
11	Samtse	15	58	–	–	32	–
12	Sarpang	10	9	3	9	8	9
13	Trashi Gang	3	–	6	–	–	37
14	Trashiyangtse	–	–	–	16	19	–
15	Thimphu*	–	1	6	–	–	–
16	Trongsa	1	–	–	9	17	–
17	Tsirang	–	–	–	7	32	–
18	Wangdue	1	1	–	–	2	9
19	Zhemgang	–	–	1	27	36	27
	TOTAL	**41**	**87**	**24**	**144**	**309**	**293**