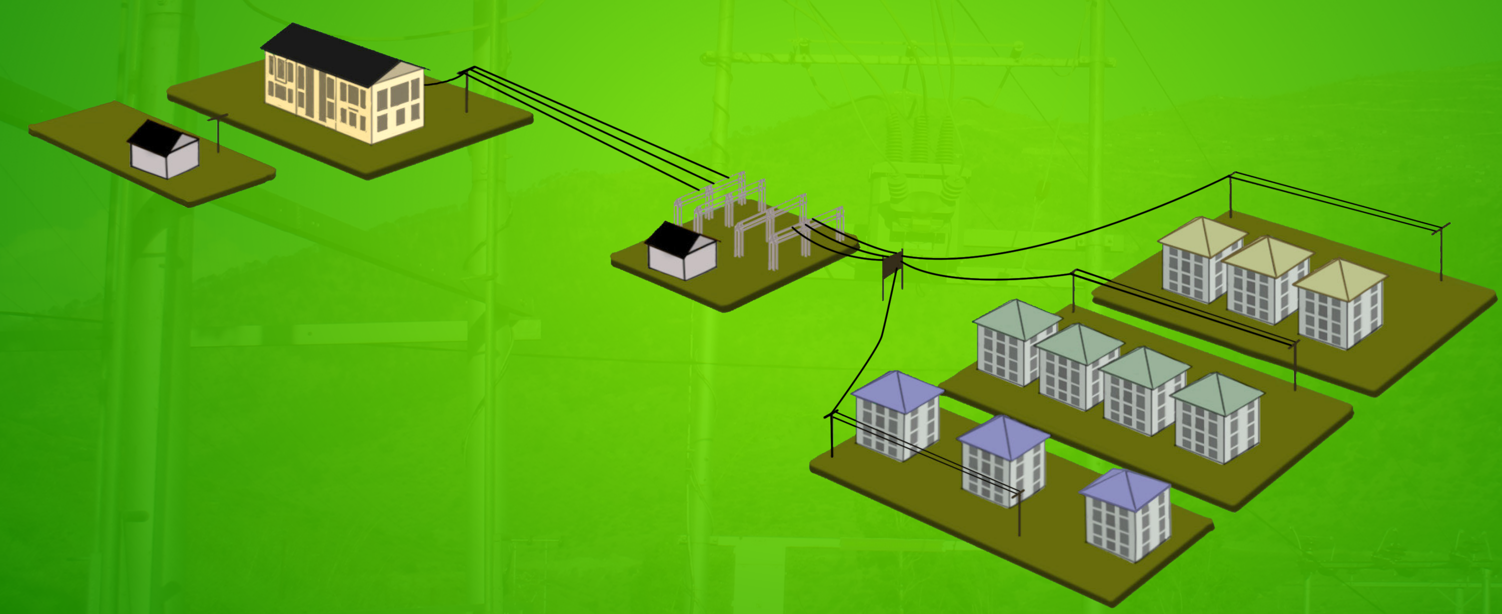
BHUTAN POWER CORPORATION LIMITED

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

P.O. Box : 580, Yarden Lam
Thimphu, Bhutan (Registered Office)
Website: www.bpc.bt

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

MONGAR DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)
MONGAR DZONGKHAG

Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

FOREWORD

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

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

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

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

(Sonam Tobjey)
Chief Executive Officer

Preparation, Review & Approval of the Document

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

Table of Contents

List of Tables

List of Figures

Abbreviations

BPC: Bhutan Power Corporation Limited
ESD: Electricity Services Division
DSMP: Distribution System Master Plan
GIS: Geographical Information System
SLD: Single Line Diagram
ETAP: Electrical Transient and Analysis Program
IS: Indian Standard on Transformers
IEC: International Electro-Technical Commission
IP: Industrial Park
DT: Distribution Transformer
ISD: Intelligent Switching Device
FPI: Fault Passage Indicator
ICT: Interconnecting Transformer
TSA: Time Series Analysis
LRM: Linear Regression Method
MV: Medium voltage (33kV, 11kV and 6.6kV)
DDCS: Distribution Design and Construction Standards
kVA: Kilo Volt Ampere
W: Watt
kWh: Kilo Watt Hour
RMU: Ring Main Unit
ARCB: Auto Recloser Circuit Breaker

Definitions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Outage - Interruption of service to an electric consumer.

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

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

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

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

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

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

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

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

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

Power supply - Source of current and voltage.

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

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

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

1. Executive Summary

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

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

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

The details on the distribution grid modernization are outlined in Smart Grid Master Plan2019 including the investment (2020-2027). The identification of the system deficiencies and qualitative remedial measures that would require system automation and remote control as per the existing and projected load is only outlined in this report.

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

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

2. Introduction

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

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

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

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

3. Objectives of the Master Plan

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

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

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

3.3 To come out with annual investment plans.

4. Scope of the Distribution System Master Plan

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

5. Methodology and Approach

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

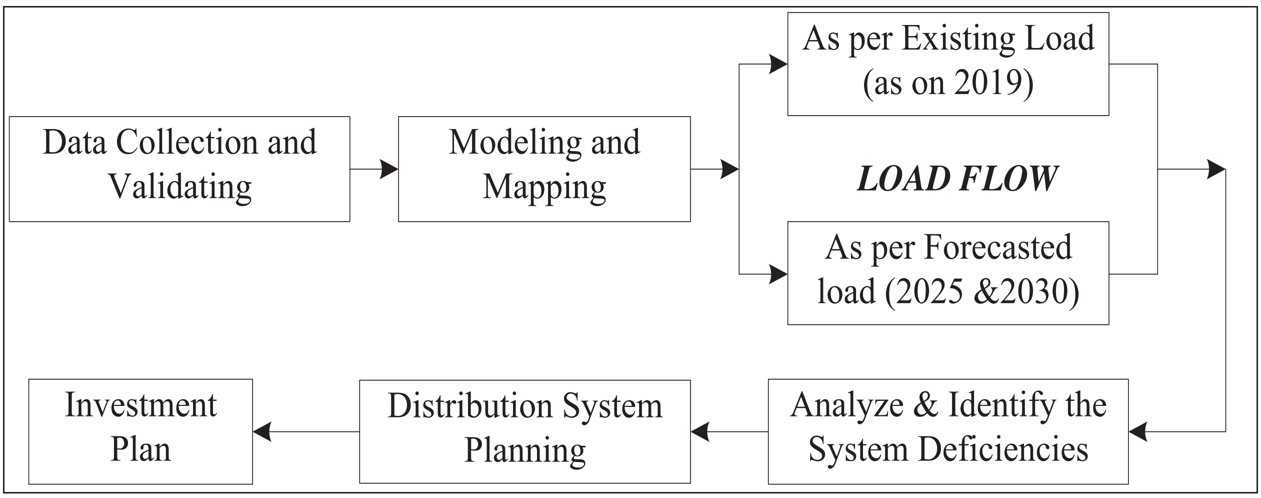


Figure 1: Block diagram for distribution system planning for thematic studies

5.1 Data Collection and Validation

To carry out the detailed studies with greater accuracy, complete and reliable data of the existing distribution infrastructure is required. Therefore, an intensive field investigation was carried out during April and May (2019-2020) to validate the information that was collected. The information required for the studies does not confine to the BPC's internal distribution network but also the developmental activities of the cross-governmental sectors. The power arrangement requirements from these developmental activities were also used to forecast the power demand. The data validation on the distribution system includes the review of all the power sources, medium voltage lines, and transformers with that of GIS data of Environment and GIS Division and SLD submitted by respective ESDs which is attached as **Annexure-1.**

5.2 Modeling and Mapping

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

5.3 Analysis and Identification of System Deficiencies

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

5.4 Distribution System Planning

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

5.5 Investment Plan

The approved investment plans (from 2020 to 2024) have been validated based on the outcome of the system studies and accordingly, the yearly investment plans are outlined as per the priority matrix as detailed in **Section 9.**

6. Existing Electricity Distribution Network

6.1 Overview of the power supply sources

Mongar Dzongkhag comprises of the seventeen Gewogs (Balam, Chaskar, Chhali, Dramitse, Drepong, Gongdue, Jurmey, Khengkhar, Mongar, Ngatshang, Saling, Sherimung, Silambi, Thangrong, Tsakaling, Narang, and Tsamang). The power supply to these Gewogs is being fed from the 132/33/11 kV Kilikhar substation. The basic electricity distribution network model as seen from the source at Kilikhar is illustrated in the schematic diagram shown in **Figure 2**.

As can be seen from the figure, a 132 kV line has been constructed from Kurichu Hydropower Pant (4x14 MW) to Kilikhar where a 132/33/11 kV substation has been installed. A transformation capacity of 15 MVA (1x10, 1x5), 132/33kV and 2x2.5 MVA, 33/11 kV is available. There are four 33kV feeders; Feeder-I (Drepong/Kengkhar), Feeder-II (Yadi/Ngatsang), Feeder-III (Lhuntse), and Feeder-IV (Khalanzi/Lingmethang). The 33kV Lhuentse outgoing feeder from the Kilikhar substation solely supplies the power to Lhuentse Dzongkhag. The 33kV Khalanzi feeder links 1x2.5 MVA, 33/11kV Khalanzi substation. Similarly, there are nine 11 kV feeders including the two incomers.

Mongar Dzongkhag also has a 2x200 kW mini hydropower plant at Khalanzi. The power output from the mini hydel is synchronized and injected into the grid. Further, part of Mongar (Narang & Dramitse Gewog) is catered by Odzorong feeder sourced from 132/33/11 kV Kanglung substation at Trashigang.

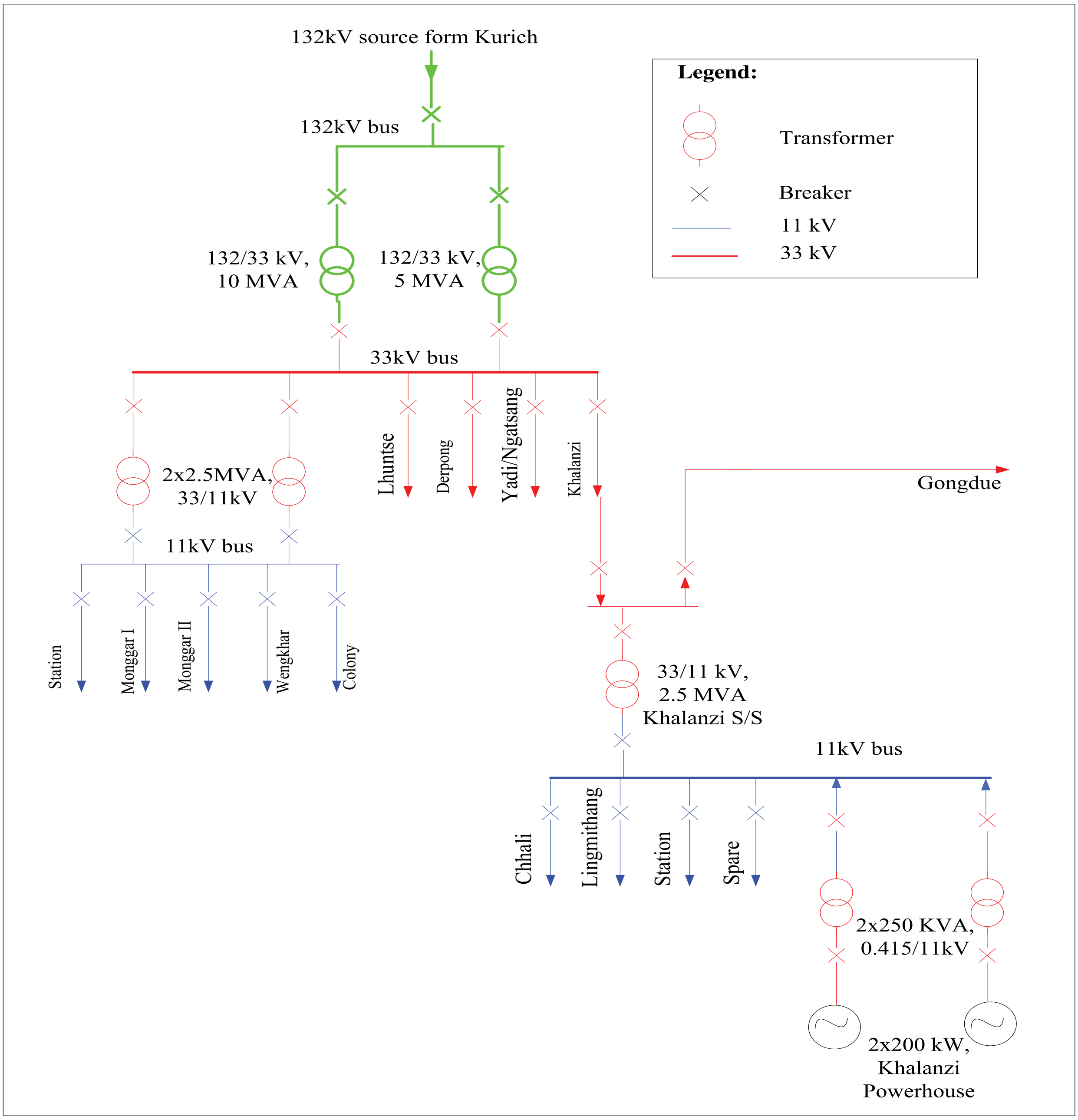


Figure 2: Electricity Distribution Schematic of Mongar Dzongkhag

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Details of ESD Mongar

Sl. No.	33 kV(KM)		11 kV (KM)		Total MV line		LV lines (KM)		Total line length (KM)
	OH	UG	OH	UG	OH	UG	OH	UG	
1	312.67	0.40	154.76	1.32	467.44	1.72	578.16	3.84	1050.79

The total MV line length is 469.16 km and the total LV line length is 582 km. The ratio of MV to LV line length is 1:1.24, which is within the generally acceptable range of 1:1.2. Hence, it is recommended to maintain the same ratio for better power distribution. While the ratio of LV to MV line length would vary according to the site conditions, as a general rule, a ratio of 1.2:1 should be maintained which would balance the initial capex and optimize the running and maintenance costs. The MV distribution network is mainly through 33 kV and 11 kV overhead lines with some networks in the town areas being through underground cables.

6.3 Distribution Transformers

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

Table 2: Total Numbers of Transformers, installed capacity & customers

Sl. No.	Name of Feeder	Voltage Ratio	Nos. of Transformer	kVA Rating	Number of customers	Line length (km)
1	33 kV Yadi/Ngatshang	33/0.240kV	21	291	2523	126.484
		33/0.415kV	73	3741		
		33/0.240kV	32	584		
2	33 kV Drepong	33/0.415kV	41	1201	1227	68.717
		33/0.240kV	19	259		
3	33 kV Khalanzi	33/0.415kV	25	550	535	80.439
		11/0.240kV	4	58		
4	11kV Mongar I	11/0.415kV	16	2130	1327	19.572
		11/0.240kV	0	0		
5	11kV Mongar II	11/0.415kV	14	3472	792	16.181
		11/0.240kV	0	0		
6	11kV Wengkhar	11/0.415kV	5	302	263	9.41

Sl. No.	Name of Feeder	Voltage Ratio	Nos. of Transformer	kVA Rating	Number of customers	Line length (km)
7	33kV Odzorong	33/0.240kV	5	80	1034	37.034
		33/0.415kV	37	1896		
8	11kV Chali/Tsakaling	11/0.240kV	4	67	819	28.884
		11/0.415kV	18	1006		
9	11kV Lingmethang	11/0.240kV	3	48	999	75.782
		11/0.415kV	49	4645		
10	11kV Station	11/0.240kV	0	0		
		11/0.415kV	1	63		
11	11kV BPC	11/0.240kV	0	0	703	4.03
		11/0.415kV	5	1445		
12	11kV KHPC Colony	11/0.240kV	0	0	240	1.32
		11/0.415kV	1	630		
	Total		**373**	**22,468.00**	**10,462.00**	**467.853**

As of September 2019, there were 373 (360 BPC & 33 Private) transformers with a total capacity of 22,468 kVA. As can be inferred from **Table 2**. The installed capacity of the transformer per customer is 2.2 kVA per customer.

7. Analysis of Distribution System

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

7.1 Assessment of Power Sources

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

7.1.1 HV Substation (220/132/66/33/11 kV)

Kilikhar substation is the primary power source for Mongar and Lhuentse Dzongkhags. To assess the capacity of the substation, the peak power consumed has been compiled based on the historical data. The details on the installed capacity of substations, existing peak load, and anticipated load in the future are tabulated in **Table 3.**

Table 3: Peak load of HV Substation

Sl. No	Name of Source	Available Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
		MVA	MW	2019	2025	2030
1	**Kilikhar Substation**					
	132/33 kV	1x10 & 1x5	12.75	7.23	11.76	15.14
	33/11kV	2x2.5	4.25	1.64	3.58	4.54

Note: *Considering the power factor of 0.85*

As seen, the 132/33 kV substation recorded a peak load of 7.23 MW at 33 kV voltage level and 1.64 MW at 11 kV voltage as of 2019. The substation has adequate capacity to cater to the existing load. However, the time series forecast suggests that the capacity of the existing 132/33 kV substation at Kilikhar would have to be Upgraded as the peak power consumptions of two Dzongkhags has been projected to reach 15.137 MW by 2030.

7.1.2 MV Substation (33/11 kV)

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

Table 4: Peak load of MV Substation *(Note: Considering the power factor of 0.85)*

Sl. No	Name of Source	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
		MVA	MW	2019	2025	2030
1	**Khalanzi Substation**					
	33/11kV	1x2.5	2.125	1.28	1.48	1.86

As seen from **Tabe 4,** the Khalanzi substation has adequate capacity to cater the present and forecasted electricity demand.

However, it is pertinent to mention that the Department of Industry, Ministry of Economic Affairs has identified Bondeyma located at Lingmithang as an Industrial park (IP). The IP has a total of 110.34 acres and is developed to promote cottage and small industries producing indigenous goods. Around 18 industries are expected to develop where the power supply should be catered from the Khalanzi substation. **Table 5** represents the projected load growth of Bondeyma IP. A load of 2.95 WM is anticipated at Bondeyma by 2030. A total load of 4.81 MW is expected when all the industries get operationalized. Therefore, the substation needs to be either upgraded or requiring to construct a 2x2.5 MVA substation at Bondeyma IP.

Table 5: Load forecast of Bondeyma IP

Sl. No	Name of Industry	Forecasted Load (MW)		
		2019	2025	2030
Bondeyma Industrial Park				
1	MV Industries	0.25	1.01	1.27
2	LV industries	0.34	1.33	1.68
Total		**0.95**	**2.34**	**2.95**

7.2 Assessment of MV Feeders

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

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

7.2.1 Assessment of MV Feeders Capacity

The load profile of MV feeders emanating from the Kilikhar and Khalanzi substation had been compiled based on the historical data. The array of daily and monthly peak demand was sorted to obtain the annual peak demand. The feeder-wise peak demand recorded at the source is presented in **Table 6** and the corresponding feeder-wise annual load curve is presented in **Figures 3.**

Table 6: Feeder wise peak power demand of ESD Mongar

Feeder Name	Peak Consumption Pattern (MW)										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
33kv feeder Depong/Kangkhar		0.02	0.47	0.04	1.41	0.35	1.02	0.96	0.45	0.97	0.65
33kv feeder Yadi/Ngatsang	0.65	0.73	0.60	0.60	0.84	0.63	1.01	2.57	1.40	6.68	0.68
33kv feeder Khalanzi/Lingmethang								0.91	0.90	1.26	1.28
11kv feeder Wengkhar	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.89	0.16	0.10
11kv feeder Mongar I	0.42	0.70	0.54	1.20	0.84	0.67	0.69	1.33	1.03	0.97	1.08
11kv feeder Mongar-II	0.67	1.00	1.08	1.36	0.80	0.65	0.67	1.54	1.55	1.31	1.52
11kv feeder Khalanzi	0.36	0.52	0.84	0.74	0.80	0.60	0.84	0.75			
11kV feeder Station						0.01	0.011	0.009	0.008	0.08	0.01
11kv feeder Colony						0.01	0.009	0.009	0.098	0.01	0.01

Source: *Monthly substation Data of TD, BPC*

As can be seen from **Figure 3** there is a lot of anomaly in the recorded peak load. The sudden rise of peak load is because of the 33 kV Yadi/Ngatsang feeder since this feeder acts as a contingency source to ESD Trashigang and Tashiyangtse. The said feeder recorded the highest power demand of 6.68 MW when it catered the load of Tashiyangtse and Trashigang Dzongkhags. However, during normal operation, the load of the feeder is less than 1.0 MW.

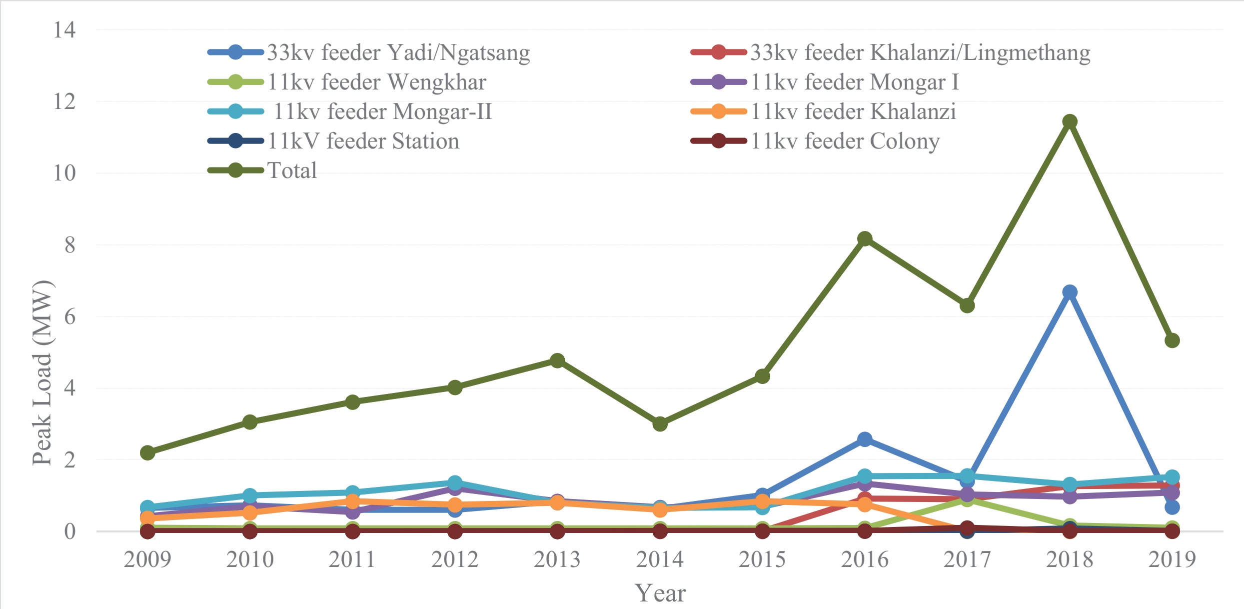


Figure 3: Feeder wise peak power demand of ESD Mongar

The load carrying capacity of a feeder is determined by the line length and degree of load connected in addition to other parameters like ampacity capability. As evident from **Table 2,** the power distribution is through 33kV and 11kV system. The types of conductors used are mostly ACSR-Rabbit and Dog. **Table 7** exhibits the ampacity capability of the conductors at different voltage levels. Ampacity capability (thermal loading) of the lines have been calculated based on IS 398 (Part-II): 1996 for maximum conductor temperature 85°C for ACSR conductors considering an ambient temperature of 40°C.

Table 7: 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

Sl. No.	ACSR Conductor Type	Ampacity of Conductor	MVA rating corresponding to the Ampacity
3	WOLF	398	7.582

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

a) System Study with Existing System
b) System Study with future load: 2025 scenario
c) System Study with future load: 2030 scenario

a) System Study with the Existing Load

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

b) Assessment of MV Feeder Capacities with Forecasted Load

The peak power demand presented in **Table 6** has been considered to forecast the power demand for the next 10 years (2020-2030). Linear Regression Method (LRM) in conjunction with Time Series Analysis (TSA) is adopted to forecast the load as detailed in **Annexure- 3**. The summary of the forecasted load for the feeders is tabulated in **Table 8**.

Table 8: Feeder wise Load forecast of ESD Mongar

Name of Feeder	Forecasted Load Growth (KW)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Drepong	1.34	1.50	1.67	1.83	1.99	2.15	2.32	2.48	2.64	2.80	2.97

Name of Feeder	Forecasted Load Growth (KW)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Yadi/Ngatsang	1.16	1.23	1.31	1.39	1.46	1.54	1.62	1.69	1.77	1.85	1.92
33kV Khalanzi	1.10	1.17	1.25	1.33	1.40	1.48	1.56	1.63	1.71	1.79	1.86
33kV Odzorong	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
11kV Wangkhar	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.20
11kV Mongar I	1.05	1.11	1.17	1.23	1.30	1.36	1.42	1.49	1.55	1.61	1.67
11kV Mongar II	1.32	1.44	1.56	1.68	1.81	1.93	2.05	2.17	2.29	2.41	2.54
11kV Colony	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12
11kV Station	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Note: A load of 11kV Chhali and Lingmithang feeders are included in the 33kV Khalanzi feeder.

From the power flow analysis of the 2025 and 2030 loading scenarios, the simulation result shows no abnormality on the distribution system parameters. Hence, the distribution system will be adequate to cater to the present and forecasted electricity demand. The detailed simulation results for all the case studies are attached as **Annexure- 4.**

7.2.2 Energy Loss Assessment of MV Feeders

Energy losses in the distribution network are inherent as the power transmission and distribution system are associated with the transformer and line loss. However, it is crucial to maintain the energy loss at an optimal level by engaging in timely improvement of the distribution infrastructures and not reacting to the localized system deficiencies. The objective of the energy loss assessment is to single out the feeder (s) with maximum loss (es) and put in additional corrective measures to minimize to the acceptable range. **Table 9** below shows the energy sales, purchase, and loss profile of the Dzongkhag.

Table 9: Energy Sales-Purchase-Loss Trend

Sl. No.	Particulars	2014	2015	2016	2017	2018	Average
1	**Energy Requirement in kWh**						
i)	Purchase from GenCos as per TD bill	11.749	12.843	13.056	14.366	16.139	
	Total Energy Requirement (kWh)	**11.749**	**12.843**	**13.056**	**14.366**	**16.139**	
	% growth over previous year	10.41%	9.31%	1.66%	10.04%	12.34%	8.75%
2	**Energy Sales in kWh (Category Wise)**						

Sl. No.	Particulars	2014	2015	2016	2017	2018	Average
i)	LV*	**9.692**	**10.291**	**10.795**	**11.500**	**12.401**	
ii)	LV Bulk	1.021	0.877	0.856	0.952	1.330	
iii)	MV Industries						
iv)	HV Industries						
	Total Energy Sales kwh	**10.713**	**11.168**	**11.651**	**12.452**	**13.731**	
	% growth over previous year	15.88%	4.24%	4.33%	6.87%	10.27%	8.32%
	Total energy loss	1.036	1.675	1.405	1.915	2.408	
3	**Total Loss (%) (1-2)**	8.81%	13.04%	10.76%	13.33%	14.92%	12.17%
4	**Number of Customers (Category wise)**						
i)	LV*	**8,450**	**8,820**	**9,114**	**9,408**	**9,708**	
ii)	LV Bulk	11	11	12	19	24	
iii)	MV Industries						
iv)	HV Industries						
	Total Customers	**8,461**	**8,831**	**9,126**	**9,427**	**9,732**	
	% growth over previous year	21.88%	4.37%	3.34%	3.30%	3.24%	7.23%

Source: Adapted from BPC Power Data Book 2018

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

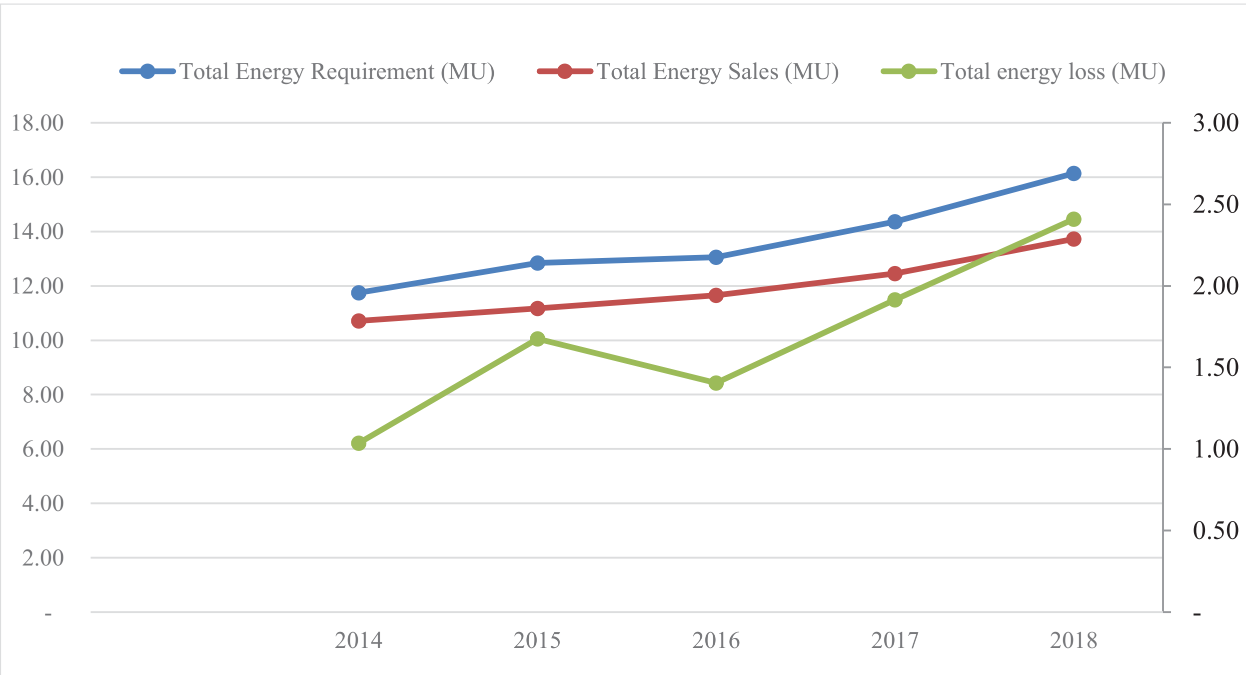


Figure 4: Energy requirement trend

Generally, the technical loss is 8.9% for the distribution network and any loss more than this range is due to commercial loss. An independent study carried out by 19 ESDs for 38 feeders in 2017 (two feeders each in ESD with more loss) showed that an average of 6.84% is due to technical loss. The study also showed that the loss pattern was never consistent because of variant characteristics of a distribution network and loading pattern. The average loss index of Mongar (2014-2018) is 12.17 % (1.69 million units on average) indicating that almost 50 % of the energy loss is due to commercial loss. Therefore, there is a need to focus more on reducing non-technical loss.

The feeder wise energy loss was exhibited in **Table 10**. In the absence of feeder-wise energy accounting, the Energy loss was derived by prorating the overall loss of the Dzongkhag by considering the line length of the feeder and the number of customers connected to it. However, it is relatable to mention that the feeder losses may not be precise and valid. Therefore, for the accurate analysis of the individual feeder loss, an energy meter for every feeder at 33/11kV substation is recommended.

Table 10: Feeder wise Energy Loss (in MU) of ESD Mongar

SL. No.	Name of Feeder	Total line length (km)	Total Customer	Energy Loss (MU)				
				2014	2015	2016	2017	2018
1	33 kV Yadi/Ngatshang Feeder	126.484	2523	0.23	0.41	0.3	0.47	0.59
2	33 kV Drepong Feeder	68.717	1227	0.11	0.2	0.17	0.23	0.29
3	33 kV Khalanzi Feeder	185.109	2353	0.22	0.38	0.32	0.44	0.55
4	11kV Mongar I Feeder	19.572	1327	0.12	0.22	0.18	0.25	0.31
5	11kV Mongar II Feeder	16.181	792	0.08	0.13	0.11	0.15	0.19
6	11kV Wengkhar Feeder	9.41	302	0.03	0.05	0.04	0.06	0.07
7	33kV Odzorong Feeder	37.034	1034	0.1	0.17	0.14	0.19	0.24
8	11kV BPC Feeder	4.03	703	0.07	0.11	0.1	0.13	0.17
	Total		**10261**	**0.98**	**1.67**	**1.4**	**1.91**	**2.41**

The energy loss profile as shown in **Figure 5** indicates that the 33kV Yadi/Ngatsang contributed the highest loss followed by the 33kV Khalanzi feeder. The longer circuit line length may be the reason for the high loss since these two feeders are comparatively longer.

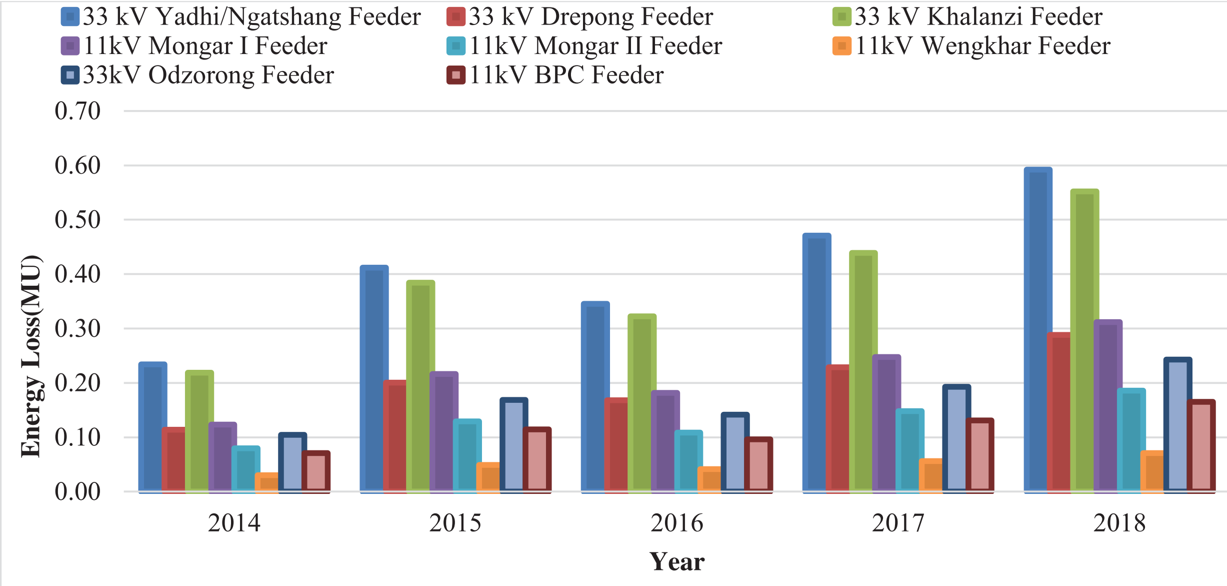


Figure 5: Feeder wise energy losses (MU) of ESD Mongar

7.2.3 Reliability Assessment of MV Feeders

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

In addition to ensuring that the MV feeders have the required capacity, it is also very important to ensure that the MV feeders are reliable. The yearly average feeder reliability assessment (2016-2018) is summarized in **Table 11.** The individual feeder reliability details used to derive the summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered to compute the actual representation of the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2016-2018 are 35.48 & 87.87 respectively which is exceptionally high.

Table 11: Feeder wise reliability indices of ESD Mongar

Sl.No.	Year	Reliability Indices	33kV Yadi/ Ngatshang	33kV Drepong	33kV Khalanzi	11kV Mongar I	11kV Mongar II	11kV Wengkhar	Total
1	2016	SAIFI	11.48	19.68	12.40	4.23	4.38	0.04	52.21
		SAIDI	12.39	48.35	22.14	7.36	5.89	0.23	96.36
2	2017	SAIFI	10.68	3.45	0.73	0.92	8.53	0.45	24.76
		SAIDI	47.91	46.66	1.45	1.90	17.81	2.36	118.09
3	2018	SAIFI	16.59	5.73	0.31	0.78	5.87	0.22	29.50
		SAIDI	13.16	16.56	13.11	0.44	5.59	0.31	49.17
Average (Feeder wise)		**SAIFI**	**12.92**	**9.62**	**4.48**	**1.98**	**6.26**	**0.24**	**35.49**
		SAIDI	**24.49**	**37.19**	**12.23**	**3.23**	**9.76**	**0.97**	**87.88**
Average (Overall)		**SAIFI**							**35.49**
		SAIDI							**87.87**

Source: System Performance Report of DCSD, BPC

Notes:

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

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

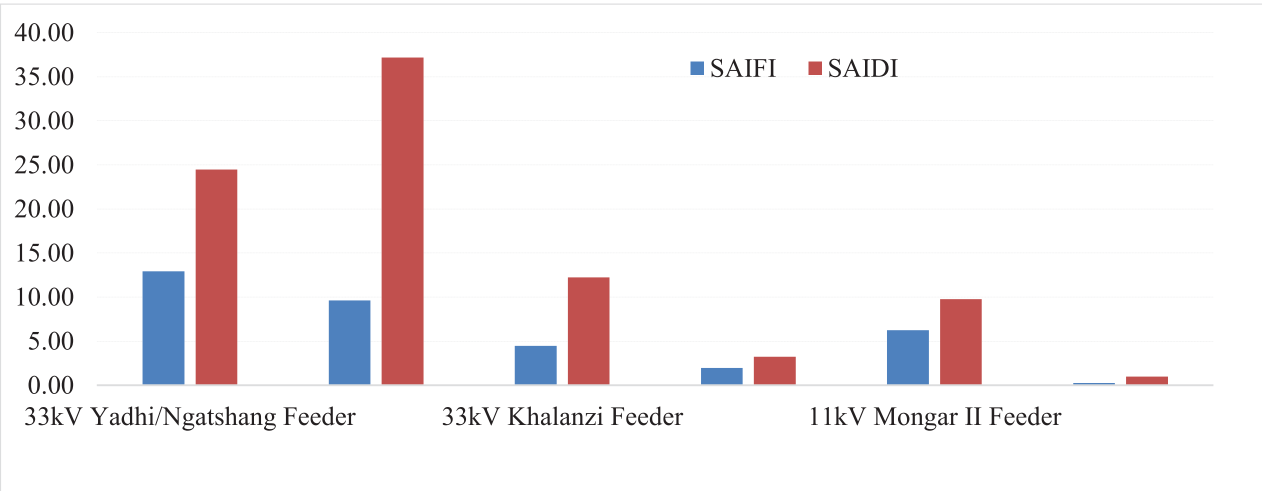


Figure 6: Graphical representation of Feeder wise reliability indices

Plotting the reliability indices data presented in **Table 11** above yields the bar graph as shown in **Figure 6** which indicates that the 33 kV Drepong and Yadi/Ngatsang feeders are more susceptible to interruptions compared to the other feeders. The high interruption frequency and the duration index could be due to feeders passing through a thick forest and feeders also consists of multiple spur lines.

To get a better understanding of the reliability index, the detailed root cause outages of the feeders had been computed in **Figure 7.**

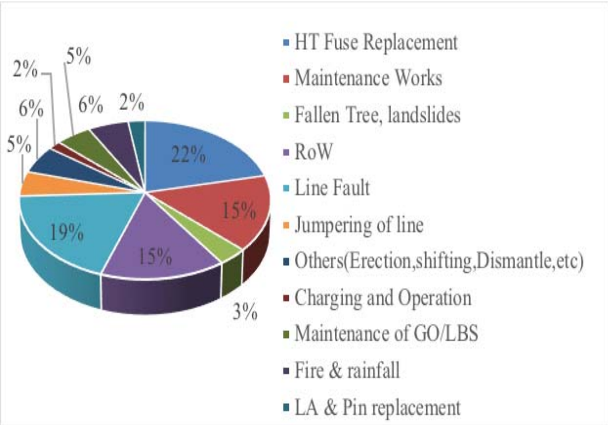


Figure 7: Root Cause Outages

It is noted that while exploring the tripping data of the previous years, most of the causes are due to the HT fuse replacement which is directly correlated to the momentary/transient fault.

The transient faults which lead to HT fuses being blown off were attributed mainly due to branches touching the lines, fallen trees on the line, and landslides damaging the distribution infrastructure. The above causes of the line faults also result in longer power restoration time being taken. Therefore, as mandated in the O&M manual, RoW clearing should be done as mandated and if need be to increase the frequency.

The reliability can be further improved by maintaining the existing ARCBs. As per the record, ESD Mongar has the maximum number of ARCBs. However, out of 19 ARCBs, only 6 ARCBs are functioning as they are intended and the rest are being used as normal isolators. To reduce the restoring downtime, all the ARCBs need to be maintained and the switching mechanism should be automated. Additionally, sectionalizer and communicable FPIs should be installed at a strategic location to the problematic feeders.

7.2.4 Single Phase to Three Phase Conversion

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

a) **Alternative -I**

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

b) **Alternative -II**

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

c) **Alternative -III**

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

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

7.3 Assessment of the Existing Distribution Transformers

7.3.1 Distribution Transformer Loading

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

Some of the existing transformer capacities would not be adequate to cater to the forecasted load growth for the next ten (10) years. Accordingly, the capacities of the transformers need to be up-graded and such a proposal is tabulated in **Table 12**. The individual DT loading details used to derive the summary is attached as **Annexure-7**.

Assuming that the load growth of the rural homes is not expected to grow similar to that of urban dwellings, it is strongly recommended to closely monitor the actual load growth and accordingly plan remedial measures for those transformers. Nevertheless, considering the actual site-specific growth rate and judgment of the field offices, it is recommended that arrangements be made for the up-gradation of 31 transformers as tabulated in **Table 12.** However, cross-swapping of the existing transformers before procurement of new transformer would mean that only 8 transformers have to be procured.

Table 12: List of Overloaded Distribution Transformers

Sl. No.	Name	Capacity (kVA)	Existing Load		% loading		Remarks
			KVA	%	2025	2030	
11kV Mongar Feeder I							
1	Kilikhar Barshong	100	45.79	45.79%	82.93%	102.08%	New 250kVA S/S
2	Nagling	63	50.92	80.83%	146.38%	180.18%	Replace with 100kVA Kilikhar Barshong S/S
3	Phosorong	63	38.53	61.16%	110.77%	136.34%	Add 16kVA Jamcholing S/S
4	Jarukharshor	63	38.30	60.80%	110.11%	135.53%	New 125kVA S/S
5	Mongar Upper Town (ESD Office)	750	453.78	60.50%	109.57%	134.87%	Load growth not expected
6	Pirmani	63	32.58	51.71%	93.65%	115.27%	New 125 kVA S/S

Sl. No.	Name	Capacity (kVA)	Existing Load		% loading		Remarks
			KVA	%	2025	2030	
7	Jamcholing	16	8.05	50.28%	91.06%	112.08%	add 16kVAmerung S/S
8	Nashong Archery Ground	63	30.82	48.92%	88.60%	109.05%	Add 25kVA Gomdari S/S
11kV Mongar Feeder II							
1	Changshingpek	100	49.74	49.74%	109.33%	143.83%	New 250kVA S/S
2	Mongar LSS	750	282.37	37.65%	82.75%	108.86%	Add 100kVAChangshingpek S/S
3	Merung	16	5.92	36.98%	81.29%	106.94%	Replace with 25kVA Tsanphu S/S
4	Pepchurung	63	39.04	61.97%	136.22%	179.20%	There is load growth
5	Hurungpam	63		41.49%			
33kV Yadi Feeder							
1	Tshanphu	25	9.55	38.18%	124.98%	105.79%	replace with 63kVA Nagling S/S
2	Yongbari	63	23.06	36.60%	119.81%	101.41%	Add 25kVA upper Gomdari S/S
3	Atingkhar	25	11.41	45.64%	149.40%	126.46%	replace with 63kVAPirmani S/S
4	Sangbari	63	39.27	62.33%	204.03%	172.70%	new 100kVA S/S
5	Yanglaphungshing/ Rebunus	63	36.53	57.98%	189.80%	160.66%	New 100kVA S/S
6	Jamling	25	9.82	39.27%	128.55%	108.82%	Replace with 63KVA Yanglaphushing S/S
7	Tongtongma	25	14.03	56.12%	183.71%	155.50%	Replace with 63kVA Sangbari S/S
8	Khurshina	25	12.86	51.44%	168.40%	142.54%	Replace with 63kVA Pepchurung S/S
9	Lower Gomdari	25	17.25	69.00%	225.87%	191.19%	Load growth not expected
10	Upper Gomdari	25	14.45	57.80%	189.21%	160.16%	New 63kVA S/S
33kV Drepong Feeder							
1	Toolookpe	25	5.85	23%	77.53%	106.79%	

Sl. No.	Name	Capacity (kVA)	Existing Load		% loading		Remarks
			KVA	%	2025	2030	
2	Upper Zunglen	63	14.63	23%	76.94%	105.97%	Load growth not expected
3	Chhagsuzor	25	6.26	25%	82.94%	114.25%	
4	Upper Tsangkhar	25	11.75	47%	155.69%	214.45%	
5	Lower Tsangkhar	25	7.38	30%	97.73%	134.62%	
6	Mangling Kengkhar	25	9.43	38%	124.88%	172.01%	
7	Doongkar Goenpa Kengkhar	25	9.34	37%	123.75%	170.46%	
8	Doongmanma	25	7.79	31%	103.22%	142.17%	
9	Kengkhar School	25	12.14	49%	160.87%	221.58%	Load growth expected(new 60beded at Kengkhar and 260beded hostel construction at nagor)
10	Nagor school	25		50.67%			

7.3.2 Asset life of Distribution Transformers

The assessment of the existing loading pattern together with the remaining asset life is crucial to ascertain its capabilities to transmit the projected load growth. The life cycle of the transformer and its mapping provides clear information for its optimal utilization and development of an asset replacement framework. Although, as listed in **Table 13**, the DTs had already outlived the asset life, proper evaluation and testing should be required to find out the actual performance of the DTs and informed decisions can be made on the continuous use of the transformers. The life of the asset has been calculated from the year transformer is put into use.

Table 13: List of outlived Distribution Transformers

Sl. No.	Substation Name/location	Capacity(kVA)	Sl. No.	MFD	2019
1	Kadam-I	63	18421	1990	29
2	Chali / Lhakhang	63	12260	1974	45
3	Wamkhar	125	3640	1989	30
4	Sawmill SS, Lingmethang	63	18417	1990	29
5	Jangdung	63	313311	1988	31

Sl. No.	Substation Name/location	Capacity(kVA)	Sl. No.	MFD	2019
6	RBP G/shing	160	18601	1990	29
7	Kurizampa	63	s/4042	1989	30
8	Pekchurung	63	31613	1980	39
9	Dedrang	63	S14041	1989	30
10	Themnangbi	50	C.6046/68	1968	51

7.3.3 Replacement of Single Phase Transformer

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

There are around 33 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu.7.37 million. As the conversion from single to three-phase transformer is demand base, the plan has been distributed in ten year-span.

7.4 Power Requirement for Urban Areas by 2030

The Ministry of Works and Human Settlements has identified the development of Mongar as the main town and Gyelposhing and Dremitse as satellite towns. Of the three urban towns identified, urban development plans have been prepared for the main urban center (i.e. Mongar town). Two LAPs have been identified at the Trailing and Jarukharhor area. Around 187 plots are expected in Trailing and 52 plots in the Jarukharshor area. No urban development plans are available as yet for the remaining two towns of Gyelposhing and Dremitse.

Mongar is already an important transit town for the eastern Dzongkhags and has been growing rapidly over the last few years. It is expected to become a very important urban center for the eastern region. The regional referral hospital is being upgraded and has a capacity of 150 beds. Similarly, with the Upgradation of Gyelposhing High school to college and Gyelposhing-Nganglam high once completed, a major impact on the socio-economic development in Mongar and its hinterland is expected. With the opportunities that will come along with the new highway, given the favorable terrain, space, and climate at Gyelposhing and Lingmithang, these places may grow into large urban centers in the future. Several small and medium-sized commercial and industrial enterprises may sprout too. It is thus difficult to accurately forecast the power demands at these places.

The core Mongar, Trailing and Jarukharshor areas are catered by 11kV Mongar I & Mongar II feeders. The feeders are constructed with ACSR Dog conductor which has a thermal rating of 300A at ambient temperature wherein it can carry a load of around 4.8 MW. The recorded peak load as of 2019 is 1.5 MW and 1.3 MW for Mongar I and Mongar II feeder respectively. Therefore, the feeders are adequate to cater to the existing and forecasted load of two LAPs. However, the following DTs located in these areas may require to be upgraded when the two LAPs are fully developed.

a) Up-grade 63kVA, 11/0.415kV transformer at Jarukharshor to 125 kVA.
b) Up-grade 63kVA, 11/0.415kV transformer at Nagling to 125 kVA.
c) Up-grade 100kVA, 11/0.415kV transformer at Changshingpek to 250 kVA.

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

8. Distribution System Planning till 2030

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

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

8.1 Power Supply Source

8.1.1 HV substation

As per the power source assessment made in **section 7.1.1**, up-gradation of 15 MVA (1x5, 1x10) 132/33 kV, Kilikhar substation is a prerequisite to cater to the load growth of Mongar and Lhuentse Dzongkhags. The power demand of two Dzongkhags has been projected to reach 15.137 MW by the year 2030.

Similarly, a load of around 4.543 MW at 2x2.5 MVA, 33/11 kV substation is anticipated requiring to up-grade the transformer.

8.1.2 MV Substations

As per secondary power source assessment made in **section 7.1.2**, the detailed action plan to address the issue of overloading and power supply arrangement for future load growth are reflected below:

a) Construction of 2x2.5 MVA, 33/11 kV substation for Bondeyma IP and connect to the 33kV Khalanzi feeder in LILO arrangement. A load of 2.95 MW is anticipated at Bondeyma IP by the year 2030. Initially, a 2.5 MVA capacity will serve the purpose. But the substation plot and the RoW for the interconnecting MV lines need to be acquired urgently. (or)

b) Up-grade 1x2.5 MVA Khalanzi substation to 2x2.5 MVA substation and construct dedicated feeder for the IP.

8.2 MV Lines

The detailed MV line assessment made in **section 7.2** shows that the MV distribution network of ESD Mongar would be adequate to cater to the existing as well as future load growth till 2030. Hence, no additional investment is required. However, the investment for the power supply arrangement to Bondeyma IP should be incorporated. **Figure 9** shows the proposed Distribution network of ESD Mongar by 2030.

8.3 Distribution Transformers

As detailed in **Section 7.3.1,** the DTs of urban areas might get overloaded as forecasted, and considering the plans of the LAPs, the following are the list of DTs requiring to be up-graded.

a) Up-grade 63kVA, 11/0.415kV transformer at Jarukharshor to 125 kVA.
b) Up-grade 100kVA, 11/0.415kV transformer at Changshingpek to 250 kVA.
c) Up-rate 63kVA, 11/0.415kV transformer at Pepchurung to 125kVA.
d) Up-rate 63kVA, 11/0.415kV transformer at Hurungpam to 125kVA.
e) Up-grade 63kVA, 11/0.415kV transformer at Pirmani to 125 kVA.
f) Up-rate 250kVA, 11/0.415kV transformer at Lingmethang town to 500kVA.
g) Installation of 63kVA, 11/0.415kV transformer at Menchugang
h) Up-grade 63kVA, 33/0.415kV transformer at Sangbari to 100kVA.
i) Up-grade 63kVA, 33/0.415kV transformer at Yanglaphungshing to 100 kVA.
j) Up-grade 25kVA, 33/0.415kV transformer at Upper Gomdari to 63 kVA.
k) Up-grade 100kVA, 11/0.415kV transformer at Kilikhar to 250 kVA.
l) Up-rate 25kVA, 33/0.415kV transformer at Kengkhar school to 63 kVA.
m) Up-rate 25kVA, 33/0.415kV transformer at Nagor school to 63 kVA.

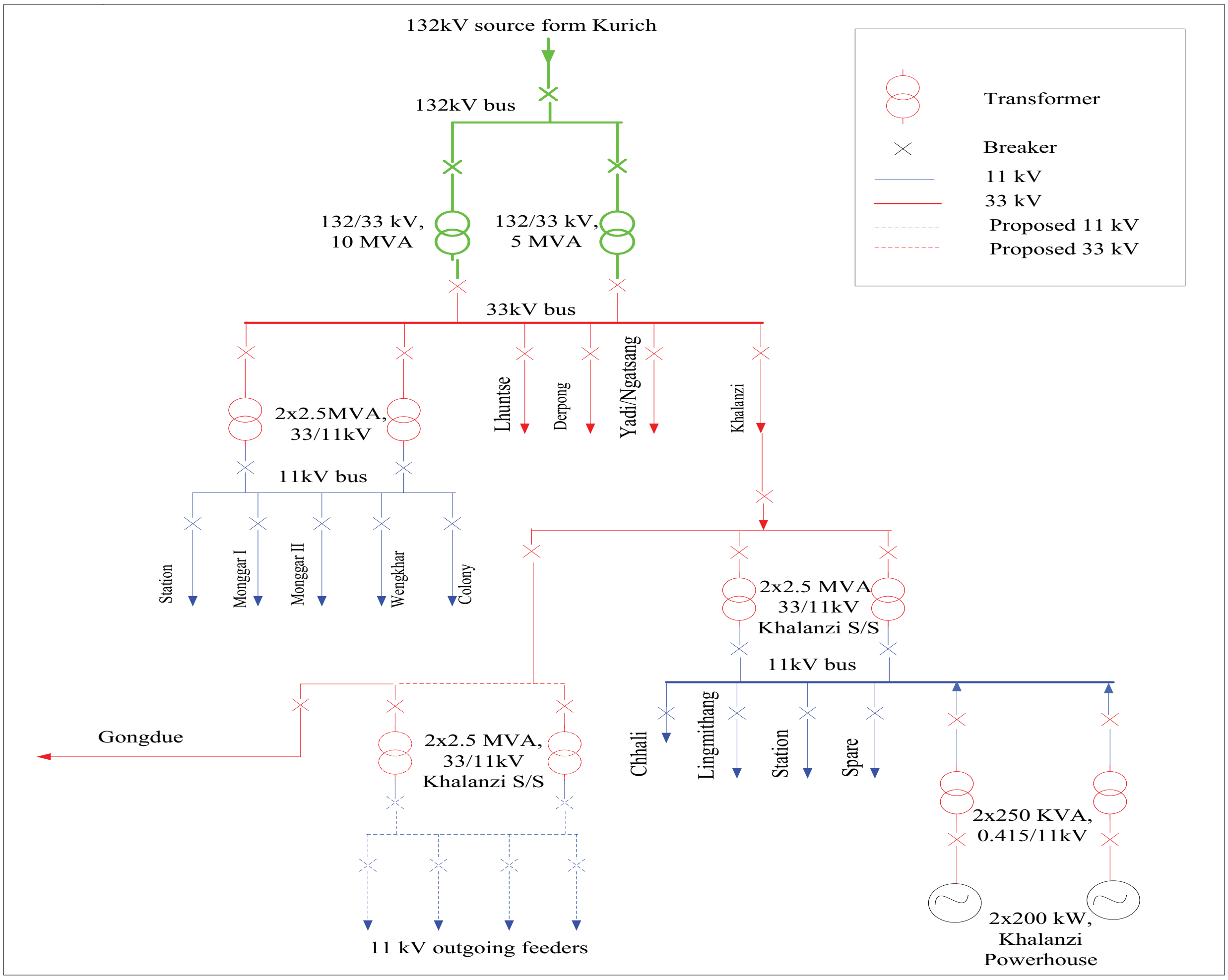


Figure 8: Proposed Distribution Network of ESD Mongar by 2030

8.4 Switching and Control

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

8.4.1 Intelligent Switching Devices

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

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

Table 14 represents the list of switching equipment under ESD Mongar and **Figure 9** shows the list of FPIs to be installed at strategic locations.

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 to the customers.

Table 14: List of Switching Equipment under ESD Mongar

Sl. No.	Name of Feeder	ARCBs	FPIs		LBS	
		Existing	Existing	Prop	Existing	Prop
1	33 kV Yadi/Ngatshang Feeder	6	0	3	20	2
2	33 kV Drepong Feeder	3	0	2	6	3
3	33 kV Khalanzi Feeder	4	0	2	2	1
4	11kV Mongar I Feeder	1	0	0	2	1
5	11kV Mongar II Feeder	0	0	0	1	2
6	11kV Wengkhar Feeder	0	0	0	1	
7	33kV Odzorong Feeder	2	0	0	8	2
8	11kV BPC Feeder	0	0	0	1	0
9	11kV Chali/Tshakaling fdr	1	0	0	6	0
10	11kV Lingmethang fdr	2	0	0	15	0
	Total	**19**	**0**	**7**	**62**	**11**

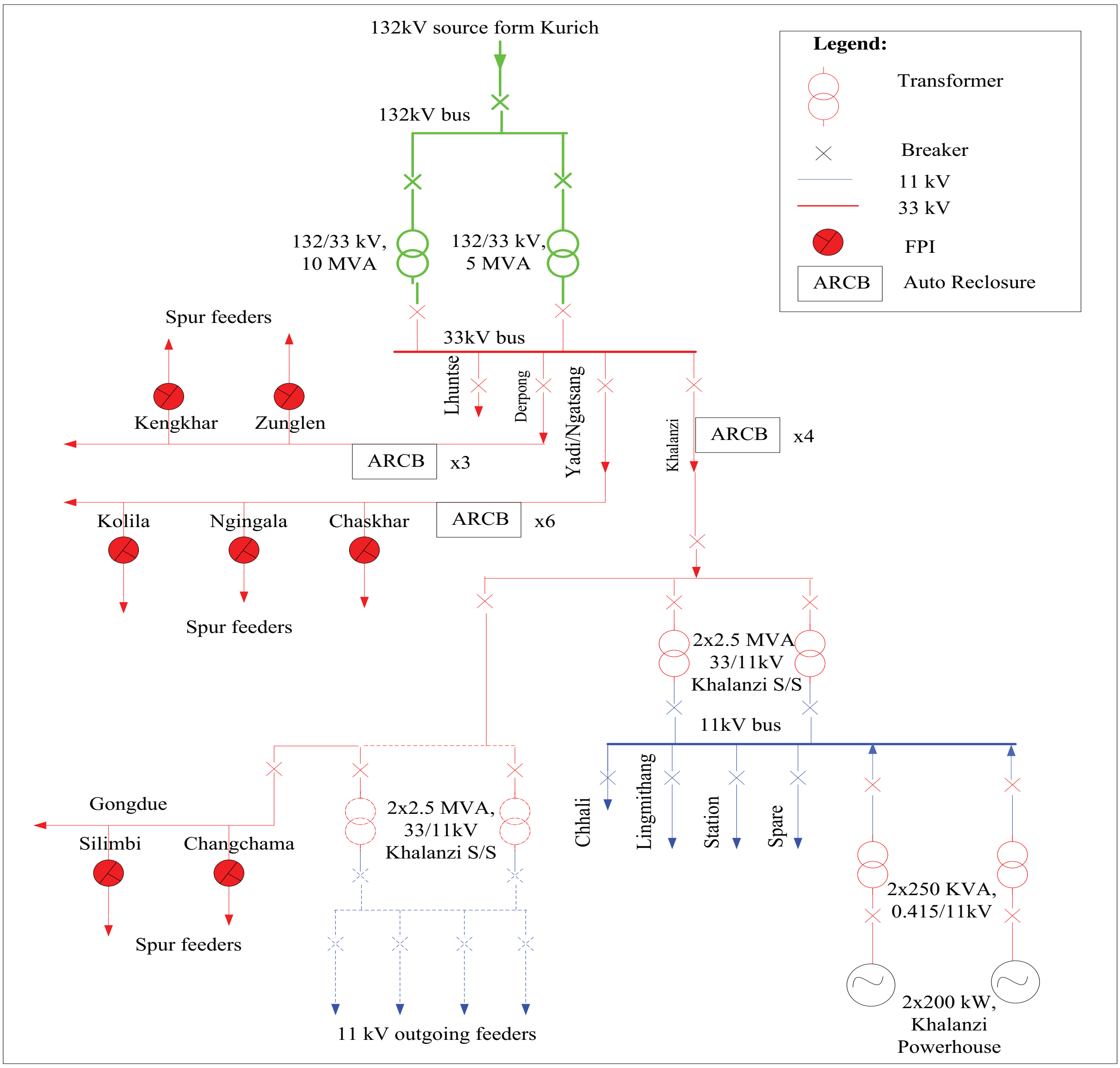


Figure 9: Proposed Switching Equipment for Distribution Network

8.4.2 Distribution System Smart Grid

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

9. Investment Plan

Following the above-mentioned contingency plans targeted to improve the power quality, reduce losses, and improve reliability indices of the Dzongkhag, an investment proposal is developed.

The investment plan has been confined to power supply sources, MV lines, DTs, switching and control equipment, and RoW. The proposed/approved (2019-2023) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 10.**

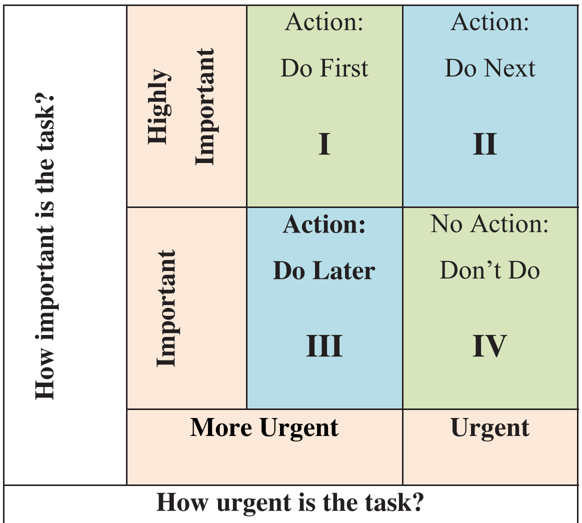


Figure 10: Priority Matrix

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

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

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 15** as an investment plan. The cost estimates have been worked out based on the BPC ESR-2015 and annual inflation is cumulatively applied to arrive at the actual investment cost for the following years.

In the span of the next 10 years (2020-2030), the total projected investment required to adequately deliver the power to the customers of Mongar Dzongkhag is Nu. 71.28 million.

Table 15: Investment Plan until 2030

Sl.No	Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1	**Power Supply Sources**	-	-	-	-	-	-	-	-	-	-	-	**-**
1.1	Construction of 2x2.5 MVA, 33/11kV substation at Bondeyma IP	-	-	10.00	30.00	-	-	-	-	-	-	-	**40.00**
2	**MV Lines**	-	-	-	-	-	-	-	-	-	-	-	**-**
2.1	Power Supply Arrangmenet to Bondeyma IP.	-	-	-	-	-	-	-	-	-	-	-	**-**
2.1.1	UG Cable trenching and laying	-	5.00	10.00	-	-	-	-	-	-	-	-	**15.00**
2.1.2	Installation of 11/0.415, 315 kVA DTs (8 Nos.)	-	1.25	-	-	1.30	-	-	-	1.50	-	-	**4.05**
3	**Distribution Transformers**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.1	Up-rate 63kVA, 11/0.415kV transformer at Jarukharshor to 125 kVA.	-	-	-	0.32	-	-	-	-	-	-	-	**0.32**
3.2	Up-rate 100kVA, 11/0.415kV transformer at Changshingpek.to 250 kVA.	-	-	-	0.50	-	-	-	-	-	-	-	**0.50**
3.3	Up-rate 63kVA, 11/0.415kV transformer at Pepchurung to 125kVA.							0.32					**0.32**
3.4	Up-rate 63kVA, 11/0.415kV transformer at Hurungpam to 125kVA.			0.32									**0.32**
3.5	Up-rate 63kVA, 11/0.415kV transformer at Pirmani to 125 kVA.	-	-	-	-	0.32	-	-	-	-	-	-	**0.32**
3.6	Up-rate 250kVA, 11/0.415kV transformer at Lingmethang town to 500kVA.						0.75						**0.75**
3.7	Installation of 63kVA, 11/0.415kV transformer at Menchugang			0.27									**0.27**
3.8	Up-rate 63kVA, 33/0.415kV transformer at Sangbari to 100 kVA.	-	-	-	-	0.32	-	-	-	-	-	-	**0.32**
3.9	Up-rate 63kVA, 33/0.415kV transformer at Yanglaphungshing to 100 kVA.	-	-	-	-	0.32	-	-	-	-	-	-	**0.32**
3.10	Up-rate 25kVA, 33/0.415kV transformer at Upper Gomdari to 63 kVA	-	-	-	-	-	0.27	-	-	-	-	-	**0.27**

Sl.No	Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
1.11	Up-rate 100kVA, 11/0.415kV transformer at Kilikhar to 250 kVA.	-	-	-	0.50	-	-	-	-	-	-	-	**0.50**
3.12	Up-rate 25kVA, 33/0.415kV transformer at Kengkhar school to 63 kVA			0.32									**0.32**
3.13	Up-rate 25kVA, 33/0.415kV transformer at Nagor school to 63 kVA			0.32									**0.32**
4	**Switching and Control**	-	-	-	-	-	-	-	-	-	-	-	**-**
5	**Conversion Works**												**-**
5.2	Single Phase Transformer to Three Phase conversion	-	-	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	**7.38**
	Total	**-**	**6.25**	**22.05**	**32.14**	**3.08**	**1.84**	**1.14**	**0.82**	**2.32**	**0.82**	**0.82**	**71.28**

10. Conclusion

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

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

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

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

11. Recommendation

Sl. No.	Parameters	Recommendations
A. Power Supply Sources		
1	HV Substations	**Substations 66/33kV 15 MVA Kilikhar Substation** To meet the power demand of Mongar and Lhuentse Dzongkhag, it recommended to Up-grade the substation to at least 20 MVA. The peak load of around 17 MW is projected for two Dzongkhags.
2	MV Substations	Up-rating/construction of new 33/11 kV substation should be implemented as described in section 8.1.2.
B. MV and LV Lines		
1	MV Lines	The MV line plans as discussed in section 7.2 are recommended.
2	LV Lines	Assessment of LV infrastructure is not in the scope of this study. Actual requirements must be studied according to the prevailing circumstances and proposed separately
3	Conversion Works	**1) HT overhead to UG cable** Convert OH conductor to UG cable in and around already developed LAPs and construction of UG network in new LAPs to enhance safety, to ease the RoW issues, and for aesthetic view. **2) LT overhead to UG cable** The LV network of LAPs has to be converted to a UG system due to RoW issues, the safety of the general public, and aesthetic point of view
C. Distribution Transformers		
1	Distribution Transformer	As reflected in **Section 7.3.1** of this report, it is proposed to regularly monitor the loading pattern especially of the urban transformers. It is desired to load the transformers less than 85% to ensure that transformer is operated at maximum efficiency. As the system study is restricted to DTs, the loads need to be uniformly distributed amongst the LV feeders to balance the load. Further service plot to be availed for long term planning.

Sl. No.	Parameters	Recommendations
2	Single to Three Phase Transformers	As reported in the "Technical and Financial Proposal on Converting Single Phase Power Supply to Three Phase in Rural Areas", it is recommended to replace the single to three phase transformers on a need basis.
D. Switching and Control Equipment		
1	Switching and Control Equipment	It is recommended to install Intelligent Switching Devices (ISD) like ARCBs, Sectionalizers, and FPIs as proposed which would reduce the downtime in locating the fault and power restoration time thereby improving the reliability.
E. others		
1	Investment Plan	As reflected in Section 9 of this report, the overall investment plan as proposed is recommended.
2	Review of the DSMP	Recommended to review the DSMP in 2025 (after five years) and if need be every after two years. It is also proposed to be sync with the DSMP studies with that of the five-year investment plan.
3	System Studies beyond DT	It is observed that the distribution of electricity is more through LV than through MV & HV and the scope of DSMP terminates at DT. Therefore, it is equally important to carry out similar system studies for LV networks till meter point. Due to time constraints and the non-available of required LV data, ESD Trashigang should carry out the studies. Nevertheless, with the entire distribution network captured in the GIS and ISU, the system studies should be carried out including the LV network in near future.
4	Customer Mapping	One of the important parameters required especially for reaffirming the capability of the DTs is through customer growth pattern. Therefore, it is recommended to consistently up-date customer mapping annually.
5	Right of Way	Since RoW constraints are already formidable and can only get worse in the future, ESD Trashigang should initiate the acquirement of the required plots for substations, DTs, RMU station, and line RoW urgently. RoW to be maintained as per the DDCS 2016 and if need be to increase the frequency of RoW clearing in the problematic sections of the line.
6	Asset life of DTs	The asset life of DTs needs to be gathered to enable the development of an asset replacement framework. However, it is recommended to regularly monitor the health of the transformers which have already outlived their lives.

Sl. No.	Parameters	Recommendations
7	Overloading of DTs	As per the load forecast, some of the rural DTs might overload. While the probability of realizing such an event is quite low. It is, however, recommended that the DTs that have already exhausted its statutory life (25 years and above) be regularly monitored.
8	New extension through 33kV network	The power carrying capacity of the 33kV system is almost 3-fold compared to that of the 11kV system. Therefore, any new extension of lines may be done through a 33kV system (based on fund availability and practical convenience).
9	Reliability	To improve the reliability of the feeder/network, it is recommended either that fault should be located within a short period of time thereby reducing the restoration time and the number of customers affected. In this regard, the following initiatives are recommended: 1) To install ISDs (communicable FPIs, Sectionalizers & ARCBs); 2) To explore the construction of feeders with customized 11kV & 33kV towers; and 3) To increase the frequency of Row clearing in a year.
10	Conversion Works	As the joint survey for laying the UG had not been done, the investment has been worked based on assumptions of likely scenarios. Therefore, ESD Mongar should incorporate the actual activities during the rolling out of the investment plans.
11	Power supply to LAPs	The power supply infrastructure plans for the urban areas as discussed in Section 7.4 are recommended.

12. Annexure

1. Annexure-1: MV Line Details and Single Line Diagram
2. Annexure-2: IS 2026, IEC 60076 (Technical parameters for Distribution Lines and Transformers)
3. Annexure-3: The details on the load forecast methodology.
4. Annexure-4: Detailed Simulation Results
5. Annexure-5: Feeder Wise Reliability Indices

6. Annexure-6: Material Cost of Upgrading single phase (11 kV and 33 kV) Lines to three-phase
7. Annexure-7: Distribution Transformer Loading
8. Annexure-8: Material Cost of three-phase (3Φ) Transformers

13. References

1. The FWPL and CPL from TD, BPC as of 2018.
2. BPC Power Data Book 2018.
3. BPC Distribution Design and Construction Standards (DDCS)-2016.
4. BPC Smart Grid Master Plan (2019-2027).
5. BPC National Transmission Grid Master Plan (2020 & 2030).
6. BPC Operation and Maintenance Manual for Distribution System (2012).
7. BPC Corporate Strategic Plan (2019-2030).
8. Population and Housing Census of Bhutan 2019.
9. The Structural Plan (2004-2027) for every Dzongkhag.
10. Industrial Parks (Department of Industry).
11. BPC Electrical Schedule of Rates 2015.

14. Assumptions

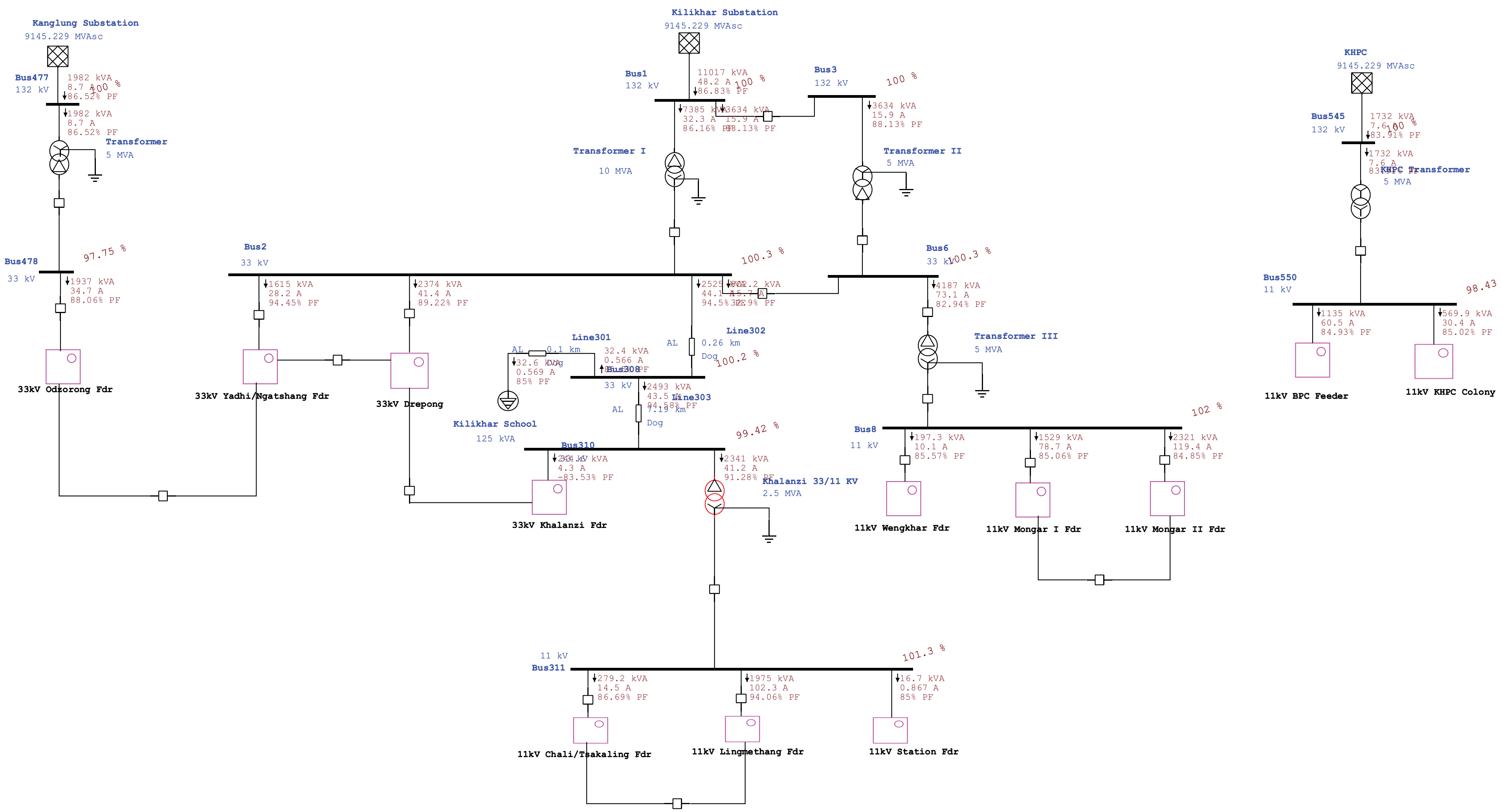
1. All the distribution network was considered as Balanced System (Restriction with the existing ETAP Key);
2. All DTs considered as lump load and depending upon the type of load connected to the feeder, a ratio of 80% (static load) to 20% (industrial feeders) were assumed;
3. The voltage level of ±10%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

15. Challenges

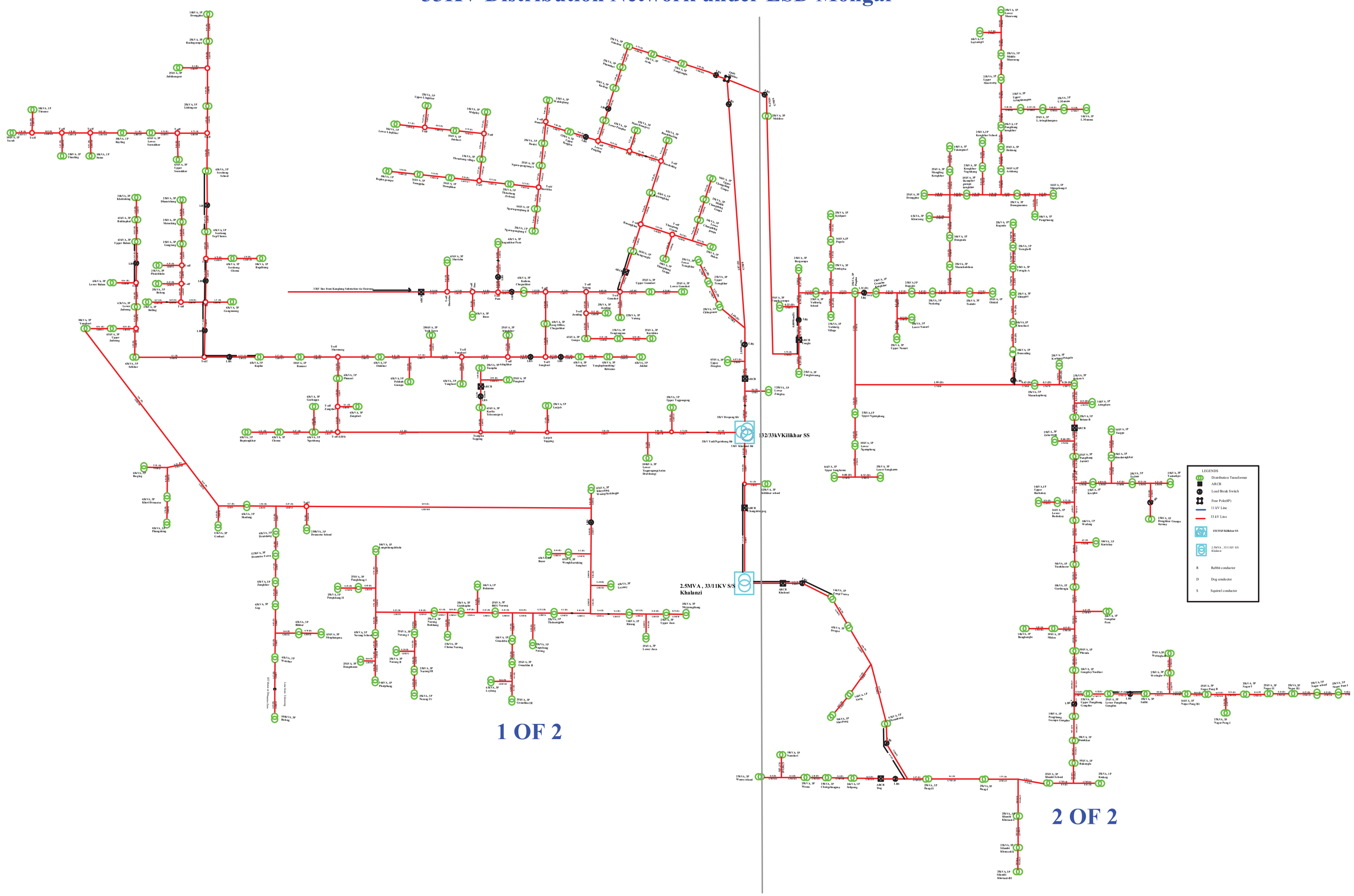
Sl. No.	Parameters	Challenges	Opportunities/Proposals
1	Software Tool (ETAP)	a) Only one key & offline Key	a) Can opt for on line key with fewer more modules especially to carry out the technical evaluation of an unbalanced load flow system. This would be more applicable and accrue good results for LV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

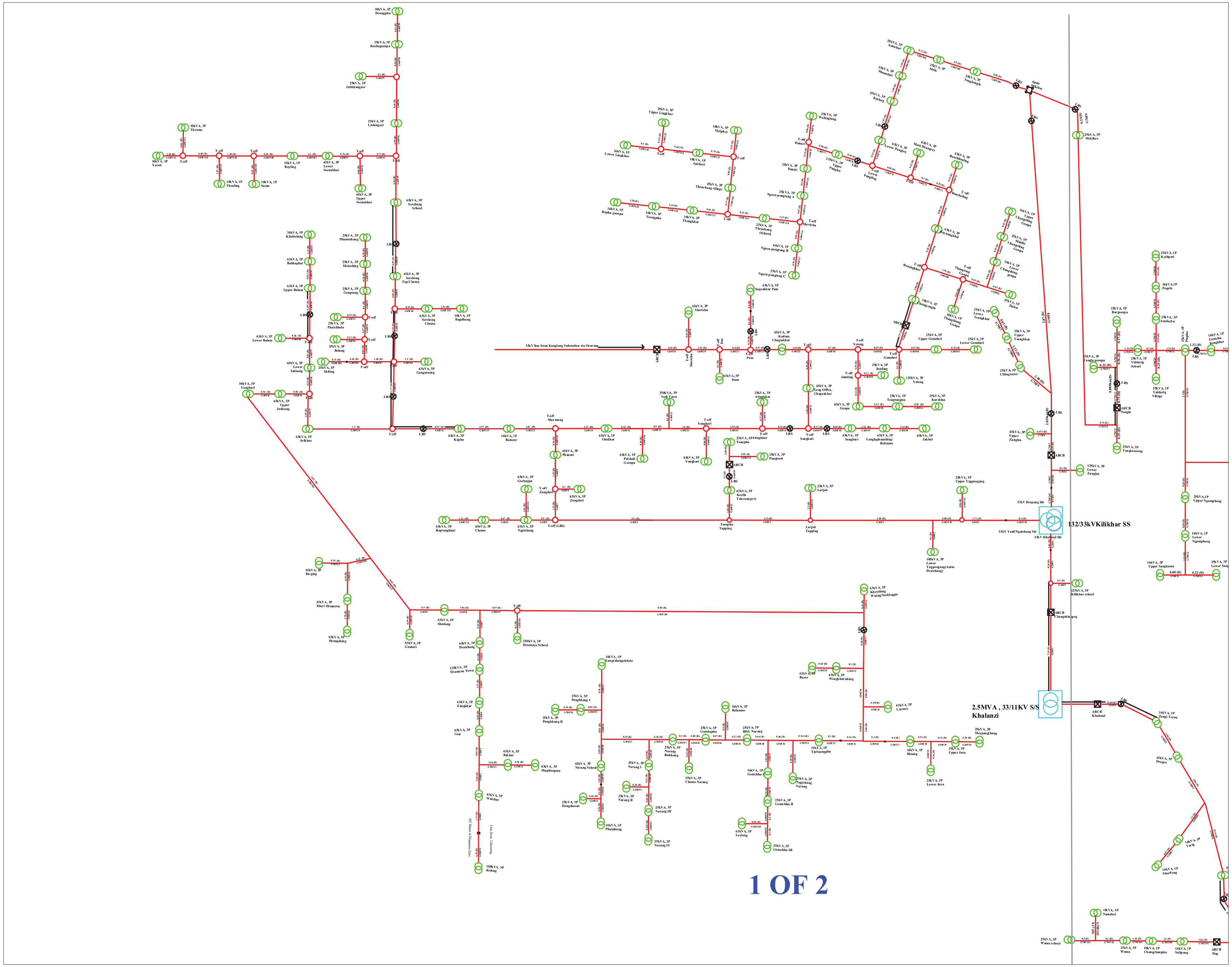
Annexure 1- SLD and MV Line Details

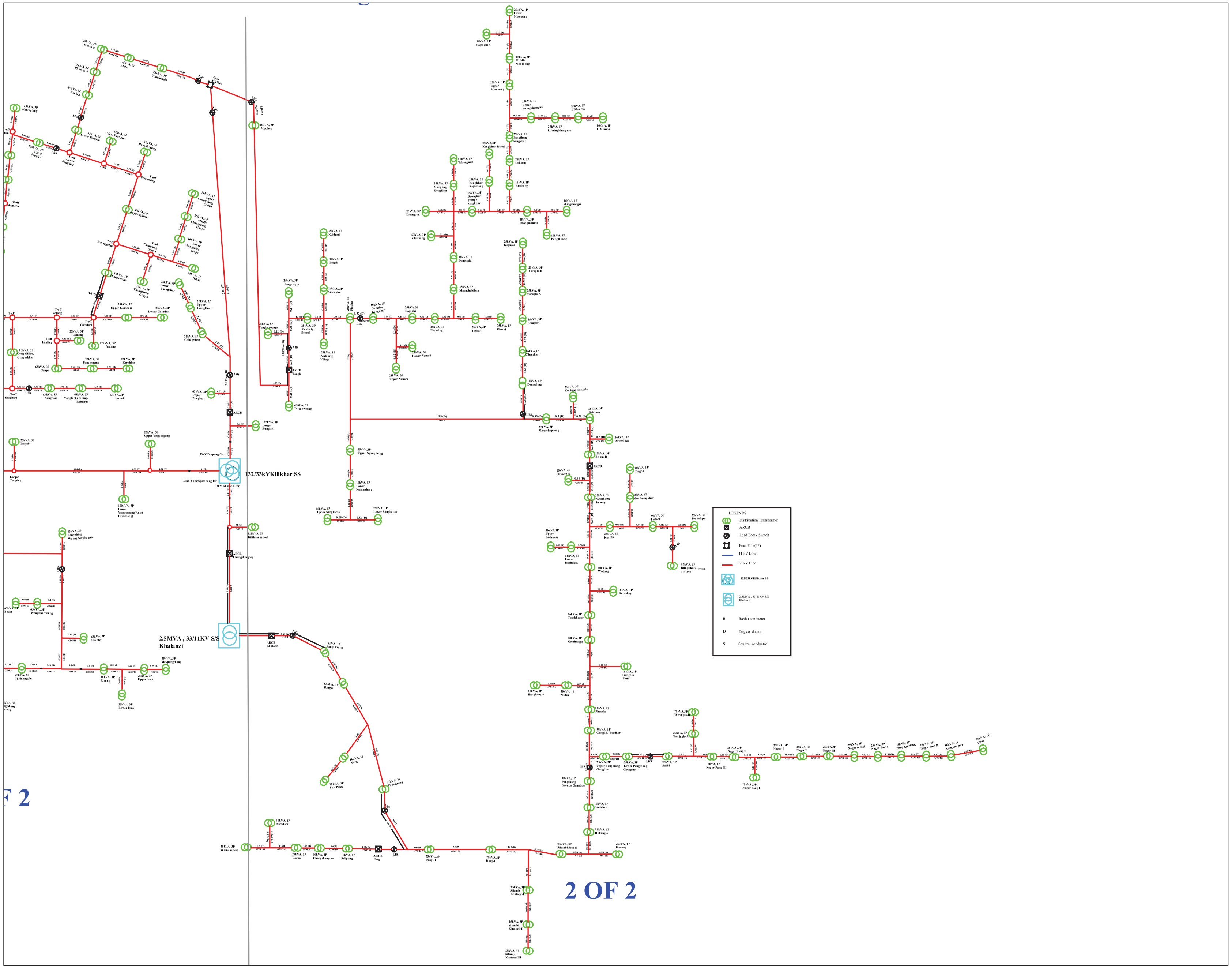
One-Line Diagram - ESD Mongar (Load Flow Analysis)



33KV Distribution Network under ESD Mongar

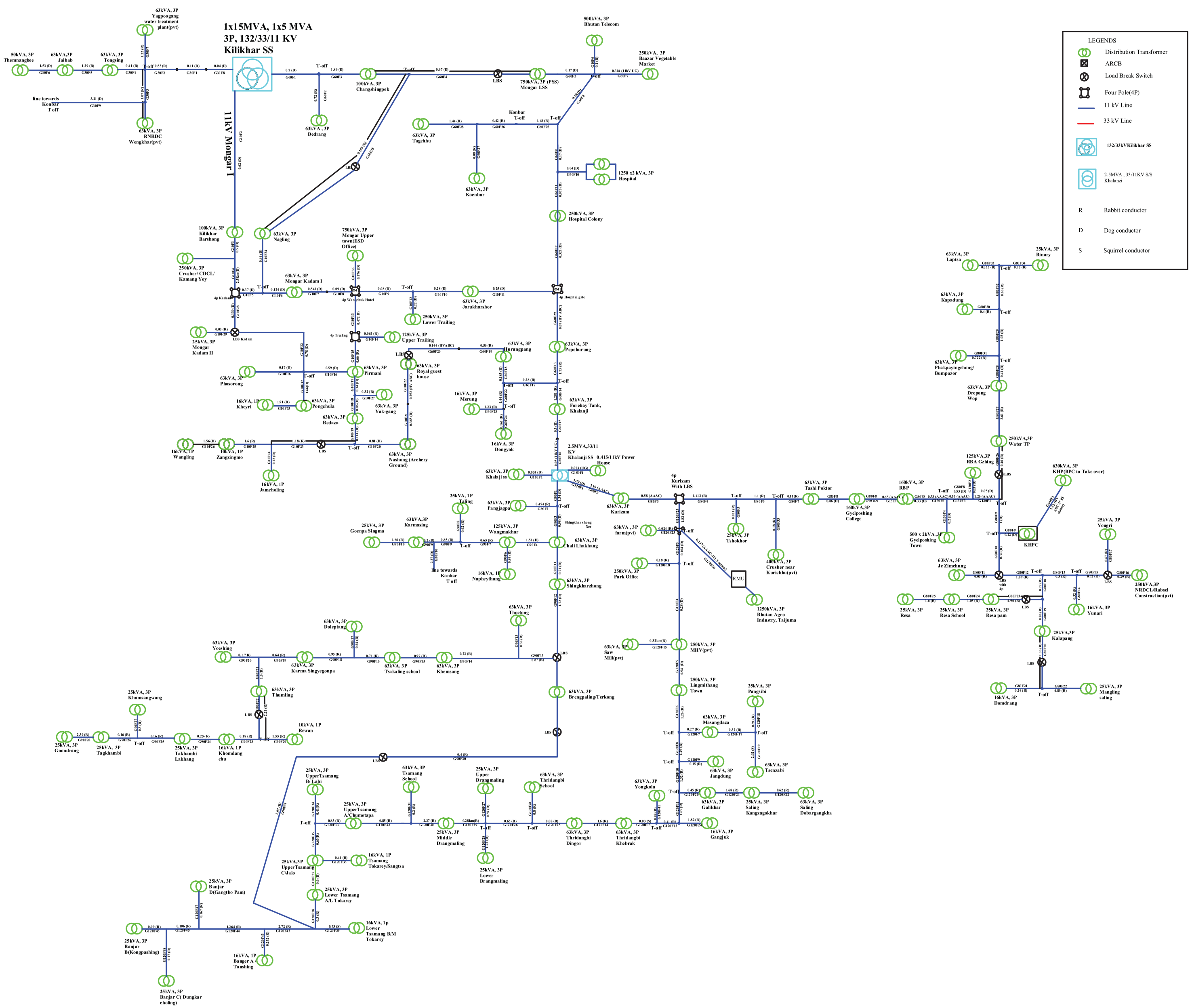



132/33kVKilikhar SS
2.5MVA , 33/11KV S/S
Khalanzi
33kV Drepong fdr
33kV Yadi/Ngatshang fdr
33kV Khalanzi fdr
1 OF 2



LEGENDS
Distribution Transformer
ARCB
Load Break Switch
Four Pole(4P)
11 kV Line
33 kV Line
132/33kVKilikhar SS
2.5MVA , 33/11KV S/S Khalanzi
R Rabbit conductor
D Dog conductor
S Squirrel conductor
132/33kVKilikhar SS
2.5MVA , 33/11KV S/S Khalanzi
2 OF 2

11KV Distribution Network under ESD Mongar



Annexure 2- IS 2026, IEC 60076

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

Annexure 3- Load Forecast adopting LRM & TSA

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.**

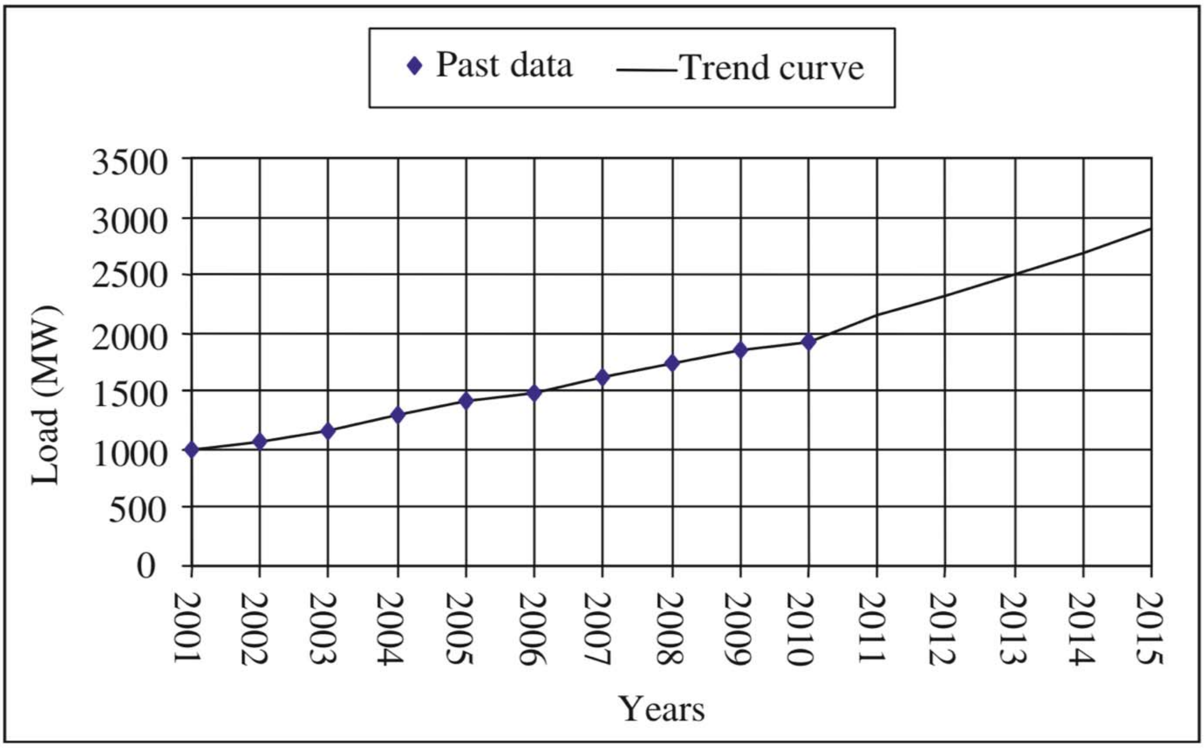


Figure 1: Typical trend curve[1]

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.

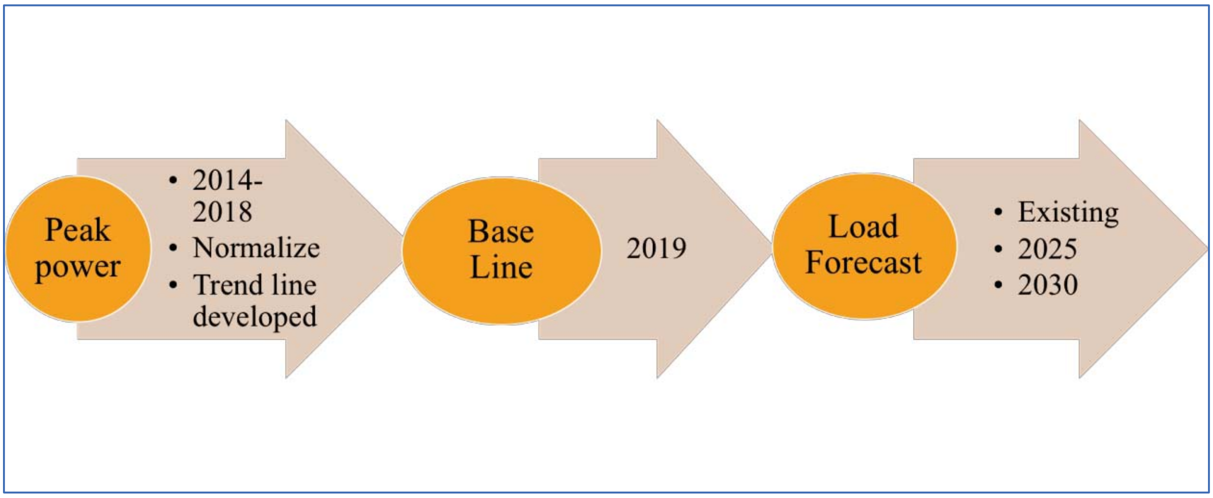


Figure 2: Flow diagram for load forecast

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**

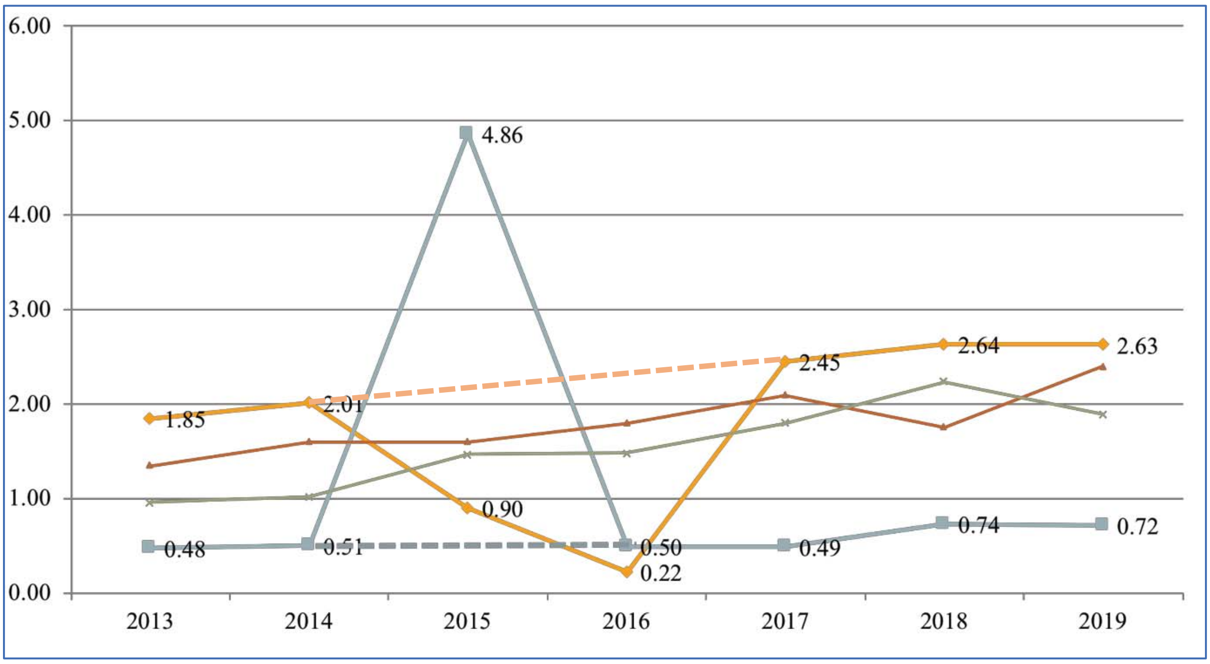


Figure 3: Actual data of Punakha Dzongkhag

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

$Where$:

$x\ is\ the\ normalized\ data$

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

Table 2: Normalized power data of Punakha Dzongkhag

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

1.3.2 Trend Line and Load Forecast

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

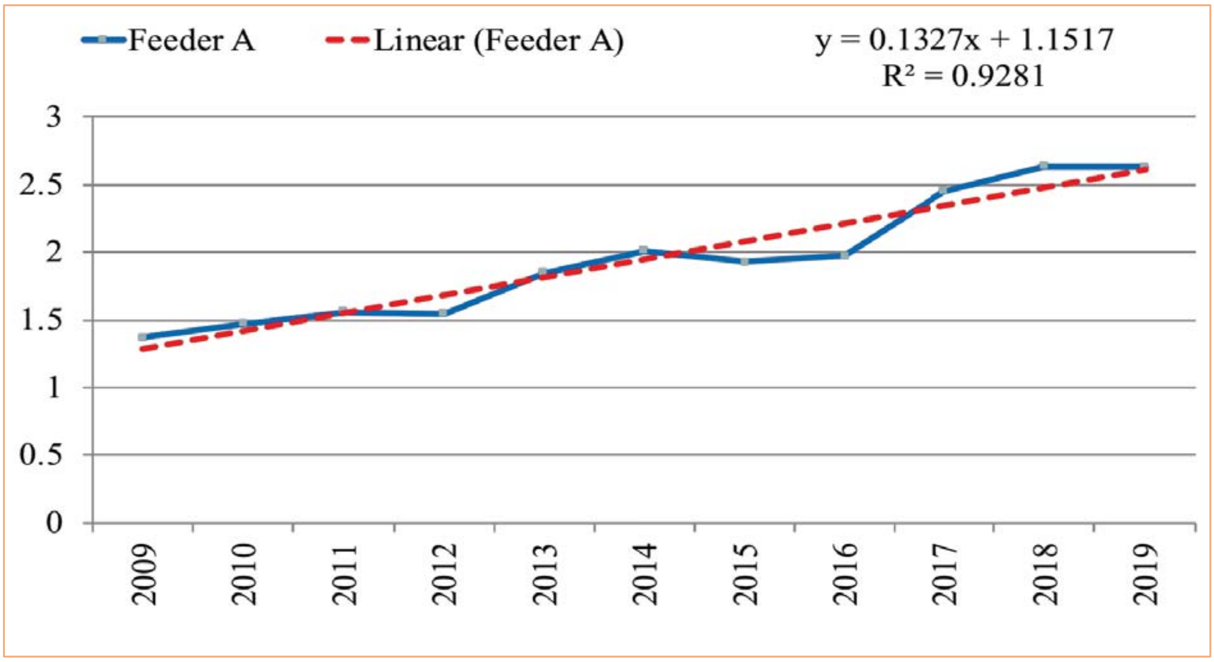


Figure 4: Trend line and load forecast for Punakha Dzongkhag

The trend line equation is given by[2]:

$y = ax + b$

$Where$:

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

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

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

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

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

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

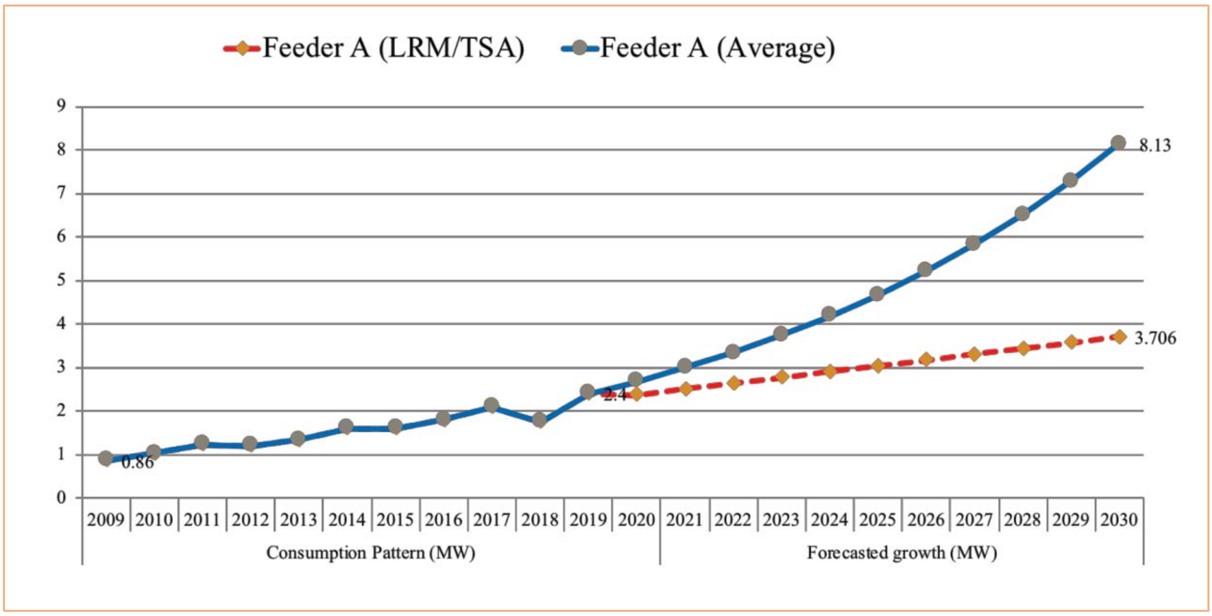


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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

2.1 ETAP Software

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

2.2 Load Flow Analysis (ETAP)

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

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

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

2.2.1 Creating the Library

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

a) Transmission Cable

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

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

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

c) Set Loading and Generation Categories.

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

2.2.2 Network Modelling and Load Flow Analysis

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

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

2.3 Consideration/Assumptions made while simulating in ETAP software

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

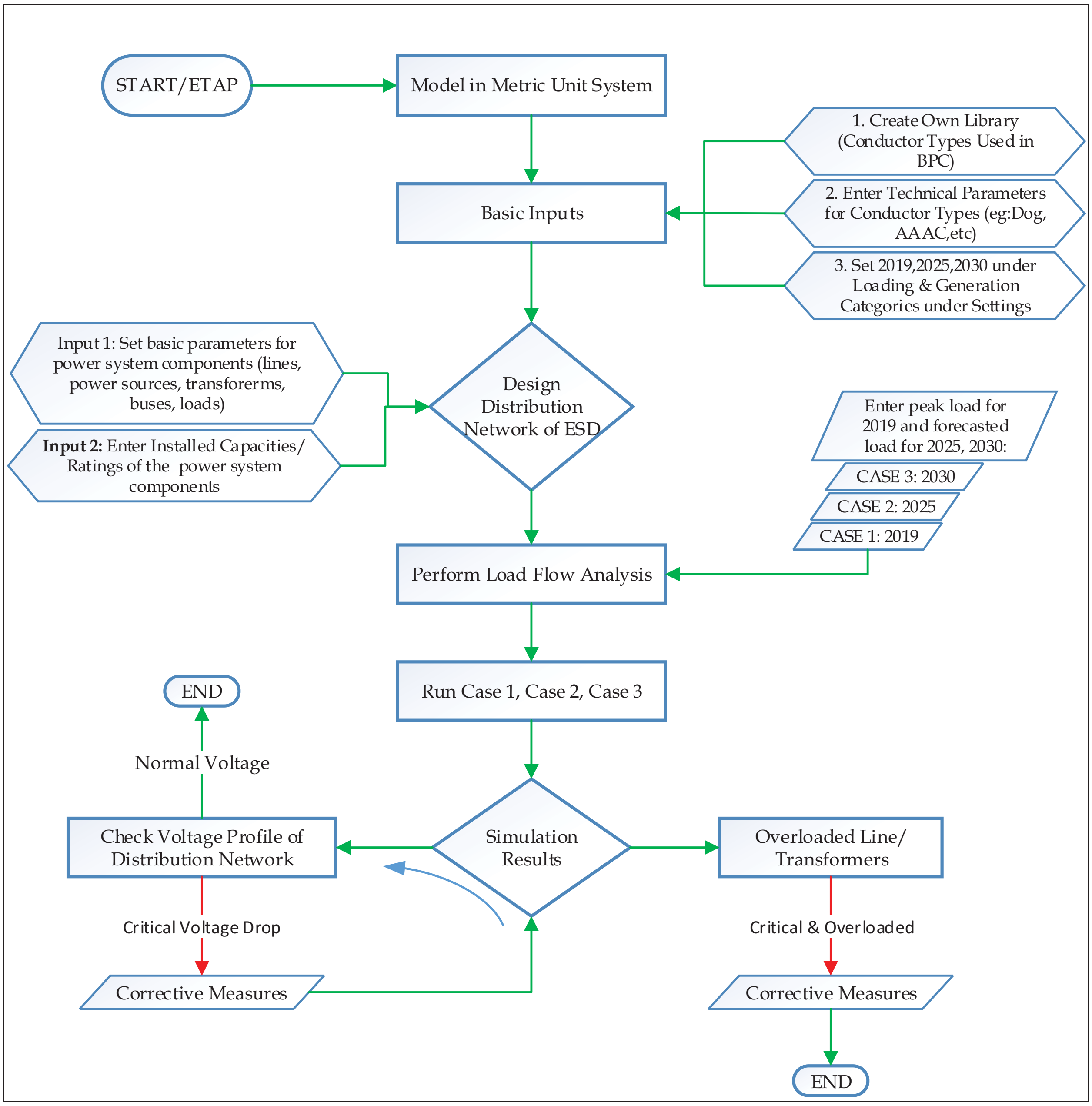


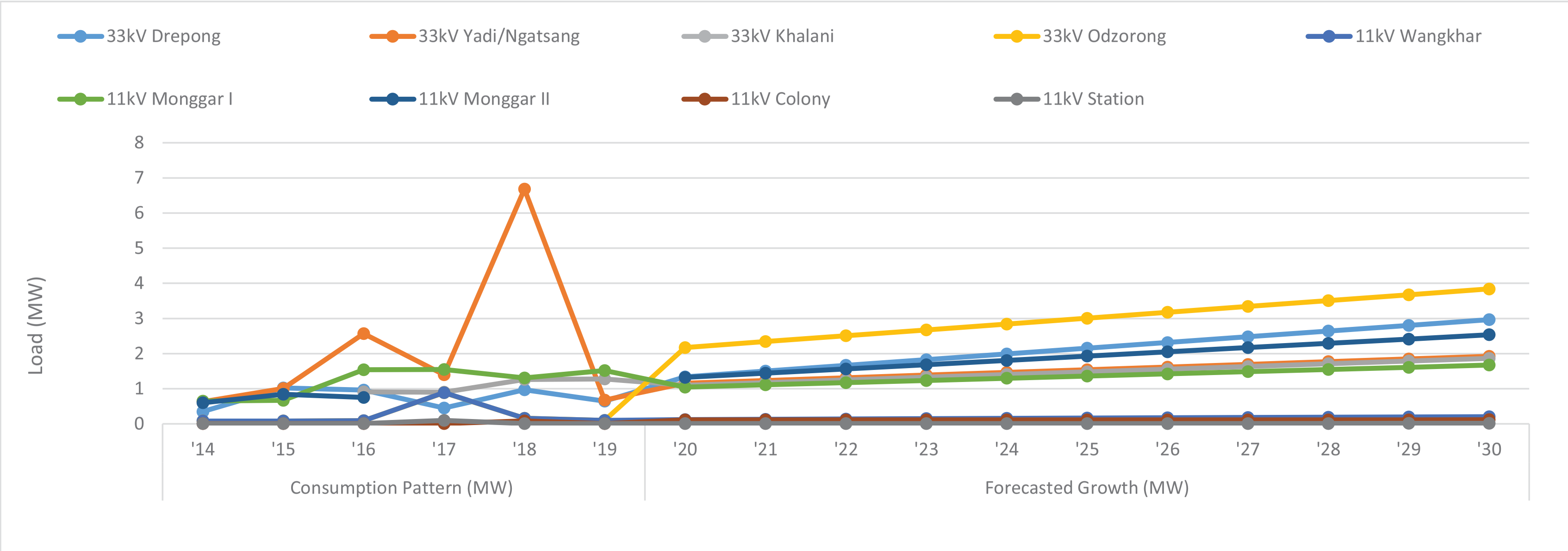
Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

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

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

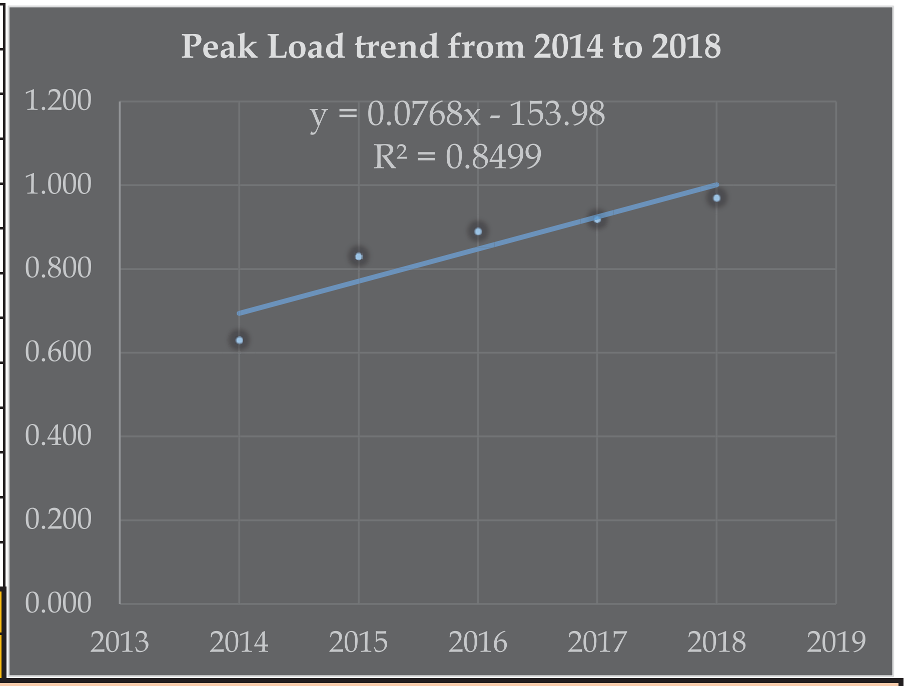
[3]http://www.powerqualityworld.com/2011/05/etap-tutorials-load-flow-analysis.html dated September 30, 2020

SL.No.		Consumption Pattern (MW)						Forecasted Growth (MW)										
		'14	'15	'16	'17	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30
1	33kV Drepong	0.35	1.02	0.96	0.45	0.97	0.65	1.340	1.503	1.665	1.827	1.990	2.152	2.315	2.477	2.640	2.803	2.965
2	33kV Yadi/Ngatsar	0.63	1.01	2.57	1.4	6.68	0.68	1.156	1.233	1.310	1.386	1.463	1.540	1.617	1.694	1.770	1.847	1.924
3	33kV Khalani			0.91	0.9	1.26	1.28	1.096	1.173	1.250	1.326	1.403	1.480	1.557	1.634	1.710	1.787	1.864
4	33kV Odzorong	0.08	0.08	0.09	0.89	0.16	0.1	2.174	2.341	2.507	2.674	2.841	3.007	3.174	3.341	3.508	3.674	3.841
5	11kV Wangkhar	0.08	0.08	0.09	0.89	0.16	0.10	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.20
6	11kV Monggar I	0.65	0.67	1.54	1.55	1.31	1.52	1.046	1.109	1.172	1.234	1.297	1.360	1.423	1.486	1.548	1.611	1.674
7	11kV Monggar II	0.6	0.84	0.75				1.320	1.441	1.563	1.684	1.806	1.927	2.049	2.170	2.292	2.413	2.535
8	11kV Colony	0.01	0.011	0.009	0.008	0.08	0.01	0.112	0.112	0.113	0.114	0.114	0.115	0.115	0.116	0.117	0.117	0.118
9	11kV Station	0.01	0.009	0.009	0.098	0.01	0.01	0.010	0.010	0.010	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013
Total		**3**	**4.33**	**8.17**	**6.31**	**11.44**	**5.33**	**8.377**	**9.053**	**9.729**	**10.405**	**11.081**	**11.757**	**12.433**	**13.109**	**13.785**	**14.461**	**15.137**



33kVFeeder Yadi/Ngatsang

Months	2014	2015	2016	2017	2018
January	0.630	0.700	0.765	0.830	0.080
February	0.380	0.070	0.890	0.827	0.080
March	0.380	0.780	0.830	0.819	0.830
April	0.400	0.710	0.769	0.828	0.630
May	0.380	0.675	0.773	0.910	0.260
June	0.380	0.640	0.776	0.912	0.500
July	0.350	0.830	0.863	0.895	0.780
August	0.440	0.650	0.748	0.845	0.830
September	0.450	0.830	0.849	0.869	0.870
October	0.470	0.781	0.837	0.892	0.940
November	0.470	0.733	0.830	0.918	0.680
December	0.420	0.635	0.850	0.905	0.970
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.630**	**0.830**	**0.890**	**0.918**	**0.970**

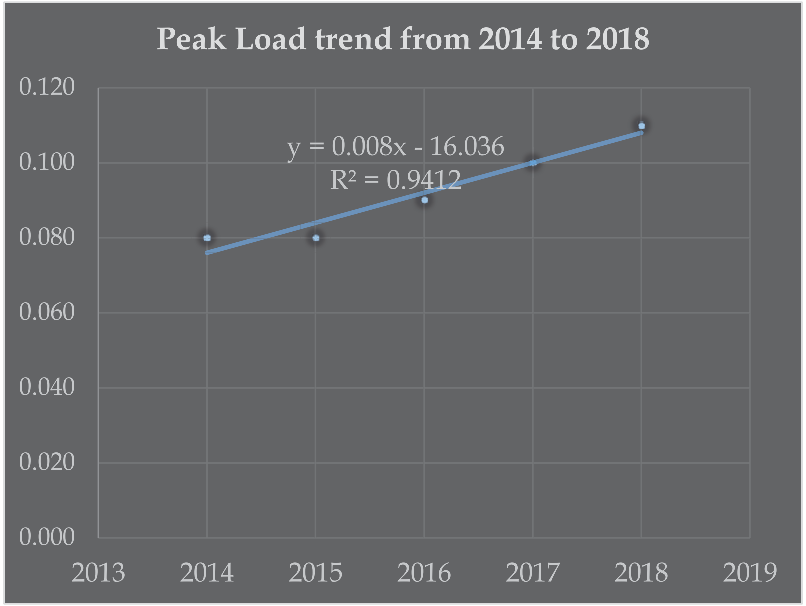


Forecasted Peak Load(MW) from 2019-2030

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Peak Load	1.079	1.156	1.233	1.310	1.386	1.463	1.540	1.617	1.694	1.770	1.847	1.924
	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	

11kV Feeder Wengkhar

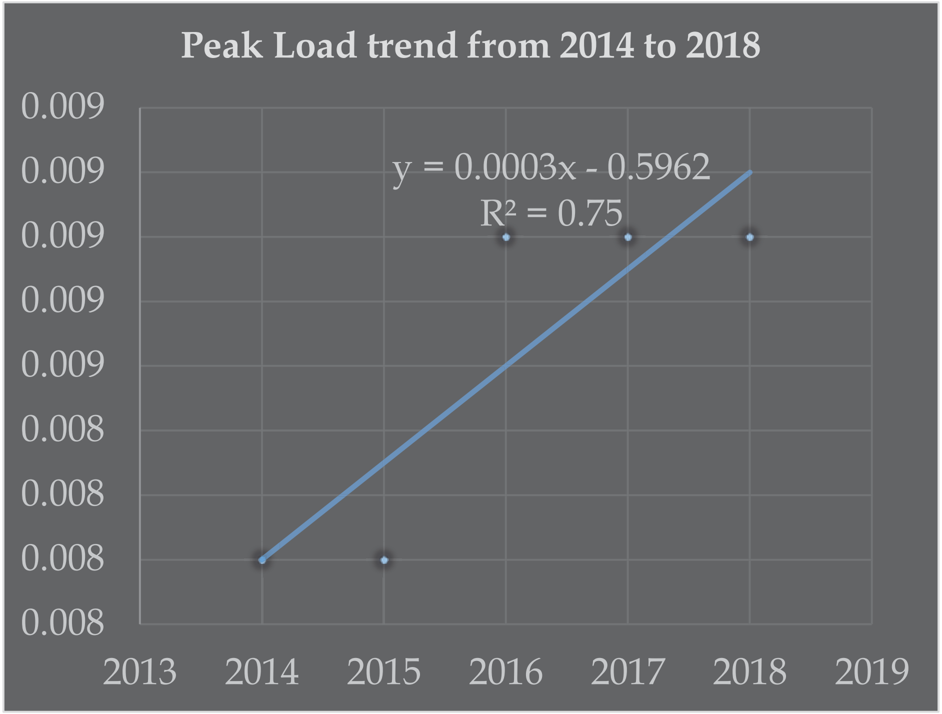
Months	2014	2015	2016	2017	2018
January	0.080	0.080	0.090	0.100	0.094
February	0.070	0.070	0.090	0.089	0.100
March	0.080	0.070	0.080	0.009	0.092
April	0.060	0.060	0.080	0.075	0.090
May	0.070	0.070	0.070	0.080	0.085
June	0.080	0.080	0.070	0.075	0.080
July	0.060	0.070	0.070	0.077	0.080
August	0.070	0.070	0.070	0.081	0.090
September	0.070	0.080	0.070	0.076	0.100
October	0.080	0.080	0.090	0.092	0.100
November	0.070	0.080	0.090	0.096	0.105
December	0.070	0.080	0.090	0.099	0.110
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.080**	**0.080**	**0.090**	**0.100**	**0.110**



Forecasted Peak Load(MW) from 2019-2030												
Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Peak Load	0.116	0.124	0.132	0.140	0.148	0.156	0.164	0.172	0.180	0.188	0.196	0.204
	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	

11kV Feeder Station

Months	2014	2015	2016	2017	2018
January	0.000	0.008	0.009	0.007	0.008
February	0.000	0.008	0.007	0.006	0.007
March	0.000	0.008	0.009	0.009	0.009
April	0.000	0.008	0.008	0.006	0.006
May	0.000	0.007	0.007	0.007	0.006
June	0.000	0.008	0.008	0.007	0.007
July	0.003	0.008	0.007	0.008	0.007
August	0.006	0.006	0.006	0.005	0.006
September	0.006	0.007	0.006	0.005	0.006
October	0.006	0.007	0.007	0.005	0.008
November	0.007	0.008	0.007	0.006	0.009
December	0.008	0.008	0.008	0.007	0.009
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.008**	**0.008**	**0.009**	**0.009**	**0.009**

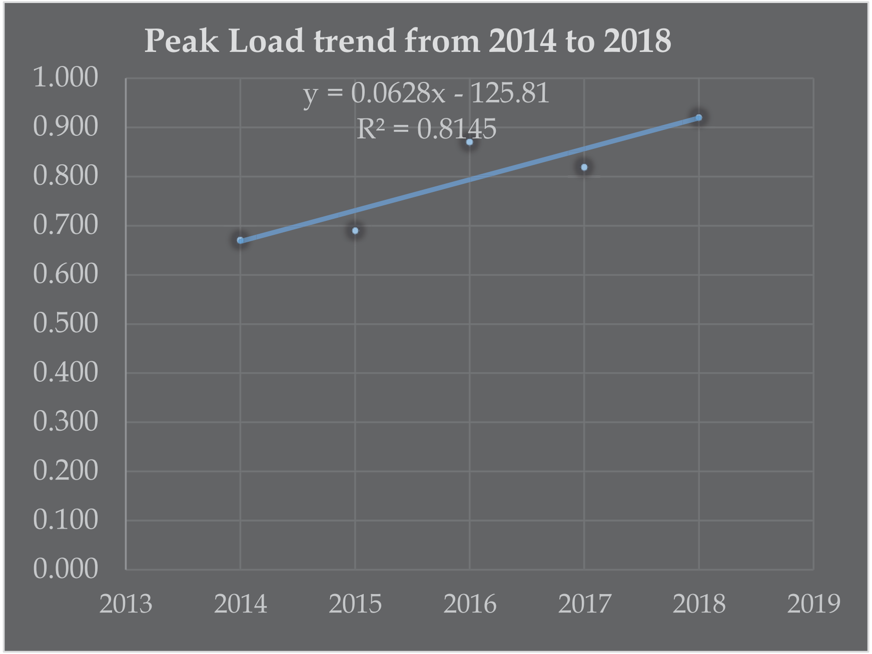


Forecasted Peak Load(MW) from 2019-2030

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Peak Load	**0.009**	**0.010**	**0.010**	**0.010**	**0.011**	**0.011**	**0.011**	**0.012**	**0.012**	**0.012**	**0.013**	**0.013**
	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	

11kV Feeder Mongar I

Months	2014	2015	2016	2017	2018
January	0.670	0.620	0.700	0.670	0.749
February	0.650	0.650	0.870	0.695	0.740
March	0.620	0.560	0.600	0.740	0.755
April	0.520	0.510	0.520	0.613	0.660
May	0.490	0.470	0.480	0.594	0.620
June	0.500	0.560	0.480	0.645	0.580
July	0.450	0.490	0.595	0.475	0.520
August	0.500	0.480	0.710	0.818	0.630
September	0.480	0.500	0.520	0.708	0.570
October	0.510	0.530	0.550	0.597	0.660
November	0.630	0.610	0.620	0.519	0.840
December	0.640	0.690	0.690	0.548	0.920
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.670**	**0.690**	**0.870**	**0.818**	**0.920**

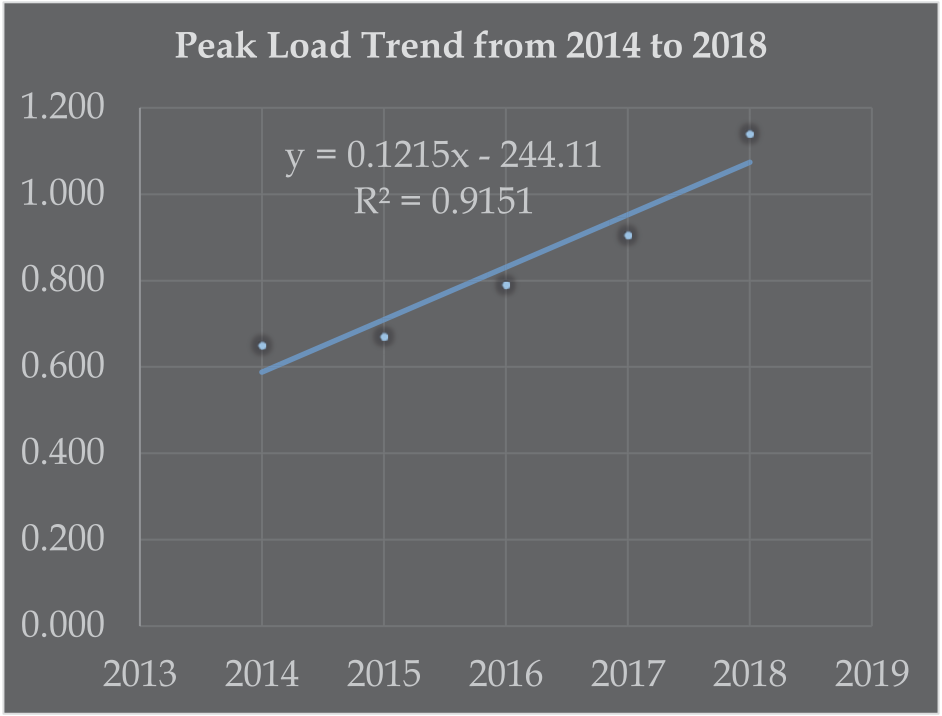


Forecasted Peak Load(MW) from 2019-2030

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Peak Load	**0.983**	**1.046**	**1.109**	**1.172**	**1.234**	**1.297**	**1.360**	**1.423**	**1.486**	**1.548**	**1.611**	**1.674**
	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	0.0628	

11kV Feeder Mongar-II

Months	2014	2015	2016	2017	2018
January	0.650	0.620	0.660	0.713	0.766
February	0.630	0.620	0.670	0.632	0.593
March	0.600	0.560	0.550	0.545	0.540
April	0.550	0.530	0.500	0.495	0.490
May	0.490	0.500	0.450	0.465	0.480
June	0.490	0.500	0.790	0.665	0.540
July	0.450	0.500	0.540	0.580	0.660
August	0.540	0.500	0.578	0.694	0.810
September	0.500	0.500	0.615	0.730	0.960
October	0.550	0.570	0.668	0.765	0.960
November	0.550	0.570	0.667	0.763	1.020
December	0.620	0.670	0.788	0.905	1.140
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.650**	**0.670**	**0.790**	**0.905**	**1.140**

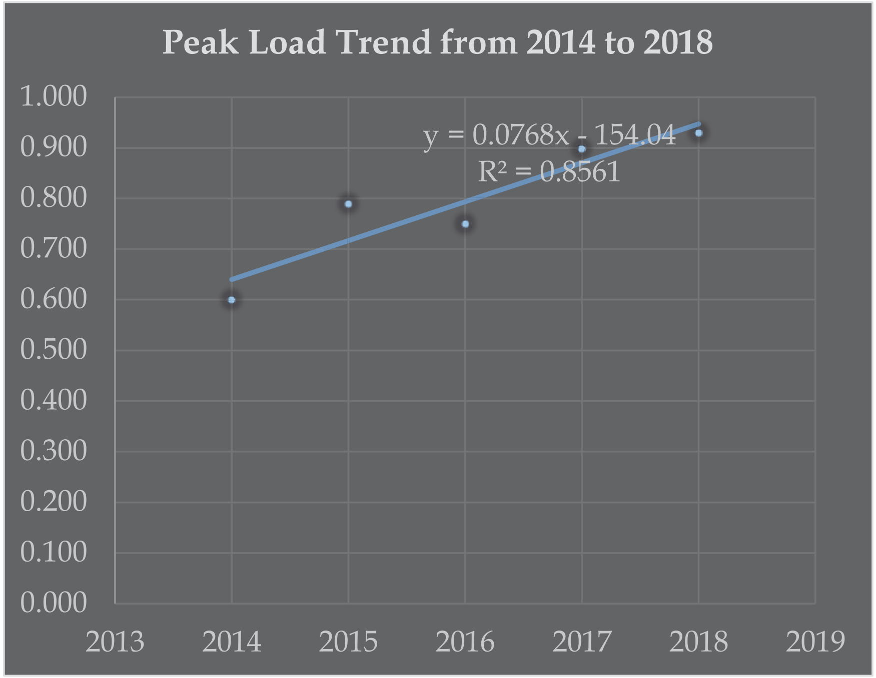


Forecasted Peak Load(MW) from 2019-2030

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	**1.198**	**1.320**	**1.441**	**1.563**	**1.684**	**1.806**	**1.927**	**2.049**	**2.170**	**2.292**	**2.413**	**2.535**
	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	0.1215	

33kV Feeder Khalanzi/Lingmethang

Months	2014	2015	2016	2017	2018
January	0.590	0.660	0.748	0.791	0.835
February	0.580	0.725	0.750	0.802	0.855
March	0.570	0.790	0.640	0.757	0.874
April	0.560	0.550	0.660	0.781	0.902
May	0.530	0.560	0.570	0.750	0.930
June	0.530	0.550	0.590	0.700	0.810
July	0.500	0.550	0.360	0.728	0.700
August	0.570	0.590	0.517	0.369	0.645
September	0.570	0.610	0.310	0.527	0.590
October	0.580	0.620	0.455	0.685	0.640
November	0.580	0.620	0.600	0.766	0.570
December	0.600	0.730	0.400	0.898	0.750
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.600**	**0.790**	**0.750**	**0.898**	**0.930**

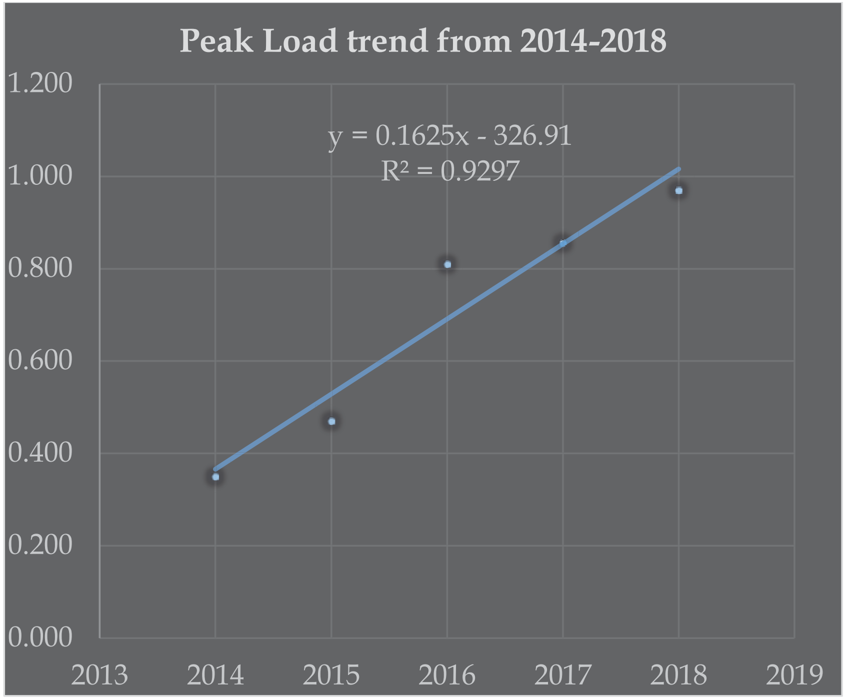


Forecasted Peak Load(MW) from 2019-2030

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Peak Load	1.019	1.096	1.173	1.250	1.326	1.403	1.480	1.557	1.634	1.710	1.787	1.864
	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	0.0768	

33kV Feeder Depong/Kangkhar(MW)

Months	2014	2015	2016	2017	2018
January	0.120	0.300	0.760	0.632	0.504
February	0.100	0.260	0.640	0.609	0.577
March	0.140	0.300	0.810	0.643	0.476
April	0.190	0.300	0.760	0.655	0.550
May	0.180	0.260	0.690	0.610	0.530
June	0.180	0.300	0.810	0.740	0.670
July	0.170	0.330	0.740	0.855	0.970
August	0.320	0.470	0.620	0.525	0.430
September	0.310	0.370	0.430	0.403	0.310
October	0.350	0.390	0.430	0.425	0.500
November	0.330	0.415	0.500	0.444	0.490
December	0.310	0.378	0.411	0.445	0.540
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.350**	**0.470**	**0.810**	**0.855**	**0.970**

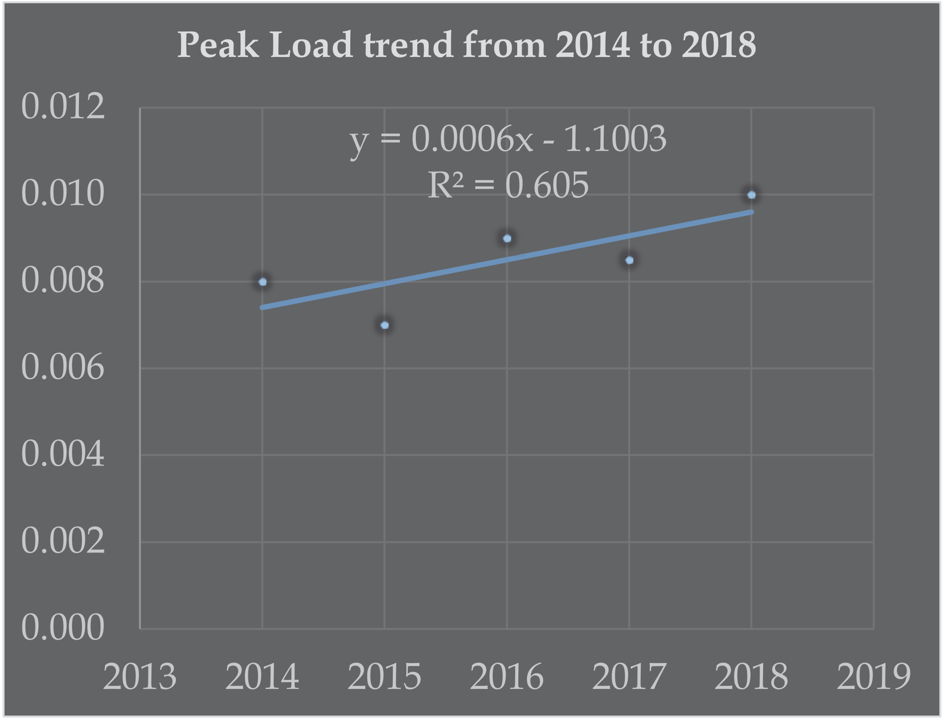


Forecasted Peak Load(MW) from 2019-2030

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.178	1.340	1.503	1.665	1.827	1.990	2.152	2.315	2.477	2.640	2.803	2.965
	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	0.1625	

11kV Feeder Colony

Months	2014	2015	2016	2017	2018
January	0.000	0.005	0.009	0.006	0.009
February	0.000	0.005	0.009	0.006	0.009
March	0.000	0.007	0.008	0.009	0.009
April	0.000	0.005	0.008	0.008	0.007
May	0.000	0.007	0.009	0.009	0.008
June	0.000	0.006	0.008	0.009	0.009
July	0.003	0.006	0.008	0.007	0.006
August	0.005	0.006	0.000	0.004	0.008
September	0.005	0.005	0.008	0.008	0.008
October	0.005	0.007	0.008	0.008	0.007
November	0.006	0.007	0.008	0.007	0.010
December	0.008	0.007	0.007	0.009	0.010
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Peak Load	**0.008**	**0.007**	**0.009**	**0.009**	**0.010**



Forecasted Peak Load(MW) from 2019-2030

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	**0.111**	**0.112**	**0.112**	**0.113**	**0.114**	**0.114**	**0.115**	**0.115**	**0.116**	**0.117**	**0.117**	**0.118**
	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	

Annexure 4- ETAP Simulation Results

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus1	132.000										14.358	85.0	62.8	
Bus2	33.000										9.179	87.8	160.0	
Bus3	132.000										4.736	86.4	20.7	
Bus4	33.000				0.012	0.007					1.973	92.8	34.5	
Bus5	33.000										1.963	92.4	34.4	
Bus6	33.000										5.367	82.2	93.5	
Bus7	33.000		0.012	0.007	0.048	0.030					2.044	92.7	35.7	
Bus8	11.000										5.135	84.9	266.6	
Bus9	33.000										0.024	98.2	0.4	
Bus10	33.000				0.012	0.007					0.014	85.0	0.2	
Bus11	33.000				0.012	0.007					0.014	85.0	0.2	
Bus12	33.000		0.006	0.004	0.024	0.015					0.035	85.0	0.6	
Bus13	33.000										1.907	92.1	33.6	
Bus14	33.000		0.006	0.004	0.024	0.015					0.135	87.8	2.4	
Bus15	33.000		0.003	0.002	0.027	0.017					0.035	85.0	0.6	
Bus16	33.000				0.030	0.018					0.068	87.4	1.2	
Bus17	33.000				0.030	0.018					0.035	85.0	0.6	
Bus18	33.000										1.773	92.2	31.2	
Bus19	33.000				0.030	0.018					0.035	85.0	0.6	
Bus20	33.000				0.029	0.018					1.739	92.3	30.7	
Bus21	33.000										1.704	92.4	30.1	
Bus22	33.000				0.029	0.018					1.114	91.6	19.7	
Bus23	33.000										1.081	91.7	19.1	
Bus24	33.000				0.029	0.018					0.035	85.0	0.6	
Bus25	33.000										1.048	91.7	18.5	
Bus26	33.000		0.024	0.015	0.093	0.058					0.138	85.0	2.4	
Bus27	33.000										0.913	92.4	16.2	
Bus28	33.000		0.006	0.004	0.023	0.015					0.035	85.0	0.6	
Bus29	33.000										0.881	92.4	15.6	
Bus30	33.000				0.012	0.007					0.014	85.0	0.2	
Bus31	33.000										0.868	92.3	15.4	
Bus32	33.000				0.029	0.018					0.772	92.5	13.7	
Bus33	33.000										0.098	89.2	1.7	
Bus34	33.000				0.029	0.018					0.099	89.1	1.7	
Bus35	33.000				0.029	0.018					0.067	87.5	1.2	
Bus36	33.000				0.029	0.018					0.034	85.0	0.6	
Bus37	33.000										0.129	90.6	2.3	
Bus38	33.000				0.029	0.018					0.131	89.5	2.3	
Bus39	33.000										0.098	90.0	1.7	

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
Bus40	33.000				0.029	0.018					0.034	85.0	0.6	
Bus41	33.000										0.065	89.8	1.2	
Bus42	33.000				0.029	0.018					0.034	85.0	0.6	
Bus43	33.000										0.033	87.6	0.6	
Bus44	33.000				0.029	0.018					0.034	85.0	0.6	
Bus45	33.000				0.029	0.018					0.035	85.0	0.6	
Bus46	33.000										0.074	87.1	1.3	
Bus47	33.000				0.029	0.018					0.060	86.7	1.1	
Bus48	33.000				0.012	0.007					0.027	87.1	0.5	
Bus49	33.000				0.012	0.007					0.014	85.0	0.2	
Bus50	33.000				0.012	0.007					0.014	85.0	0.2	
Bus51	33.000										0.612	92.7	10.8	
Bus52	33.000										0.541	93.1	9.6	
Bus53	33.000				0.058	0.036					0.068	85.0	1.2	
Bus54	33.000				0.012	0.007					0.026	89.1	0.5	
Bus55	33.000				0.012	0.007					0.014	85.0	0.2	
Bus56	33.000				0.005	0.003					0.453	93.1	8.0	
Bus57	33.000										0.450	92.6	8.0	
Bus58	33.000										0.046	92.3	0.8	
Bus59	33.000				0.005	0.003					0.005	85.0	0.1	
Bus60	33.000										0.042	89.5	0.8	
Bus61	33.000				0.007	0.005					0.009	85.0	0.2	
Bus62	33.000				0.012	0.007					0.022	87.7	0.4	
Bus63	33.000				0.007	0.005					0.030	89.2	0.5	
Bus64	33.000				0.012	0.007					0.014	85.0	0.2	
Bus65	33.000				0.029	0.018					0.407	92.1	7.2	
Bus66	33.000										0.374	92.3	6.6	
Bus67	33.000				0.029	0.018					0.034	85.0	0.6	
Bus68	33.000										0.341	92.7	6.0	
Bus69	33.000										0.341	92.7	6.0	
Bus70	33.000				0.029	0.018					0.034	85.0	0.6	
Bus71	33.000										0.308	93.1	5.5	
Bus72	33.000				0.029	0.018					0.113	92.9	2.0	
Bus73	33.000				0.029	0.018					0.081	92.8	1.4	
Bus74	33.000				0.012	0.007					0.049	94.5	0.9	
Bus75	33.000				0.012	0.007					0.037	93.3	0.7	
Bus76	33.000				0.012	0.007					0.025	93.5	0.4	
Bus77	33.000				0.012	0.007					0.014	85.0	0.2	
Bus78	33.000				0.058	0.036					0.197	92.7	3.5	
Bus79	33.000										0.131	95.0	2.3	
Bus80	33.000				0.012	0.007					0.014	85.0	0.2	
Bus81	33.000				0.012	0.007					0.119	95.0	2.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus82	33.000				0.012	0.007					0.107	95.0	1.9	
Bus83	33.000										0.093	96.0	1.7	
Bus84	33.000				0.007	0.005					0.021	88.2	0.4	
Bus85	33.000				0.012	0.007					0.014	85.0	0.2	
Bus86	33.000				0.012	0.007					0.075	94.9	1.3	
Bus87	33.000										0.061	96.2	1.1	
Bus88	33.000				0.012	0.007					0.044	91.2	0.8	
Bus89	33.000										0.030	93.1	0.5	
Bus90	33.000				0.005	0.003					0.005	85.0	0.1	
Bus91	33.000				0.005	0.003					0.026	89.8	0.5	
Bus92	33.000										0.022	86.6	0.4	
Bus93	33.000				0.012	0.007					0.014	85.0	0.2	
Bus94	33.000				0.007	0.005					0.009	85.0	0.2	
Bus95	33.000				0.007	0.005					0.020	97.3	0.4	
Bus96	33.000				0.007	0.005					0.013	93.4	0.2	
Bus97	33.000				0.005	0.003					0.005	85.0	0.1	
Bus98	33.000				0.005	0.003					0.593	93.2	10.5	
Bus99	33.000				0.029	0.018					0.591	92.7	10.4	
Bus100	33.000										0.558	93.0	9.9	
Bus101	33.000				0.029	0.018					0.229	89.1	4.1	
Bus102	33.000										0.197	88.7	3.5	
Bus103	33.000				0.029	0.018					0.049	87.7	0.9	
Bus104	33.000				0.014	0.009					0.016	85.0	0.3	
Bus105	33.000				0.029	0.018					0.149	88.3	2.6	
Bus106	33.000										0.116	88.2	2.0	
Bus107	33.000				0.029	0.018					0.035	85.0	0.6	
Bus108	33.000				0.029	0.018					0.082	88.3	1.5	
Bus109	33.000				0.029	0.018					0.049	88.2	0.9	
Bus110	33.000				0.014	0.009					0.016	85.0	0.3	
Bus111	33.000										0.333	94.2	5.9	
Bus112	33.000										0.078	90.2	1.4	
Bus113	33.000				0.012	0.007					0.014	85.0	0.2	
Bus114	33.000										0.066	87.8	1.2	
Bus115	33.000				0.012	0.007					0.014	85.0	0.2	
Bus116	33.000										0.054	87.2	0.9	
Bus117	33.000				0.012	0.007					0.014	85.0	0.2	
Bus118	33.000				0.012	0.007					0.041	86.3	0.7	
Bus119	33.000				0.012	0.007					0.027	86.0	0.5	
Bus120	33.000				0.012	0.007					0.014	85.0	0.2	
Bus121	33.000										0.228	94.0	4.0	
Bus122	33.000				0.029	0.018					0.039	88.2	0.7	
Bus123	33.000				0.005	0.003					0.005	85.0	0.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus124	33.000				0.029	0.018					0.035	85.0	0.6	
Bus125	33.000				0.029	0.018					0.192	93.9	3.4	
Bus126	33.000				0.029	0.018					0.160	94.7	2.8	
Bus127	33.000										0.126	96.3	2.2	
Bus128	33.000				0.012	0.007					0.043	91.2	0.8	
Bus129	33.000										0.030	91.8	0.5	
Bus130	33.000				0.012	0.007					0.014	85.0	0.2	
Bus131	33.000				0.012	0.007					0.018	91.4	0.3	
Bus132	33.000				0.005	0.003					0.005	85.0	0.1	
Bus133	33.000										0.086	96.0	1.5	
Bus134	33.000		0.006	0.004	0.023	0.015					0.056	94.5	1.0	
Bus135	33.000				0.005	0.003					0.024	97.6	0.4	
Bus136	33.000										0.019	97.0	0.3	
Bus137	33.000				0.005	0.003					0.005	85.0	0.1	
Bus138	33.000										0.014	98.8	0.3	
Bus139	33.000				0.005	0.003					0.005	85.0	0.1	
Bus140	33.000										0.010	95.9	0.2	
Bus141	33.000				0.005	0.003					0.005	85.0	0.1	
Bus142	33.000				0.005	0.003					0.005	85.0	0.1	
Bus143	11.000										0.241	85.4	12.5	
Bus144	11.000										0.241	85.4	12.5	
Bus145	11.000		0.021	0.013	0.022	0.013					0.050	85.0	2.6	
Bus146	11.000		0.008	0.005	0.034	0.021					0.051	85.0	2.6	
Bus147	11.000		0.008	0.005	0.034	0.021					0.141	85.4	7.3	
Bus148	11.000		0.008	0.005	0.034	0.021					0.090	85.3	4.7	
Bus149	11.000		0.007	0.004	0.027	0.017					0.040	85.0	2.1	
Bus150	11.000		0.010	0.006	0.037	0.023					0.931	84.4	49.8	
Bus151	11.000				0.012	0.007					0.014	85.0	0.7	
Bus152	11.000				0.046	0.029					0.068	85.5	3.6	
Bus153	11.000		0.010	0.006	0.037	0.023					0.055	85.0	2.9	
Bus154	11.000										0.599	86.3	32.0	
Bus155	11.000				0.019	0.011					0.022	85.0	1.2	
Bus156	11.000										0.622	86.2	33.2	
Bus157	11.000		0.010	0.006	0.037	0.023					0.055	85.0	2.9	
Bus158	11.000										0.987	84.4	52.7	
Bus159	11.000										1.610	85.1	85.8	
Bus160	11.000		0.077	0.047	0.019	0.012					0.113	85.0	5.9	
Bus161	11.000										1.751	85.0	91.7	
Bus162	11.000		0.015	0.009	0.062	0.038					1.848	85.0	96.4	
Bus163	11.000										0.932	85.0	49.9	
Bus164	11.000		0.115	0.071	0.441	0.273					0.932	85.0	49.9	
Bus165	11.000										0.278	85.0	14.9	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus166	11.000				0.046	0.029					0.054	85.0	2.9	
Bus167	11.000		0.172	0.107	0.018	0.011					0.224	85.0	12.0	
Bus168	11.000										0.167	88.2	8.9	
Bus169	11.000		0.019	0.012	0.073	0.046					0.109	85.0	5.8	
Bus170	11.000		0.010	0.006	0.037	0.023					0.476	86.4	25.4	
Bus171	11.000										0.254	85.4	13.6	
Bus172	11.000		0.005	0.003	0.042	0.026					0.055	85.0	2.9	
Bus173	11.000		0.005	0.003	0.042	0.026					0.199	85.5	10.7	
Bus174	11.000										0.144	85.7	7.7	
Bus175	11.000				0.046	0.029					0.109	85.1	5.8	
Bus176	11.000										0.055	85.1	2.9	
Bus177	11.000		0.005	0.003	0.042	0.026					0.055	85.0	2.9	
Bus178	11.000										0.036	86.5	1.9	
Bus179	11.000				0.012	0.007					0.014	85.0	0.7	
Bus180	11.000				0.007	0.005					0.022	86.2	1.2	
Bus181	11.000				0.012	0.007					0.014	85.0	0.7	
Bus182	11.000										3.009	84.8	157.6	
Bus183	11.000		0.005	0.003	0.042	0.026					0.054	85.0	2.8	
Bus184	11.000		0.007	0.005	0.063	0.039					2.885	85.0	154.8	
Bus185	11.000		0.055	0.034	0.464	0.288					2.778	85.0	150.4	
Bus186	11.000										2.164	85.1	117.3	
Bus187	11.000		0.073	0.045	0.274	0.170					0.408	85.0	22.1	
Bus188	11.000										0.204	85.0	11.1	
Bus189	11.000		0.037	0.023	0.137	0.085					0.204	85.0	11.1	
Bus190	11.000										1.550	85.1	84.1	
Bus191	11.000										0.101	85.2	5.5	
Bus192	11.000				0.043	0.027					0.050	85.0	2.7	
Bus193	11.000				0.043	0.027					0.050	85.0	2.7	
Bus194	11.000										1.448	85.1	78.7	
Bus195	11.000		0.822	0.510	0.085	0.053					1.068	85.0	58.0	
Bus196	11.000		0.018	0.011	0.153	0.095					0.380	85.3	20.6	
Bus197	11.000										0.178	85.6	9.7	
Bus198	11.000		0.009	0.006	0.034	0.021					0.178	85.6	9.7	
Bus199	11.000										0.127	85.6	6.9	
Bus200	11.000										0.076	85.6	4.1	
Bus201	11.000		0.009	0.006	0.034	0.021					0.051	85.0	2.8	
Bus202	11.000										0.025	85.9	1.4	
Bus203	11.000				0.011	0.007					0.013	85.0	0.7	
Bus204	11.000				0.011	0.007					0.013	85.0	0.7	
Bus205	11.000		0.009	0.006	0.034	0.021					0.051	85.0	2.8	
Bus206	33.000										3.264	87.8	57.5	
Bus207	33.000		0.041	0.026	0.163	0.101					3.262	87.7	57.5	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus208	33.000										3.021	87.9	53.3	
Bus209	33.000		0.021	0.013	0.082	0.051					0.121	85.0	2.1	
Bus210	33.000										2.895	88.0	51.2	
Bus211	33.000		0.008	0.005	0.032	0.020					0.133	91.8	2.4	
Bus212	33.000		0.008	0.005	0.032	0.020					0.090	90.2	1.6	
Bus213	33.000		0.008	0.005	0.032	0.020					0.048	85.0	0.8	
Bus214	33.000										2.761	87.5	49.0	
Bus215	33.000		0.008	0.005	0.032	0.020					2.760	87.5	49.0	
Bus216	33.000										2.702	87.3	48.4	
Bus217	33.000		0.008	0.005	0.032	0.020					0.047	85.0	0.8	
Bus218	33.000										2.653	87.3	47.6	
Bus219	33.000				0.039	0.024					0.046	85.0	0.8	
Bus220	33.000										2.607	87.3	46.8	
Bus221	33.000				0.039	0.024					0.046	85.0	0.8	
Bus222	33.000				0.039	0.024					2.559	87.3	46.0	
Bus223	33.000										2.512	87.3	45.1	
Bus224	33.000				0.039	0.024					0.046	85.0	0.8	
Bus225	33.000				0.039	0.024					0.120	86.1	2.2	
Bus226	33.000				0.025	0.016					0.075	86.0	1.3	
Bus227	33.000				0.039	0.024					0.046	85.0	0.8	
Bus228	33.000		0.033	0.021	0.008	0.005					2.345	87.3	42.2	
Bus229	33.000				0.016	0.010					1.266	86.5	22.8	
Bus230	33.000										1.249	86.5	22.5	
Bus231	33.000										1.249	86.4	22.5	
Bus232	33.000				0.039	0.024					0.046	85.0	0.8	
Bus233	33.000				0.039	0.024					0.046	85.0	0.8	
Bus234	33.000				0.039	0.024					1.157	86.5	20.9	
Bus235	33.000				0.039	0.024					1.112	86.5	20.0	
Bus236	33.000										1.067	86.5	19.2	
Bus237	33.000				0.039	0.024					0.089	87.3	1.6	
Bus238	33.000				0.039	0.024					0.046	85.0	0.8	
Bus239	33.000				0.039	0.024					0.979	86.3	17.7	
Bus240	33.000				0.025	0.015					0.933	86.3	16.8	
Bus241	33.000										0.904	86.3	16.3	
Bus242	33.000				0.098	0.061					0.116	85.0	2.1	
Bus243	33.000										0.790	86.4	14.2	
Bus244	33.000				0.039	0.024					0.046	85.0	0.8	
Bus245	33.000				0.039	0.024					0.063	86.3	1.1	
Bus246	33.000				0.016	0.010					0.018	85.0	0.3	
Bus247	33.000				0.039	0.024					0.683	86.2	12.3	
Bus248	33.000										0.638	86.2	11.5	
Bus249	33.000				0.039	0.024					0.092	85.3	1.7	

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
Bus250	33.000		0.008	0.005	0.031	0.019					0.046	85.0	0.8	
Bus251	33.000										0.547	86.2	9.9	
Bus252	33.000		0.008	0.005	0.031	0.019					0.092	87.0	1.7	
Bus253	33.000										0.047	86.4	0.9	
Bus254	33.000		0.005	0.003	0.020	0.012					0.030	85.0	0.5	
Bus255	33.000		0.003	0.002	0.012	0.008					0.019	85.0	0.3	
Bus256	33.000		0.005	0.003	0.020	0.012					0.455	85.9	8.2	
Bus257	33.000		0.008	0.005	0.031	0.019					0.426	85.9	7.7	
Bus258	33.000		0.008	0.005	0.031	0.019					0.380	85.8	6.9	
Bus259	33.000										0.334	85.9	6.0	
Bus260	33.000		0.008	0.005	0.031	0.019					0.168	85.4	3.0	
Bus261	33.000		0.008	0.005	0.031	0.019					0.122	85.4	2.2	
Bus262	33.000										0.076	85.4	1.4	
Bus263	33.000		0.005	0.003	0.020	0.012					0.030	85.0	0.5	
Bus264	33.000		0.008	0.005	0.031	0.019					0.046	85.0	0.8	
Bus265	33.000		0.008	0.005	0.031	0.019					0.166	86.0	3.0	
Bus266	33.000		0.008	0.005	0.031	0.019					0.120	86.2	2.2	
Bus267	33.000		0.008	0.005	0.031	0.019					0.075	85.6	1.4	
Bus268	33.000				0.025	0.015					0.029	85.0	0.5	
Bus269	33.000										1.035	87.9	18.7	
Bus270	33.000				0.039	0.024					0.136	87.4	2.4	
Bus271	33.000				0.016	0.010					0.091	87.5	1.6	
Bus272	33.000										0.075	85.8	1.3	
Bus273	33.000				0.025	0.015					0.029	85.0	0.5	
Bus274	33.000				0.039	0.024					0.046	85.0	0.8	
Bus275	33.000										0.902	87.6	16.3	
Bus276	33.000				0.016	0.010					0.225	87.2	4.1	
Bus277	33.000				0.025	0.015					0.208	87.0	3.8	
Bus278	33.000		0.004	0.003	0.035	0.022					0.180	86.7	3.2	
Bus279	33.000				0.039	0.024					0.136	85.9	2.5	
Bus280	33.000				0.039	0.024					0.091	86.0	1.6	
Bus281	33.000				0.039	0.024					0.046	85.0	0.8	
Bus282	33.000				0.039	0.024					0.678	87.5	12.2	
Bus283	33.000										0.633	87.6	11.4	
Bus284	33.000				0.039	0.024					0.046	85.0	0.8	
Bus285	33.000				0.039	0.024					0.588	87.7	10.6	
Bus286	33.000										0.542	87.8	9.8	
Bus287	33.000				0.025	0.015					0.029	85.0	0.5	
Bus288	33.000				0.039	0.024					0.514	87.8	9.3	
Bus289	33.000										0.470	87.7	8.5	
Bus290	33.000				0.039	0.024					0.046	85.0	0.8	
Bus291	33.000				0.039	0.024					0.426	87.7	7.7	

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
Bus292	33.000										0.380	87.9	6.9	
Bus293	33.000				0.039	0.024					0.253	86.7	4.6	
Bus294	33.000										0.207	87.0	3.7	
Bus295	33.000				0.039	0.024					0.074	85.8	1.3	
Bus296	33.000				0.025	0.015					0.029	85.0	0.5	
Bus297	33.000				0.039	0.024					0.135	86.4	2.4	
Bus298	33.000										0.090	86.2	1.6	
Bus299	33.000				0.039	0.024					0.046	85.0	0.8	
Bus300	33.000				0.039	0.024					0.046	85.0	0.8	
Bus301	33.000										0.131	87.7	2.4	
Bus302	33.000				0.025	0.015					0.058	85.9	1.0	
Bus303	33.000				0.025	0.015					0.029	85.0	0.5	
Bus304	33.000				0.016	0.010					0.075	87.3	1.4	
Bus305	33.000										0.058	86.4	1.0	
Bus306	33.000				0.025	0.015					0.029	85.0	0.5	
Bus307	33.000				0.025	0.015					0.029	85.0	0.5	
Bus308	33.000										3.076	94.3	53.6	
Bus309	33.000		0.007	0.004	0.027	0.017					0.040	85.0	0.7	
Bus310	33.000										3.052	93.1	53.7	
Bus311	11.000										2.764	93.1	145.2	
Bus312	33.000				0.004	0.003					0.258	97.0	4.6	
Bus313	33.000				0.017	0.010					0.251	98.1	4.4	
Bus314	33.000										0.231	99.1	4.1	
Bus315	33.000				0.004	0.003					0.009	94.7	0.2	
Bus316	33.000				0.004	0.003					0.005	85.0	0.1	
Bus317	33.000		0.010	0.006	0.007	0.004					0.224	98.4	4.0	
Bus318	33.000										0.205	99.4	3.6	
Bus319	33.000				0.004	0.003					0.025	93.3	0.4	
Bus320	33.000				0.003	0.002					0.019	97.8	0.3	
Bus321	33.000				0.007	0.004					0.018	91.2	0.3	
Bus322	33.000										0.010	94.0	0.2	
Bus323	33.000				0.003	0.002					0.003	85.0	0.1	
Bus324	33.000		0.001	0.001	0.005	0.003					0.008	85.0	0.1	
Bus325	33.000				0.007	0.004					0.181	99.7	3.2	
Bus326	33.000				0.007	0.004					0.175	99.5	3.1	
Bus327	33.000										0.168	99.3	3.0	
Bus328	33.000				0.007	0.004					0.022	91.0	0.4	
Bus329	33.000				0.007	0.004					0.015	89.7	0.3	
Bus330	33.000				0.007	0.004					0.008	85.0	0.1	
Bus331	33.000		0.001	0.000	0.006	0.004					0.149	98.8	2.6	
Bus332	33.000										0.142	98.9	2.5	
Bus333	33.000				0.007	0.004					0.008	85.0	0.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus334	33.000				0.003	0.002					0.135	99.3	2.4	
Bus335	33.000				0.003	0.002					0.131	99.8	2.3	
Bus336	33.000				0.003	0.002					0.128	99.8	2.3	
Bus337	33.000										0.132	95.2	2.3	
Bus338	33.000				0.004	0.003					0.046	42.3	0.8	
Bus339	33.000				0.003	0.002					0.040	37.1	0.7	
Bus340	33.000										0.031	39.7	0.5	
Bus341	33.000				0.003	0.002					0.010	53.6	0.2	
Bus342	33.000				0.003	0.002					0.003	85.0	0.1	
Bus343	33.000										0.014	48.4	0.3	
Bus344	33.000				0.004	0.003					0.005	85.0	0.1	
Bus345	33.000				0.003	0.002					0.010	27.9	0.2	
Bus346	33.000				0.007	0.004					0.112	94.6	2.0	
Bus347	33.000				0.007	0.004					0.105	94.8	1.9	
Bus348	33.000				0.007	0.004					0.099	93.7	1.8	
Bus349	33.000										0.093	93.1	1.6	
Bus350	33.000				0.007	0.004					0.015	86.6	0.3	
Bus351	33.000				0.007	0.004					0.008	85.0	0.1	
Bus352	33.000				0.004	0.003					0.079	92.1	1.4	
Bus353	33.000				0.007	0.004					0.075	91.3	1.3	
Bus354	33.000										0.068	91.7	1.2	
Bus355	33.000				0.007	0.004					0.008	85.0	0.1	
Bus356	33.000				0.007	0.004					0.061	91.4	1.1	
Bus357	33.000				0.007	0.004					0.053	91.8	0.9	
Bus358	33.000				0.007	0.004					0.045	92.4	0.8	
Bus359	33.000		0.001	0.001	0.005	0.003					0.038	92.8	0.7	
Bus360	33.000				0.007	0.004					0.031	93.5	0.5	
Bus361	33.000				0.007	0.004					0.023	95.2	0.4	
Bus362	33.000				0.007	0.004					0.016	96.5	0.3	
Bus363	33.000				0.004	0.003					0.009	95.5	0.2	
Bus364	33.000				0.004	0.003					0.005	85.0	0.1	
Bus365	11.000										0.334	86.3	17.6	
Bus366	11.000				0.017	0.011					0.020	85.0	1.1	
Bus367	11.000				0.017	0.011					0.314	86.3	16.6	
Bus368	11.000				0.034	0.021					0.080	86.0	4.2	
Bus369	11.000				0.004	0.003					0.005	85.0	0.3	
Bus370	11.000										0.035	86.6	1.9	
Bus371	11.000				0.007	0.004					0.008	85.0	0.4	
Bus372	11.000				0.017	0.011					0.028	86.0	1.5	
Bus373	11.000				0.007	0.004					0.008	85.0	0.4	
Bus374	11.000				0.017	0.011					0.215	86.4	11.3	
Bus375	11.000										0.195	86.4	10.3	

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
Bus376	11.000				0.017	0.010					0.020	85.0	1.0	
Bus377	11.000										0.175	86.2	9.3	
Bus378	11.000				0.017	0.010					0.020	85.0	1.0	
Bus379	11.000				0.017	0.010					0.156	86.3	8.2	
Bus380	11.000				0.017	0.010					0.136	86.4	7.2	
Bus381	11.000										0.116	86.5	6.2	
Bus382	11.000				0.017	0.010					0.020	85.0	1.0	
Bus383	11.000				0.017	0.010					0.097	86.5	5.1	
Bus384	11.000										0.077	86.8	4.1	
Bus385	11.000				0.017	0.010					0.020	85.0	1.0	
Bus386	11.000				0.017	0.010					0.058	87.0	3.1	
Bus387	11.000										0.038	87.1	2.0	
Bus388	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus389	11.000				0.004	0.003					0.036	86.5	1.9	
Bus390	11.000				0.007	0.004					0.031	86.6	1.6	
Bus391	11.000										0.023	87.0	1.2	
Bus392	11.000				0.007	0.004					0.008	85.0	0.4	
Bus393	11.000				0.007	0.004					0.015	87.5	0.8	
Bus394	11.000				0.007	0.004					0.008	85.0	0.4	
Bus395	11.000				0.016	0.010					2.339	94.3	126.9	
Bus396	11.000										2.307	94.5	125.9	
Bus397	11.000										0.458	86.1	25.1	
Bus398	11.000				0.006	0.004					0.007	85.0	0.4	
Bus399	11.000										0.449	86.1	24.7	
Bus400	11.000		0.098	0.061	0.010	0.006					0.127	85.0	7.0	
Bus401	11.000				0.016	0.010					0.322	86.5	17.8	
Bus402	11.000										0.303	86.5	16.8	
Bus403	11.000		0.054	0.034	0.012	0.008					0.157	85.8	8.7	
Bus404	11.000				0.015	0.009					0.079	85.9	4.4	
Bus405	11.000										0.061	86.1	3.4	
Bus406	11.000		0.002	0.001	0.014	0.009					0.018	85.0	1.0	
Bus407	11.000										0.043	85.6	2.4	
Bus408	11.000		0.002	0.001	0.014	0.009					0.018	85.0	1.0	
Bus409	11.000										0.025	85.4	1.4	
Bus410	11.000		0.002	0.001	0.014	0.009					0.018	85.0	1.0	
Bus411	11.000		0.001	0.000	0.005	0.003					0.007	85.0	0.4	
Bus412	11.000										0.146	87.0	8.1	
Bus413	11.000										0.146	86.9	8.1	
Bus414	11.000		0.000	0.000	0.015	0.009					0.018	85.0	1.0	
Bus415	11.000										0.128	87.1	7.1	
Bus416	11.000										0.091	85.3	5.0	
Bus417	11.000		0.000	0.000	0.004	0.002					0.005	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
Bus418	11.000										0.086	85.2	4.8	
Bus419	11.000		0.000	0.000	0.006	0.004					0.007	85.0	0.4	
Bus420	11.000		0.061	0.038	0.006	0.004					0.079	85.0	4.4	
Bus421	11.000										0.038	90.4	2.1	
Bus422	11.000		0.000	0.000	0.006	0.004					0.018	90.0	1.0	
Bus423	11.000										0.011	91.4	0.6	
Bus424	11.000				0.004	0.002					0.005	85.0	0.3	
Bus425	11.000				0.006	0.004					0.007	85.0	0.4	
Bus426	11.000				0.006	0.004					0.021	86.8	1.2	
Bus427	11.000		0.001	0.001	0.005	0.003					0.014	86.7	0.8	
Bus428	11.000				0.006	0.004					0.007	85.0	0.4	
Bus429	11.000										0.998	85.5	54.9	
Bus430	11.000		0.003	0.002	0.012	0.008					0.019	85.0	1.0	
Bus431	11.000										0.586	85.8	32.3	
Bus432	11.000		0.014	0.008	0.049	0.031					0.074	85.0	4.1	
Bus433	11.000		0.054	0.034	0.012	0.008					0.512	86.0	28.2	
Bus434	11.000		0.272	0.169	0.062	0.038					0.393	85.0	21.6	
Bus435	11.000		0.054	0.034	0.012	0.008					0.079	85.0	4.3	
Bus436	11.000		0.014	0.008	0.049	0.031					0.355	86.3	19.6	
Bus437	11.000		0.835		0.085						0.921	100.0	50.3	
Bus438	11.000										0.280	86.6	15.5	
Bus439	11.000		0.003	0.002	0.012	0.008					0.043	86.1	2.4	
Bus440	11.000										0.025	86.8	1.4	
Bus441	11.000		0.000	0.000	0.006	0.004					0.007	85.0	0.4	
Bus442	11.000				0.015	0.010					0.018	85.0	1.0	
Bus443	11.000										0.236	86.6	13.1	
Bus444	11.000				0.015	0.010					0.018	85.0	1.0	
Bus445	11.000										0.218	86.6	12.1	
Bus446	11.000				0.015	0.009					0.043	85.8	2.4	
Bus447	11.000				0.006	0.004					0.025	85.4	1.4	
Bus448	11.000				0.015	0.009					0.018	85.0	1.0	
Bus449	11.000				0.004	0.002					0.005	85.0	0.3	
Bus450	11.000										0.171	86.6	9.5	
Bus451	11.000				0.015	0.009					0.018	85.0	1.0	
Bus452	11.000				0.015	0.009					0.153	86.7	8.5	
Bus453	11.000				0.015	0.009					0.135	86.7	7.5	
Bus454	11.000										0.118	87.0	6.5	
Bus455	11.000				0.015	0.009					0.018	85.0	1.0	
Bus456	11.000										0.100	87.1	5.6	
Bus457	11.000				0.006	0.004					0.007	85.0	0.4	
Bus458	11.000				0.006	0.004					0.086	87.0	4.8	
Bus459	11.000				0.006	0.004					0.007	85.0	0.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus460	11.000										0.079	86.7	4.4	
Bus461	11.000				0.015	0.009					0.018	85.0	1.0	
Bus462	11.000				0.006	0.004					0.062	87.0	3.4	
Bus463	11.000										0.055	87.0	3.1	
Bus464	11.000				0.006	0.004					0.007	85.0	0.4	
Bus465	11.000				0.006	0.004					0.048	87.0	2.7	
Bus466	11.000				0.004	0.002					0.005	85.0	0.3	
Bus467	11.000				0.006	0.004					0.036	87.2	2.0	
Bus468	11.000										0.029	87.5	1.6	
Bus469	11.000				0.004	0.002					0.005	85.0	0.3	
Bus470	11.000										0.025	86.2	1.4	
Bus471	11.000				0.004	0.002					0.005	85.0	0.3	
Bus472	11.000										0.021	85.4	1.2	
Bus473	11.000				0.006	0.004					0.007	85.0	0.4	
Bus474	11.000										0.014	85.3	0.8	
Bus475	11.000				0.006	0.004					0.007	85.0	0.4	
Bus476	11.000				0.006	0.004					0.007	85.0	0.4	
Bus477	132.000										2.413	85.6	10.6	
Bus478	33.000										2.346	87.5	42.2	
Bus479	33.000										2.334	87.0	42.5	
Bus480	33.000		0.015	0.009	0.055	0.034					2.333	86.9	42.6	
Bus481	33.000										2.250	87.0	41.1	
Bus482	33.000		0.015	0.009	0.055	0.034					0.164	85.7	3.0	
Bus483	33.000		0.015	0.009	0.055	0.034					0.082	85.0	1.5	
Bus484	33.000										2.089	86.9	38.1	
Bus485	33.000				0.069	0.043					2.088	86.9	38.2	
Bus486	33.000		0.030	0.018	0.109	0.067					2.007	86.9	36.7	
Bus487	33.000				0.068	0.042					1.844	87.0	33.8	
Bus488	33.000										1.763	87.1	32.3	
Bus489	33.000				0.068	0.042					0.395	86.8	7.2	
Bus490	33.000										0.316	87.0	5.8	
Bus491	33.000		0.015	0.009	0.055	0.034					0.082	85.0	1.5	
Bus492	33.000										0.235	87.1	4.3	
Bus493	33.000										0.236	86.9	4.3	
Bus494	33.000				0.068	0.042					0.080	85.0	1.5	
Bus495	33.000				0.068	0.042					0.156	87.4	2.9	
Bus496	33.000				0.068	0.042					0.080	85.0	1.5	
Bus497	33.000										1.371	87.0	25.1	
Bus498	33.000		0.060	0.037	0.217	0.135					0.325	85.0	6.0	
Bus499	33.000										1.046	87.5	19.2	
Bus500	33.000				0.068	0.042					0.080	85.0	1.5	
Bus501	33.000										0.967	87.5	17.7	

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
Bus502	33.000				0.068	0.042					0.160	85.6	2.9	
Bus503	33.000				0.068	0.042					0.080	85.0	1.5	
Bus504	33.000										0.808	87.7	14.8	
Bus505	33.000				0.068	0.042					0.080	85.0	1.5	
Bus506	33.000										0.731	87.6	13.4	
Bus507	33.000										0.081	88.5	1.5	
Bus508	33.000				0.017	0.011					0.081	87.5	1.5	
Bus509	33.000										0.063	86.3	1.1	
Bus510	33.000													
Bus511	33.000				0.027	0.017					0.063	85.8	1.2	
Bus512	33.000				0.027	0.017					0.032	85.0	0.6	
Bus513	33.000										0.651	87.4	12.0	
Bus514	33.000				0.027	0.017					0.652	87.3	12.0	
Bus515	33.000										0.620	87.4	11.4	
Bus516	33.000				0.027	0.017					0.032	85.0	0.6	
Bus517	33.000										0.589	87.3	10.8	
Bus518	33.000				0.017	0.011					0.162	85.9	3.0	
Bus519	33.000				0.027	0.017					0.142	85.8	2.6	
Bus520	33.000										0.110	85.9	2.0	
Bus521	33.000				0.068	0.042					0.080	85.0	1.5	
Bus522	33.000				0.027	0.017					0.032	85.0	0.6	
Bus523	33.000				0.027	0.017					0.431	87.1	7.9	
Bus524	33.000										0.400	87.2	7.3	
Bus525	33.000				0.017	0.011					0.020	85.0	0.4	
Bus526	33.000				0.027	0.017					0.380	87.2	7.0	
Bus527	33.000										0.348	87.4	6.4	
Bus528	33.000				0.027	0.017					0.032	85.0	0.6	
Bus529	33.000				0.027	0.017					0.318	87.3	5.8	
Bus530	33.000										0.287	87.4	5.3	
Bus531	33.000										0.162	88.2	3.0	
Bus532	33.000										0.082	86.7	1.5	
Bus533	33.000				0.017	0.011					0.020	85.0	0.4	
Bus534	33.000				0.027	0.017					0.063	85.4	1.2	
Bus535	33.000				0.027	0.017					0.032	85.0	0.6	
Bus536	33.000		0.003	0.002	0.024	0.015					0.080	88.8	1.5	
Bus537	33.000										0.050	88.2	0.9	
Bus538	33.000				0.027	0.017					0.032	85.0	0.6	
Bus539	33.000				0.017	0.011					0.020	85.0	0.4	
Bus540	33.000				0.027	0.017					0.126	85.9	2.3	
Bus541	33.000										0.094	85.9	1.7	
Bus542	33.000				0.027	0.017					0.032	85.0	0.6	
Bus543	33.000				0.027	0.017					0.063	85.5	1.2	

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
Bus544	33.000				0.027	0.017					0.032	85.0	0.6	
Bus545	132.000										2.877	83.1	12.6	
Bus548	11.000										1.663	85.0	90.4	
Bus549	11.000										1.514	85.0	82.6	
Bus550	11.000										2.801	84.9	151.0	
Bus551	11.000		0.026	0.016	0.097	0.060					0.144	85.0	7.8	
Bus552	11.000		0.207	0.129	0.766	0.475					1.146	85.0	62.6	
Bus553	11.000		0.033	0.021	0.123	0.076					0.367	85.0	20.0	
Bus554	11.000		0.033	0.021	0.123	0.076					0.183	85.0	10.0	
Bus555	11.000		0.200	0.124	0.749	0.464					1.117	85.0	60.6	
Bus556	11.000		0.003	0.002	0.014	0.008					0.020	85.0	1.1	

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

Branch Loading Summary Report

CKT / Branch		Cable & Reactor			Transformer				
						Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	Capability (MVA)	MVA	%	MVA	%
11 KV UG	Cable	338.03	11.07	3.27					
Cable1	Cable	338.03	50.35	14.89					
Cable2	Cable	338.03	1.06	0.31					
UG	Cable	229.86	11.07	4.82					
Khalanzi 33/11 KV	Transformer				4.090	2.820	68.9	2.764	67.6
KHPC Transformer	Transformer				4.090	2.877	70.3	2.801	68.5
Transformer	Transformer				5.000	2.413	48.3	2.346	46.9
* Transformer I	Transformer				7.778	9.625	123.7	9.179	118.0
Transformer II	Transformer				5.000	4.736	94.7	4.517	90.3
* Transformer III	Transformer				5.000	5.367	107.3	5.135	102.7

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

Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
	MW	Mvar	MW	Mvar	kW	kvar	From	To	
Transformer I	8.115	5.174	-8.056	-4.400	59.6	774.4	100.0	100.4	0.39
Line1	1.896	0.764	-1.894	-0.768	2.8	-4.2	100.4	100.2	0.17
Line199	2.892	1.563	-2.864	-1.565	27.6	-1.5	100.4	99.3	1.08
Line302	2.902	1.022	-2.901	-1.023	0.9	-0.2	100.4	100.4	0.04
Transformer II	4.093	2.383	-4.048	-2.003	44.7	379.5	100.0	100.4	0.39
Line2	-1.830	-0.737	1.834	0.731	3.6	-6.0	100.0	100.2	0.23
Line3	1.818	0.730	-1.815	-0.736	3.6	-6.0	100.0	99.8	0.23
Line4	0.024	-0.012	-0.024	-0.005	0.0	-17.0	99.8	99.8	0.01
Line7	0.030	0.015	-0.030	-0.019	0.0	-3.7	99.8	99.8	0.00
Line8	1.761	0.734	-1.755	-0.745	6.1	-11.0	99.8	99.4	0.40
Transformer III	4.413	3.054	-4.357	-2.717	56.1	336.8	100.4	101.1	0.72
Line138	0.206	0.125	-0.206	-0.125	0.0	0.0	101.1	101.1	0.02
Line157	1.578	0.979	-1.571	-0.974	7.0	5.7	101.1	100.6	0.50
Line177	2.573	1.612	-2.552	-1.594	21.2	17.7	101.1	100.2	0.92
Line5	0.012	0.004	-0.012	-0.007	0.0	-3.4	99.8	99.8	0.00
Line6	0.012	0.001	-0.012	-0.007	0.0	-6.7	99.8	99.8	0.00
Line9	0.119	0.063	-0.119	-0.065	0.0	-1.8	99.4	99.4	0.00
Line13	1.637	0.682	-1.635	-0.685	1.4	-3.0	99.4	99.3	0.10
Line10	0.030	0.015	-0.030	-0.018	0.0	-3.4	99.4	99.4	0.00
Line11	0.059	0.031	-0.059	-0.033	0.0	-1.7	99.4	99.4	0.00
Line12	0.030	0.015	-0.030	-0.018	0.0	-3.7	99.4	99.4	0.00
Line14	0.030	0.018	-0.030	-0.018	0.0	-0.4	99.3	99.3	0.00
Line15	1.606	0.667	-1.604	-0.670	1.5	-3.4	99.3	99.2	0.11
Line17	1.575	0.652	-1.575	-0.652	0.2	-0.4	99.2	99.1	0.01
Line18	1.021	0.440	-1.020	-0.447	1.0	-6.7	99.1	99.0	0.11
Line92	0.553	0.212	-0.553	-0.215	0.1	-3.5	99.1	99.1	0.03
Line19	0.991	0.429	-0.991	-0.432	0.4	-3.2	99.0	99.0	0.05
Line20	0.029	0.017	-0.029	-0.018	0.0	-1.5	99.0	99.0	0.00
Line21	0.961	0.415	-0.961	-0.417	0.2	-1.4	99.0	99.0	0.02
Line16	0.117	0.072	-0.117	-0.073	0.0	-0.4	99.0	99.0	0.00
Line22	0.844	0.345	-0.843	-0.350	0.5	-5.3	99.0	98.9	0.07
Line23	0.814	0.332	-0.814	-0.337	0.5	-5.1	98.9	98.8	0.06
Line24	0.029	0.018	-0.029	-0.018	0.0	-0.2	98.9	98.9	0.00
Line25	0.012	0.005	-0.012	-0.007	0.0	-2.6	98.8	98.8	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
Line26	0.802	0.332	-0.802	-0.333	0.1	-1.1	98.8	98.8	0.01
Line27	0.714	0.290	-0.714	-0.294	0.3	-3.9	98.8	98.8	0.04
Line28	0.088	0.043	-0.088	-0.045	0.0	-1.3	98.8	98.8	0.00
Line32	0.117	0.049	-0.117	-0.055	0.0	-6.1	98.8	98.8	0.01
Line40	0.567	0.227	-0.567	-0.230	0.1	-2.4	98.8	98.8	0.02
Line29	0.088	0.045	-0.088	-0.045	0.0	-0.2	98.8	98.8	0.00
Line30	0.059	0.027	-0.059	-0.032	0.0	-5.8	98.8	98.8	0.01
Line31	0.029	0.014	-0.029	-0.018	0.0	-4.0	98.8	98.8	0.00
Line33	0.117	0.055	-0.117	-0.058	0.0	-3.5	98.8	98.8	0.01
Line34	0.088	0.040	-0.088	-0.043	0.0	-2.5	98.8	98.8	0.00
Line35	0.029	0.015	-0.029	-0.018	0.0	-2.8	98.8	98.8	0.00
Line36	0.058	0.027	-0.058	-0.029	0.0	-1.4	98.8	98.8	0.00
Line37	0.029	0.018	-0.029	-0.018	0.0	-0.3	98.8	98.8	0.00
Line38	0.029	0.011	-0.029	-0.016	0.0	-5.2	98.8	98.8	0.00
Line39	0.029	0.016	-0.029	-0.018	0.0	-2.0	98.8	98.8	0.00
Line128	-0.029	-0.018	0.029	0.016	0.0	-2.2	99.0	99.0	0.00
Line41	-0.064	-0.036	0.064	0.034	0.0	-1.8	98.8	98.8	0.00
Line42	0.052	0.029	-0.052	-0.030	0.0	-0.7	98.8	98.8	0.00
Line45	0.012	0.007	-0.012	-0.007	0.0	-0.4	98.8	98.8	0.00
Line43	0.023	0.012	-0.023	-0.013	0.0	-1.1	98.8	98.8	0.00
Line44	0.012	0.006	-0.012	-0.007	0.0	-1.3	98.8	98.8	0.00
Line46	0.503	0.195	-0.503	-0.198	0.1	-2.4	98.8	98.7	0.02
Line47	0.058	0.036	-0.058	-0.036	0.0	-0.3	98.7	98.7	0.00
Line48	0.023	0.008	-0.023	-0.012	0.0	-3.6	98.7	98.7	0.00
Line50	0.422	0.154	-0.422	-0.166	0.3	-12.2	98.7	98.7	0.07
Line49	0.012	0.005	-0.012	-0.007	0.0	-2.5	98.7	98.7	0.00
Line51	0.417	0.163	-0.417	-0.170	0.2	-7.2	98.7	98.6	0.04
Line52	0.043	0.013	-0.043	-0.018	0.0	-5.1	98.6	98.6	0.01
Line59	0.374	0.158	-0.374	-0.159	0.0	-1.0	98.6	98.6	0.01
Line53	0.005	0.001	-0.005	-0.003	0.0	-1.8	98.6	98.6	0.00
Line54	0.038	0.017	-0.038	-0.019	0.0	-2.2	98.6	98.6	0.00
Line56	0.026	0.012	-0.026	-0.013	0.0	-1.5	98.6	98.6	0.00
Line57	0.012	0.007	-0.012	-0.007	0.0	-0.1	98.6	98.6	0.00
Line58	-0.007	-0.005	0.007	0.003	0.0	-1.4	98.6	98.6	0.00
Line55	-0.019	-0.010	0.019	0.009	0.0	-1.6	98.6	98.6	0.00
Line60	0.345	0.141	-0.345	-0.144	0.1	-3.4	98.6	98.6	0.02
Line61	0.029	0.018	-0.029	-0.018	0.0	-0.5	98.6	98.6	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd
	MW	Mvar	MW	Mvar	kW	kvar	From	To	% Drop in Vmag
Line62	0.316	0.126	-0.316	-0.127	0.0	-1.0	98.6	98.6	0.00
Line63	0.316	0.127	-0.316	-0.128	0.0	-0.3	98.6	98.6	0.00
Line64	0.029	0.017	-0.029	-0.018	0.0	-0.7	98.6	98.6	0.00
Line65	0.287	0.110	-0.287	-0.113	0.0	-2.4	98.6	98.6	0.01
Line66	0.105	0.041	-0.105	-0.042	0.0	-0.8	98.6	98.6	0.00
Line72	0.182	0.072	-0.182	-0.074	0.0	-1.6	98.6	98.6	0.00
Line67	0.075	0.024	-0.075	-0.030	0.0	-6.6	98.6	98.6	0.01
Line68	0.046	0.012	-0.046	-0.016	0.0	-3.8	98.6	98.6	0.00
Line69	0.035	0.009	-0.035	-0.013	0.0	-4.6	98.6	98.6	0.00
Line70	0.023	0.006	-0.023	-0.009	0.0	-2.5	98.6	98.6	0.00
Line71	0.012	0.002	-0.012	-0.005	0.0	-3.2	98.6	98.6	0.00
Line546	0.000	-0.002	0.000	0.000	0.0	-2.4	98.6	98.6	0.00
Line73	0.124	0.038	-0.124	-0.041	0.0	-3.0	98.6	98.6	0.01
Line74	0.012	0.004	-0.012	-0.007	0.0	-3.0	98.6	98.6	0.00
Line75	0.113	0.037	-0.113	-0.037	0.0	-0.5	98.6	98.6	0.00
Line76	0.101	0.030	-0.101	-0.033	0.0	-3.2	98.6	98.6	0.00
Line77	0.090	0.026	-0.090	-0.026	0.0	-0.2	98.6	98.6	0.00
Line78	0.019	0.007	-0.019	-0.010	0.0	-2.9	98.6	98.6	0.00
Line80	0.071	0.019	-0.071	-0.023	0.0	-4.3	98.6	98.6	0.00
Line79	0.012	0.006	-0.012	-0.007	0.0	-1.6	98.6	98.6	0.00
Line81	0.059	0.016	-0.059	-0.017	0.0	-0.4	98.6	98.6	0.00
Line82	0.040	0.017	-0.040	-0.018	0.0	-1.3	98.6	98.6	0.00
Line89	0.019	0.000	-0.019	-0.002	0.0	-2.3	98.6	98.6	0.00
Line83	0.028	0.011	-0.028	-0.011	0.0	-0.3	98.6	98.6	0.00
Line84	0.005	0.002	-0.005	-0.003	0.0	-0.7	98.6	98.6	0.00
Line85	0.024	0.009	-0.024	-0.012	0.0	-2.6	98.6	98.6	0.00
Line86	0.019	0.009	-0.019	-0.011	0.0	-2.3	98.6	98.6	0.00
Line87	0.012	0.007	-0.012	-0.007	0.0	-0.4	98.6	98.6	0.00
Line88	0.007	0.004	-0.007	-0.005	0.0	-0.4	98.6	98.6	0.00
Line90	0.012	-0.002	-0.012	-0.002	0.0	-4.1	98.6	98.6	0.00
Line91	0.005	-0.003	-0.005	-0.003	0.0	-5.6	98.6	98.6	0.00
Line93	0.548	0.213	-0.548	-0.221	0.3	-8.9	99.1	99.1	0.07
Line94	0.519	0.203	-0.518	-0.205	0.1	-2.0	99.1	99.0	0.02
Line95	0.204	0.100	-0.204	-0.104	0.1	-4.3	99.0	99.0	0.02
Line105	0.314	0.106	-0.314	-0.112	0.1	-6.2	99.0	99.0	0.03
Line96	0.175	0.086	-0.175	-0.091	0.0	-5.2	99.0	99.0	0.02
Line97	0.043	0.022	-0.043	-0.024	0.0	-1.9	99.0	99.0	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line99	0.132	0.069	-0.132	-0.070	0.0	-0.8	99.0	99.0	0.00
Line98	0.014	0.006	-0.014	-0.009	0.0	-3.1	99.0	99.0	0.00
Line100	0.102	0.052	-0.102	-0.054	0.0	-2.7	99.0	99.0	0.01
Line101	0.029	0.017	-0.029	-0.018	0.0	-1.5	99.0	99.0	0.00
Line102	0.073	0.038	-0.073	-0.039	0.0	-0.8	99.0	99.0	0.00
Line103	0.043	0.020	-0.043	-0.023	0.0	-2.8	99.0	99.0	0.00
Line104	0.014	0.005	-0.014	-0.009	0.0	-3.7	99.0	99.0	0.00
Line106	0.070	0.029	-0.070	-0.034	0.0	-4.9	99.0	99.0	0.01
Line115	0.215	0.070	-0.215	-0.078	0.0	-7.9	99.0	99.0	0.02
Line118	0.029	0.013	-0.029	-0.018	0.0	-5.0	99.0	99.0	0.00
Line107	0.012	0.004	-0.012	-0.007	0.0	-3.4	99.0	99.0	0.00
Line108	0.058	0.030	-0.058	-0.032	0.0	-2.0	99.0	99.0	0.00
Line109	0.012	0.007	-0.012	-0.007	0.0	-0.4	99.0	99.0	0.00
Line110	0.047	0.025	-0.047	-0.026	0.0	-1.2	99.0	99.0	0.00
Line111	0.012	0.006	-0.012	-0.007	0.0	-1.2	99.0	99.0	0.00
Line112	0.035	0.020	-0.035	-0.020	0.0	-0.3	99.0	99.0	0.00
Line113	0.023	0.013	-0.023	-0.014	0.0	-0.6	99.0	99.0	0.00
Line114	0.012	0.007	-0.012	-0.007	0.0	-0.6	99.0	99.0	0.00
Line116	0.034	0.012	-0.034	-0.015	0.0	-2.6	99.0	99.0	0.00
Line119	0.181	0.066	-0.181	-0.066	0.0	-0.2	99.0	99.0	0.00
Line117	0.005	-0.003	-0.005	-0.003	0.0	-6.4	99.0	99.0	0.00
Line120	0.151	0.048	-0.151	-0.051	0.0	-3.3	99.0	99.0	0.01
Line121	0.122	0.033	-0.122	-0.034	0.0	-1.2	99.0	99.0	0.00
Line122	0.040	0.012	-0.040	-0.018	0.0	-5.3	99.0	99.0	0.01
Line127	0.082	0.022	-0.082	-0.024	0.0	-2.4	99.0	99.0	0.00
Line123	0.028	0.011	-0.028	-0.012	0.0	-1.5	99.0	99.0	0.00
Line124	0.012	0.007	-0.012	-0.007	0.0	-0.3	99.0	99.0	0.00
Line125	0.016	0.005	-0.016	-0.007	0.0	-1.9	99.0	99.0	0.00
Line126	0.005	0.000	-0.005	-0.003	0.0	-3.0	99.0	99.0	0.00
Line129	0.053	0.008	-0.053	-0.011	0.0	-2.5	99.0	99.0	0.00
Line130	0.023	-0.008	-0.023	0.002	0.0	-5.3	99.0	99.0	0.00
Line131	0.019	-0.005	-0.019	0.004	0.0	-1.6	99.0	99.0	0.00
Line132	0.005	0.001	-0.005	-0.003	0.0	-1.8	99.0	99.0	0.00
Line133	0.014	-0.005	-0.014	0.001	0.0	-4.0	99.0	99.0	0.00
Line134	0.005	-0.002	-0.005	-0.003	0.0	-5.1	99.0	99.0	0.00
Line135	0.009	0.002	-0.009	-0.002	0.0	-0.2	99.0	99.0	0.00
Line136	0.005	0.003	-0.005	-0.003	0.0	-0.1	99.0	99.0	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
Line137	0.005	-0.001	-0.005	-0.003	0.0	-3.9	99.0	99.0	0.00
Line139	0.206	0.125	-0.206	-0.125	0.2	-0.1	101.1	101.0	0.09
Line140	0.043	0.026	-0.043	-0.026	0.0	-0.5	101.0	101.0	0.04
Line141	0.043	0.026	-0.043	-0.027	0.0	-0.4	101.0	101.0	0.04
Line142	0.120	0.073	-0.120	-0.073	0.1	-0.1	101.0	101.0	0.04
Line143	0.077	0.047	-0.077	-0.047	0.1	-0.5	101.0	100.9	0.08
Line144	0.034	0.020	-0.034	-0.021	0.0	-0.6	100.9	100.8	0.03
Line145	-0.786	-0.500	0.786	0.500	0.4	0.3	98.2	98.3	0.05
Line158	0.739	0.471	-0.737	-0.469	1.7	1.2	98.2	98.0	0.25
Line146	-0.012	-0.007	0.012	0.007	0.0	-0.7	98.1	98.2	0.02
Line147	-0.058	-0.035	0.058	0.035	0.0	-0.6	98.2	98.2	0.05
Line148	-0.047	-0.029	0.047	0.029	0.0	-0.1	98.2	98.2	0.00
Line149	-0.517	-0.303	0.518	0.304	1.0	0.5	98.2	98.4	0.21
Line165	0.411	0.239	-0.411	-0.239	0.5	0.2	98.2	98.1	0.12
Line150	-0.019	-0.011	0.019	0.011	0.0	0.0	98.4	98.4	0.00
Line151	-0.536	-0.315	0.536	0.315	0.2	0.1	98.4	98.5	0.04
Line152	-0.047	-0.029	0.047	0.029	0.0	-0.2	98.3	98.3	0.01
Line543	0.000	0.000	0.000	0.000	0.0	-0.1	98.3	98.3	0.00
Line153	-0.833	-0.529	0.835	0.530	1.2	0.9	98.3	98.5	0.16
Line154	-1.371	-0.845	1.393	0.863	22.4	18.1	98.5	100.2	1.78
Line155	-0.096	-0.059	0.096	0.059	0.1	-0.6	100.2	100.2	0.07
Line156	-1.489	-0.922	1.494	0.926	5.1	4.1	100.2	100.6	0.38
XLPE	0.792	0.491	-0.792	-0.491	0.1	0.1	98.0	98.0	0.02
Line162	-0.055	-0.021	0.055	0.021	0.0	-0.2	98.0	98.0	0.01
Line159	0.237	0.147	-0.237	-0.147	0.0	0.0	98.0	98.0	0.01
Line160	0.046	0.029	-0.046	-0.029	0.0	-0.1	98.0	98.0	0.01
Line161	0.191	0.118	-0.190	-0.118	0.0	-0.1	98.0	97.9	0.02
Line163	0.093	0.057	-0.093	-0.057	0.0	0.0	98.0	98.0	0.00
Line164	-0.147	-0.079	0.148	0.078	0.1	-0.2	98.0	98.1	0.08
Line166	0.217	0.132	-0.217	-0.132	0.1	-0.1	98.1	98.0	0.04
Line167	0.047	0.029	-0.047	-0.029	0.0	-0.1	98.0	98.0	0.01
Line168	0.170	0.103	-0.170	-0.103	0.0	0.0	98.0	98.0	0.01
Line169	0.124	0.074	-0.124	-0.074	0.0	0.0	98.0	98.0	0.01
Line170	0.093	0.057	-0.093	-0.057	0.0	-0.3	98.0	98.0	0.04
Line173	0.031	0.017	-0.031	-0.018	0.0	-0.4	98.0	98.0	0.03
Line171	0.046	0.029	-0.046	-0.029	0.0	-0.1	98.0	98.0	0.01
Line172	0.046	0.029	-0.046	-0.029	0.0	-0.1	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
Line174	0.012	0.007	-0.012	-0.007	0.0	0.0	98.0	98.0	0.00
Line175	0.019	0.011	-0.019	-0.011	0.0	-0.6	98.0	98.0	0.03
Line176	0.012	0.007	-0.012	-0.007	0.0	-0.6	98.0	98.0	0.01
Line178	0.046	0.028	-0.046	-0.029	0.0	-0.3	100.2	100.2	0.03
Line179	2.506	1.566	-2.451	-1.521	54.2	45.4	100.2	97.8	2.39
Line180	2.381	1.477	-2.363	-1.462	18.4	15.4	97.8	97.0	0.84
Line181	1.844	1.140	-1.841	-1.138	2.8	2.4	97.0	96.8	0.17
11 KV UG	0.174	0.108	-0.174	-0.108	0.0	0.0	96.8	96.8	0.01
Line182	0.347	0.215	-0.347	-0.215	0.1	0.0	96.8	96.8	0.03
Line183	1.320	0.815	-1.319	-0.814	1.5	1.3	96.8	96.7	0.13
UG	0.174	0.108	-0.174	-0.108	0.0	0.0	96.8	96.8	0.00
Line184	0.086	0.052	-0.086	-0.053	0.1	-0.6	96.7	96.5	0.15
Line187	1.233	0.762	-1.232	-0.761	1.3	1.0	96.7	96.6	0.11
Line185	0.043	0.026	-0.043	-0.027	0.0	-0.5	96.5	96.5	0.05
Line186	0.043	0.027	-0.043	-0.027	0.0	0.0	96.5	96.5	0.00
Line188	0.908	0.563	-0.908	-0.562	0.2	0.1	96.6	96.5	0.02
Line189	0.324	0.198	-0.324	-0.198	0.0	0.0	96.6	96.6	0.01
Line190	0.152	0.092	-0.152	-0.092	0.0	-0.1	96.6	96.5	0.03
Line191	0.152	0.092	-0.152	-0.092	0.0	0.0	96.5	96.5	0.01
Line192	0.109	0.065	-0.109	-0.066	0.2	-0.5	96.5	96.4	0.17
Line193	0.065	0.039	-0.065	-0.039	0.0	-0.1	96.4	96.3	0.02
Line198	0.043	0.026	-0.043	-0.027	0.0	-0.4	96.4	96.3	0.05
Line194	0.043	0.027	-0.043	-0.027	0.0	-0.1	96.3	96.3	0.01
Line195	0.022	0.012	-0.022	-0.013	0.0	-0.5	96.3	96.3	0.03
Line196	0.011	0.006	-0.011	-0.007	0.0	-0.4	96.3	96.3	0.01
Line197	0.011	0.007	-0.011	-0.007	0.0	-0.1	96.3	96.3	0.00
Line200	2.864	1.565	-2.862	-1.565	2.4	-0.1	99.3	99.2	0.09
Line201	2.657	1.438	-2.656	-1.438	1.1	-0.2	99.2	99.2	0.05
Line202	0.103	0.064	-0.103	-0.064	0.0	-0.3	99.2	99.2	0.00
Line203	2.553	1.375	-2.547	-1.376	6.4	-1.7	99.2	98.9	0.28
Line204	0.122	0.044	-0.122	-0.053	0.0	-8.8	98.9	98.9	0.02
Line207	2.425	1.332	-2.416	-1.335	8.4	-3.0	98.9	98.5	0.38
Line205	0.081	0.028	-0.081	-0.039	0.0	-11.4	98.9	98.9	0.01
Line206	0.041	0.014	-0.041	-0.025	0.0	-11.4	98.9	98.9	0.01
Line208	2.416	1.335	-2.416	-1.336	0.7	-0.2	98.5	98.5	0.03
Line209	2.375	1.310	-2.359	-1.317	16.3	-6.2	98.5	97.7	0.76
Line210	0.040	0.024	-0.040	-0.025	0.0	-0.9	97.7	97.7	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
Line211	2.319	1.293	-2.317	-1.294	2.4	-1.0	97.7	97.6	0.12
Line212	0.039	0.024	-0.039	-0.024	0.0	-0.8	97.6	97.6	0.00
Line213	2.277	1.270	-2.276	-1.271	1.0	-0.4	97.6	97.5	0.05
Line214	0.039	0.024	-0.039	-0.024	0.0	-0.6	97.5	97.5	0.00
Line215	2.237	1.247	-2.233	-1.248	3.4	-1.7	97.5	97.4	0.17
Line216	2.194	1.224	-2.194	-1.224	0.5	-0.3	97.4	97.4	0.02
Line217	0.039	0.023	-0.039	-0.024	0.0	-0.9	97.4	97.4	0.00
Line218	0.104	0.060	-0.104	-0.061	0.0	-1.3	97.4	97.4	0.00
Line221	2.051	1.141	-2.048	-1.143	2.9	-2.2	97.4	97.2	0.16
Line219	0.064	0.037	-0.064	-0.038	0.0	-1.3	97.4	97.4	0.00
Line220	0.039	0.023	-0.039	-0.024	0.0	-1.8	97.4	97.4	0.00
Line222	1.096	0.632	-1.095	-0.636	0.8	-3.8	97.2	97.1	0.08
Line262	0.910	0.486	-0.909	-0.494	1.1	-8.3	97.2	97.1	0.14
Line223	1.080	0.626	-1.079	-0.627	0.3	-1.6	97.1	97.1	0.03
Line224	1.079	0.627	-1.079	-0.628	0.1	-0.6	97.1	97.1	0.01
Line225	0.039	0.024	-0.039	-0.024	0.0	-0.4	97.1	97.1	0.00
Line226	0.039	0.024	-0.039	-0.024	0.0	-0.4	97.1	97.1	0.00
Line227	1.001	0.580	-1.001	-0.581	0.1	-0.4	97.1	97.1	0.01
Line228	0.962	0.557	-0.962	-0.558	0.2	-1.3	97.1	97.0	0.02
Line229	0.923	0.534	-0.923	-0.536	0.3	-1.9	97.0	97.0	0.03
Line230	0.078	0.042	-0.078	-0.044	0.0	-1.5	97.0	97.0	0.00
Line232	0.845	0.494	-0.845	-0.494	0.1	-0.8	97.0	97.0	0.01
Line231	0.039	0.019	-0.039	-0.024	0.0	-4.7	97.0	97.0	0.00
Line233	0.806	0.470	-0.805	-0.471	0.1	-1.3	97.0	97.0	0.02
Line234	0.780	0.456	-0.780	-0.456	0.0	-0.3	97.0	97.0	0.00
Line235	0.098	0.060	-0.098	-0.061	0.0	-1.1	97.0	97.0	0.00
Line236	0.682	0.396	-0.682	-0.398	0.1	-1.2	97.0	97.0	0.01
Line237	0.039	0.022	-0.039	-0.024	0.0	-2.3	97.0	97.0	0.00
Line238	0.055	0.030	-0.055	-0.032	0.0	-1.5	97.0	97.0	0.00
Line240	0.589	0.345	-0.589	-0.347	0.1	-1.4	97.0	96.9	0.01
Line239	0.016	0.008	-0.016	-0.010	0.0	-1.8	97.0	97.0	0.00
Line241	0.550	0.323	-0.550	-0.324	0.1	-1.2	96.9	96.9	0.01
Line242	0.078	0.047	-0.078	-0.048	0.0	-0.5	96.9	96.9	0.00
Line244	0.471	0.276	-0.471	-0.277	0.0	-0.6	96.9	96.9	0.00
Line243	0.039	0.024	-0.039	-0.024	0.0	-0.7	96.9	96.9	0.00
Line245	0.080	0.045	-0.080	-0.046	0.0	-0.3	96.9	96.9	0.00
Line249	0.391	0.232	-0.391	-0.233	0.0	-1.4	96.9	96.9	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
Line246	0.041	0.021	-0.041	-0.024	0.0	-2.8	96.9	96.9	0.00
Line247	0.025	0.015	-0.025	-0.016	0.0	-0.4	96.9	96.9	0.00
Line248	0.016	0.009	-0.016	-0.010	0.0	-1.1	96.9	96.9	0.00
Line250	0.365	0.218	-0.365	-0.218	0.0	-0.5	96.9	96.9	0.00
Line251	0.326	0.194	-0.326	-0.195	0.0	-1.1	96.9	96.9	0.01
Line252	0.287	0.170	-0.287	-0.171	0.0	-0.3	96.9	96.9	0.00
Line253	0.143	0.087	-0.143	-0.088	0.0	-0.3	96.9	96.9	0.00
Line258	0.143	0.084	-0.143	-0.085	0.0	-1.3	96.9	96.9	0.00
Line254	0.104	0.063	-0.104	-0.063	0.0	-0.3	96.9	96.9	0.00
Line255	0.065	0.039	-0.065	-0.039	0.0	-0.3	96.9	96.9	0.00
Line256	0.025	0.015	-0.025	-0.016	0.0	-0.6	96.9	96.9	0.00
Line257	0.039	0.024	-0.039	-0.024	0.0	-0.1	96.9	96.9	0.00
Line259	0.104	0.060	-0.104	-0.061	0.0	-0.5	96.9	96.9	0.00
Line260	0.064	0.037	-0.064	-0.039	0.0	-2.3	96.9	96.9	0.00
Line261	0.025	0.014	-0.025	-0.015	0.0	-1.0	96.9	96.9	0.00
Line263	0.119	0.065	-0.119	-0.066	0.0	-0.9	97.1	97.1	0.00
Line268	0.791	0.429	-0.790	-0.436	0.6	-6.3	97.1	97.0	0.09
Line264	0.080	0.042	-0.080	-0.044	0.0	-2.4	97.1	97.1	0.00
Line265	0.064	0.034	-0.064	-0.038	0.0	-3.8	97.1	97.1	0.00
Line266	0.025	0.015	-0.025	-0.015	0.0	-0.3	97.1	97.1	0.00
Line267	0.039	0.023	-0.039	-0.024	0.0	-1.1	97.1	97.1	0.00
Line269	0.197	0.108	-0.197	-0.110	0.0	-2.1	97.0	97.0	0.01
Line275	0.593	0.327	-0.593	-0.329	0.1	-1.4	97.0	97.0	0.01
Line270	0.181	0.101	-0.181	-0.103	0.0	-2.0	97.0	97.0	0.01
Line271	0.156	0.087	-0.156	-0.090	0.0	-2.7	97.0	97.0	0.01
Line272	0.117	0.066	-0.117	-0.070	0.0	-4.1	97.0	96.9	0.01
Line273	0.078	0.045	-0.078	-0.046	0.0	-0.7	96.9	96.9	0.00
Line274	0.039	0.022	-0.039	-0.024	0.0	-2.0	96.9	96.9	0.00
Line276	0.554	0.305	-0.554	-0.306	0.0	-1.0	97.0	96.9	0.01
Line277	0.039	0.024	-0.039	-0.024	0.0	-0.4	96.9	96.9	0.00
Line278	0.515	0.282	-0.515	-0.283	0.0	-0.9	96.9	96.9	0.01
Line279	0.476	0.259	-0.476	-0.259	0.0	-0.5	96.9	96.9	0.00
Line280	0.025	0.014	-0.025	-0.015	0.0	-1.7	96.9	96.9	0.00
Line281	0.451	0.245	-0.451	-0.246	0.0	-1.1	96.9	96.9	0.01
Line282	0.412	0.222	-0.412	-0.226	0.1	-3.9	96.9	96.9	0.03
Line283	0.039	0.022	-0.039	-0.024	0.0	-2.3	96.9	96.9	0.00
Line284	0.373	0.204	-0.373	-0.205	0.0	-0.3	96.9	96.9	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line285	0.335	0.181	-0.335	-0.181	0.0	-0.7	96.9	96.9	0.00
Line286	0.219	0.121	-0.219	-0.126	0.0	-4.7	96.9	96.9	0.02
Line294	0.115	0.060	-0.115	-0.063	0.0	-2.9	96.9	96.9	0.01
Line287	0.180	0.102	-0.180	-0.102	0.0	-0.2	96.9	96.9	0.00
Line288	0.064	0.036	-0.064	-0.038	0.0	-2.6	96.9	96.9	0.00
Line290	0.117	0.066	-0.117	-0.068	0.0	-1.6	96.9	96.9	0.00
Line289	0.025	0.014	-0.025	-0.015	0.0	-1.3	96.9	96.9	0.00
Line291	0.078	0.044	-0.078	-0.046	0.0	-1.7	96.9	96.9	0.00
Line292	0.039	0.023	-0.039	-0.024	0.0	-0.7	96.9	96.9	0.00
Line293	0.039	0.022	-0.039	-0.024	0.0	-1.7	96.9	96.9	0.00
Line295	0.050	0.027	-0.050	-0.030	0.0	-2.5	96.9	96.9	0.00
Line297	0.065	0.036	-0.065	-0.037	0.0	-0.6	96.9	96.9	0.00
Line296	0.025	0.014	-0.025	-0.015	0.0	-1.2	96.9	96.9	0.00
Line298	0.050	0.027	-0.050	-0.029	0.0	-2.1	96.9	96.9	0.00
Line299	0.025	0.014	-0.025	-0.015	0.0	-1.7	96.9	96.9	0.00
Line300	0.025	0.015	-0.025	-0.015	0.0	-0.2	96.9	96.9	0.00
Line301	0.034	0.021	-0.034	-0.021	0.0	-0.4	100.4	100.4	0.00
Line303	2.867	1.002	-2.843	-1.007	24.6	-5.1	100.4	99.4	0.99
Line304	0.251	-0.105	-0.251	0.060	0.3	-45.2	99.4	99.3	0.09
Khalanzi 33/11 KV	2.592	1.112	-2.574	-1.007	17.5	105.0	99.4	99.9	0.52
Cable2	0.017	0.011	-0.017	-0.011	0.0	0.0	99.9	99.9	0.00
Line357	0.289	0.169	-0.289	-0.169	0.5	-0.1	99.9	99.7	0.19
Line387	2.268	0.828	-2.206	-0.776	61.7	51.3	99.9	96.7	3.13
Line305	0.246	-0.062	-0.246	0.038	0.2	-24.8	99.3	99.2	0.05
Line306	0.229	-0.048	-0.229	0.031	0.1	-17.2	99.2	99.2	0.04
Line307	0.009	-0.001	-0.009	-0.003	0.0	-3.9	99.2	99.2	0.00
Line309	0.221	-0.030	-0.221	0.029	0.0	-0.7	99.2	99.2	0.00
Line308	0.004	0.000	-0.004	-0.003	0.0	-2.4	99.2	99.2	0.00
Line310	0.204	-0.040	-0.203	0.022	0.1	-17.5	99.2	99.2	0.03
Line311	0.023	-0.012	-0.023	0.006	0.0	-5.8	99.2	99.2	0.00
Line317	0.180	-0.010	-0.180	0.010	0.0	-0.2	99.2	99.2	0.00
Line312	0.019	-0.009	-0.019	-0.004	0.0	-12.9	99.2	99.1	0.00
Line313	0.016	0.002	-0.016	-0.007	0.0	-4.9	99.1	99.1	0.00
Line314	0.009	0.003	-0.009	-0.003	0.0	-0.4	99.1	99.1	0.00
Line315	0.003	0.001	-0.003	-0.002	0.0	-0.6	99.1	99.1	0.00
Line316	0.007	0.002	-0.007	-0.004	0.0	-1.8	99.1	99.1	0.00
Line318	0.174	-0.014	-0.174	0.013	0.0	-1.4	99.2	99.1	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
Line319	0.167	-0.017	-0.167	0.011	0.0	-5.6	99.1	99.1	0.01
Line320	0.020	0.009	-0.020	-0.009	0.0	-0.5	99.1	99.1	0.00
Line323	0.147	-0.020	-0.147	0.018	0.0	-1.5	99.1	99.1	0.00
Line321	0.013	0.005	-0.013	-0.007	0.0	-1.5	99.1	99.1	0.00
Line322	0.007	0.002	-0.007	-0.004	0.0	-1.7	99.1	99.1	0.00
Line324	0.140	-0.023	-0.140	0.019	0.0	-3.2	99.1	99.1	0.00
Line325	0.007	0.002	-0.007	-0.004	0.0	-2.2	99.1	99.1	0.00
Line326	0.134	-0.021	-0.134	0.014	0.0	-7.3	99.1	99.1	0.01
Line327	0.131	-0.016	-0.131	0.006	0.0	-9.4	99.1	99.1	0.01
Line328	0.128	-0.008	-0.128	0.006	0.0	-2.1	99.1	99.1	0.00
Line329	0.126	-0.008	-0.126	0.005	0.0	-2.6	99.1	99.1	0.00
Line330	0.019	-0.040	-0.019	0.039	0.0	-1.9	99.1	99.1	0.00
Line338	0.106	0.035	-0.106	-0.037	0.0	-1.1	99.1	99.1	0.00
Line331	0.015	-0.041	-0.015	0.036	0.0	-5.5	99.1	99.1	0.00
Line332	0.012	-0.037	-0.012	0.028	0.0	-9.0	99.1	99.1	0.00
Line333	0.005	-0.009	-0.005	0.007	0.0	-2.1	99.1	99.1	0.00
Line335	0.007	-0.020	-0.007	0.011	0.0	-8.9	99.1	99.1	0.00
Line334	0.003	-0.008	-0.003	-0.002	0.0	-10.1	99.1	99.1	0.00
Line336	0.004	0.002	-0.004	-0.003	0.0	-0.8	99.1	99.1	0.00
Line337	0.003	-0.013	-0.003	0.008	0.0	-5.0	99.1	99.1	0.00
Line544	0.000	-0.009	0.000	0.000	0.0	-9.2	99.1	99.1	0.00
Line339	0.100	0.032	-0.100	-0.034	0.0	-1.1	99.1	99.1	0.00
Line340	0.093	0.029	-0.093	-0.035	0.0	-5.2	99.1	99.1	0.01
Line341	0.086	0.031	-0.086	-0.034	0.0	-3.2	99.1	99.1	0.00
Line342	0.013	0.007	-0.013	-0.008	0.0	-0.8	99.1	99.1	0.00
Line344	0.073	0.027	-0.073	-0.031	0.0	-4.0	99.1	99.1	0.00
Line343	0.007	0.004	-0.007	-0.004	0.0	-0.6	99.1	99.1	0.00
Line345	0.069	0.028	-0.069	-0.031	0.0	-2.4	99.1	99.1	0.00
Line346	0.062	0.026	-0.062	-0.027	0.0	-0.5	99.1	99.1	0.00
Line347	0.007	0.003	-0.007	-0.004	0.0	-0.9	99.1	99.1	0.00
Line348	0.055	0.024	-0.055	-0.025	0.0	-0.9	99.1	99.1	0.00
Line349	0.049	0.020	-0.049	-0.021	0.0	-0.6	99.1	99.1	0.00
Line350	0.042	0.017	-0.042	-0.017	0.0	-0.4	99.1	99.1	0.00
Line351	0.035	0.013	-0.035	-0.014	0.0	-1.0	99.1	99.1	0.00
Line352	0.029	0.010	-0.029	-0.011	0.0	-0.8	99.1	99.1	0.00
Line353	0.022	0.007	-0.022	-0.007	0.0	-0.4	99.1	99.1	0.00
Line354	0.015	0.003	-0.015	-0.004	0.0	-0.6	99.1	99.1	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
Line355	0.009	-0.001	-0.009	-0.002	0.0	-2.2	99.1	99.1	0.00
Line356	0.004	-0.001	-0.004	-0.003	0.0	-3.7	99.1	99.1	0.00
Line358	0.017	0.010	-0.017	-0.011	0.0	-0.2	99.7	99.7	0.01
Line359	0.271	0.158	-0.271	-0.159	0.3	-0.1	99.7	99.6	0.13
Line360	0.068	0.040	-0.068	-0.041	0.0	-0.6	99.6	99.5	0.05
Line366	0.186	0.108	-0.186	-0.108	0.2	-0.3	99.6	99.5	0.09
Line361	0.004	0.002	-0.004	-0.003	0.0	-0.3	99.5	99.5	0.00
Line362	0.030	0.017	-0.030	-0.018	0.0	-0.2	99.5	99.5	0.02
Line363	0.007	0.004	-0.007	-0.004	0.0	-0.2	99.5	99.5	0.00
Line364	0.024	0.014	-0.024	-0.014	0.0	-0.4	99.5	99.5	0.01
Line365	0.007	0.004	-0.007	-0.004	0.0	-0.6	99.5	99.5	0.01
Line367	0.169	0.098	-0.168	-0.098	0.4	-0.4	99.5	99.2	0.24
Line368	0.017	0.010	-0.017	-0.010	0.0	-0.6	99.2	99.2	0.02
Line369	0.151	0.089	-0.151	-0.089	0.2	-0.2	99.2	99.1	0.11
Line534	0.000	0.000	0.000	0.000	0.0	-0.2	99.2	99.2	0.00
Line370	0.017	0.010	-0.017	-0.010	0.0	-0.2	99.1	99.1	0.01
Line371	0.134	0.079	-0.134	-0.079	0.0	-0.1	99.1	99.1	0.03
Line372	0.117	0.068	-0.117	-0.069	0.1	-0.3	99.1	99.0	0.10
Line373	0.101	0.058	-0.101	-0.058	0.1	-0.2	99.0	98.9	0.06
Line374	0.017	0.010	-0.017	-0.010	0.0	-0.2	98.9	98.9	0.01
Line375	0.084	0.048	-0.084	-0.049	0.1	-0.3	98.9	98.9	0.07
Line376	0.067	0.038	-0.067	-0.038	0.0	-0.2	98.9	98.8	0.04
Line377	0.017	0.010	-0.017	-0.010	0.0	-0.1	98.8	98.8	0.00
Line378	0.050	0.028	-0.050	-0.028	0.0	-0.4	98.8	98.8	0.04
Line379	0.033	0.018	-0.033	-0.019	0.0	-0.8	98.8	98.7	0.06
Line380	0.003	0.001	-0.003	-0.002	0.0	-0.6	98.7	98.7	0.00
Line381	0.031	0.018	-0.031	-0.018	0.0	-0.1	98.7	98.7	0.00
Line382	0.027	0.015	-0.026	-0.015	0.0	-0.1	98.7	98.7	0.01
Line383	0.020	0.011	-0.020	-0.011	0.0	-0.1	98.7	98.7	0.00
Line384	0.007	0.004	-0.007	-0.004	0.0	-0.1	98.7	98.7	0.00
Line385	0.013	0.007	-0.013	-0.007	0.0	-0.1	98.7	98.7	0.00
Line386	0.007	0.003	-0.007	-0.004	0.0	-0.9	98.7	98.7	0.01
Line388	2.190	0.766	-2.179	-0.757	11.2	9.3	96.7	96.2	0.57
Cable1	0.923	0.001	-0.921	0.000	1.9	1.3	96.2	96.0	0.20
Line389	0.397	0.233	-0.395	-0.233	2.1	0.5	96.2	95.7	0.49
Line421	0.860	0.522	-0.853	-0.517	6.7	5.0	96.2	95.4	0.83
Line390	0.006	0.004	-0.006	-0.004	0.0	0.0	95.7	95.7	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
Line391	0.388	0.229	-0.387	-0.229	1.6	0.4	95.7	95.3	0.38
Line392	0.108	0.067	-0.108	-0.067	0.0	-0.1	95.3	95.3	0.02
Line393	0.279	0.162	-0.279	-0.162	0.1	0.0	95.3	95.3	0.03
Line394	0.263	0.152	-0.262	-0.152	1.2	-0.3	95.3	94.8	0.50
Line395	0.135	0.080	-0.135	-0.081	0.1	-0.1	94.8	94.7	0.06
Line404	0.127	0.072	-0.127	-0.072	0.1	-0.3	94.8	94.7	0.07
Line396	0.068	0.039	-0.068	-0.040	0.2	-1.1	94.7	94.5	0.22
Line397	0.053	0.031	-0.053	-0.031	0.0	-0.1	94.5	94.5	0.02
Line398	0.015	0.009	-0.015	-0.010	0.0	-0.2	94.5	94.5	0.01
Line399	0.037	0.022	-0.037	-0.022	0.0	-0.6	94.5	94.4	0.06
Line400	0.015	0.009	-0.015	-0.010	0.0	-0.1	94.4	94.4	0.01
Line401	0.022	0.013	-0.022	-0.013	0.0	-0.2	94.4	94.4	0.01
Line402	0.015	0.010	-0.015	-0.010	0.0	0.0	94.4	94.4	0.00
Line403	0.006	0.004	-0.006	-0.004	0.0	-0.2	94.4	94.4	0.00
Line405	0.127	0.072	-0.127	-0.072	0.1	-0.1	94.7	94.7	0.04
Line406	0.015	0.010	-0.015	-0.010	0.0	0.0	94.7	94.7	0.00
Line407	0.112	0.063	-0.112	-0.063	0.1	-0.3	94.7	94.6	0.11
Line408	0.077	0.047	-0.077	-0.047	0.0	-0.1	94.6	94.6	0.02
Line413	0.034	0.016	-0.034	-0.016	0.0	-0.3	94.6	94.6	0.02
Line409	0.004	0.002	-0.004	-0.002	0.0	-0.1	94.6	94.6	0.00
Line410	0.073	0.045	-0.073	-0.045	0.0	-0.2	94.6	94.5	0.05
Line411	0.006	0.004	-0.006	-0.004	0.0	-0.2	94.5	94.5	0.00
Line412	0.067	0.042	-0.067	-0.042	0.0	-0.1	94.5	94.5	0.02
Line414	0.016	0.007	-0.016	-0.008	0.0	-0.3	94.6	94.5	0.01
Line418	0.018	0.009	-0.018	-0.010	0.0	-1.7	94.6	94.5	0.08
Line415	0.010	0.004	-0.010	-0.004	0.0	-0.5	94.5	94.5	0.01
Line416	0.004	0.002	-0.004	-0.002	0.0	-0.1	94.5	94.5	0.00
Line417	0.006	0.002	-0.006	-0.004	0.0	-1.7	94.5	94.5	0.03
Line419	0.012	0.007	-0.012	-0.007	0.0	-0.4	94.5	94.5	0.01
Line420	0.006	0.003	-0.006	-0.004	0.0	-0.5	94.5	94.5	0.01
Line422	0.016	0.010	-0.016	-0.010	0.0	0.0	95.4	95.4	0.00
Line423	0.503	0.301	-0.503	-0.301	0.0	0.0	95.4	95.3	0.00
Line426	0.334	0.207	-0.334	-0.207	0.1	0.0	95.4	95.3	0.02
Line424	0.063	0.039	-0.063	-0.039	0.0	-0.1	95.3	95.3	0.01
Line425	0.440	0.262	-0.440	-0.262	0.3	0.1	95.3	95.3	0.07
Line427	0.067	0.041	-0.067	-0.041	0.0	-0.1	95.3	95.3	0.02
Line428	0.306	0.179	-0.306	-0.179	0.3	0.0	95.3	95.2	0.09

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line429	0.243	0.140	-0.243	-0.140	0.7	-0.1	95.2	94.9	0.27
Line430	0.037	0.022	-0.037	-0.022	0.0	-0.1	94.9	94.9	0.01
Line434	0.205	0.118	-0.205	-0.118	0.5	-0.2	94.9	94.7	0.23
Line431	0.022	0.012	-0.022	-0.012	0.0	-0.1	94.9	94.9	0.01
Line432	0.006	0.003	-0.006	-0.004	0.0	-0.3	94.9	94.9	0.00
Line433	0.015	0.009	-0.015	-0.010	0.0	-0.7	94.9	94.9	0.03
Line435	0.015	0.009	-0.015	-0.010	0.0	-0.1	94.7	94.7	0.00
Line436	0.189	0.109	-0.189	-0.109	0.5	-0.2	94.7	94.5	0.22
Line437	0.037	0.022	-0.037	-0.022	0.0	-0.1	94.5	94.5	0.01
Line440	0.004	0.002	-0.004	-0.002	0.0	-0.6	94.5	94.5	0.01
Line441	0.148	0.086	-0.148	-0.086	0.1	-0.1	94.5	94.4	0.05
Line438	0.021	0.012	-0.021	-0.013	0.0	-0.6	94.5	94.4	0.03
Line439	0.015	0.009	-0.015	-0.009	0.0	-0.2	94.4	94.4	0.01
Line442	0.015	0.009	-0.015	-0.009	0.0	-0.3	94.4	94.4	0.01
Line443	0.133	0.076	-0.133	-0.076	0.0	0.0	94.4	94.4	0.00
Line444	0.118	0.067	-0.117	-0.067	0.2	-0.4	94.4	94.2	0.17
Line445	0.102	0.058	-0.102	-0.058	0.0	0.0	94.2	94.2	0.01
Line446	0.015	0.009	-0.015	-0.009	0.0	-0.3	94.2	94.2	0.01
Line447	0.087	0.049	-0.087	-0.049	0.0	-0.2	94.2	94.2	0.05
Line448	0.006	0.004	-0.006	-0.004	0.0	-0.2	94.2	94.2	0.00
Line449	0.075	0.042	-0.075	-0.042	0.0	-0.1	94.2	94.2	0.02
Line450	0.006	0.003	-0.006	-0.004	0.0	-0.6	94.2	94.2	0.01
Line451	0.069	0.039	-0.069	-0.039	0.1	-0.7	94.2	94.0	0.14
Line452	0.015	0.009	-0.015	-0.009	0.0	-0.1	94.0	94.0	0.00
Line453	0.054	0.030	-0.054	-0.030	0.0	-0.3	94.0	94.0	0.04
Line454	0.048	0.027	-0.048	-0.027	0.0	-0.3	94.0	94.0	0.03
Line455	0.006	0.004	-0.006	-0.004	0.0	-0.1	94.0	93.9	0.00
Line456	0.042	0.023	-0.041	-0.024	0.0	-0.2	94.0	93.9	0.02
Line457	0.004	0.002	-0.004	-0.002	0.0	-0.1	93.9	93.9	0.00
Line458	0.032	0.018	-0.032	-0.018	0.0	-0.2	93.9	93.9	0.02
Line459	0.026	0.014	-0.026	-0.014	0.0	-0.1	93.9	93.9	0.01
Line460	0.004	0.002	-0.004	-0.002	0.0	-0.1	93.9	93.9	0.00
Line461	0.022	0.012	-0.022	-0.013	0.0	-0.9	93.9	93.9	0.05
Line462	0.004	0.002	-0.004	-0.002	0.0	-0.1	93.9	93.9	0.00
Line463	0.018	0.011	-0.018	-0.011	0.0	-0.4	93.9	93.8	0.02
Line464	0.006	0.004	-0.006	-0.004	0.0	-0.1	93.8	93.8	0.00
Line465	0.012	0.007	-0.012	-0.007	0.0	0.0	93.8	93.8	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
Line466	0.006	0.004	-0.006	-0.004	0.0	0.0	93.8	93.8	0.00
Line467	0.006	0.004	-0.006	-0.004	0.0	-0.1	93.8	93.8	0.00
Transformer	2.065	1.249	-2.052	-1.137	13.2	112.2	100.0	97.2	2.80
Line468	2.052	1.137	-2.030	-1.152	21.8	-15.3	97.2	96.0	1.16
Line469	2.030	1.152	-2.027	-1.154	2.6	-1.7	96.0	95.9	0.14
Line470	1.957	1.111	-1.957	-1.111	0.1	0.0	95.9	95.9	0.00
Line471	0.140	0.079	-0.140	-0.084	0.0	-5.2	95.9	95.9	0.02
Line473	1.817	1.031	-1.815	-1.033	1.5	-1.5	95.9	95.8	0.09
Line472	0.070	0.041	-0.070	-0.043	0.0	-2.4	95.9	95.9	0.01
Line474	1.815	1.033	-1.814	-1.035	1.6	-1.7	95.8	95.7	0.10
Line475	1.745	0.992	-1.743	-0.995	2.2	-2.6	95.7	95.6	0.14
Line476	1.604	0.909	-1.604	-0.909	0.3	-0.2	95.6	95.6	0.02
Line477	1.536	0.867	-1.535	-0.867	0.4	-0.3	95.6	95.5	0.02
Line478	0.343	0.190	-0.343	-0.196	0.2	-6.0	95.5	95.5	0.07
Line486	1.192	0.676	-1.192	-0.677	0.1	-0.2	95.5	95.5	0.01
Line479	0.275	0.154	-0.275	-0.156	0.0	-1.5	95.5	95.5	0.01
Line480	0.070	0.042	-0.070	-0.043	0.0	-1.2	95.5	95.5	0.00
Line481	0.205	0.114	-0.205	-0.116	0.0	-2.0	95.5	95.4	0.01
Line482	0.205	0.116	-0.205	-0.117	0.0	-1.0	95.4	95.4	0.01
Line483	0.068	0.042	-0.068	-0.042	0.0	-0.6	95.4	95.4	0.00
Line484	0.137	0.075	-0.137	-0.076	0.0	-1.1	95.4	95.4	0.00
Line485	0.068	0.034	-0.068	-0.042	0.0	-8.6	95.4	95.4	0.02
Line487	0.277	0.171	-0.277	-0.171	0.0	-0.3	95.5	95.5	0.00
Line488	0.915	0.505	-0.915	-0.507	0.5	-1.5	95.5	95.5	0.05
Line489	0.068	0.041	-0.068	-0.042	0.0	-1.3	95.5	95.5	0.00
Line490	0.847	0.466	-0.846	-0.468	0.5	-1.9	95.5	95.4	0.06
Line491	0.137	0.082	-0.137	-0.083	0.0	-0.3	95.4	95.4	0.00
Line493	0.710	0.385	-0.709	-0.388	0.5	-2.5	95.4	95.4	0.06
Line492	0.068	0.040	-0.068	-0.042	0.0	-2.0	95.4	95.4	0.00
Line494	0.068	0.042	-0.068	-0.042	0.0	-0.3	95.4	95.4	0.00
Line495	0.641	0.346	-0.640	-0.352	0.4	-6.4	95.4	95.3	0.08
Line496	0.071	0.036	-0.071	-0.038	0.0	-1.3	95.3	95.3	0.00
Line502	0.569	0.316	-0.569	-0.317	0.0	-0.5	95.3	95.3	0.01
Line497	0.071	0.038	-0.071	-0.039	0.0	-1.9	95.3	95.3	0.00
Line498	0.054	0.029	-0.054	-0.030	0.0	-1.6	95.3	95.3	0.00
Line499	0.000	-0.001	0.000	0.000	0.0	-1.2	95.3	95.3	0.00
Line500	0.054	0.032	-0.054	-0.032	0.0	-0.7	95.3	95.3	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
Line501	0.027	0.016	-0.027	-0.017	0.0	-1.2	95.3	95.3	0.00
Line503	0.569	0.317	-0.569	-0.317	0.1	-0.9	95.3	95.3	0.02
Line504	0.542	0.301	-0.542	-0.302	0.1	-0.9	95.3	95.3	0.02
Line505	0.027	0.016	-0.027	-0.017	0.0	-0.9	95.3	95.2	0.00
Line506	0.515	0.286	-0.515	-0.287	0.1	-1.4	95.3	95.2	0.02
Line507	0.139	0.077	-0.139	-0.083	0.0	-6.0	95.2	95.2	0.03
Line512	0.376	0.210	-0.376	-0.212	0.1	-1.3	95.2	95.2	0.02
Line508	0.122	0.072	-0.122	-0.073	0.0	-0.8	95.2	95.2	0.00
Line509	0.095	0.056	-0.095	-0.056	0.0	-0.3	95.2	95.2	0.00
Line510	0.068	0.040	-0.068	-0.042	0.0	-2.0	95.2	95.2	0.00
Line511	0.027	0.016	-0.027	-0.017	0.0	-0.3	95.2	95.2	0.00
Line513	0.349	0.195	-0.349	-0.196	0.0	-0.7	95.2	95.2	0.01
Line514	0.017	0.010	-0.017	-0.011	0.0	-0.9	95.2	95.2	0.00
Line515	0.331	0.186	-0.331	-0.186	0.0	-0.2	95.2	95.2	0.00
Line516	0.304	0.169	-0.304	-0.170	0.0	-0.2	95.2	95.2	0.00
Line517	0.027	0.015	-0.027	-0.017	0.0	-1.3	95.2	95.2	0.00
Line518	0.277	0.154	-0.277	-0.155	0.0	-0.9	95.2	95.2	0.01
Line519	0.250	0.138	-0.250	-0.139	0.0	-1.1	95.2	95.2	0.01
Line520	0.143	0.075	-0.143	-0.076	0.0	-0.8	95.2	95.2	0.00
Line529	0.108	0.064	-0.108	-0.064	0.0	-0.2	95.2	95.2	0.00
Line521	0.071	0.039	-0.071	-0.041	0.0	-1.7	95.2	95.2	0.00
Line525	0.071	0.037	-0.071	-0.037	0.0	-0.1	95.2	95.2	0.00
Line522	0.017	0.008	-0.017	-0.011	0.0	-2.4	95.2	95.2	0.00
Line523	0.054	0.033	-0.054	-0.033	0.0	-0.2	95.2	95.2	0.00
Line524	0.027	0.016	-0.027	-0.017	0.0	-0.6	95.2	95.2	0.00
Line526	0.044	0.020	-0.044	-0.024	0.0	-3.5	95.2	95.2	0.00
Line527	0.027	0.015	-0.027	-0.017	0.0	-2.0	95.2	95.2	0.00
Line528	0.017	0.009	-0.017	-0.011	0.0	-1.7	95.2	95.2	0.00
Line530	0.081	0.048	-0.081	-0.048	0.0	-0.6	95.2	95.2	0.00
Line531	0.027	0.016	-0.027	-0.017	0.0	-0.9	95.2	95.2	0.00
Line532	0.054	0.032	-0.054	-0.033	0.0	-0.2	95.2	95.2	0.00
Line533	0.027	0.016	-0.027	-0.017	0.0	-0.8	95.2	95.2	0.00
KHPC Transformer	2.392	1.598	-2.378	-1.480	13.9	118.4	100.0	97.4	2.64
Line535	-1.413	-0.877	1.423	0.887	10.0	10.4	96.5	97.4	0.83
Line536	1.290	0.801	-1.287	-0.797	3.5	3.6	96.5	96.2	0.32
Line537	0.123	0.076	-0.123	-0.076	0.0	0.0	96.5	96.5	0.00
Line538	0.312	0.193	-0.312	-0.193	0.1	0.0	96.2	96.2	0.05

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line539	0.975	0.604	-0.974	-0.603	1.0	0.7	96.2	96.1	0.10
Line541	0.955	0.593	-0.949	-0.588	6.0	4.3	97.4	96.7	0.66
Line540	0.156	0.096	-0.156	-0.097	0.1	-0.2	96.2	96.1	0.05
					619.8	1031.3			

Alert Summary Report

	% Alert Settings	
	Critical	**Marginal**
Loading		
Bus	100.0	95.0
Cable	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	110.0	108.0
UnderVoltage	90.0	92.0
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
Transformer I	Transformer	Overload	7.778	MVA	9.625	123.7	3-Phase
Transformer III	Transformer	Overload	5.000	MVA	5.37	107.3	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	16.665	10.405	19.647	84.82 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	16.665	10.405	19.647	84.82 Lagging
Total Motor Load:	4.003	1.963	4.458	89.78 Lagging
Total Static Load:	12.043	7.410	14.140	85.17 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.620	1.031		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annexure 5- Feeder Wise Reliability Indices

2016

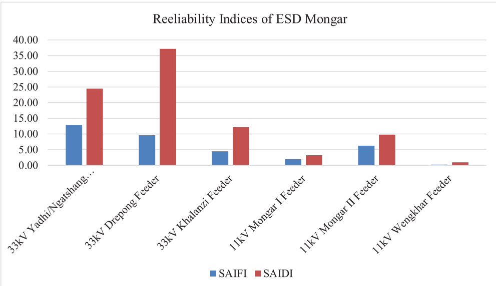
Name of Feeders	Jan		Feb		March		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	**SAIFI**	**SAIDI**
33kV Yadhi/Ngatshang Feeder	0.44	0.662192	0.58	1.342944	1.16	2.495298	1.16	0.748291	1.45	1.871453	0.87	0.431538	1.45	1.256838	1.45	2.301538	0.58	0.104615	0.73	0.294501	0.58	0.232119	1.02	0.651383	**11.48**	**12.39**
33kV Drepong Feeder	1.46	2.674983	0.84	0.719015	3.66	7.29256	2.33	3.022582	2.16	4.29919	2.00	4.573819	2.50	8.809762	2.00	5.141386	0.83	1.128475	1.14	4.269976	0.76	6.418225	0.00	0	**19.68**	**48.35**
33kV Khalanzi Feeder	0.17	0.575119	0.51	1.016492	0.84	0.527362	2.02	1.892294	0.67	2.101053	1.18	2.488266	0.51	0.548833	1.85	5.171822	2.86	4.872152	0.36	0.127037	0.89	1.272156	0.54	1.5477	**12.40**	**22.14**
11kV Mongar I Feeder	0	0	0.24	0.182013	0.36	0.090658	0.24	0.428779	0.12	0.126822	0.12	0.126822	0.60	1.010951	2.05	5.081329	0.12	0.054352	0.36	0.260891	0.00	0	0.00	0	**4.23**	**7.36**
11kV Mongar II Feeder	0	0	0.09	0.131203	0.09	0.090287	0.34	0.488884	0.17	0.055848	0.26	0.076469	1.37	1.10493	1.55	3.467728	0.17	0.049834	0.00	0.034368	0.26	0.358286	0.09	0.03265	**4.38**	**5.89**
11kV Wengkhar Feeder	0.01	0	0	0	0.00	0	0.00	0	0.00	0.203132	0.00	0	0	0	0.00	0	0.00	0	0.00	0	0.03	0.026758	0.00	0	**0.04**	**0.23**

2017

Name of Feeders	Jan		Feb		March		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	**SAIFI**	**SAIDI**
33kV Yadhi/Ngatshang Feeder	1.02	0.80117	0.29	0.131579	0.71		1.22	1.396916	1.79	21.06986	1.78	11.05375	1.56	2.476954	0.52	8.014438	0.52	2.52	0.77	0	0.00	0	0.51	0.44	**10.68**	**47.91**
33kV Drepong Feeder	0.54	0.458839	0.13	0.137652	0.00	0	0.63	3.045694	0.30	2.524156	0.20	0.508168	0.76	12.18605	0.13	25.09183	0.38	2.59	0.13	0	0.13	0	0.13	0.12	**3.45**	**46.66**
33kV Khalanzi Feeder	0.18	0.066202	0.00	0	0.00	0	0.06	0.030848	0.12	0.12092	0.18	0.122082	0.00	0	0.15	1.106481	0.00	-	0.00	0	0.00	0	0.05	0.01	**0.73**	**1.45**
11kV Mongar I Feeder	0.00	0	0.00	0	0.00	0	0.06	0.077954	0.23	1.363991	0.28	0.138985	0.00	0	0.04	0.016505	0.04	0.06	0.04	0.01	0.00	0	0.23	0.24	**0.92**	**1.90**
11kV Mongar II Feeder	0.36	0.157254	0.09	0.02843	0.43	0.127184	0.74	0.122303	1.05	0.951346	1.52	2.305632	0.79	0.416247	1.98	12.67769	0.39	0.88	0.79	0	0.00	0	0.39	0.14	**8.53**	**17.81**
11kV Wengkhar Feeder	0.00	0	0	0	0.00	0.008292	0.11	0.061114	0.07	0.503089	0.15	0.87392	0.03	0.447709	0.03	0.325237	0.00	0	0.03	0.07	0.00	0	0.05	0.08	**0.45**	**2.36**

2018

Name of Feeders	Jan		Feb		March		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Total	
	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	SAIFI	SAIDI	**SAIFI**	**SAIDI**
33kV Yadhi/Ngatshang Feeder	0.03	0.01	0.00	0	1.60	0.36	0.53	0.21	0.26	0.14	0.51	1.50	2.54	1.98	3.05	3.97	2.03	0.47	1.52	1.20	2.02	2.17	2.52	1.15	**16.59**	**13.16**
33kV Drepong Feeder	0.51	0.25	0.25	0.19	0.25	1.32	0.25	0.05	0.25	0.10	0.50	0.37	1.24	9.63	1.24	3.13	0.12	0.02	0.62	1.23	0.25	0.18	0.25	0.09	**5.73**	**16.56**
33kV Khalanzi Feeder	0.00	0	0.00	0	0.00	0	0.00	0	0.90	1.45	0.22	0.25	0.22	0.27	0.89	0.63	0.00	0	1.33	10.38	0.00	0	0.22	0.13	**0.31**	**13.11**
11kV Mongar I Feeder	0.12	0.19	0.00	0	0.12	0.02	0.04	0.04	0.12	0.02	0.04	0.01	0.08	0.05	0.12	0.08	0.04	0.01	0.04	0.01	0.00	0	0.08	0.01	**0.78**	**0.44**
11kV Mongar II Feeder	2.79	2.32	0.87	0.41	0.00	0	0.00	1.36	0.51	0.43	0.17	0.09	0.00	0	0.51	0.26	0.34	0.11	0.17	0.17	0.34	0.25	0.17	0.21	**5.87**	**5.59**
11kV Wengkhar Feeder	0.05	0.06	0	0	0.00	0	0.00	0	0.00	0	0.07	0.11	0.02	0.01	0.02	0.01	0.02	0.01	0.00	0	0.00	0	0.02	0.11	**0.22**	**0.31**



Sl.No	Year	Reliability Indices	33kV Yadhi/Ngatshang Feeder	33kV Drepong Feeder	33kV Khalanzi Feeder	11kV Mongar I Feeder	11kV Mongar II Feeder	11kV Wengkhar Feeder	Total
1	2016	SAIFI	**11.48**	19.68	**12.40**	4.23	**4.38**	0.04	52.21
		SAIDI	12.39	48.35	22.14	7.36	5.89	0.23	96.37
2	2017	SAIFI	10.68	3.45	0.73	0.92	8.53	0.45	24.76
		SAIDI	47.91	46.66	1.45	1.90	17.81	2.36	118.10
3	2018	SAIFI	16.59	5.73	0.31	0.78	5.87	0.22	29.51
		SAIDI	13.16	16.56	13.11	0.44	5.59	0.31	49.17
	Average	**SAIFI**	**12.92**	**9.62**	**4.48**	**1.98**	**6.26**	**0.24**	35.49
		SAIDI	**24.49**	**37.19**	**12.24**	**3.24**	**9.77**	**0.97**	87.88

Annexure 6- Material Cost of Upgrading single phase Lines to three phase

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

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

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

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

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

Annexure 7- Distribution Transformer Loading

Sl. No.	Name		2019		2025		2030	
		KVA Rating	KVA	% Loading	KVA	% Loading	KVA	% Loading
11kV Wengkhar Feeder								
1	Yagpoogang Water Treatment Plant(pvt)	63	14.95	23.73%	24.52	38.92%	30.50	48.41%
2	Wengkhar(pvt)	63	14.54	23.08%	23.85	37.85%	29.66	47.09%
3	Tongsing	63	28.05	44.52%	46.00	73.02%	57.22	90.83%
4	Jaibab	63	2.16	3.43%	3.54	5.63%	4.41	7.00%
5	Themnangbee	50	3.36	6.72%	5.51	11.02%	6.85	13.71%
11kV Mongar Feeder I								
1	Kilikhar Barshong	100	45.79	45.79%	82.93	82.93%	102.08	102.08%
2	CDCL(pvt)	250	-	0.00%	-	0.00%	-	0.00%
3	Mongar Kadam II	25	-	0.00%	-	0.00%	-	0.00%
4	Mongar Kadam I	63	14.93	23.69%	27.03	42.91%	33.27	52.82%
5	Nagling	63	50.92	80.83%	92.22	146.38%	113.51	180.18%
6	Kheyri	16	5.80	36.22%	10.49	65.59%	12.92	80.74%
7	Phosorong	63	38.53	61.16%	69.78	110.77%	85.89	136.34%
8	Pongchula	63	14.90	23.66%	26.99	42.85%	33.23	52.74%
9	Jarukharshor	63	38.30	60.80%	69.37	110.11%	85.39	135.53%
10	Lower Trailing(sawmill/Workshop)	250	63.31	25.32%	114.66	45.86%	141.13	56.45%
11	Mongar Upper Town (Esd Office)	750	453.78	60.50%	821.80	109.57%	1,011.54	134.87%
12	Upper Trailing(Bus terminal)	125	44.20	35.36%	80.05	64.04%	98.53	78.82%
13	Pirmani	63	32.58	51.71%	59.00	93.65%	72.62	115.27%
14	Yak-gang	63	6.35	10.08%	11.51	18.26%	14.16	22.48%
15	Redaza	63	25.51	40.49%	46.20	73.33%	56.86	90.26%
16	Jamcholing	16	8.05	50.28%	14.57	91.06%	17.93	112.08%
17	Zangzingmo	10	2.58	25.76%	4.67	46.65%	5.74	57.42%
18	Wangling	16	7.13	44.56%	12.91	80.70%	15.89	99.34%
19	Nashong Archery Ground	63	30.82	48.92%	55.82	88.60%	68.70	109.05%
20	Royal Guest House	63	6.70	10.64%	12.14	19.27%	14.94	23.72%
	Sum of peak kVA		883.48					
	Sum of peak in MW		0.75					
11kV Mongar Feeder II								
1	Dedrang	63	7.83	12.43%	17.22	27.33%	22.65	35.95%
2	Changshingpek	100	49.74	49.74%	109.33	109.33%	143.83	143.83%
3	Mongar LSS	750	282.37	37.65%	620.66	82.75%	816.49	108.86%
4	Bhutan Telecom	500	146.05	29.21%	321.02	64.20%	422.31	84.46%
5	Bazzar Vegetable market	250	80.96	32.38%	177.95	71.18%	234.10	93.64%
6	Koenbar	25	7.75	30.98%	17.03	68.10%	22.40	89.59%
7	Tagchhu	63	8.77	13.92%	19.27	30.59%	25.35	40.24%
8	Hospital	1250	356.50	28.52%	783.60	62.69%	1,030.84	82.47%
9	Hospital Colony	250	25.12	10.05%	55.23	22.09%	72.65	29.06%
10	Hurungpam	63	11.10	17.63%	24.41	38.74%	32.11	50.97%
11	Merung	16	5.92	36.98%	13.01	81.29%	17.11	106.94%
12	Dongyok	16	3.83	23.91%	8.41	52.56%	11.06	69.14%
13	Pepchurung	63	39.04	61.97%	85.82	136.22%	112.89	179.20%
14	Khalanji forebay tank	63	6.42	10.19%	14.11	22.40%	18.56	29.46%
33kV Yadi Feeder								
1	Lower Yagpoogang(Anim Dratshang)	100	20.93	20.93%	68.51	68.51%	57.99	57.99%

Sl. No.	Name	KVA Rating	2019		2025		2030	
			KVA	% Loading	KVA	% Loading	KVA	% Loading
2	Upper Yagpoogang	25	5.41	21.63%	17.70	70.81%	14.98	59.93%
3	Larjab	25	5.18	20.71%	16.95	67.79%	14.34	57.38%
4	Korila	63	8.51	13.51%	27.86	44.22%	23.58	37.43%
5	Pangtoed	25	8.40	33.58%	27.48	109.92%	23.26	93.05%
6	Tshanphu	25	9.55	38.18%	31.25	124.98%	26.45	105.79%
7	Ngatshang	63	15.87	25.19%	51.95	82.46%	43.97	69.80%
8	Chema	63	12.57	19.96%	41.16	65.34%	34.84	55.30%
9	Roptangkhar	63	5.58	8.85%	18.26	28.99%	15.46	24.53%
10	Gochagpa	63	7.70	12.22%	25.21	40.01%	21.34	33.87%
11	Zangdari	63	18.25	28.97%	59.75	94.84%	50.57	80.28%
12	Phanasi	63	17.18	27.27%	56.24	89.27%	47.60	75.56%
13	Bamzor	25	4.33	17.32%	14.17	56.69%	12.00	47.98%
14	Omkhar	63	16.93	26.88%	55.43	87.98%	46.92	74.47%
15	Pelshub Goenpa	63	12.14	19.27%	39.74	63.07%	33.64	53.39%
16	Yadi Town	250	29.67	11.87%	97.12	38.85%	82.21	32.88%
17	Yongbari	63	23.06	36.60%	75.48	119.81%	63.89	101.41%
18	Atingkhar	25	11.41	45.64%	37.35	149.40%	31.62	126.46%
19	Sangbari	63	39.27	62.33%	128.54	204.03%	108.80	172.70%
20	Yanglaphungshing/Rebunus	63	36.53	57.98%	119.57	189.80%	101.21	160.66%
21	Jakhoi	63	21.00	33.34%	68.76	109.14%	58.20	92.38%
22	Geog office Chagsakhar	63	17.81	28.27%	58.29	92.53%	49.34	78.32%
23	Kadam Chagsakhar	63	12.55	19.92%	41.09	65.21%	34.78	55.20%
24	Chagsakhar Pam	63	20.28	32.19%	66.39	105.37%	56.19	89.20%
25	Itnus	63	19.09	30.30%	62.49	99.19%	52.90	83.96%
26	Sherichu	63	11.25	17.86%	36.83	58.45%	31.17	49.48%
27	Jamling	25	9.82	39.27%	32.14	128.55%	27.20	108.82%
28	Gonpa	63	22.43	35.60%	73.42	116.55%	62.15	98.65%
29	Tongtongma	25	14.03	56.12%	45.93	183.71%	38.88	155.50%
30	Khurshina	25	12.86	51.44%	42.10	168.40%	35.64	142.54%
31	Yatong	125	39.72	31.78%	130.03	104.02%	110.06	88.05%
32	Upper Gomdari	25	14.45	57.80%	47.30	189.21%	40.04	160.16%
33	Lower Gomdari	25	17.25	69.00%	56.47	225.87%	47.80	191.19%
34	Changyongla	10	0.47	4.74%	1.55	15.51%	1.31	13.13%
35	Thangthong Goenpa	10	0.83	8.33%	2.73	27.25%	2.31	23.07%
36	Daksa	25	2.21	8.85%	7.24	28.97%	6.13	24.52%
37	Lower Changshing Goenpa	16	1.84	11.49%	6.02	37.60%	5.09	31.82%
38	Middle Changshing Goenpa	25	5.64	22.54%	18.45	73.80%	15.62	62.47%
39	Upper Changshing Goenpa	16	0.92	5.76%	3.02	18.87%	2.55	15.97%
40	Raynangkhoi	63	12.44	19.74%	40.72	64.63%	34.47	54.71%
41	Baucholing	63	3.64	5.77%	11.91	18.90%	10.08	16.00%
42	Mani Drangrey	63	4.67	7.41%	15.28	24.26%	12.94	20.54%
43	Lower Panglen	63	7.89	12.53%	25.83	41.00%	21.87	34.71%
44	Kachag	63	4.86	7.72%	15.92	25.28%	13.48	21.40%
45	Phumdari	25	2.16	8.63%	7.06	28.25%	5.98	23.91%
46	Solochur	25	2.61	10.45%	8.55	34.19%	7.24	28.94%
47	Atola	25	2.16	8.63%	7.06	28.25%	5.98	23.91%
48	Tongkongla	25	1.01	4.06%	3.32	13.27%	2.81	11.24%
49	Upper Panglen	125	18.84	15.07%	61.67	49.33%	52.20	41.76%
50	Wahlagtang	25	6.67	26.68%	21.83	87.34%	18.48	73.93%

Sl. No.	Name		2019		2025		2030	
		KVA Rating	KVA	% Loading	KVA	% Loading	KVA	% Loading
51	Daniri	25	5.52	22.08%	18.07	72.28%	15.30	61.18%
52	Ngaru-Pontang A	25	4.00	15.99%	13.09	52.34%	11.08	44.30%
53	Ngaru-Pontang B	16	2.24	13.97%	7.32	45.74%	6.19	38.72%
54	Ngaru-Pontang C	25	2.33	9.31%	7.62	30.48%	6.45	25.80%
55	Thruebang school	25	2.44	9.76%	7.99	31.95%	6.76	27.04%
56	Thongkhar	16	1.52	9.53%	4.99	31.20%	4.23	26.41%
57	Toongphu	16	3.06	19.12%	10.01	62.58%	8.48	52.98%
58	Rephu Goenpa	10	0.78	7.79%	2.55	25.49%	2.16	21.57%
59	Thruebang village	25	6.11	24.44%	20.00	79.99%	16.93	67.71%
60	Melphey	10	0.83	8.33%	2.73	27.25%	2.31	23.07%
61	Jatshari	10	0.88	8.82%	2.89	28.86%	2.44	24.43%
62	Upper Lingkhar	25	7.33	29.32%	23.99	95.98%	20.31	81.24%
63	Lower Lingkhar	16	2.25	14.04%	7.36	45.97%	6.23	38.92%
64	Kaphu	63	3.23	5.13%	10.58	16.80%	8.96	14.22%
65	Gangmoong	63	3.69	5.86%	12.09	19.18%	10.23	16.24%
66	Shiling	25	2.23	8.93%	7.31	29.22%	6.18	24.74%
67	Bolong	25	5.32	21.28%	17.41	69.66%	14.74	58.96%
68	Phaichhelu	25	5.24	20.95%	17.15	68.58%	14.51	58.05%
69	Gongtang	25	3.58	14.33%	11.72	46.89%	9.92	39.69%
70	Metoshing	25	4.17	16.68%	13.65	54.61%	11.56	46.23%
71	Dhamtshang	25	2.66	10.65%	8.72	34.87%	7.38	29.52%
72	Sherzhong Chema	63	12.32	19.55%	40.32	64.00%	34.13	54.17%
73	Bagdhung	10	0.74	7.36%	2.41	24.09%	2.04	20.39%
74	Serzhong Top	63	11.15	17.69%	36.49	57.92%	30.88	49.02%
75	Serzhong school	63	12.85	20.40%	42.07	66.78%	35.61	56.52%
76	Jabkhangzor	25	3.07	12.29%	10.06	40.25%	8.52	34.07%
77	Lishingzor	25	4.20	16.82%	13.76	55.05%	11.65	46.59%
78	Rashogoenpa	25	4.51	18.06%	14.78	59.10%	12.51	50.03%
79	Drongphu	10	1.85	18.52%	6.06	60.61%	5.13	51.30%
80	Upper Soenakhar	63	5.47	8.68%	17.89	28.40%	15.15	24.04%
81	Lower Soenakhar	63	10.41	16.52%	34.06	54.07%	28.83	45.77%
82	Rayling	10	1.17	11.73%	3.84	38.40%	3.25	32.50%
83	Suma	10	1.22	12.19%	3.99	39.90%	3.38	33.78%
84	Thueling	10	1.40	14.03%	4.59	45.93%	3.89	38.88%
85	Thramo	10	1.21	12.14%	3.98	39.75%	3.36	33.65%
86	Yarab	10	0.94	9.43%	3.09	30.87%	2.61	26.13%
87	Selkhar	63	7.71	12.23%	25.22	40.04%	21.35	33.89%
88	Upper Jadoong	63	6.73	10.69%	22.04	34.98%	18.65	29.61%
89	Lower Jadoong	63	9.27	14.71%	30.34	48.16%	25.68	40.77%
90	Lower Balam	63	6.41	10.18%	21.00	33.33%	17.77	28.21%
91	Upper Balam	63	6.73	10.69%	22.04	34.99%	18.66	29.61%
92	Bahkhaphai	63	10.34	16.42%	33.85	53.74%	28.66	45.49%
93	Khebishing	30	5.82	19.42%	19.07	63.56%	16.14	53.80%
94	Yangbari	30	2.09	6.97%	6.85	22.82%	5.79	19.32%
33kV Khalanzi Feeder								
1	Kilikhar school	125	17.47	13.97%	17.32	13.85%	17.32	13.86%
2	Zangi Tsawa	16	2.06	12.89%	2.04	12.78%	2.05	12.78%
3	Drogsa	63	10.78	17.11%	10.69	16.96%	10.69	16.97%
4	Yarig	16	0.96	6.01%	0.95	5.96%	0.95	5.96%
5	Sheripong	16	0.74	4.60%	0.73	4.56%	0.73	4.56%
6	Themdrang	63	2.04	3.24%	2.02	3.21%	2.02	3.21%
7	Salipong	16	0.99	6.18%	0.98	6.13%	0.98	6.13%
8	Changchangma	10	0.48	4.81%	0.48	4.77%	0.48	4.77%

Sl. No.	Name	KVA Rating	2019		2025		2030	
			KVA	% Loading	KVA	% Loading	KVA	% Loading
9	Wama	25	2.73	10.93%	2.71	10.84%	2.71	10.84%
10	Namdari	10	0.97	9.66%	0.96	9.58%	0.96	9.58%
11	Wama School	25	2.97	11.86%	2.94	11.76%	2.94	11.77%
12	Dag II	25	1.76	7.06%	1.75	7.00%	1.75	7.00%
13	Dag I	25	1.88	7.53%	1.87	7.46%	1.87	7.47%
14	Silambi Khatoed I	25	1.66	6.62%	1.64	6.57%	1.64	6.57%
15	Silambi Khatoed II	25	1.26	5.04%	1.25	5.00%	1.25	5.00%
16	Silambi Khatoed III	25	1.60	6.42%	1.59	6.36%	1.59	6.37%
17	Silambi School	25	3.37	13.46%	3.34	13.35%	3.34	13.35%
18	Kadag	25	0.73	2.93%	0.73	2.90%	0.73	2.91%
19	Rukangla	10	0.85	8.52%	0.84	8.45%	0.84	8.45%
20	Damkhar	10	2.85	28.55%	2.83	28.30%	2.83	28.31%
21	Pangthang Goenpa Gongdue	10	0.74	7.36%	0.73	7.30%	0.73	7.30%
22	Lower Pangthang Gongdue	25	2.36	9.45%	2.34	9.37%	2.34	9.37%
23	Upper Pangthang Gongdue	25	1.79	7.15%	1.77	7.09%	1.77	7.09%
24	Salibi	25	2.29	9.18%	2.27	9.10%	2.28	9.10%
25	Weringla - A	25	2.99	11.95%	2.96	11.85%	2.96	11.85%
26	Weringla - B	25	3.00	12.02%	2.98	11.91%	2.98	11.92%
27	Nagor Pang III	16	0.97	6.09%	0.97	6.03%	0.97	6.04%
28	Nagor Pang II	25	11.92	47.66%	11.81	47.25%	11.82	47.27%
29	Nagor Pang I	25	10.40	41.59%	10.31	41.23%	10.31	41.24%
30	Nagor I	25	15.00	59.99%	14.87	59.47%	14.87	59.49%
31	Nagor II	25	13.93	55.70%	13.81	55.22%	13.81	55.24%
32	Nagor III	25	13.45	53.81%	13.34	53.35%	13.34	53.37%
33	Nagor school	25	14.15	56.61%	14.03	56.13%	14.04	56.15%
34	Nagor Pam I	25	13.56	54.24%	13.44	53.78%	13.45	53.80%
35	Pang-gyerteng	25	14.54	58.15%	14.41	57.65%	14.42	57.67%
36	Nagor Pam II	25	14.19	56.77%	14.07	56.29%	14.08	56.31%
37	Kangkangma	16	2.07	12.95%	2.05	12.84%	2.05	12.84%
38	Lijuk	16	1.97	12.31%	1.95	12.20%	1.95	12.21%
39	Gongdey/Toedkor	16	3.96	24.75%	3.93	24.54%	3.93	24.55%
40	Phosola	10	3.25	32.53%	3.23	32.25%	3.23	32.26%
41	Midhen	10	3.27	32.75%	3.25	32.46%	3.25	32.48%
42	Bangbala	10	3.75	37.49%	3.72	37.17%	3.72	37.18%
43	Gongdue Pam	16	4.00	25.01%	3.97	24.80%	3.97	24.81%
44	Gorthongla	10	3.73	37.34%	3.70	37.02%	3.70	37.04%
45	Pangjagpa	63	17.19	27.29%	17.05	27.06%	17.05	27.07%
46	Chali Lhakhang	63	32.79	52.05%	32.51	51.60%	32.52	51.62%
47	Wangmakhar	125	16.10	12.88%	15.96	12.77%	15.97	12.77%
48	Napheythang	16	10.02	62.64%	9.94	62.10%	9.94	62.12%
49	Taling	25	9.45	37.80%	9.37	37.47%	9.37	37.48%
50	Karmasing	63	32.05	50.87%	31.77	50.43%	31.79	50.45%
51	Goenpa Singma	25	9.91	39.63%	9.82	39.29%	9.83	39.31%
52	Shingkharzhong	63	15.14	24.03%	15.01	23.82%	15.01	23.83%
53	Thoetong	63	24.10	38.26%	23.90	37.93%	23.91	37.94%
54	Khemsang	63	29.44	46.73%	29.19	46.33%	29.20	46.35%
55	Tsakaling school	63	41.69	66.18%	41.33	65.61%	41.35	65.63%
56	Doleptang	63	19.49	30.94%	19.32	30.67%	19.33	30.68%
57	Karma Singyegoenpa	63	8.97	14.24%	8.89	14.12%	8.90	14.12%
58	Yoeshing	63	27.37	43.44%	27.13	43.07%	27.14	43.09%

Sl. No.	Name	KVA Rating	2019		2025		2030	
			KVA	% Loading	KVA	% Loading	KVA	% Loading
59	Thumling	63	32.18	51.07%	31.90	50.63%	31.91	50.65%
60	Rewan	10	0.92	9.20%	0.91	9.12%	0.91	9.12%
61	Khomdangchu	16	1.31	8.19%	1.30	8.12%	1.30	8.13%
62	Tagkhambi Lhakhang	25	9.55	38.18%	9.46	37.85%	9.47	37.86%
63	Khamsangwang	25	9.27	37.08%	9.19	36.76%	9.19	36.77%
64	Tagkhambi	25	8.17	32.66%	8.09	32.38%	8.10	32.39%
65	Goondrang	25	10.03	40.11%	9.94	39.77%	9.95	39.78%
66	Brengpaling/Terkong	63	36.26	57.56%	35.95	57.06%	35.96	57.08%
67	Kurizam	63	18.20	28.89%	18.04	28.64%	18.05	28.65%
68	Lingmethang farm(pvt)	63	16.34	25.94%	16.20	25.72%	16.21	25.73%
69	Park Office(pvt)	250	5.31	2.12%	5.26	2.10%	5.26	2.11%
70	Bhutan Agro Industry(pvt)	1250	100.97	8.08%	100.10	8.01%	100.14	8.01%
71	Saw Mill(pvt)	63	6.90	10.96%	6.84	10.86%	6.85	10.87%
72	MHV(pvt)	250	22.39	8.96%	22.19	8.88%	22.20	8.88%
73	Lingmethang town	250	118.37	47.35%	117.35	46.94%	117.40	46.96%
74	Masangdaza	63	7.75	12.30%	7.68	12.20%	7.69	12.20%
75	Pangsibi	25	5.04	20.15%	4.99	19.97%	5.00	19.98%
76	Tsenzabi	63	19.39	30.78%	19.22	30.51%	19.23	30.52%
77	Jangdung	63	15.16	24.06%	15.03	23.85%	15.03	23.86%
78	Galikhar	63	14.19	22.53%	14.07	22.34%	14.08	22.35%
79	Saling Kangzagokhar	25	12.47	49.88%	12.36	49.45%	12.37	49.47%
80	Saling Dobargangkha	63	8.32	13.21%	8.25	13.10%	8.26	13.10%
81	Gangjuk	16	14.71	91.93%	14.58	91.14%	14.59	91.17%
82	Yongkola	63	6.36	10.10%	6.31	10.02%	6.31	10.02%
83	Thridangbi Khebrak	63	9.10	14.44%	9.02	14.31%	9.02	14.32%
84	Thridangbi school	63	8.65	13.73%	8.57	13.61%	8.58	13.61%
85	Thridangbi Dingor	63	6.37	10.12%	6.32	10.03%	6.32	10.03%
86	Middle Drangmaling	25	9.60	38.42%	9.52	38.09%	9.53	38.10%
87	Lower Drangmaling	25	8.65	34.59%	8.57	34.29%	8.58	34.31%
88	Upper Drangmaling	25	9.60	38.42%	9.52	38.09%	9.53	38.10%
89	Tsamang school	63	35.60	56.51%	35.30	56.03%	35.31	56.05%
90	Upper Tsamnag A/Chumetapa	25	11.41	45.64%	11.31	45.24%	11.32	45.26%
91	Upper Tsamang B/Labi	25	14.88	59.52%	14.75	59.01%	14.76	59.03%
92	Upper Tsamang C/Jalo	25	11.88	47.53%	11.78	47.12%	11.78	47.14%
93	Tsamang Tokarey/sangtsa	16	8.32	52.02%	8.25	51.58%	8.26	51.59%
94	Lower Tsamang A/Lower Tokarey	25	14.70	58.79%	14.57	58.28%	14.58	58.30%
95	Lower Tsamang B/Middle Tokarey	16	6.37	39.83%	6.32	39.49%	6.32	39.50%
96	Banjar A/Tonshing	16	9.60	60.03%	9.52	59.51%	9.53	59.53%
97	Banjar D/ Gangthopam	25	8.65	34.59%	8.57	34.29%	8.58	34.31%
98	Banjar B/Kongpashing	25	6.12	24.47%	6.07	24.26%	6.07	24.27%
99	Banjar C/Dungkar Choling	25	8.21	32.84%	8.14	32.56%	8.14	32.57%
100	Tshokhor	25	3.75	15.00%	3.72	14.87%	3.72	14.87%
101	Crusher plant(pvt)	400	69.00	17.25%	68.41	17.10%	68.43	17.11%
102	Tashi Poktor	63	12.18	19.34%	12.08	19.17%	12.08	19.18%
103	Gzhing Water treatment plant	250	42.80	17.12%	42.43	16.97%	42.45	16.98%
104	Drepong wop	63	16.31	25.90%	16.17	25.67%	16.18	25.68%

Sl. No.	Name	KVA Rating	2019 KVA	2019 % Loading	2025 KVA	2025 % Loading	2030 KVA	2030 % Loading
105	Phakyingchong/Bumpazor	63	8.92	14.16%	8.84	14.04%	8.85	14.04%
106	Kapadung	63	7.90	12.54%	7.83	12.43%	7.84	12.44%
107	Binary	25	10.66	42.65%	10.57	42.28%	10.57	42.30%
108	Laptsa	63	19.95	31.67%	19.78	31.40%	19.79	31.41%
109	JE Zimchung	63	21.48	34.09%	21.29	33.80%	21.30	33.81%
110	Resa Pam	25	2.59	10.36%	2.57	10.27%	2.57	10.28%
111	Resa School	25	3.03	12.10%	3.00	12.00%	3.00	12.00%
112	Resa	25	1.45	5.80%	1.44	5.75%	1.44	5.75%
113	Kalapang	25	8.76	35.06%	8.69	34.76%	8.69	34.77%
114	Domdrang	16	3.93	24.53%	3.89	24.32%	3.89	24.33%
115	Mangling Saling	25	8.51	34.02%	8.43	33.73%	8.44	33.74%
116	Yunari	16	8.76	54.78%	8.69	54.31%	8.69	54.33%
117	Yongri	25	8.89	35.57%	8.81	35.26%	8.82	35.27%
118	Rabsel Construction(pvt)	250	214.27	85.71%	212.42	84.97%	212.50	85.00%
119	Khalanzi station	63	1.79	2.85%	1.78	2.82%	1.78	2.82%
33kV Odzoring Feeder								
1	Ba-ging	63	10.52	16.70%	11.99	19.02%	12.42	19.71%
2	Kheri Drametse	63	4.57	7.25%	5.20	8.26%	5.39	8.56%
3	Phungshing	63	2.02	3.20%	2.30	3.65%	2.38	3.78%
4	Gashari	63	7.03	11.15%	8.00	12.70%	8.29	13.16%
5	Shadang	63	5.69	9.03%	6.48	10.28%	6.71	10.66%
6	Drametse Dratshang	63	17.14	27.21%	19.52	30.99%	20.23	32.11%
7	Drametse town	125	28.88	23.11%	32.89	26.31%	34.08	27.27%
8	Zangkhar	63	8.65	13.73%	9.85	15.63%	10.21	16.20%
9	Gop	63	3.90	6.19%	4.44	7.05%	4.60	7.31%
10	Waichur	63	10.30	16.34%	11.73	18.61%	12.15	19.29%
11	Bikhar	63	5.23	8.30%	5.95	9.45%	6.17	9.79%
12	Shaphangma	63	7.18	11.39%	8.18	12.98%	8.47	13.45%
13	Drametse school	250	45.34	18.14%	51.64	20.65%	53.51	21.40%
14	Kheyshing woong/Serkhagpo	63	4.54	7.21%	5.17	8.21%	5.36	8.51%
15	Wengkhartshing	63	11.40	18.09%	12.98	20.60%	13.45	21.35%
16	Bazor	63	11.10	17.62%	12.64	20.06%	13.10	20.79%
17	Laymey	63	3.47	5.51%	3.95	6.27%	4.09	6.50%
18	Rizung	16	0.75	4.70%	0.86	5.35%	0.89	5.54%
19	Lower Juca	25	2.50	9.98%	2.84	11.37%	2.95	11.78%
20	Upper Juca	25	1.15	4.61%	1.31	5.25%	1.36	5.44%
21	Meypangthang	25	3.03	12.13%	3.45	13.81%	3.58	14.31%
22	Thrinangphu	25	0.68	2.72%	0.77	3.10%	0.80	3.21%
23	Nagtshang Narang	25	0.25	1.00%	0.28	1.14%	0.29	1.18%
24	Gomchhu I	16	0.25	1.57%	0.29	1.78%	0.30	1.85%
25	Gomchhu II	25	1.63	6.54%	1.86	7.45%	1.93	7.72%
26	Gomchhu III	25	2.03	8.10%	2.31	9.23%	2.39	9.56%
27	Leylong	63	0.53	0.84%	0.60	0.96%	0.62	0.99%
28	BHU Narang	25	7.44	29.78%	8.48	33.91%	8.79	35.14%
29	Balanmo	16	0.23	1.44%	0.26	1.64%	0.27	1.70%
30	Gutshaphu	25	1.06	4.25%	1.21	4.84%	1.25	5.02%
31	Chema Narang	25	1.98	7.92%	2.25	9.01%	2.34	9.34%
32	Narang Lhakhang	25	4.83	19.32%	5.50	22.01%	5.70	22.80%
33	Narang I	25	2.98	11.90%	3.39	13.56%	3.51	14.05%
34	Narang II	25	2.91	11.63%	3.31	13.24%	3.43	13.72%
35	Narang III	25	3.39	13.55%	3.86	15.43%	4.00	15.99%

Sl. No.	Name	KVA Rating	2019		2025		2030	
			KVA	% Loading	KVA	% Loading	KVA	% Loading
36	Narang IV	25	2.35	9.42%	2.68	10.73%	2.78	11.11%
37	Narang School	63	5.61	8.91%	6.39	10.14%	6.62	10.51%
38	Dongshoom	25	2.10	8.39%	2.39	9.55%	2.47	9.90%
39	Phaiphung	16	0.21	1.29%	0.23	1.47%	0.24	1.52%
40	Pangkhang I	25	1.63	6.50%	1.85	7.41%	1.92	7.68%
41	Pangkhang II	25	1.14	4.56%	1.30	5.19%	1.34	5.38%
42	Lungtshangchhelu	16	0.09	0.57%	0.10	0.65%	0.11	0.68%
33kV Drepong Feeder								
1	Tsankhazor	16	0.37	2%	1.23	7.67%	1.69	10.56%
2	Kurtakey	16	1.53	10%	5.06	31.60%	6.97	43.53%
3	Wodang	10	1.38	14%	4.58	45.81%	6.31	63.10%
4	Lower Bachakay	16	1.74	11%	5.76	35.99%	7.93	49.57%
5	Upper Bachakay	16	0.69	4%	2.28	14.23%	3.14	19.60%
6	Korphu	25	1.50	6%	4.97	19.87%	6.84	27.36%
7	Moodoongkhar	25	1.14	5%	3.79	15.16%	5.22	20.88%
8	Tsegpa	16	1.03	6%	3.41	21.33%	4.70	29.38%
9	Tselam	25	0.88	4%	2.90	11.60%	3.99	15.98%
10	Toolookpe	25	5.85	23%	19.38	77.53%	26.70	106.79%
11	Dungkhar Goenpa Jurmey	25	1.75	7%	5.79	23.16%	7.97	31.90%
12	Pangthang Jurmey	25	3.39	14%	11.24	44.96%	15.48	61.92%
13	Orkawang	25	3.50	14%	11.58	46.33%	15.95	63.81%
14	Belam - B	25	2.68	11%	8.89	35.54%	12.24	48.96%
15	Aringdaza	16	0.71	4%	2.35	14.70%	3.24	20.25%
16	Belam - A	25	2.93	12%	9.71	38.83%	13.37	53.49%
17	Korkang/Pekpela	25	0.76	3%	2.53	10.11%	3.48	13.93%
18	Maenchaphoog	25	1.90	8%	6.29	25.18%	8.67	34.68%
19	Damzaling	10	0.21	2%	0.68	6.83%	0.94	9.40%
20	Chenchari	16	0.30	2%	1.01	6.28%	1.39	8.66%
21	Shingsiri	25	0.94	4%	3.11	12.44%	4.29	17.14%
22	Yaragla - A	25	3.14	13%	10.39	41.56%	14.31	57.24%
23	Yaragla - B	25	1.50	6%	4.98	19.90%	6.85	27.41%
24	Kognala	25	0.59	2%	1.94	7.77%	2.67	10.70%
25	Upper Ngamphoog	25	1.04	4%	3.43	13.71%	4.72	18.89%
26	Lower Ngamphoog	10	0.48	5%	1.59	15.93%	2.19	21.95%
27	Upper Sangkama	16	0.94	6%	3.12	19.52%	4.30	26.89%
28	Lower Sangkama	25	2.66	11%	8.81	35.25%	12.14	48.55%
29	Pinphu	25	1.83	7%	6.05	24.20%	8.33	33.34%
30	Yuldarig village	25	1.91	8%	6.32	25.29%	8.71	34.84%
31	Amdaybu	25	2.77	11%	9.17	36.69%	12.64	50.54%
32	Pogola	16	1.88	12%	6.23	38.93%	8.58	53.63%
33	Kyidpari	25	2.78	11%	9.21	36.84%	12.69	50.74%
34	Yuldarig school	25	1.97	8%	6.52	26.06%	8.97	35.90%
35	Bargoenpa	25	3.17	13%	10.50	42.00%	14.46	57.85%
36	Tongla Goenpa	25	4.14	17%	13.71	54.82%	18.88	75.52%
37	Tonglawoong	25	1.25	5%	4.14	16.56%	5.70	22.81%
38	Mekibee	25	2.99	12%	9.78	39.13%	13.63	54.53%
39	Lower Zunglen	125	6.37	5%	21.09	16.87%	29.05	23.24%
40	Upper Zunglen	63	14.63	23%	48.47	76.94%	66.76	105.97%
41	Chhagsuzor	25	6.26	25%	20.74	82.94%	28.56	114.25%
42	Upper Tsangkhar	25	11.75	47%	38.92	155.69%	53.61	214.45%
43	Lower Tsangkhar	25	7.38	30%	24.43	97.73%	33.65	134.62%
44	Gomchu Kengkhar	10	0.93	9%	3.09	30.93%	4.26	42.61%

Sl. No.	Name		2019		2025		2030	
		KVA Rating	KVA	% Loading	KVA	% Loading	KVA	% Loading
45	Upper Nanari	25	2.99	12%	9.89	39.57%	13.63	54.51%
46	Lower Nanari	25	3.05	12%	10.09	40.35%	13.89	55.58%
47	Dogsabi	25	1.45	6%	4.80	19.19%	6.61	26.44%
48	Neykolog	25	3.21	13%	10.64	42.56%	14.66	58.63%
49	Tsalabi	25	1.19	5%	3.95	15.80%	5.44	21.77%
50	Olokid	25	0.57	2%	1.87	7.50%	2.58	10.33%
51	Maenchabilam	25	0.65	3%	2.17	8.67%	2.98	11.94%
52	Dongnala	16	0.60	4%	1.97	12.32%	2.72	16.97%
53	Khurzong	63	1.53	2%	5.08	8.06%	6.99	11.10%
54	Drongphu	25	1.57	6%	5.19	20.76%	7.15	28.60%
55	Mangling Kengkhar	25	9.43	38%	31.22	124.88%	43.00	172.01%
56	Tshangnari	10	0.23	2%	0.77	7.69%	1.06	10.60%
57	Doongkargoenpa Kengkhar	25	9.34	37%	30.94	123.75%	42.61	170.46%
58	Kengkhar Nagtshang	25	2.75	11%	9.12	36.48%	12.56	50.25%
59	Kengkhar School	25	12.14	49%	40.22	160.87%	55.40	221.58%
60	Doongmanma	25	7.79	31%	25.80	103.22%	35.54	142.17%
61	Pangthoong	10	1.43	14%	4.72	47.23%	6.51	65.05%
62	Shingchongri	16	0.56	4%	1.86	11.61%	2.56	15.99%
63	Artshong	16	0.38	2%	1.27	7.92%	1.74	10.90%
64	Doktang	25	0.89	4%	2.95	11.81%	4.07	16.27%
65	Pangthang Kengkhar	25	1.36	5%	4.51	18.04%	6.21	24.85%
66	Upper Aringkhangma	25	0.17	1%	0.56	2.25%	0.77	3.10%
67	Lower Aringkhangma	25	0.07	0%	0.23	0.91%	0.31	1.26%
68	Upper Munma	25	0.17	1%	0.56	2.25%	0.77	3.10%
69	Lower Munma	16	0.05	0%	0.15	0.95%	0.21	1.31%
70	Upper Mooroong	25	0.30	1%	1.00	3.99%	1.37	5.49%
71	Middle Mooroong	25	0.41	2%	1.34	5.37%	1.85	7.40%
72	Lower Mooroong	25	1.56	6%	5.17	20.69%	7.12	28.50%
73	Saytsangri	16	0.10	1%	0.33	2.09%	0.46	2.88%

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**