BHUTAN POWER CORPORATION LIMITED
(An ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 Certified Company)
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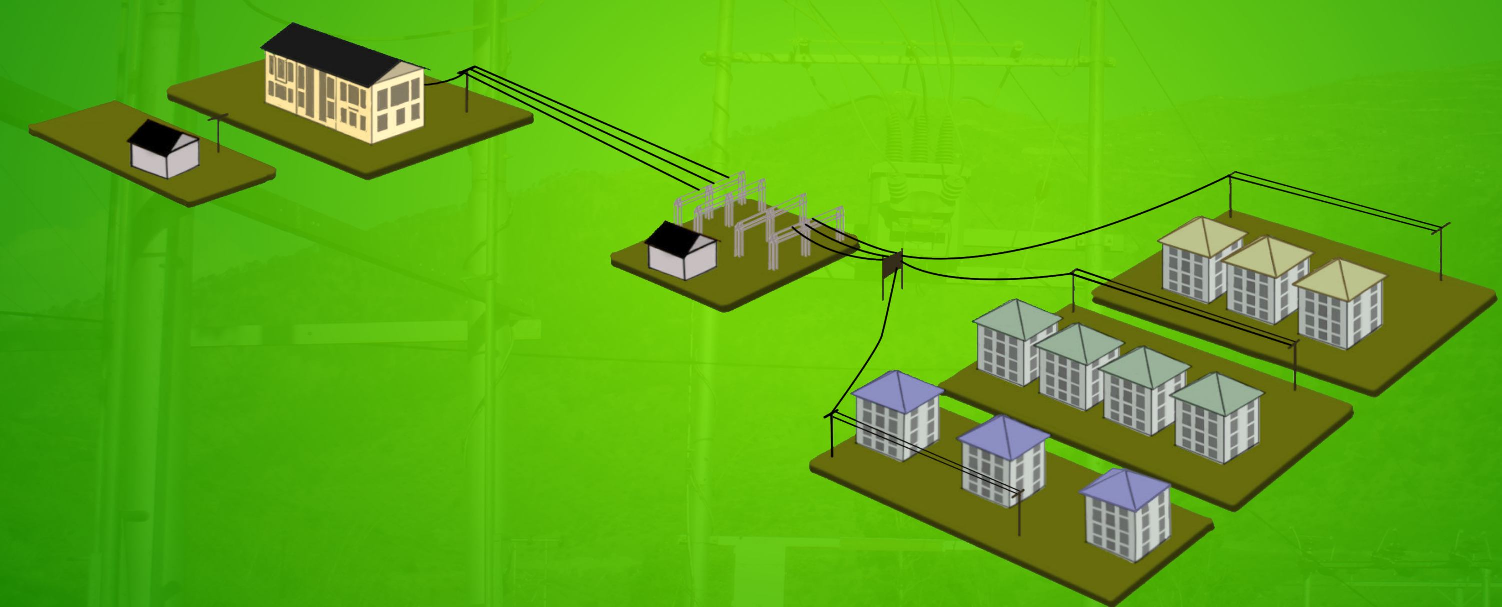
DISTRIBUTION SYSTEM MASTER PLAN (2020-2030)

TRASHIGANG DZONGKHAG



Distribution and Customer Services Department
Distribution Services
Bhutan Power Corporation Limited

2020

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FOREWORD

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

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

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

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

(Sonam Tobjey)
Chief Executive Officer

Preparation, Review & Approval of the Document

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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**

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Abbreviations

BPC: Bhutan Power Corporation Limited

ESD: Electricity Services Division

DSMP: Distribution System Master Plan

GIS: Geographical Information System

SLD: Single Line Diagram

ETAP: Electrical Transient and Analysis Program

IS: Indian Standard on Transformers

IEC: International Electro-Technical Commission

IP: Industrial Park

DT: Distribution Transformer

TSA: Time Series Analysis

LRM: Linear Regression Method

MV: Medium voltage (33kV, 11kV and 6.6kV)

DDCS: Distribution Design and Construction Standards

kVA: Kilo Volt Ampere

W: Watt

kWh: Kilo Watt Hour

RMU: Ring Main Unit

ARCB: Auto Recloser Circuit Breaker

ISD: Intelligent Switching Device

FPI: Fault Passage Indicator

ICT: Interconnecting Transformer

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.

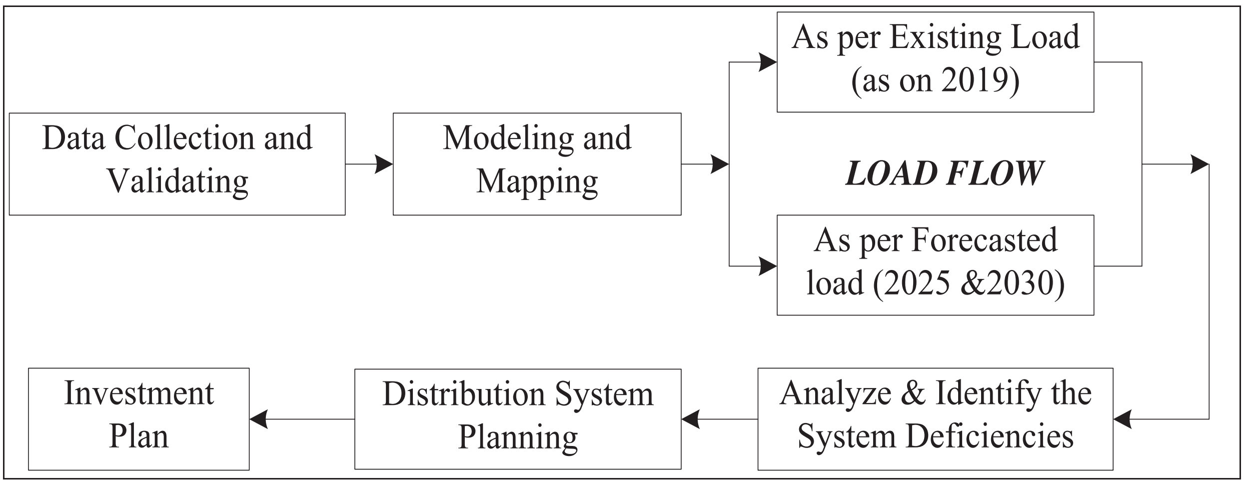


Figure 1: Block diagram for distribution system planning for thematic studies

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 Power supply sources

Trashigang Dzongkhag comprises of three (3) Dungkhags (i.e. Thrimshing, Wamrong & Sakteng) and fifteen (15) Gewogs (Samkhar, Bartsham, Yangneer, Kanglung, Udzrong, Shongphu, Radhi, Bidung, Phongmey, Merak, Saketeng, Khaling, Kangpara, Lumang, and Thungkhar). The power supply to these Gewogs is being catered from 132/33/11kV Kanglung and Nangkhor substations. Further, 2.2MW generation from Rangjung Mini Hydel is synced to the grid. The basic electricity distribution network model as seen from the source at Kanglung, Nangkhor, and Rangjung Mini Hydel is illustrated in the schematic diagram shown in **Figure 2**. The detailed overview network of the Dzongkhag is explained under the following subheadings:

a) 132/33/11kV, 10MVA Kanglung substation at Kanglung;
b) 132/33/11kV, 10 MVA Nangkhor substation at Pemagatshel and
c) 2.2 MW Rangjung Mini Hydel.

The 132/33/11kV Kanglung substation has three (3) number of 11kV outgoing feeders (*i.e. 11kV Younphula, 11kV Khaling, and 11kV Chenary*) and three (3) number of 33kV outgoing feeder (*i.e.33kV Udzrong feeder, 33kV Chenary, and 33kV Yangtse*). The 11kV Younphula and 11kV Chenary feeders cater the power supply to the customers of Kanglung Gewog. Similarly, the 11kV Khaling feeder caters to the power supply to all the villages under Khaling Gewog. This particular feeder is further interconnected with ***33/11kV, 2x2.5 MVA Wamrong substation*** and is also the 11kV incomer to Wamrong substation.

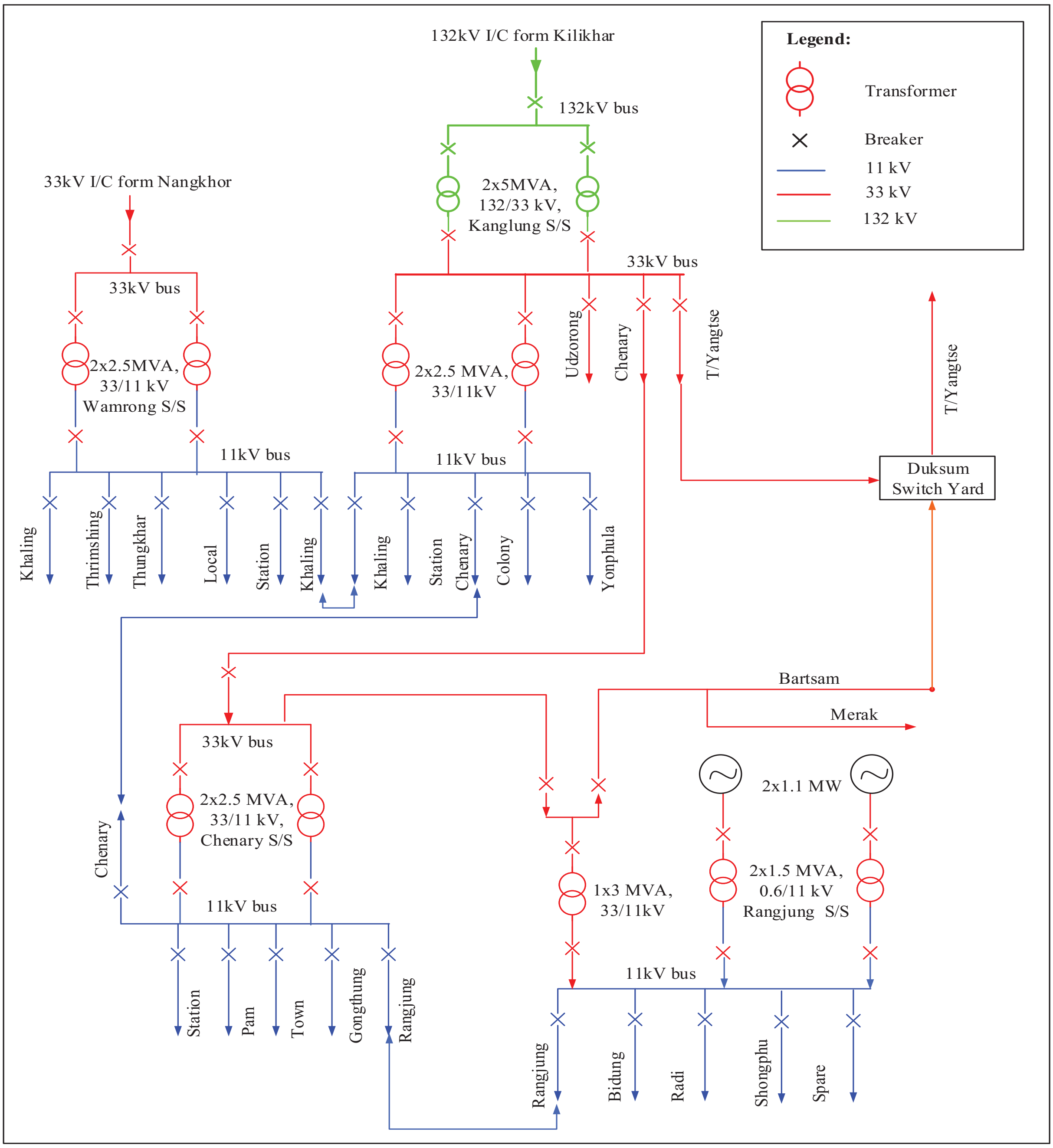


Figure 2: Electricity Distribution Schematic of Trashigang Dzongkhag

Similarly, 33kV Udzrong feeder caters to the power supply to all the villages under Udzrong Gewog. This particular feeder is further connected to the ***132/33/11kV Kilikhar substation*** at Mongar via Dremtse-Nagtshang and at present, the feeder is used as a contingency feeder when the power supply is not available from Kanglung substation. The 33kV Yangtse outgoing feeder from the Kanglung substation is the dedicated feeder for Trashiyangtse Dzongkhag. The 33kV Chenary outgoing feeder from Kanglung substation serves as the primary in-comer for the ***33/11kV, 2x2.5 MVA Chenary substation***. From Chenary substation, the power supply is further distributed through four (4) number of 11kV feeders and a 33kV feeder. The Chenary substation is also connected with a secondary 11kV Chenary in-comer from the Kanglung substation.

The 33kV line source from the 132/33/11kV Nangkhor substation at Pemagatshel serves as the primary in-comer to 33/11kV, 2x2.5 MVA Wamrong substation. From Wamrong substation, the power is further distributed through four 11kV outgoing feeders covering four Gewogs (*i.e. Thrimshing, Kangpara, Thungkhar, and Lumang*).

The power generated from 2.2MW Rangjung Mini Hydel is distributed to seven (7) Gewogs (*i.e. Bidung, Radhi, Phongmay, Shongphu, Bartsham, Merak, and Sakteng*) through three (3) numbers of 11kV feeder and 33kV feeder. This generation is also connected to the grid through both 11kV & 33kVoutgoing feeders from Chenary substation.

6.2 Electricity Distribution Lines

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

Table 1: MV and LV Line Infrastructure Details

Sl. No.	33 kV		11 kV		Total MV line		LV lines		Total LV length
	OH	UG	OH	UG	OH	UG	OH	UG	
1	132.083km	-	296.07km	-	428.153km	-	605.60	88.76	605.60km

The total MV line length is 428.153 km and the total LV line length is 694.36 km. The ratio of MV to LV line length is 1:1.62, which reflects a high portion of the LV distribution network resulting in high losses and low voltage profile at the consumer end. 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.

6.3 Distribution Transformers

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

Table 2: Total Numbers of Transformers & Installed Capacity

Source	Capacity (MVA)	Peak Load (MW)	Feeder	Peak Load (MW)	DTS (Nos.)	Connected (kVA)
132/33/11kV Kanglung	10	7.48	11kV Khaling	1.34	45	2,965.00
			11kV Younphula	0.521	12	1,941.00
			11kV Chenary/College	0.517	9	1,957.00
			33kV Udzrong	1.32	17	1,042.00
			33kV Chenary	2.496	0	8,391.00
			33kV Trashiyangtse	2.106	0	
33/11kV Chenary Substation	5	2.5	**33kV Incomer**			
			11kV Trashigang Town		8	3,653.00
			11kV Pam		7	839.00
			11kV Gongthung		14	693.00
			11kV Rangjung		27	2,893.00
			33kV Rangjung		2	313.00
2.2 MV Rangjung PH	2.2	1.2	11kV Radhi		28	1,649.00
			11kV Shongphu		5	475.00
			11kV Bidung		19	1,168.00
			33kV Bartsham-Merak		12	1,166.00
33/11kV Wamrong Substation	5	1.1	33kV Incomer	0.89	2	93.00
			11kV Thrimshing Kangpara	0.33	39	2,014.00
			11kV Thungkhar	0.127	20	552.00
			11kV Wamrong Local	0.157	12	922.00
Total					**278**	**32,726.00**

As of September 2019, there were 278 distribution transformers with a total capacity of 32,726 kVA. As can be inferred from **Table 2,** the installed capacity of the transformer per customer is 2.37kVA per customer (13,816 customers as of September 2019).

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)

Kanglung and Nangkhor substations are the primary power sources for the Dzongkhag. 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 Kanglung and Nangkhor Substation

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW	2019	2025	2030
1	Kanglung Substation	132/33	2x5	8.5	7.42	9.93	11.56
		33/11	2x2.5	4.25	1.33	1.70	2.16
2	Nangkhor Substation	132/33	2x5	8.5	0.659	1.74	2.17
		33/11	2x2.5	4.25	-	-	-
3	Korlung (Upcoming)	132/33	2x10	17			

Note: *The detailed assessment of the Nangkhor substation will be cover in the DSMP report of Pemagatshel*

a) 132/33/11kV Kanglung Substation

As can be inferred from **Table 3,** the recorded peak load at Kanglung substation in 2019 is 7.42 MW (at 132/33 kV voltage level), which is 87 % loaded against the installed capacity of 10MVA (i.e. 8.5 MW). Similarly, at 33/11 kV voltage level, the recorded peak load is 1.33MW, which is 31% loaded (i.e. 4.25 OR 5MVA@0.85pf). The substations have adequate capacity to cater to the existing load. However, the time series load forecast suggests that the capacity of the existing 132/33 kV substation needs to be up-graded as the peak power demand is projected to reach 13.60MW and 17.32MW by 2025 and 2030 respectively. The time series forecasted load growth on 33/11kV substation implies adequate capacity till 2030.

The overloading issue on the 132/33kV substation at Kanglung can be resolved when the power supply to Trashiyangtse Dzongkhag is catered from 2x10MVA, 132/33kV Korlung substation. The existing recorded peak load for Trashiyangtse Dzongkhag is 2.2MW.

Table 4: Load on Kanglung S/S after transferring Trashiyangtse load to Korlung S/S

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW	2019	2025	2030
1	Kanglung Substation	132/33	2x5	8.5	7.42	9.93	11.56
2	Trashiyangte Load				2.2	3.207	3.933
3	Load at Kanglung SS (1-2)				**5.22**	**6.732**	**7.627**

The forecasted load at Kanglung substation after alleviating the Trashiyangtse load is shown in **Table 4**. From the table, it is evident that the Kanglung substation can cater to the present and forecasted load when the load of Trashiyangtse Dzongkhag is fed from the Korlung substation.

b) 132/33/11kV Nangkhor Substation

As evident from **Table 3,** the source feeder for Wamrong 33/11kV substation from the 132/33/11kV substation has an existing load of 0.659MW and is forecasted to reach 1.74MW and 2.17MW by 2025 & 2030 respectively. However, the detailed capacity assessment for the Nangkhor substation is included in the DSMP report of Pemagatshel Dzongkhag.

7.1.2 MV Substation (33/11 kV)

The power imported from 132/33kV Kanglung and 132/33kV Nangkhor substations is further distributed to various parts of the Dzongkhag through 33/11kV Chenary and Wamrong substations. In addition to this, some portion of the Trashigang area is also supplied through grid connected embedded generation *(i.e. 2.2 KW Rangjung Power Plant Generation)*. The details on the installed capacity of the substations, existing peak load, and anticipated load in the future are tabulated in **Table 5**.

Table 5: Peak load of Chenary and Wamrong 33/11kV Substation

Sl. No.	Name of Source	Voltage Level (kV)	Installed Capacity		Peak Load (MW)	Forecasted Load (MW)	
			MVA	MW	2019	2025	2030
1	Chenary Substation	33/11	2x2.5	4.25	2.68	6.32	8.02
2	Rangjung Power House	0.66/11	-	2.2	1.3	1.83	3.03
Total				**6.7**	**3.98**	**8.15**	**11.05**
3	Wamrong Substation	33/11	2x2.5	4.5	0.659	1.74	2.17

Note: C*onsidering the power factor of 0.85*

As seen from **Table 5**, the Chenary substation is 63% loaded against its total installed capacity (*i.e.2x2.5MVA=5*pf=4.25MW*) excluding a load of Rangjung Power House. Thus, Chenary substation has adequate capacity to cater to the power for the existing load. However; as per the projected load for the year 2025 and 2030, it is going to exceed its installed capacity. Therefore, to address the issue of overloading in the year 2025, a necessary plan has to be considered for up-grading substation capacity.

Similarly, the existing loading of the Wamrong substation is 16% loaded against its total installed capacity (***i.e. 4.25MW***). Hence, as evident from **Table 5,** the substation has adequate capacity to cater to the existing as well as forecasted peak power 2030.

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 various substations 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 and 4.**

Table 6: Historical Feeder wise peak power demand of ESD Trashigang

Substation	Feeder Name	Peak Load Consumption Pattern (MW)					
		2014	2015	2016	2017	2018	2019
132/33/11kV Kanglung Substation	11kV Khaling	0.49	1.19	1.34	1.24	1.29	1.67
	11kV College	0.92	0.98	0.99	1.02	1.89	1.56
	11kV Younphula	0.46	0.99	0.95	0.99	0.65	1.03
	33kV Udzrong	1.14	1.01	1.34	1.44	1.49	2.01
	33kV Chenary	2.31	2.09	2.98	3.91	3.96	4.27
33/11kV Wamrong Substation	33kV Nangkhor Incomer	0.758	0.687	1.207	1.136	1.035	1.213
	11kV Kangpar	0.23	0.25	0.29	0.303	0.374	0.394
	11kV Thungkhar	0.076	0.082	0.088	0.094	0.1	0.106
	11kV Wamrong Local	0.119	0.125	0.131	0.137	0.143	0.149
33/11kV Chenary Substation	11kV Town	1.8	1.82	1.87	1.9	1.98	2.3
	11kV Pam	0.139	0.198	0.253	0.267	0.28	0.28
	11kV Gongthung	0.12	0.13	0.14	0.15	0.16	0.17

Substation	Feeder Name	Peak Load Consumption Pattern (MW)					
		2014	2015	2016	2017	2018	2019
	11kV Rangjung	0.55	0.56	0.57	0.58	0.59	0.6
	33kV Rangjung-Bartsham	0.49	0.5	0.51	0.52	0.56	0.57
Rangjung Power House	11kV Bidung	0.148	0.158	0.168	0.178	0.188	0.198
	11kV Radhi	0.78	0.79	0.8	0.81	0.82	0.83
	11kV Songphu	0.226	0.236	0.246	0.256	0.266	0.276

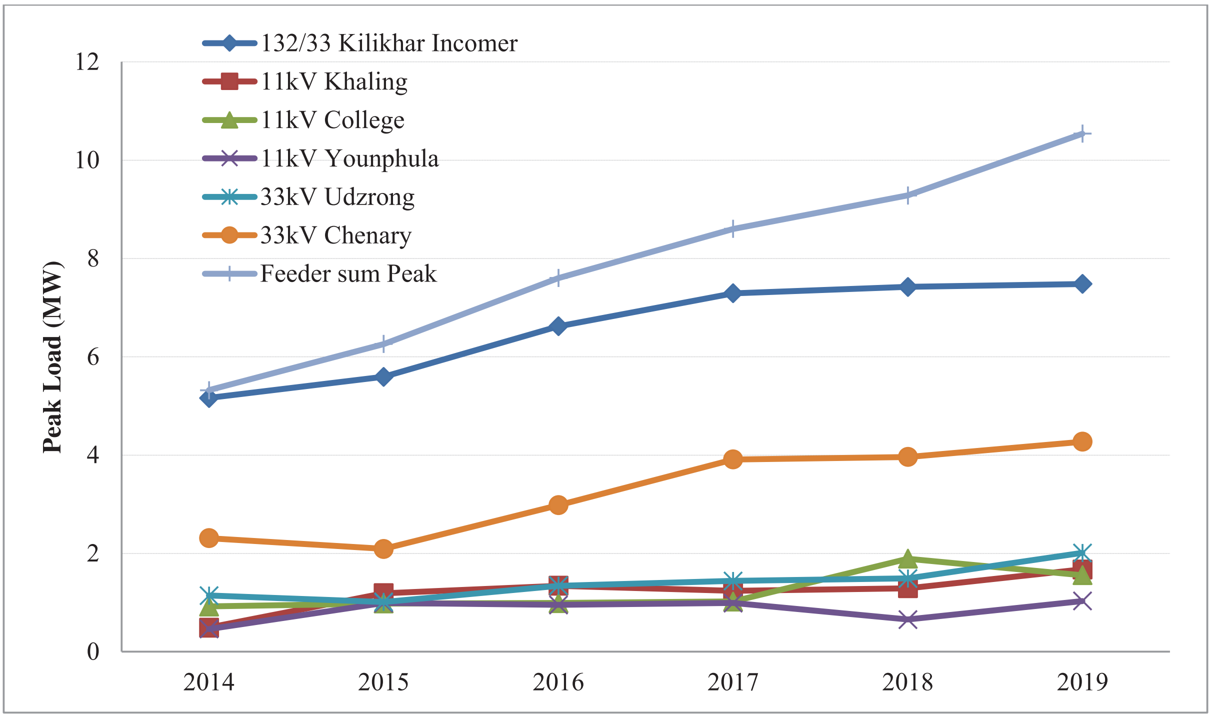
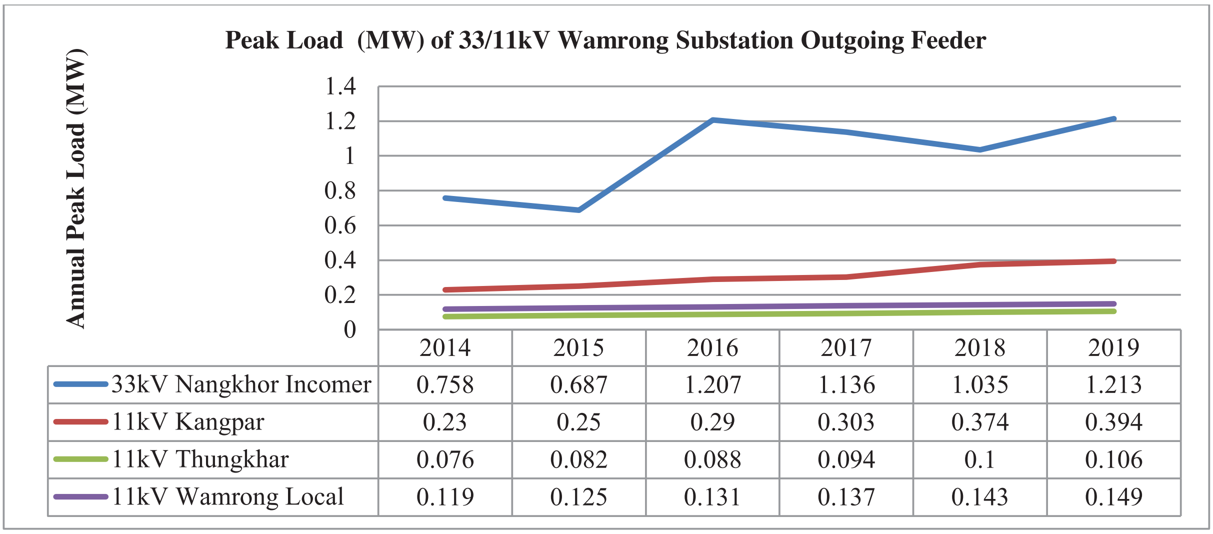


Figure 3: Feeder Wise Peak Load (MW) of 132/33/11kV Kanglung Substation Outgoing Feeders

As can be seen from **Figure 3**, the overall load on the 132/33/11kV Kanglung substation has gradually increased over the last six (6) years.

From **Figure 4**, we observe that the load growth on 33/11kV Wamrong substation from 2014 to 2019 is fluctuating. The randomness of the load has occurred due to a change of sources (Kanglung and Nanong) on 11kV Khaling feeders when even there is power interruption in either source. Though we observe fluctuating peak power, the highest recorded peak demand is just 1.214MW which is within the feeder capacity.



	2014	2015	2016	2017	2018	2019
33kV Nangkhor Incomer	0.758	0.687	1.207	1.136	1.035	1.213
11kV Kangpar	0.23	0.25	0.29	0.303	0.374	0.394
11kV Thungkhar	0.076	0.082	0.088	0.094	0.1	0.106
11kV Wamrong Local	0.119	0.125	0.131	0.137	0.143	0.149

Figure 4: Feeder Wise Peak Load Demand of Wamrong Substation's Outgoing Feeders

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
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 Trashigang

Feeder Name	Forecasted Load Growth (MW)										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Kanglung Substation											
11kV Khaling	2.01	2.35	2.69	3.03	3.37	3.72	4.06	4.40	4.74	5.08	5.42
11kV College	1.70	1.84	1.98	2.13	2.27	2.41	2.55	2.69	2.84	2.98	3.12
11kV Younphula	1.09	1.15	1.21	1.27	1.33	1.40	1.46	1.52	1.58	1.64	1.70
33kV Udzrong	2.17	2.34	2.51	2.67	2.84	3.01	3.17	3.34	3.51	3.67	3.84

Feeder Name	Forecasted Load Growth (MW)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
33kV Chenary	4.61	4.95	5.29	5.63	5.97	6.32	6.66	7.00	7.34	7.68	8.02
Wamrong Substation											
Feeder sum Peak	11.59	12.64	13.69	14.74	15.79	16.84	17.89	18.94	20.00	21.05	22.10
33kV Nangkhor Incomer	1.30	1.39	1.47	1.56	1.65	1.73	1.82	1.91	2.00	2.08	2.17
11kV Kangpar	0.99	1.00	1.01	1.02	1.03	1.04	1.25	1.26	1.27	1.28	1.29
11kV Thungkhar	0.23	0.24	0.25	0.26	0.27	0.28	0.31	0.32	0.33	0.34	0.35
11kV Wamrong Local	0.35	0.36	0.37	0.38	0.39	0.40	0.45	0.46	0.47	0.48	0.49
Chenary Substation											
11kV Town	2.91	2.92	2.93	2.94	2.95	2.96	3.16	3.17	3.18	3.19	3.20
11kV Pam	0.71	0.72	0.73	0.74	0.75	0.76	0.78	0.79	0.80	0.81	0.82
11kV Gongthung	0.34	0.35	0.36	0.37	0.38	0.39	0.46	0.47	0.48	0.49	0.50
11kV Rangjung	1.36	1.37	1.38	1.39	1.40	1.41	1.75	1.76	1.77	1.78	1.79
33kV Rangjung-Bartsham	1.30	1.31	1.32	1.33	1.34	1.35	1.67	1.68	1.69	1.70	1.71
Rangjung Power House											
11kV Bidung	0.47	0.48	0.49	0.50	0.51	0.52	0.54	0.55	0.56	0.57	0.58
11kV Radhi	0.73	0.74	0.75	0.76	0.77	0.78	0.11	0.12	0.13	0.14	0.15
11kV Songphu	0.48	0.49	0.50	0.51	0.52	0.53	0.69	0.70	0.71	0.72	0.73

From the power flow analysis of the 2025 and 2030 loading scenarios, the simulation results show that there will be a significant drop in bus voltage and marginal and critical voltage drops in respective feeders as presented in **Table 9.**

Table 9: Voltage Profile of the problematic feeders.

Feeder Name	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage (%)		
	Load	Bus	End	Load	Bus	End
11kVKanglung Bus		**90.4**		**2.408**	**87.51**	
11kV Khaling	0.99		82.3	1.364		75.84
11kV College	0.509		89.55	0.625		86.43
11kV Younphula	0.364		89.41	0.419		86.33
33kV Chenary bus	**3.954**	**90.42**		**4.845**	**87.73**	

Feeder Name	2025 Load (MW) and Voltage (%)			2030 Load (MW) and Voltage (%)		
	Load	Bus	End	Load	Bus	End
33kV Barthsham/Merak	0.919		89.41	1.11		86.42
11k Chenary Bus voltage	**2.642**	**85.48**		**3.598**	**81.64**	
11kV Gongthung	0.258		84.82	0.305		80.82
11kV Town	1.565		83.62	1.575		79.68
11kV Pam	0.506		84.65	0.51		80.76
11kV Rangjung	0.571		75.01	1.34		64.47
11kV RPH Bus	**1.6**	**75**		**1.6**	**63.33**	
11kV Bidung	0.286		74.04	0.352		69.7
11kV Radhi	0.43		72.8	0.658		59.31
11k Shongphu	0.291		74.64	0.323		62.85

The feeders reflected in **Table 9** will be experiencing a low voltage profile which will be beyond the permissible range. The improvement measures and strategies to improve the low voltage profile is detailed as follows.

The voltage of the Kanglung bus can be improved by the transformer tap changing. However, the voltage profile of the 11kV Khaling feeder is not expected to reach within the range even with the usage of the tap changer. During normal operation power supply to the customers of Khaling Gewog is catered by this feeder though it is interconnected to 33/11 kV Wamrong substation. It is recommended to offload half of the load to the Wamrong substation and this reconfiguration of the power source is expected to improve the voltage profile from 75.84 % to 96.37 %. There are 45 DTs with a total capacity of 2,965 kVA of connected to the feeder.

Similarly, the voltage profile of the 33 kV Bartsham/Merak feeder can be improved by isolating Bartshma and Merak Gewogs and back feed the Bartsham from the Duksum switchyard.

The drop-in voltage at Chenary substation is because of transformer overloading. With the up-rating of 2x2.5 MVA transformer to 2x5 MVA, the voltage profile is expected to improve significantly. Further, by sharing a load of 11kV Rangjung feeder from RPH the voltage drop of the feeder can be improved.

At present, the power generation from RPH (2x1.1 MW) is synchronized with an 11 kV Rangjung feeder and injected into the grid which caters to the power requirement of Radi, Bidung, and Shongphu areas. These areas are expected to experience a low voltage profile with the increase of load in the future since the capacity of 11 kV Rangjung will be exhausted. However, with the synchronization of RPH with the 33kV Chenary feeder, the voltage profile is anticipated to improve. With the augmentation of substations, reconfiguration of the sources, and usage of the tap-changers, the voltage profile is expected to be within the permissible range as tabulated in **Table 10.**

Table 10: Improved Voltage Profile

Sl. No.	Feeder Name	Voltage Profile (Before)	Voltage Profile (After)	Corrective Action
1	**11kV Kanglung Bus**			Maintain 100% volt at 11kV Bus (Transformer tap changing)
1.1	11kV Khaling	75.840	96.370	Isolating half of feeder load on 33kV Wamrong Substation
1.2	11kV College	86.430	100.000	
1.3	11kV Younphula	86.330	100.000	
2	**33kV Chenary bus**			
2.1	33kV Barthsham/Merak	86.420	95.280	Isolated Bartsham load (to be back feed from Duksum)
3	**11k Chenary Bus voltage**			2x2.5 MVA to be Up-grade at 2x5MVA
3.1	11kV Gongthung	80.820	99.270	
3.2	11kV Town	79.680	98.280	
3.3	11kV Pam	80.760	99.350	
3.4	11kV Rangjung	64.470	94.120	Share the load form RPH
4	**11kV RPH Bus**			Grid line to RPH is change on 33kV Chenary feeder and synchronise at 11kV after Transforming to 11kV
4.1	11kV Bidung	69.700	93.680	
4.2	11kV Radhi	59.310	90.500	
4.3	11k Shongphu	62.850	94.720	

It is also important for BPC to explore the best fit technology (e.g. installing AVR/voltage boosters) to improve the voltage profile rather than proposing to up-grade the entire conductor size which would be inconvenient to implement as it will involve frequent power interruptions. The detailed simulation results for all the case studies are attached as **Annexure- 4.**

7.2.2 Energy Loss Assessment of MV Feeders

Energy losses in the distribution network are inherent as the power transmission and distribution system are associated with the transformer and line loss. However, it is crucial to maintain the energy loss at an optimal level by engaging in timely improvement of the distribution infrastructures and not reacting to the localized system deficiencies. The objective of the energy loss assessment is to single out the feeder (s) with maximum loss (es) and put in additional corrective measures to minimize to the acceptable range. **Table 11** shows the energy sales, purchase, and loss profile of the Dzongkhag.

Table 11: Energy Sales-Purchase-Loss Trend

Sl. No.	Particulars	2014	2015	2016	2017	2018	Average
1	**Total Energy Purchase (MU)**	**16.0**	**17.8**	**18.1**	**19.2**	**20.0**	
	% growth over previous year	9.11%	10.98%	1.78%	6.27%	3.96%	
i	Total LV	13.18	13.67	14.54	14.86	15.12	
ii	LV Bulk	1.13	1.45	1.51	1.80	2.26	
2	**Total Energy Sales (MU)**	**14.31**	**15.12**	**16.05**	**16.67**	**17.38**	
	% growth over previous year	5.22%	5.65%	6.15%	3.86%	4.27%	
3	**Total Loss (%)**	**10.72%**	**10.94%**	**8.00%**	**9.37%**	**13.11%**	**10.43 %**

Source: Adapted from BPC Power Data Book 2018

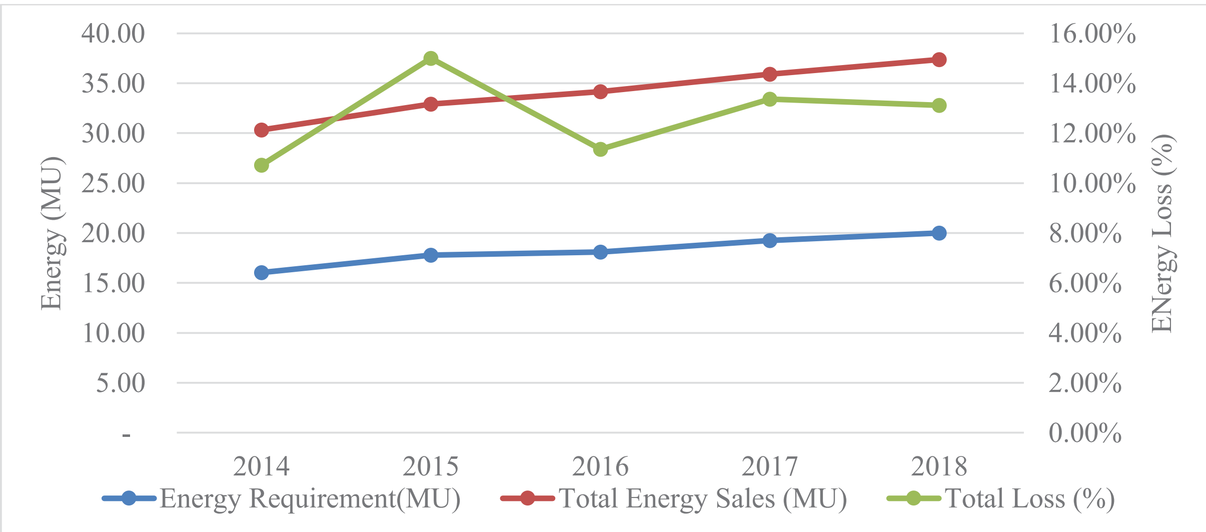


Figure 5: Energy Demand and Energy Losses Trend

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 Trashigang (2014-2018) is 10.43 % 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 is tabulated in **Table 12**. 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 12: Feeder Wise Energy Loss

Sl. No.	Name of feeders	Customer (Nos.)	Line Length (km)	Feeder Loss (%)				
				2014	2015	2016	2017	2018
1	11kV Khaling	1,582.00	71.69	1.84	1.88	1.37	1.61	1.53
2	11kV College	552.00	10.12	0.26	0.26	0.19	0.23	0.22
3	11kV Younphula	934.00	7.76	0.20	0.20	0.15	0.17	0.17
4	33kV Udzrong	653.00	27.70	0.71	0.72	0.53	0.62	0.59
5	33kV Chenary	7,760.00	223.95	5.74	5.86	4.28	5.02	4.77
6	11kV Kangpar	1,309.00	46.98	1.20	1.23	0.90	1.05	1.00
7	11kV Thungkhar	340.00	17.63	0.45	0.46	0.34	0.39	0.38
8	11kV Wamrong Local	654.00	12.43	0.32	0.33	0.24	0.28	0.26
	Total Customer	**13,784**	**418.3**	**10.72**	**10.94**	**8.00**	**9.37**	**8.90**

The energy loss profile as shown in **Figure 6** indicates that the 33kV Chenary feeder contributed the highest energy loss followed by the 11kV Khaling feeder. The 33 kV Chenary feeder has the highest customer connected through various sub-distribution feeders at 33/11 kV Chenary substation and Rangjung Power House.

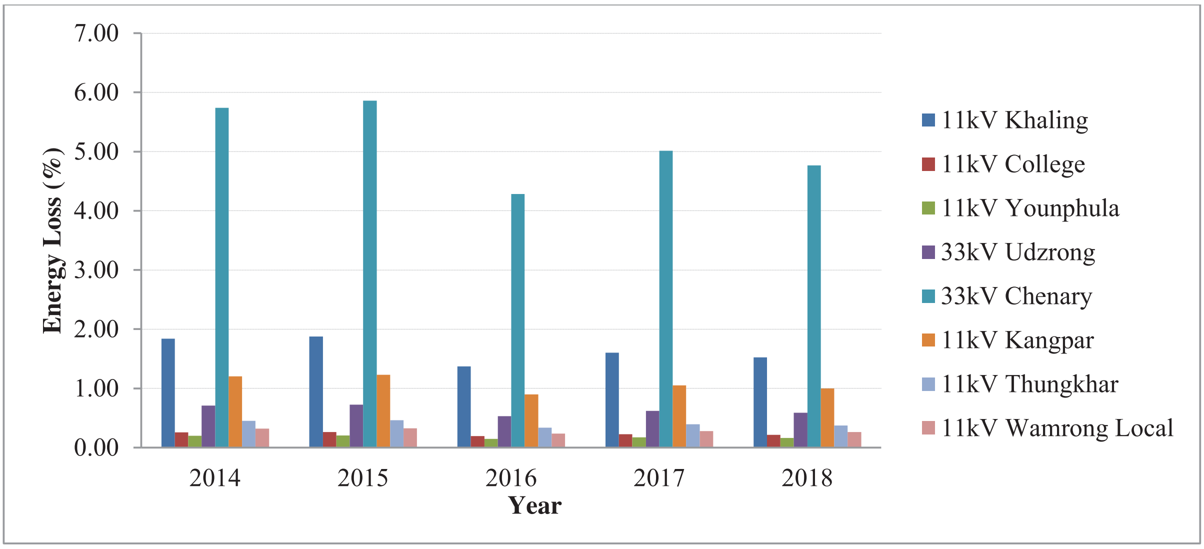


Figure 6: Feeder Wise Energy Loss of ESD Trashigang

7.2.3 Reliability Assessment of the MV Feeders

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

In addition to ensuring that the MV feeders have the required capacity, it is also very important to ensure that the MV feeders are reliable. The yearly average feeder reliability assessment (2016-2018) is summarized in **Table 13.** The individual feeder reliability details used to derive the summary is attached as **Annexure-5**. The interruptions with less than five minutes were omitted from the computation. The actual records (both within and beyond ESDs control) were considered to compute the actual representation of the reliability indices. The average reliability indices viz a viz SAIFI & SAIDI compiled from 2017-2018 are 11.67 and 13.64 respectively which indicates that the power supply to the customers of Trashigang Dzongkhag is quite reliable.

Table 13: Feeder wise reliability indices of ESD Trashigang for 2017-2018

Sl. No.	Feeder	2017		2018	
		SAFI	SAIDI	SAFI	SAIDI
1	33kV Udzrong	5.26	11.40	1.1	1.58
2	11kV Khaling	2.96	4.74	5.12	1.21
3	11kV College	2.63	1.06	0.27	0.29
4	11kV Younphula	0.76	1.78	0.63	0.95
5	33kV Chenary	2.66	2.23	1.95	2.06
Total SAIFI & SAIDI		**14.27**	**21.20**	**9.07**	**6.09**
Average SAIFI		**11.67**			
Average SAIDI		**13.64**			

Source: Adapted from monthly system performance report of DCSD, BPC
Notes:

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

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

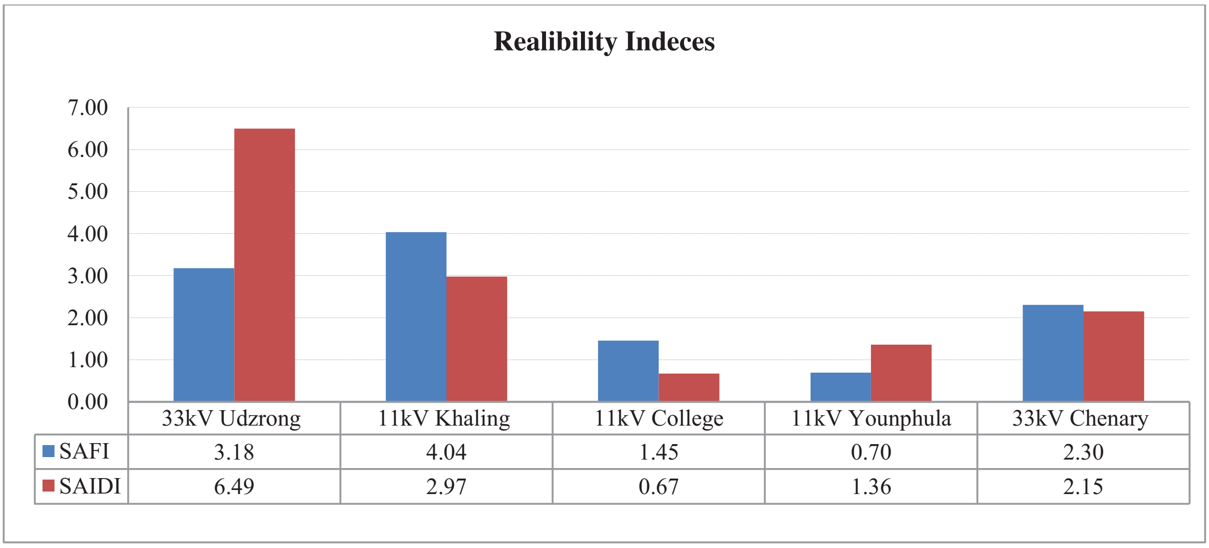


Figure 7: Graphical Representation of Reliability Indices

The bar graph as shown in **Figure 7** indicates that the 33kV Udzrong and 11kV Khaling feeders are more susceptible to interruptions compared to the other feeders. However, it is pertinent to mention that the high reliability indices in the 33kV Udzrong feeder is because of the planned shutdown taken by ESD Mongar for the maintenance of 33 kV RMU at Drametsi.

To get a better understanding of the reliability index, the detailed root cause outages of the feeders had been computed in **Table 14.**

Table 14: The Root Cause Outages

Sl. No.	Causes of Outages	Frequency (Nos.)	Interruption (%)
1	HT fuse Replace	48.5	26%
2	Line Jumpering	22	12%
3	Collapse of Pole-Breakdown	1	1%
4	Snap of Conductor	0.5	0%
5	Puncture of insulator/Leakage	5.5	3%
6	Puncture of LA/LA Maintenance	6.5	3%
7	Lightening & Strom	11.5	6%
8	Tree/branch fall on line	5.5	3%
9	RoW Clearing	19.5	10%
10	Land Slide	0.5	0%
11	Forest fire	3	2%
12	Preventive Maintenance of Line/LBS/GO/ARCB	21.5	11%
13	Preventive Maintenance of substation/Switchyard	9	5%
14	Breakdown Maintenance of Line/LBS/GO/ARCB	4.5	2%
15	Breakdown Maintenance of Substation/Switchyard	2	1%
16	SMD Planned shutdown	4.5	2%
17	Adhoc Shutdown (Tapping, Emergency request)	11	6%
18	Momentary/Transient fault	6.5	3%
19	Trace of fault on line	3	2%
20	Because of Bird/Animals	1.5	1%
21	Close and Open of GO/LBS	1.5	1%

From **Table 14,** It is noted that in 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 improved by maintaining the existing ARCBs. As per the record, ESD Trashigang has four numbers of ARCBs which are manually operated and serving as a function of a normal isolator. 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.

The total single phase line length in the Dzongkhag is 12.001 km (33 kV: 8.047 km, 11 kV: 3.954 km). The estimated cost for the conversion of such is Nu. 1.3 million.

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

7.3 Assessment of the Existing Distribution Transformers

7.3.1 Distribution Transformer Loading

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

Some of the existing transformer capacities would not be adequate to cater to the forecasted load growth for the next ten (10) years. Accordingly, the capacities of the transformers need to be upgraded and such a proposal is tabulated in **Table 15**. 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 41 transformers as tabulated in **Table 15.** However, cross-swapping of the existing transformers before procurement of new transformer would mean that only 5 transformers have to be procured.

Table 15: List of Overloaded Distribution Transformers

Name of substation location	Capacity (kVA)	Existing Loading 2019		Loading (%)		Remarks
		(kVA)	%	2025	2030	
Transformer-Upper Lemi	63.00	20.00	31.75%	70.57%	102.91%	Load growth not expected
Transformer-Barshong Gonpa (KTD)	125.00	42.09	33.67%	74.84%	109.14%	
Transformer-Gomchu	100.00	34.33	34.33%	76.31%	111.29%	
Transformer-Dewang	50.00	16.83	33.66%	74.81%	109.11%	
Transformer-Dungmanma School	25.00	10.71	42.85%	95.24%	138.90%	
Transformer-Regay	16.00	5.02	31.39%	69.76%	101.74%	
Transformer-Ashamdelo	150.00	56.37	37.58%	83.53%	121.82%	
Transformer-K/Mani	16.00	6.25	39.04%	86.77%	126.55%	New 63kVA
Transformer-KIPL Substation, Chenary	315.00	94.50	30.00%	113.17%	122.16%	Load growth not expected
Transformer-Dejung	500.00	125.00	25.00%	94.30%	101.80%	250kV Cross Swap from Upper Pam
Transformer-Chazam Substation, Trashigang	25.00	11.25	45.00%	169.75%	183.24%	Load growth not expected
Transformer-Upper Pam	250.00	80.00	32.00%	120.71%	130.31%	New 500kVA
Transformer-Lengkhar	125.00	53.75	43.00%	162.20%	175.10%	New 500kV
Transformer-Khabti Village Substation	63.00	15.75	25.00%	80.16%	101.80%	Load growth not expected
Transformer-Chutung	16.00	5.76	35.99%	115.41%	146.57%	

Name of substation location	Capacity (kVA)	Existing Loading 2019		Loading (%)		Remarks
		(kVA)	%	2025	2030	
Transformer-Thongphu	25.00	7.40	29.60%	94.92%	120.55%	
Transformer-BHU/PWD	25.00	9.34	37.34%	119.74%	152.07%	63kVA to be cross swap from Drupdhey, Gongthung
Transformer-Lower Market/FCB	250.00	75.49	30.19%	96.81%	122.95%	500kVA new
Transformer-Drupdhey Substation, Gongthung	63.00	18.90	30.00%	96.19%	122.16%	100kVA to be cross swap from Dzongthung, Bartsham
Transformer-Daliphangma Substation, Yangneer	63.00	18.27	29.00%	92.98%	118.09%	Load growth not expected
Transformer-Darjeeling	125.00	31.25	25.00%	80.16%	101.80%	
Transformer-Chador Lhakang Substation, Bartsham	63.00	18.27	29.00%	92.98%	118.09%	
Transformer-Bartsham Central School, Bartsham	250.00	72.50	29.00%	92.98%	118.09%	
Transformer-Dzongthung Substation, Bartsham	100.00	28.00	28.00%	89.78%	114.02%	250kVA to be Cross Swap from Lower Market, Rangjung
Transformer-Gonorteng A	63.00	7.23	28.92%	92.73%	117.77%	Load growth not expected
Transformer-Gonorteng B	63.00	7.13	28.52%	91.46%	116.15%	
Transformer-Pamtem	16.00	6.01	37.55%	118.09%	181.67%	
Transformer-Saling	50.00	14.59	29.17%	91.74%	141.14%	
Transformer-Kakaney	160.00	44.44	27.78%	87.36%	134.39%	
Transformer-Jhonla	63.00	14.35	22.77%	65.31%	124.96%	
Transformer-Pangthang	100.00	53.36	53.36%	153.03%	292.79%	
Transformer-Phajo Gonpa	25.00	5.80	23.22%	66.58%	127.39%	
Transformer-Dorshing	63.00	33.15	52.62%	150.92%	288.75%	
Transformer-Tshozor	63.00	30.60	48.57%	127.80%	159.84%	

Name of substation location	Capacity (kVA)	Existing Loading 2019		Loading (%)		Remarks
		(kVA)	%	2025	2030	
Transformer-Trashiyangphu (Nublang Farm)	63.00	20.01	31.76%	83.56%	104.50%	
Transformer-Phakpari	125.00	43.57	34.86%	91.71%	114.70%	New 250kVA/500kVA
Transformer-Thrimshing A	63.00	20.55	32.62%	85.84%	107.36%	Load growth not expected
Transformer-Threphu A	25.00	8.03	32.13%	84.53%	105.72%	
Transformer-Thrimshing CS	125.00	38.85	31.08%	81.76%	102.26%	
Transformer-Thungkhar School	63.00	19.98	31.72%	83.45%	104.37%	
Transformer-Thungkhar C	25.00	8.15	32.60%	85.78%	107.29%	

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 16**, the DTs had already outlived the asset life, proper evaluation and testing should be done to find out the actual performance of the DTs and informed decisions can be made on the continuous use of the transformers. The life of the asset has been calculated from the year transformer is put to use.

Table 16: List of outlived Distribution Transformers

Asset Code	Substation Name/Location	Capacity (kVA)	MFD	2019	2025	2030
1503692	Transformer-Kholdung	63	1988	31	37	42
1502825	Transformer-Monangkhola	63	1988	31	37	42
1502797	Transformer-Telecome,Kanglung	250	1983	36	42	47
1502901	Transformer-S/Gonpa -I	63	1980	39	45	50

Asset Code	Substation Name/Location	Capacity (kVA)	MFD	2019	2025	2030
1502830	Transformer-Thragom	63	1985	34	40	45
1502832	Transformer-Kanglung	125	1988	31	37	42

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 46 single phase transformers in the Dzongkhag. The estimated cost for the conversion of such is Nu.9.28 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

Due to geographical constrain, the expansion of the town in Trashigang is very limited. The only possible expansion of town is expected in the upper Melphay area. As per the Municipal Authority of Trashigang, around 25 plots of land are already allotted for construction. A load of around 500 kVA is anticipated in this area by 2030. **Figure 8** depicts the proposed location of 500kVA, 11/0.415kV substation, and 11 kV overhead line extension (approximately 0.2 km) to the new town.

Similarly, the other expected area for development in Trashigang is in Rangjung it is being identified as the satellite town in Trashigang Dzongkhag. Around 30 plots are identified, and the construction of buildings is expected within 2030. Therefore, to meet the power requirement, a 500 kVA additional substation is proposed in 2025 after the construction of 0.3km of 11kV UG line as shown in **Figure 9:**

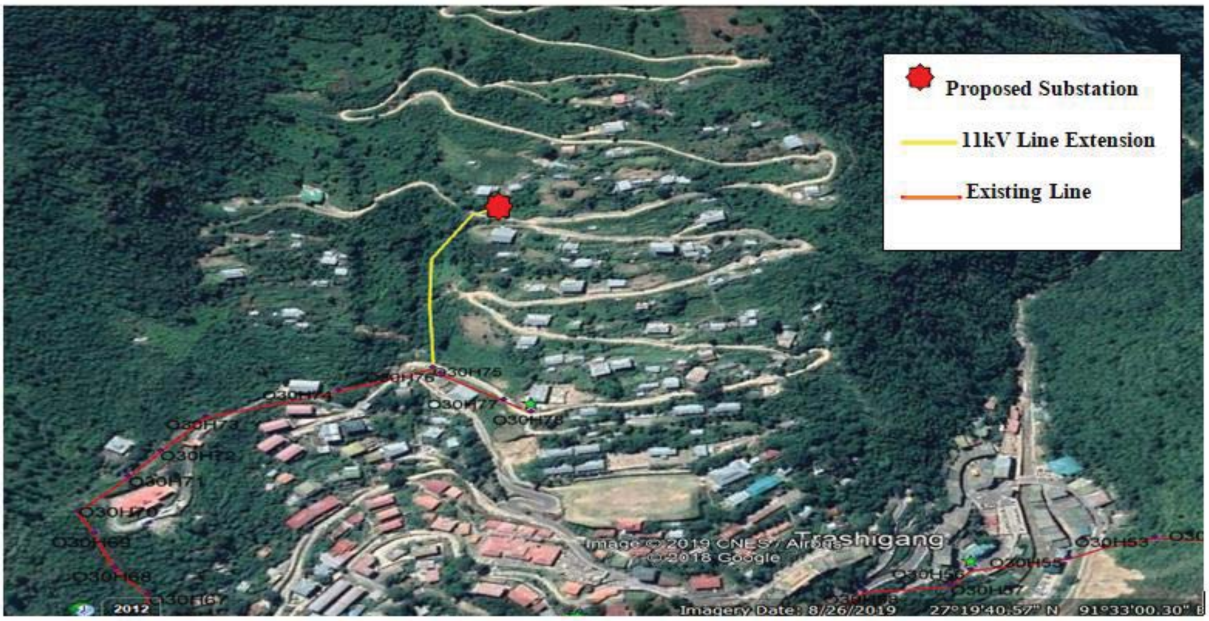


Figure 8: Distribution Network for Upper Melphay

Figure 9: Distribution Network for Rangjung Satellite Town

8. Distribution System Planning

The distribution network of Trashigang 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 7.1.2**, the 132/33, 2x15 MVA Kanglung substation has adequate capacity to cater to the existing and forecasted peak power demand without having to invest.

8.1.2 MV Substations

As per the power source assessment made in **section 7.2.2**, the 33/11kV, 2x2.5 MVA Chenary substations is anticipated to get overloaded by the year 2025. Therefore, the detailed action plan is drawn below to address the issue of overloading on Chenary substation:

a) The load on 2x2.5MVA, 33/11kV Chenary substation is projected at 8.15MW and 11.05MW in the year 2025 and 2030 respectively. Therefore, to meet the projected load, the capacity of Chenary substation is proposed to Up-grade from 2x2.5MVA to 2x5MVA in the year 2024; and

b) The load on 2x2.5MVA, 33/11kV Wamrong substation is projected within the existing capacity of the substation. Therefore, no investment is required for the substation up-gradation. However, minimal investment is required for the installation of an additional 33kV control breaker. At present, the 2.5 transformer I at Wamrong substation is in operation without any protection system.

8.2 MV Lines

The detailed MV line assessment made in **section 7.2** shows that the MV distribution lines of ESD Trashigang would be adequate to cater to the existing as well as future load growth till 2030. However, to improve the voltage profile of the Bartsham/Merak feeder, the load of Bartsham and Merak Gewogs needs to be segregated. The load of Merak can be catered from an existing feeder, while the Bartshem can be back feed from Duksum switchyard. A 33 kV control panel at Chenary is recommended to isolate Bartsham and Merak feeder.

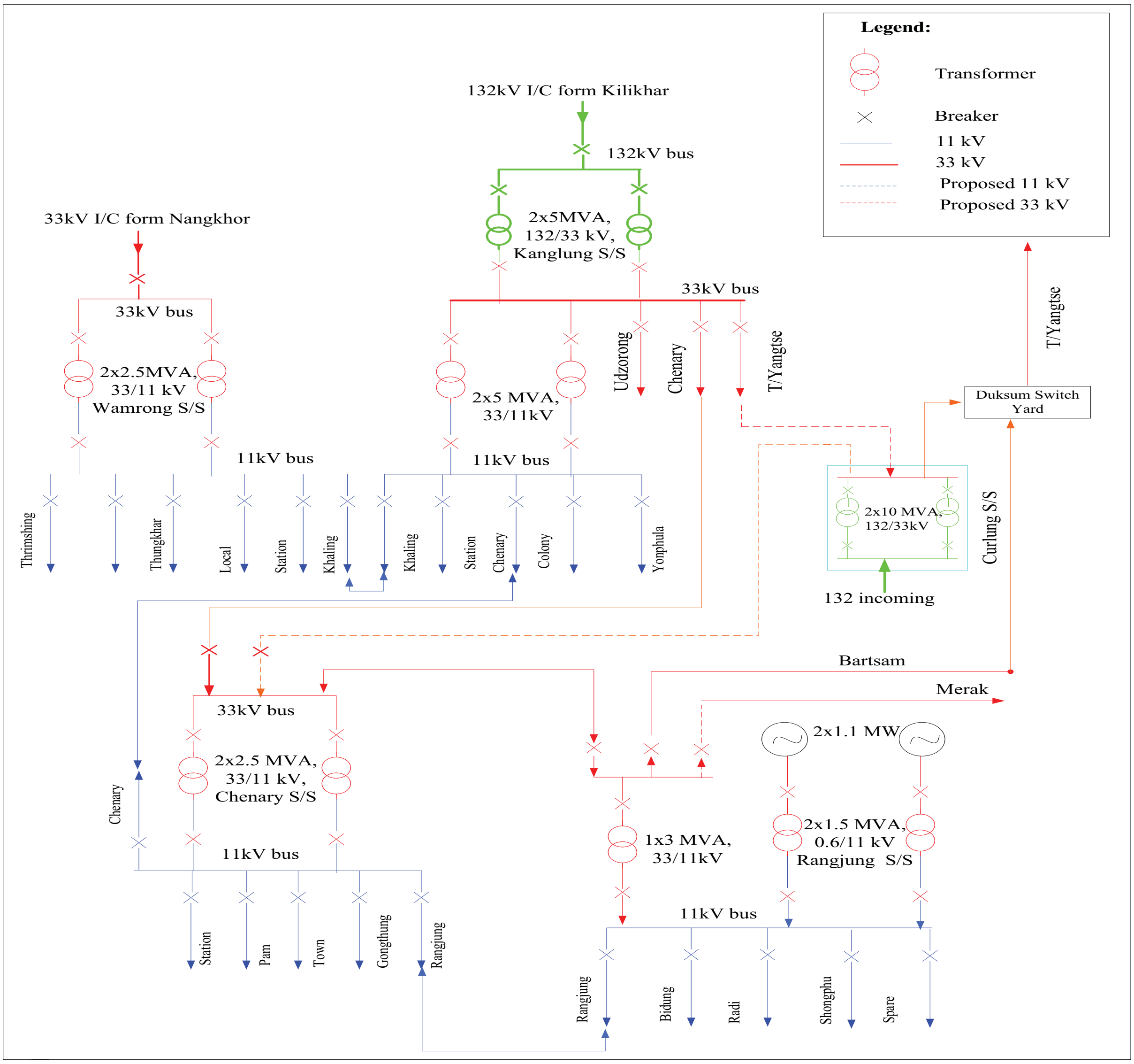


Figure 10: Proposal of LILO arrangement to ease overloading on Kanglung substation

Similarly, around a 1km stretch from Wonbugang village to Phekpari requires to be realigned to improve the reliability of the 11 kV Thrimshing feeder. The said location is prone to landslide and risky during monsoon season.

8.3 Distribution Transformers

As detailed in **Section 7.3.1,** the DTs of urban areas might get overloaded as forecasted, and considering the plans of the LAPs, the following are the list of DTs which would require either up-gradation or installation of new substations.

a) Up-grade 16 kVA, 11/0.415kV transformer at K/Mani to 63 kVA.
b) Up-grade 250 kVA, 11/0.415kV transformer at upper Pam to 500 kVA.
c) Up-grade 125 kVA, 11/0.415kV transformer at Lengkhar to 500 kVA.
d) Up-grade 250 kVA, 11/0.415kV transformer at a lower market to 500 kVA.
e) Up-grade 125 kVA, 11/0.415kV transformer at Phakpari to 315 kVA.
f) Construction of 500 kVA, 11/0.415 transformer at upper Melphay
g) Construction of 500 kVA, 11/0.415 transformer at Ranjung satellite town.

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 11 kV Khaling and Thrimshing (Knagpara) 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 17 shows the existing and proposed switching devices to be installed in the respective feeders.

Table 17: List of Switching Equipment under ESD Trashigang

Sl. No	Name of Feeder	ARCBs		FPIs	
		Existing	Proposed	Existing	Proposed
1	11kV Khaling feeder	2	0	0	1
2	11kV Thrimshing (Kangpara) feeder	0	2	0	2
3	33 kV Bartsham/Merek Meeder feeder	2	0	0	2
	Total	**4**	**2**	**0**	**5**

8.4.2 Distribution System Smart Grid

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

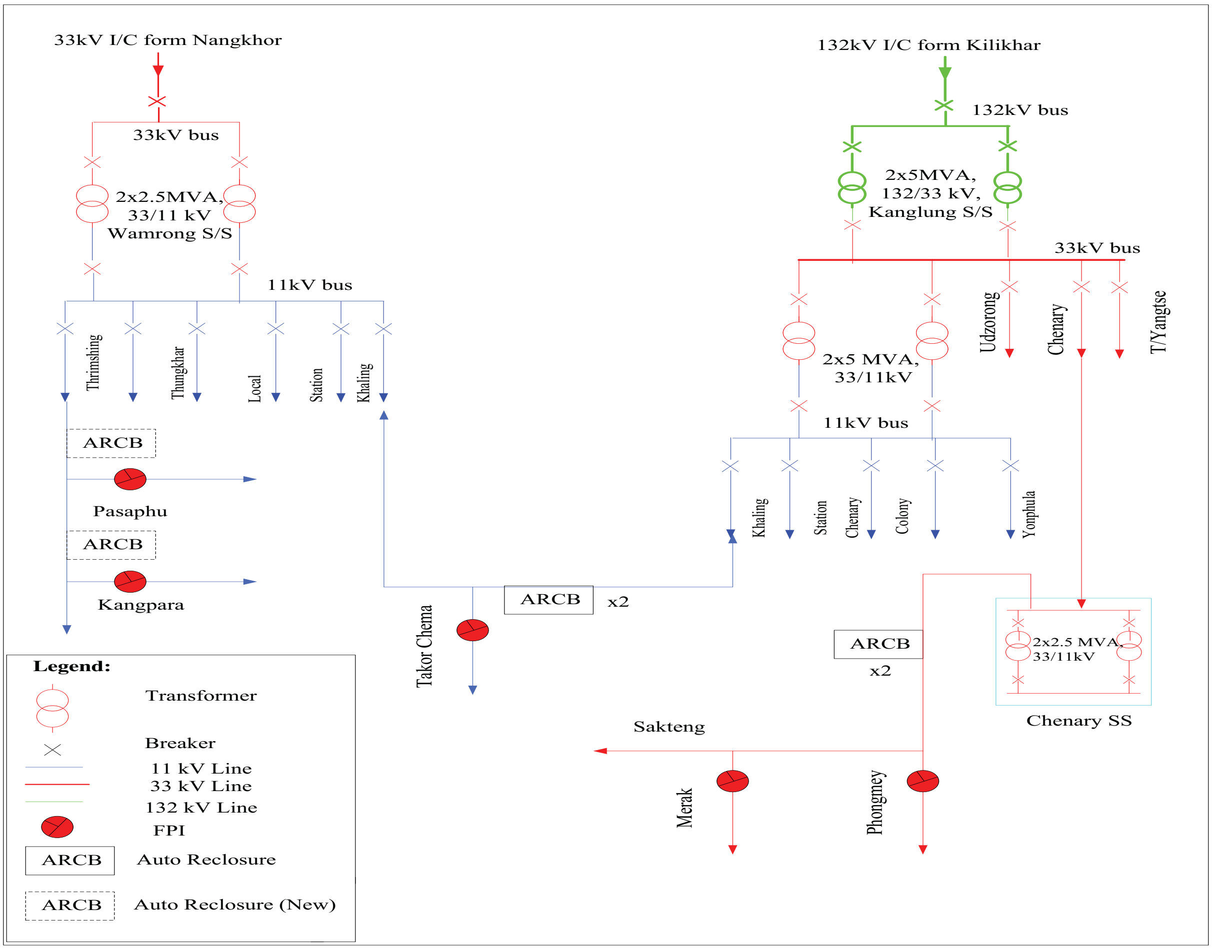


Figure 11: Proposed Switching Equipment for Distribution Network

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 (2020-2024) investment plan and any new investment plans have been validated and synced with the system studies carried out. The annual investment plan (2020-2030) has been worked out based on the priority parameters set out as shown in **Figure 12.**

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

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

Figure 12: Priority Matrix

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

According to the investment prioritization matrix framework, the yearly investment plan along with the cost estimation is derived and is consolidated in **Table 18** 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 Trashigang Dzongkhag is Nu. 32.19 million.

Table 18: 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	Uprate 2x2.5 MVA Chenery SS to 2x5 MVA.	-	-	-	2.00	8.00	-	-	-	-	-	-	**10.00**
2	**MV Lines**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
2.1	11kV OH line extension to upper Melphay (0.2 km pprox.)	-	-	0.10	-	-	-	-	-	-	-	-	**0.10**
2.2	11 kV UG network to Ranjung Satellite town. (0.3 km pprox.)	-	-	0.40	-	-	-	-	-	-	-	-	**0.40**
2.3	Realignment of 1 km 11 kV Thrimshing feeder from Wonbugang village to Phekpari village	-	2.38	-	-	-	-	-	-	-	-	-	**2.38**
3	**Distribution Transformers**	-	-	-	-	-	-	-	-	-	-	-	**-**
3.1	Up-grade 16 kVA, 11/0.415kV transformer at K/Mani to 63 kVA.	-	-	-	-	-	0.30	-	-	-	-	-	**0.30**
3.2	Up-grade 250 kVA, 11/0.415kV transformer at upper Pam to 500 kVA.	-	-	-	0.70	-	-	-	-	-	-	-	**0.70**
3.3	Up-grade 125 kVA, 11/0.415kV transformer at Lengkhar to 500 kVA.	-	-	-	0.70	-	-	-	-	-	-	-	**0.70**
3.4	Up-grade 250 kVA, 11/0.415kV transformer at lower market to 500 kVA.	-	-	-	-	0.70	-	-	-	-	-	-	**0.70**
3.5	Up-grade 125 kVA, 11/0.415kV transformer at Phakpari to 315 kVA.	-	-	-	-	0.60	-	-	-	-	-	-	**0.60**

Sl.No.	Activities	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total (million)
3.6	Construction of 500 kVA, 11/0.415 transformer at Ranjung satellite town	-	-	0.70	-	-	0.27	-	-	-	-	-	**0.97**
3.7	Construction of 500 kVA, 11/0.415 transformer at upper Melphay	-	-	0.70	-	-	0.27	-	-	-	-	-	**0.97**
4	**Switching and Control**	-	-	-	-	-	-	-	-	-	-	-	**-**
4.1	33kV Control panel at Wamrong and Chenary	-	3.79	-	-	-	-	-	-	-	-	-	**3.79**
5	**Conversion**												**-**
5.1	Single Phase to Three Phase Line conversion	-	-	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	**1.30**
5.2	Single Phase Transformer to Three Phase conversion	-	-	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	**9.28**
	Total	**-**	**6.17**	**3.08**	**4.58**	**10.48**	**2.02**	**1.18**	**1.18**	**1.18**	**1.18**	**1.18**	**32.19**

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 study beyond 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	HV substation has adequate capacity to cater to the present and forecasted peak power demand.
2	MV Substations	Up-rating/construction of new 33/11 kV substation should be implemented as reflected in section 8.1.2.
B. MV and LV Lines		
1	MV Lines	The MV line plans as discussed in section 8.2 are recommended.
2	LV Lines	Assessment of LV infrastructure is not in the scope of this study. Actual requirements must be studied according to the prevailing circumstances and proposed separately.
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 the 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 and to procure the service plot.
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.

Sl. No.	Parameters	Recommendations
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.
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

Sl. No.	Parameters	Recommendations
		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 Trashigang 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

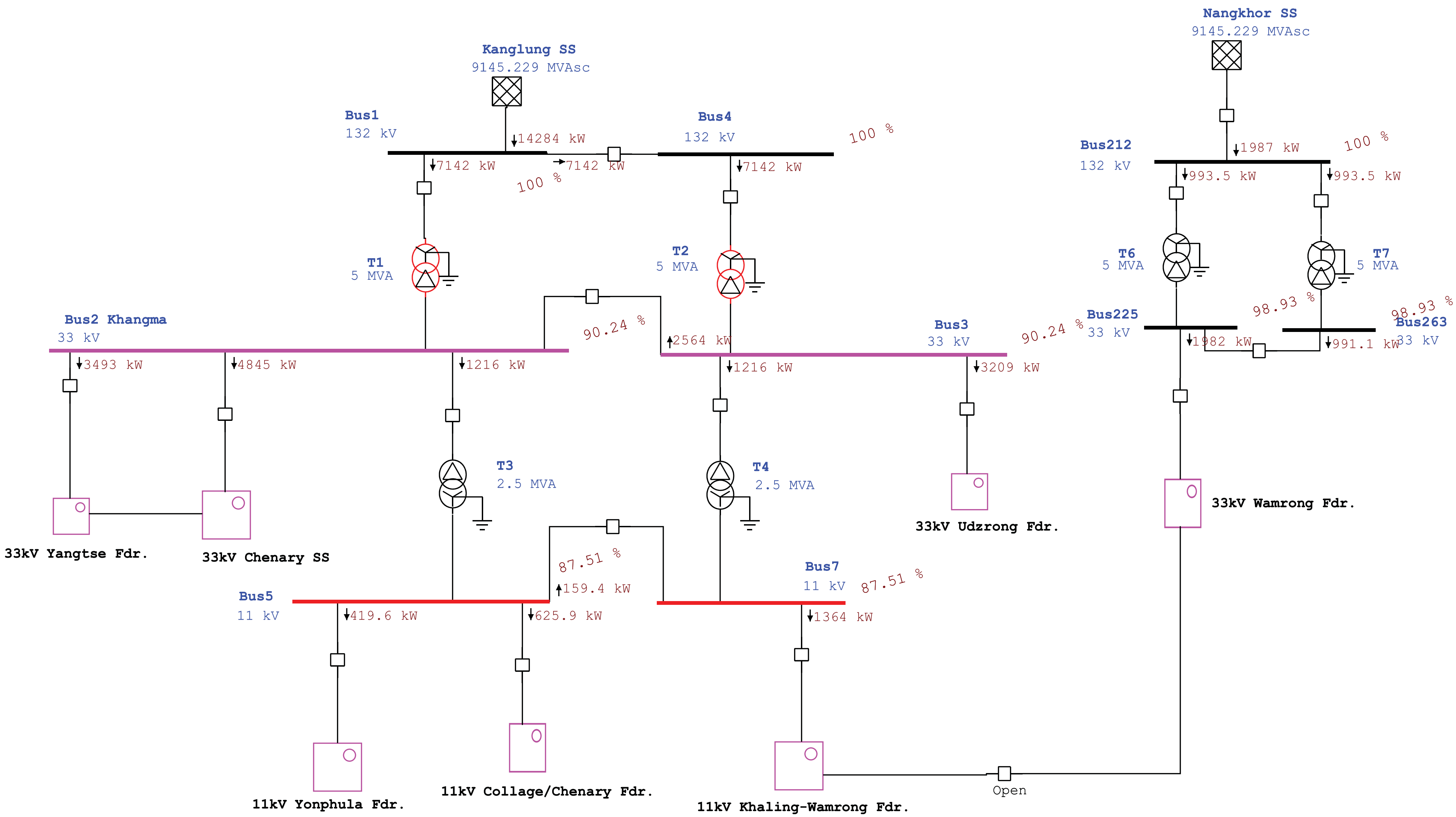
1. All the distribution network was considered as Balanced System (Restriction with the existing ETAP Key);
2. All DTs considered as lump load and depending upon the type of load connected to the feeder, a ratio of 80% (static load) to 20% (industrial feeders) were assumed;
3. The voltage level of ±10% 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.

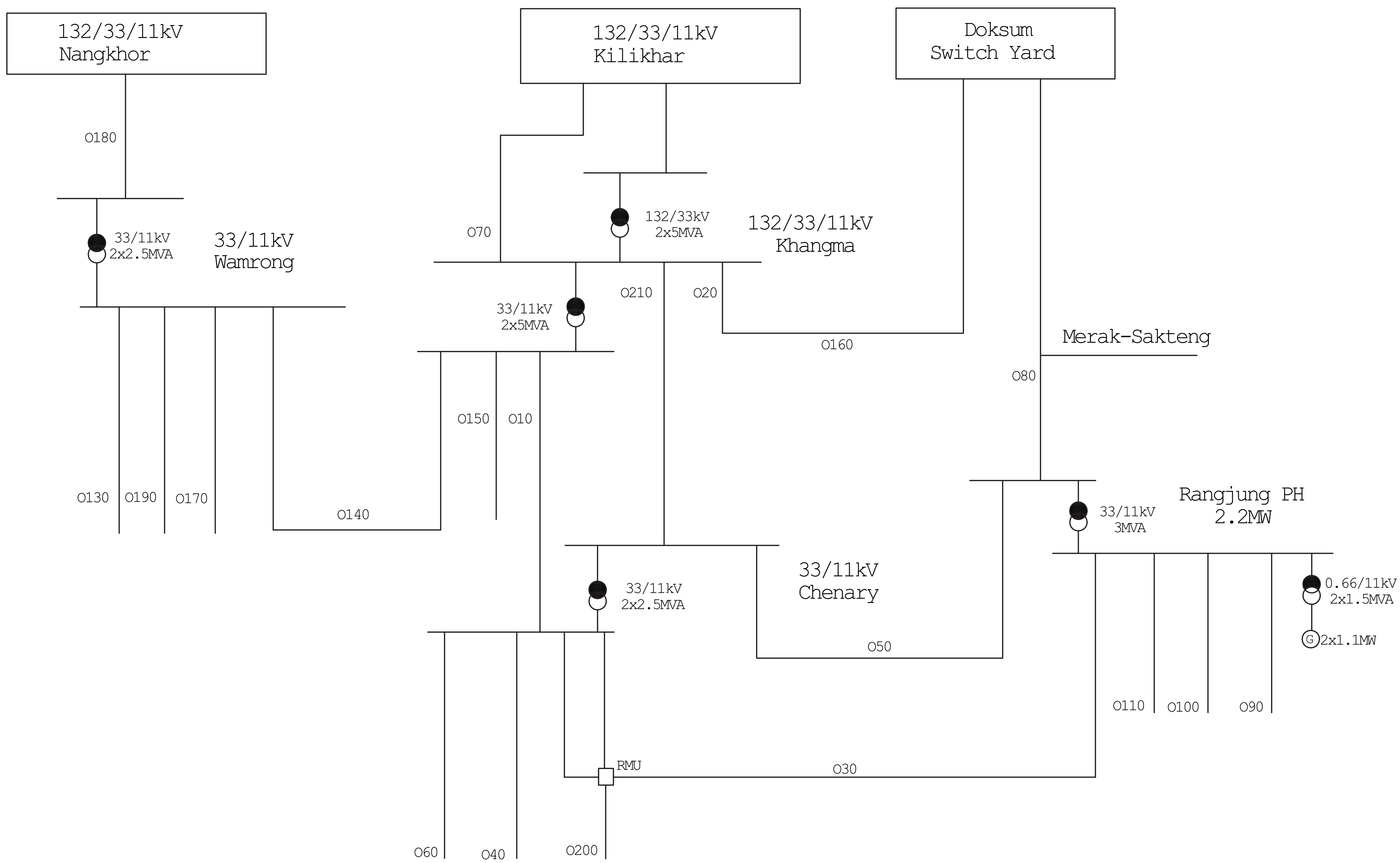
15. Challenges

Sl. No.	Parameters	Challenges	Opportunities/Proposals
1	Software Tool (ETAP)	a) Only one key & offline Key b) Balanced Load Flow c) Limitations of No. of buses (1000)	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.
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

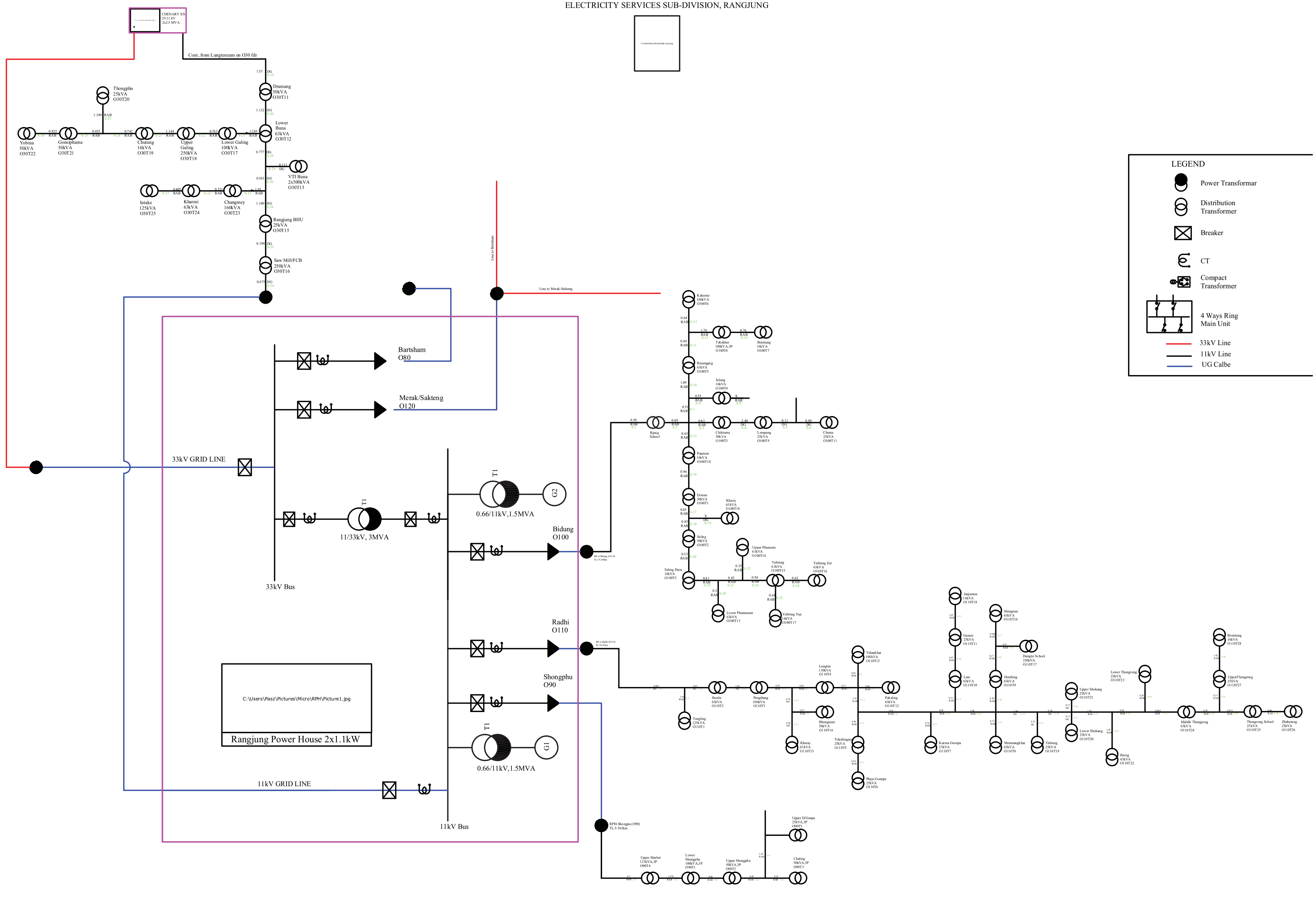
One-Line Diagram - ESD Tashigang Overall (Load Flow Analysis)

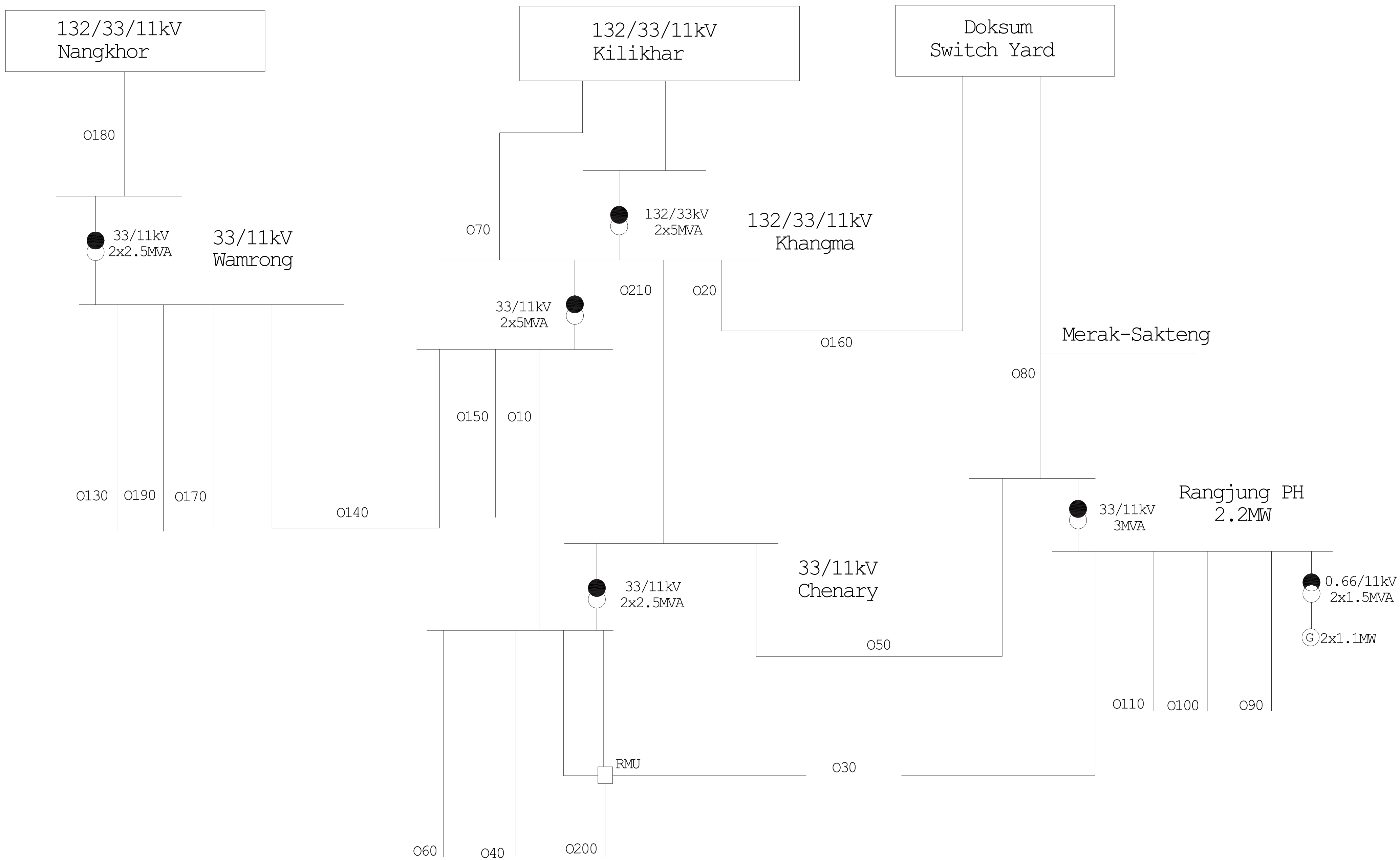



132/33/11kV
Nangkhor
132/33/11kV
Kilikhar
Doksum
Switch Yard
O180
O70
132/33kV
2x5MVA
132/33/11kV
Khangma
33/11kV
2x2.5MVA
33/11kV
Wamrong
O210
O20
33/11kV
2x5MVA
O160
Merak-Sakteng
O80
O150
O10
O130
O190
O170
O140
Rangjung PH
2.2MW
33/11kV
3MVA
33/11kV
Chenary
33/11kV
2x2.5MVA
0.66/11kV
2x1.5MVA
G
2x1.1MW
O50
O110
O100
O90
RMU
O30
O60
O40
O200

SINGLE LINE DIAGRAM FOR ELECTRIC DISTRIBUTION NETWORK

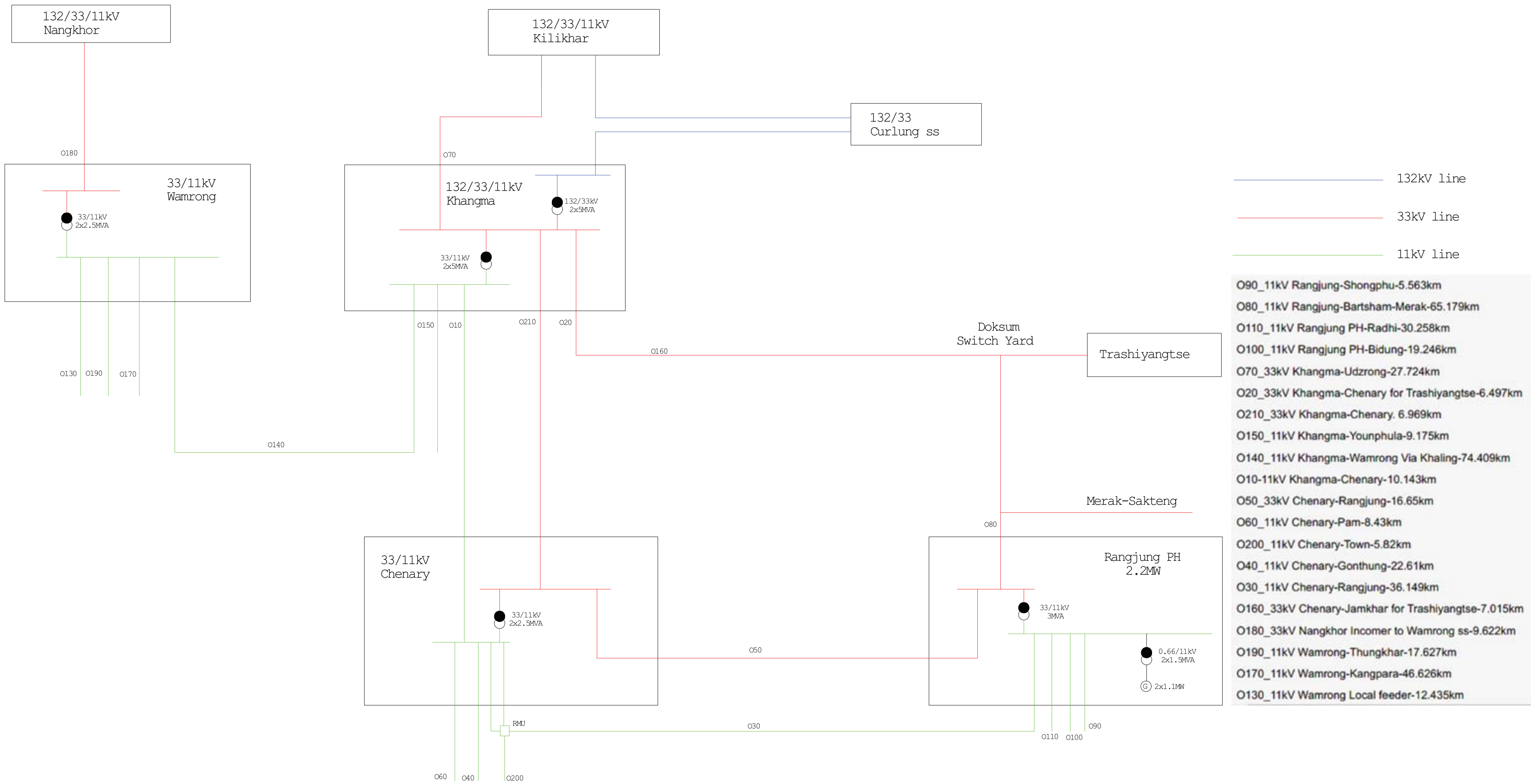
ELECTRICITY SERVICES SUB-DIVISION, RANGJUNG




132/33/11kV
Nangkhor
132/33/11kV
Kilikhar
Doksum
Switch Yard
O180
33/11kV
2x2.5MVA
33/11kV
Wamrong
O70
132/33kV
2x5MVA
132/33/11kV
Khangma
O210
O20
33/11kV
2x5MVA
O160
Merak-Sakteng
O80
O150
O10
O130
O190
O170
O140
33/11kV
3MVA
Rangjung PH
2.2MW
33/11kV
2x2.5MVA
33/11kV
Chenary
0.66/11kV
2x1.5MVA
G
2x1.1MW
O50
O110
O100
O90
RMU
O30
O60
O40
O200

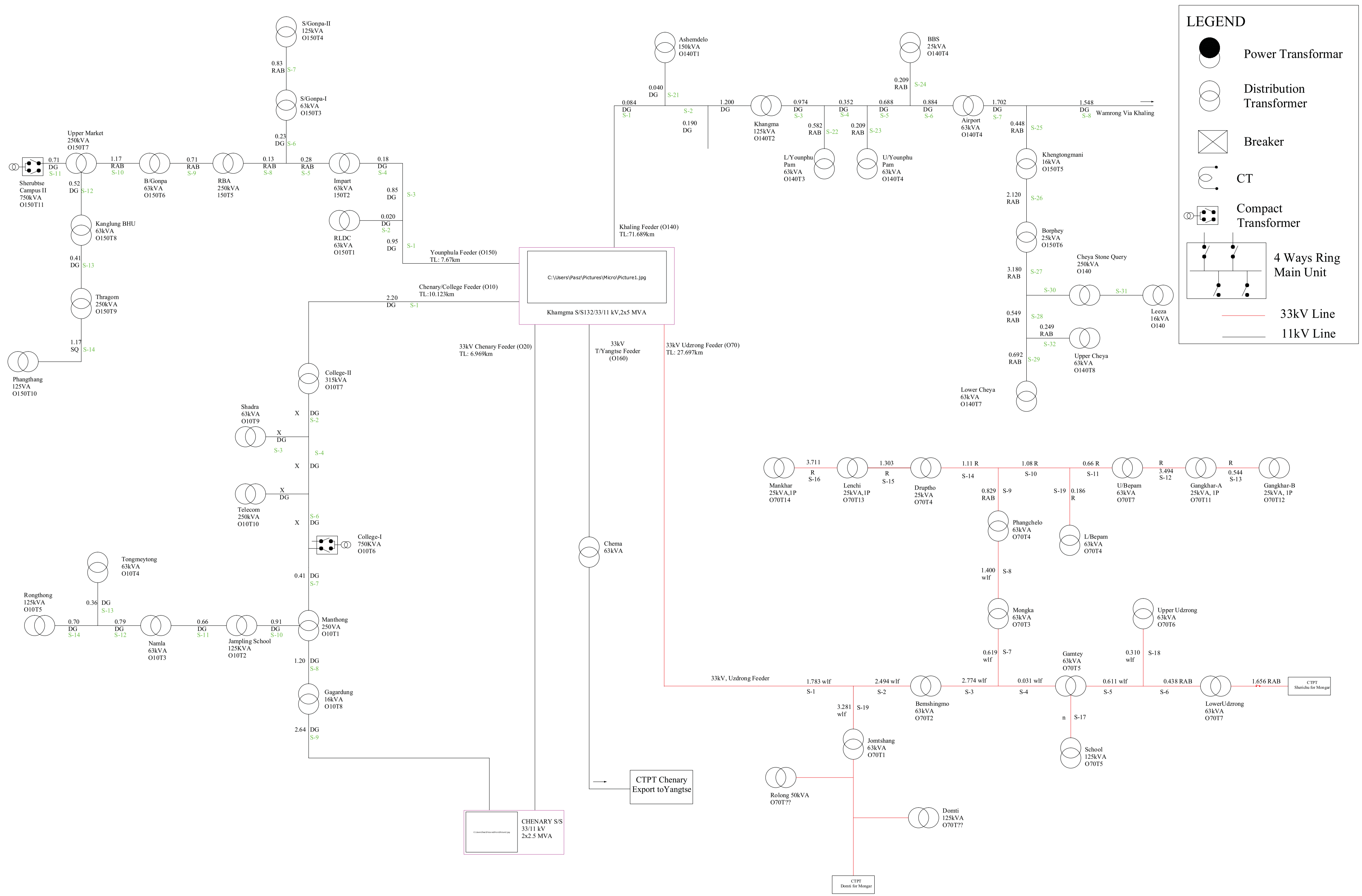
DISTRIBUTION NETWORK

ELECTRICITY SERVICES DIVISION, TRASHIGANG



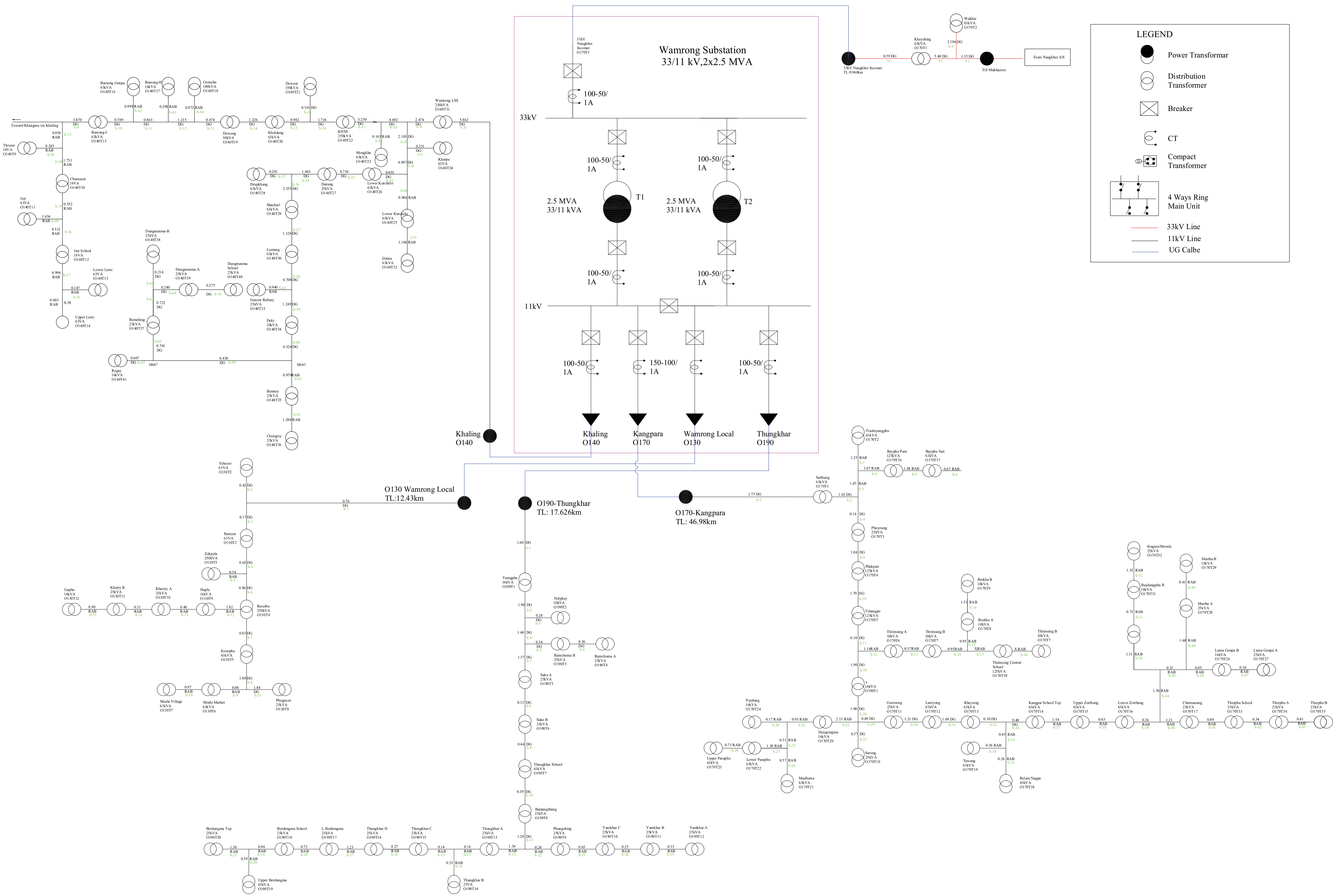
SINGLE LINE DIAGRAM FOR ELECTRIC DISTRIBUTION NETWORK

ELECTRICITY SERVICES SUB-DIVISION, KANGLUNG



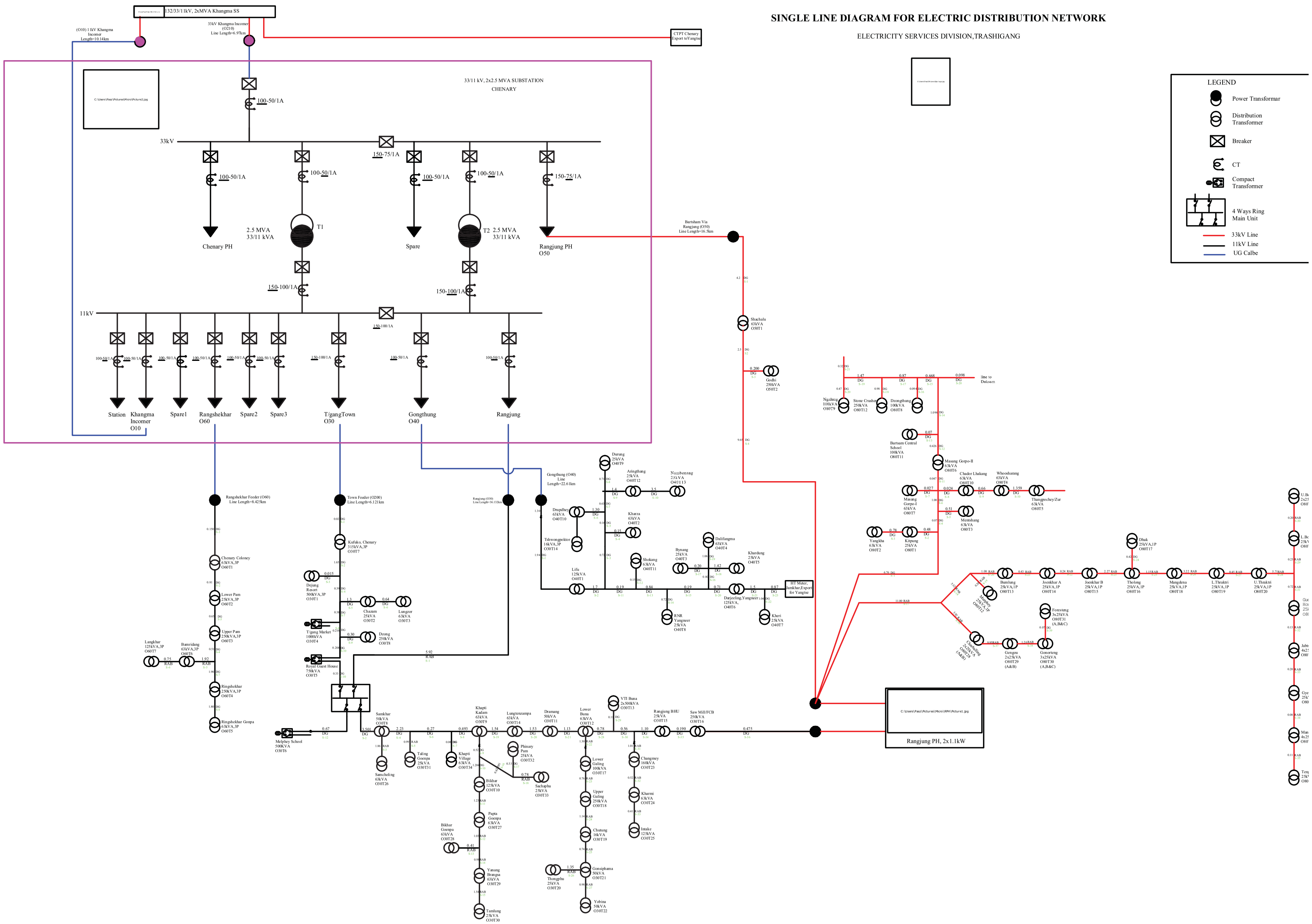
SINGLE LINE DIAGRAM FOR ELECTRIC DISTRIBUTION NETWORK

ELECTRICITY SERVICES SUB-DIVISION, WAMRONG



SINGLE LINE DIAGRAM FOR ELECTRIC DISTRIBUTION NETWORK

ELECTRICITY SERVICES DIVISION,TRASHIGANG



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.**

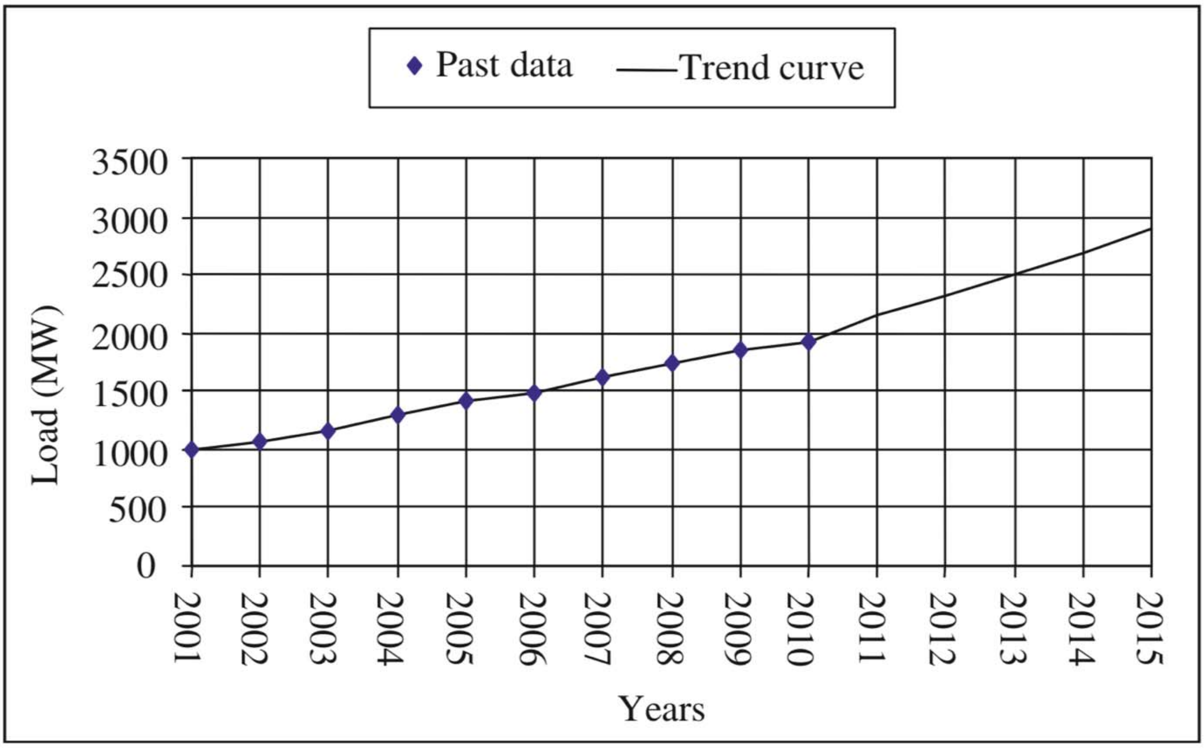


Figure 1: Typical trend curve[1]

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.

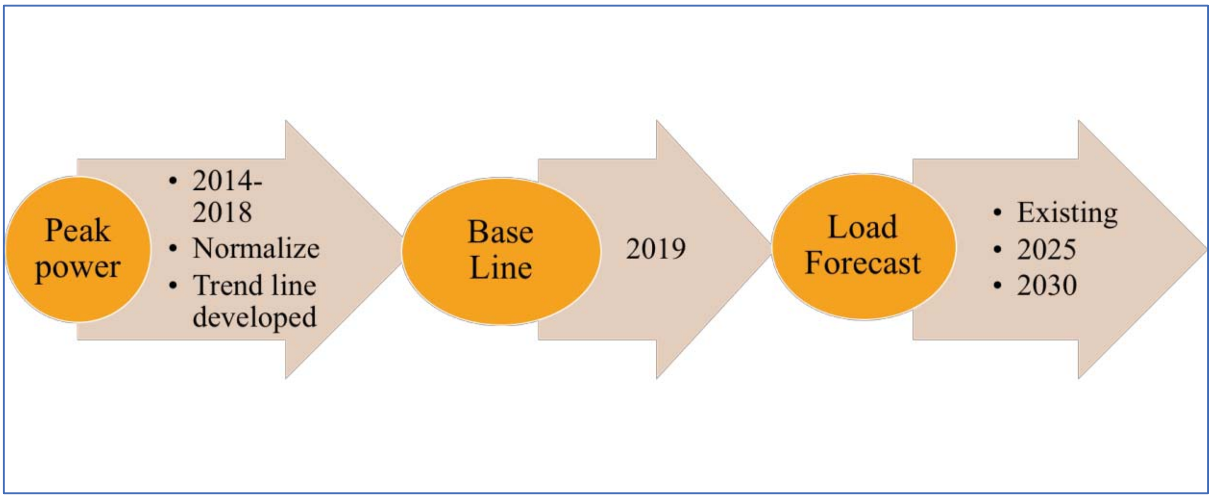


Figure 2: Flow diagram for load forecast

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**

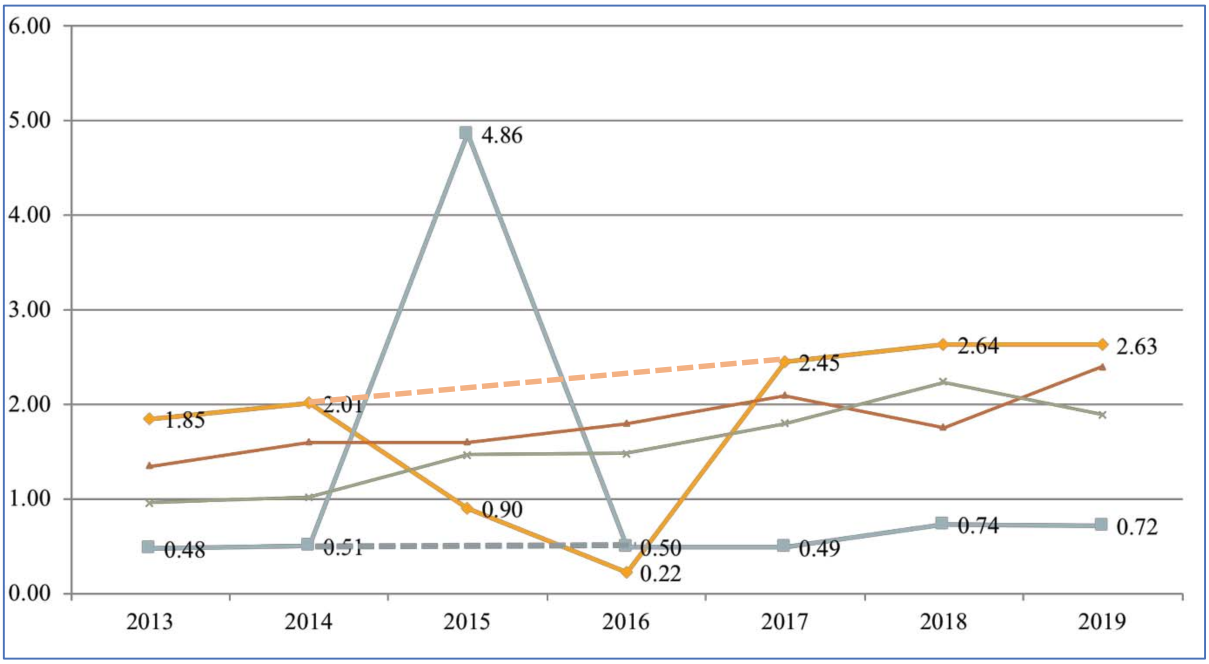


Figure 3: Actual data of Punakha Dzongkhag

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

$Where$:

$x\ is\ the\ normalized\ data$

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

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.**

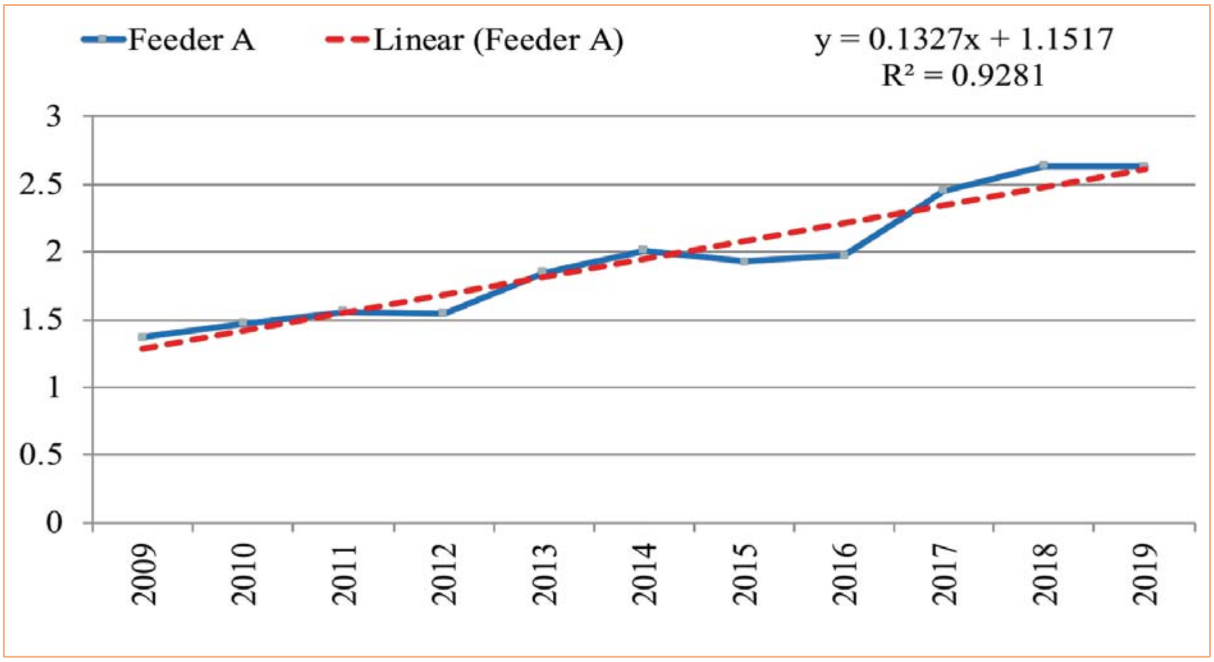


Figure 4: Trend line and load forecast for Punakha Dzongkhag

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.

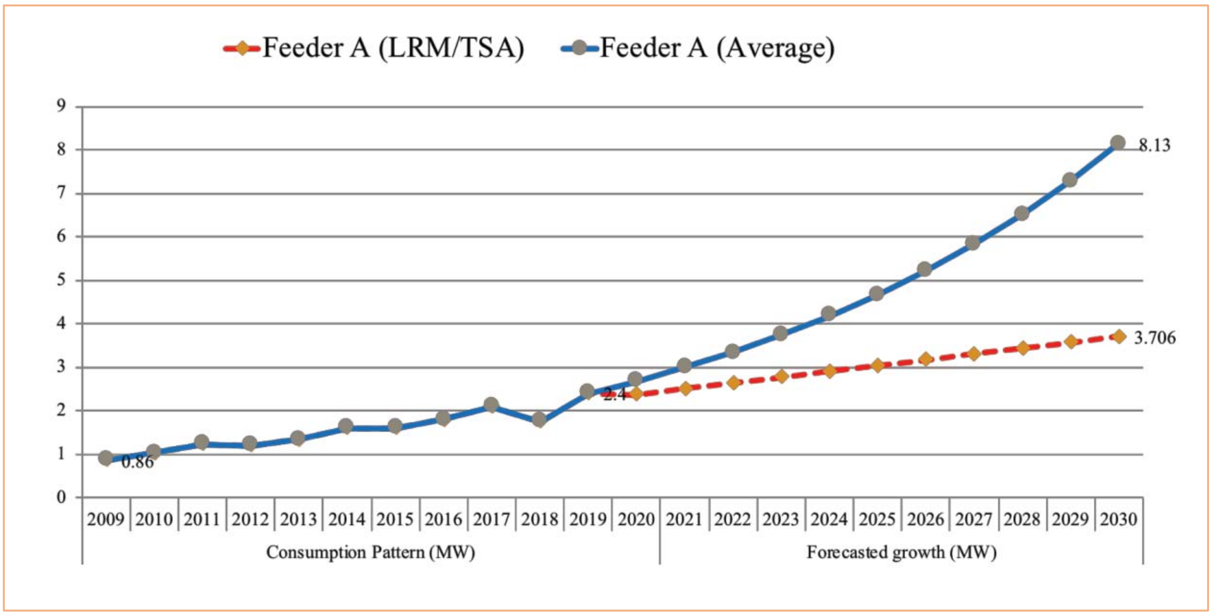


Figure 5: Forecasted load (trend line with red shows the linear regression and one with blue shows the forecast with average method)

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.

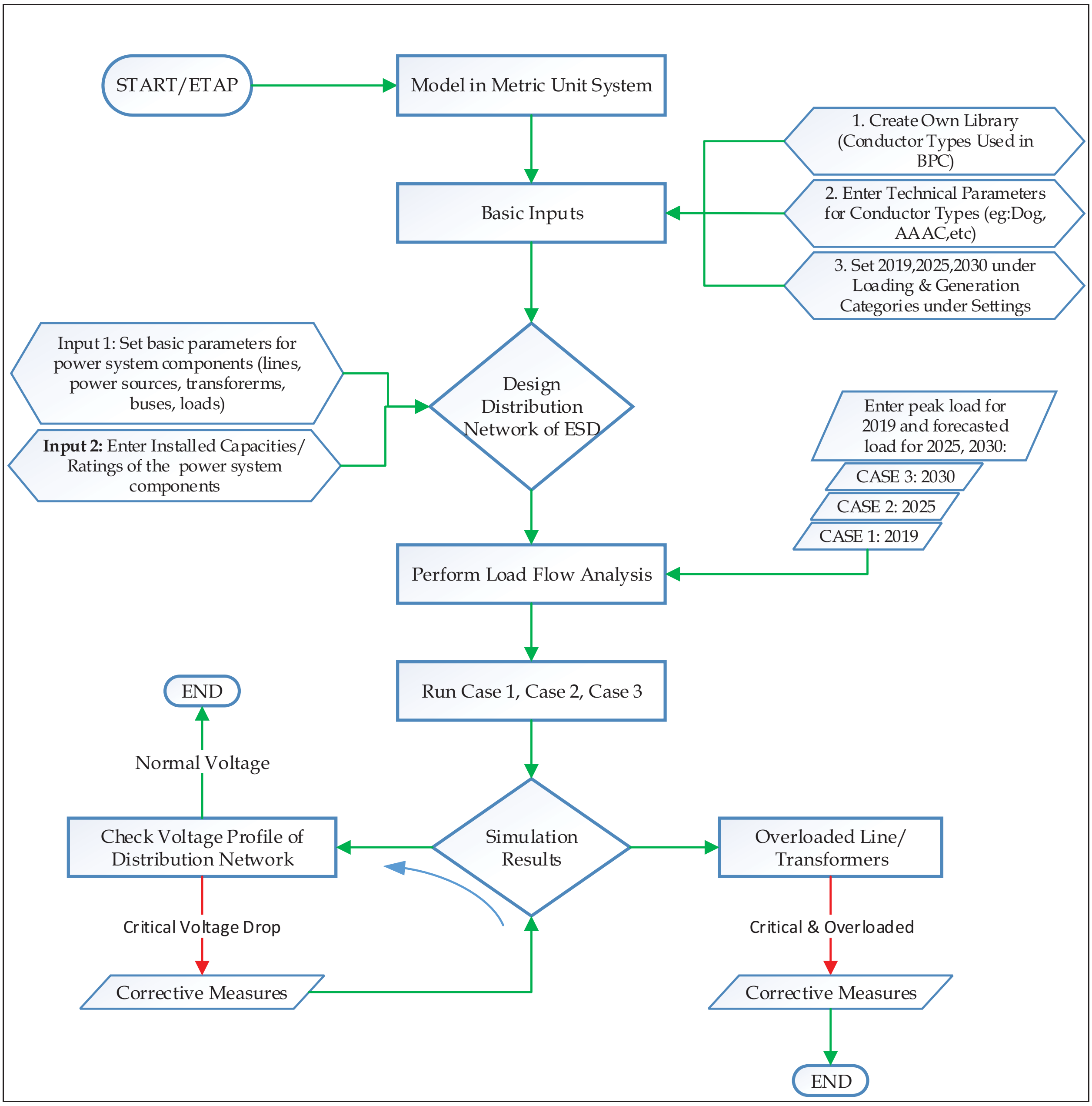


Figure 6: Flow Chart for Network Modelling & Load Flow Analysis (ETAP)

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

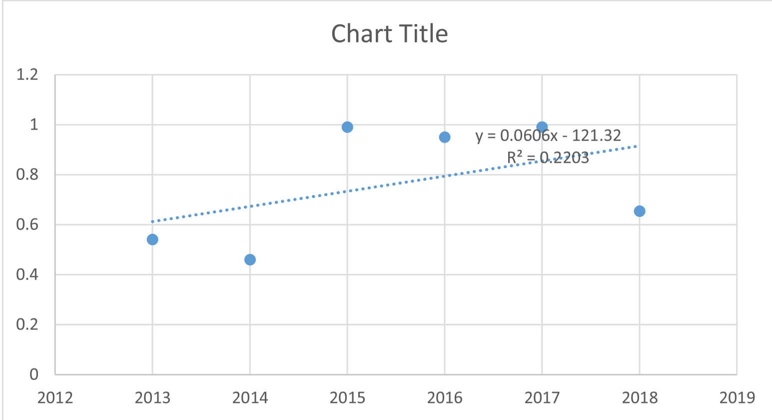
[2]http://sites.utexas.edu/sos/guided/inferential/numeric/bivariate/cor/: dated September 29, 2020

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

Feeder Name	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kanglung Substation											
132/33 Kilikhar Incomer											
11kV Khaling	2.01	2.35	2.69	3.03	3.37	3.72	4.06	4.40	4.74	5.08	5.42
11kV College	1.70	1.84	1.98	2.13	2.27	2.41	2.55	2.69	2.84	2.98	3.12
11kV Younphula	1.09	1.15	1.21	1.27	1.33	1.40	1.46	1.52	1.58	1.64	1.70
33kV Udzrong	2.17	2.34	2.51	2.67	2.84	3.01	3.17	3.34	3.51	3.67	3.84
33kV Chenary	4.61	4.95	5.29	5.63	5.97	6.32	6.66	7.00	7.34	7.68	8.02
Wamrong Substation											
Feeder sum Peak	11.59	12.64	13.69	14.74	15.79	16.84	17.89	18.94	20.00	21.05	22.10
33kV Nangkhor Incomer	1.30	1.39	1.47	1.56	1.65	1.73	1.82	1.91	2.00	2.08	2.17
11kV Kangpar	0.99	1.00	1.01	1.02	1.03	1.04	1.25	1.26	1.27	1.28	1.29
11kV Thungkhar	0.23	0.24	0.25	0.26	0.27	0.28	0.31	0.32	0.33	0.34	0.35
11kV Wamrong Local	0.35	0.36	0.37	0.38	0.39	0.40	0.45	0.46	0.47	0.48	0.49
Chenary Substation											
11kV Town	2.91	2.92	2.93	2.94	2.95	2.96	3.16	3.17	3.18	3.19	3.20
11kV Pam	0.71	0.72	0.73	0.74	0.75	0.76	0.78	0.79	0.80	0.81	0.82
11kV Gongthung	0.34	0.35	0.36	0.37	0.38	0.39	0.46	0.47	0.48	0.49	0.50
11kV Rangjung	1.36	1.37	1.38	1.39	1.40	1.41	1.75	1.76	1.77	1.78	1.79
33kV Rangjung-Bartsham	1.30	1.31	1.32	1.33	1.34	1.35	1.67	1.68	1.69	1.70	1.71
Rangjung Power House											
11kV Bidung	0.47	0.48	0.49	0.50	0.51	0.52	0.54	0.55	0.56	0.57	0.58
11kV Radhi	0.73	0.74	0.75	0.76	0.77	0.78	0.11	0.12	0.13	0.14	0.15
11kV Songphu	0.48	0.49	0.50	0.51	0.52	0.53	0.69	0.70	0.71	0.72	0.73

11 kV Yonphula Feeder

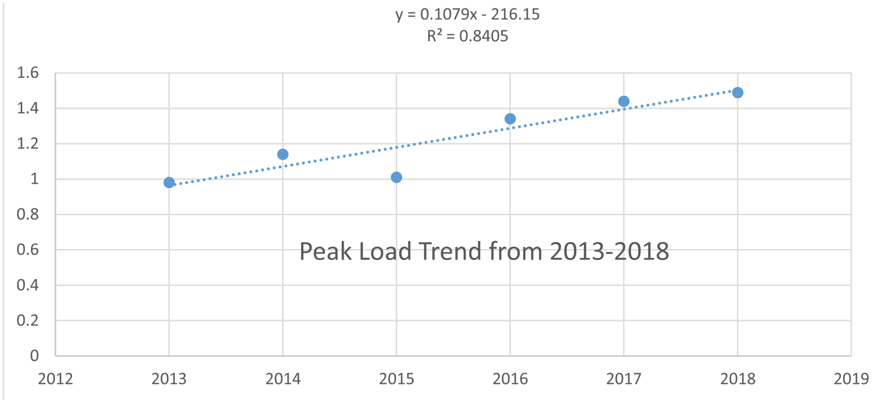
month	2013	2014	2015	2016	2017	2018	2019
Jan	0.54	0.23	0.28	0.39	0.38	0.42	0.50
Feb	0.36	0.36	0.34	0.63	0.62	0.65	0.72
Mar	0.32	0.34	0.32	0.47	0.68	0.60	0.63
Apr	0.36	0.26	0.46	0.56	0.53	0.56	0.76
May	0.32	0.26	0.99	0.46	0.43	0.48	0.52
Jun	0.24	0.24	0.99	0.42	0.40	0.47	0.479
Jul	0.28	0.24	0.48	0.38	0.33	0.40	0.429
Aug	0.24	0.26	0.41	0.38	0.99	0.44	
Sep	0.32	0.28	0.42	0.40	0.44	0.50	
Oct	0.38	0.34	0.44	0.40	0.74	0.65	
Nov	0.42	0.34	0.50	0.95	0.56	0.59	
Dec	0.39	0.46	0.48	0.51	0.49	0.57	
Peak Load	0.54	0.46	0.99	0.95	0.99	0.65	0.76



	DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equation y = 0.0465x - 93.397											
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.54	0.46	0.99	0.95	0.99	0.654	1.031	1.092	1.153	1.213	1.274	1.334	1.395	1.456	1.516	1.577	1.637	1.698
Load Growth in kW							0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	0.0606	

Ratio 0.35 0.65

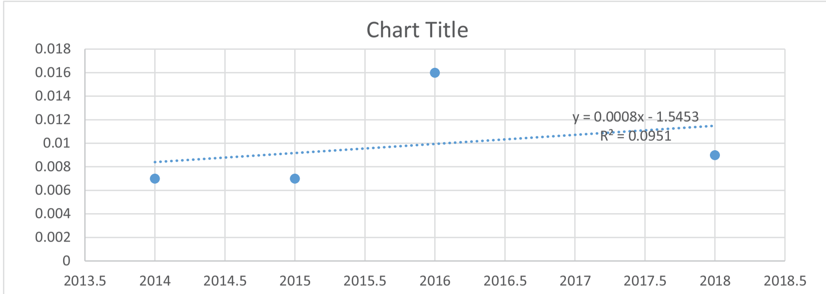
month	2013	2014	2015	2016	2017	2018	2019
Jan	0.86	0.66	0.72	0.84	0.54	1.40	2.18
Feb	0.98	1.14	0.98	0.90	0.49	1.48	2.01
Mar	0.89	0.61	0.84	1.02	1.25	1.49	3.54
Apr	0.98	0.61	0.60	0.87	0.85	1.46	1.69
May	0.93	0.64	0.96	0.46	0.45	0.79	2.09
Jun	0.87	0.69	0.52	0.54	0.49	0.73	0.680
Jul	0.87	0.71	0.98	1.28	1.12	0.70	0.670
Aug	0.67	0.82	0.74	1.28	1.24	0.79	
Sep	0.69	0.79	0.99	0.62	0.56	0.76	
Oct	0.97	0.80	1.01	1.34	0.56	0.62	
Nov	0.71	0.79	0.90	0.61	0.65	0.94	
Dec	0.70	0.75	0.87	0.63	1.44	0.98	
Peak Load	0.98	1.14	1.01	1.34	1.44	1.49	3.54



	DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equation(y = 0.1667x - 334.56)											
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.98	1.14	1.01	1.34	1.44	1.49	2.0073	2.174	2.3407	2.5074	2.6741	2.8408	3.0075	3.1742	3.3409	3.5076	3.6743	3.841
Load Growth in kW							0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	

11 kV Station Feeder

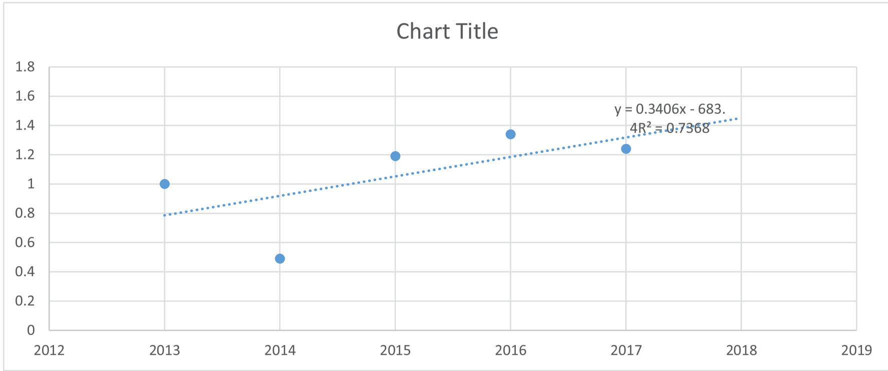
	2013	2014	2015	2016	2017	2018	2019
Jan			0.006	0.005	0.008	0.01	0.046
Feb			0.007	0.005	0.009	0.01	0.090
Mar			0.006	0.006	0.006	0.01	0.040
Apr			0.006	0.005	0.006	0.01	0.050
May			0.006	0.005	0.114	0.01	0.006
Jun			0.005	0.005	0.014	0.01	0.005
Jul		0.004	0.006	0.005	0.005	0.01	0.006
Aug		0.004	0.005	0.006	0.005	0.01	
Sep		0.005	0.005	0.016	0.005	0.01	
Oct		0.004	0.005	0.006	0.007	0.01	
Nov		0.004	0.005	0.003	0.007	0.006	
Dec		0.007	0.005	0.005	0.006	0.007	
Peak Loac	-	0.01	0.01	0.02	0.11	0.01	0.09



	DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equation (y = 0.0008x - 1.5453)											
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load		0.007	0.007	0.016		0.01	0.070	0.071	0.072	0.072	0.073	0.074	0.075	0.076	0.076	0.077	0.078	0.079
Load Growth in kW							0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	

11 kV Khaling Feeder

month	2012	2013	2014	2015	2016	2017	2018	2019
Jan	0.51	1.00	0.49	0.28	0.67	0.89	1.29	1.23
Feb	0.64	0.66	0.24	0.46	0.73	1.06	1.02	1.13
Mar	0.56	0.49	0.28	0.48	1.33	1.24	1.42	1.15
Apr	0.73	0.69	0.24	1.05	0.60	0.64	1.10	1.33
May	0.49	0.42	0.40	0.97	1.13	1.14	1.51	1.20
Jun	0.45	0.44	0.34	0.81	1.01	1.12	1.09	1.250
Jul	0.58	0.66	0.40	0.98	1.01	1.03	1.07	1.190
Aug	1.62	0.64	0.44	1.05	1.30	1.16	3.68	
Sep	0.70	0.42	0.40	1.19	1.11	1.13	1.25	
Oct	0.74	0.52	0.28	0.68	0.62	0.99	1.35	
Nov		0.51	0.28	0.67	0.73	0.67	1.30	
Dec		0.52	0.46	0.69	1.34	1.16	0.76	
Peak Load	1.62	1	0.49	1.19	1.34	1.24	3.68	1.334

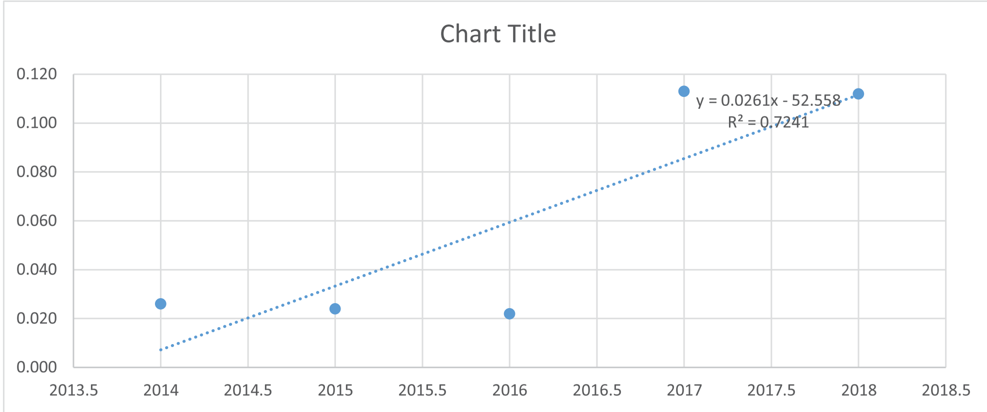


		DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equation (y = 0.3406x - 683.4)											
Year		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.62	1	0.49	1.19	1.34	1.24		1.671	2.012	2.353	2.693	3.034	3.374	3.715	4.056	4.396	4.737	5.077	5.418
Load Growth in kW								0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	

Ratio 1.22 2.24

11 kV Colony Feeder

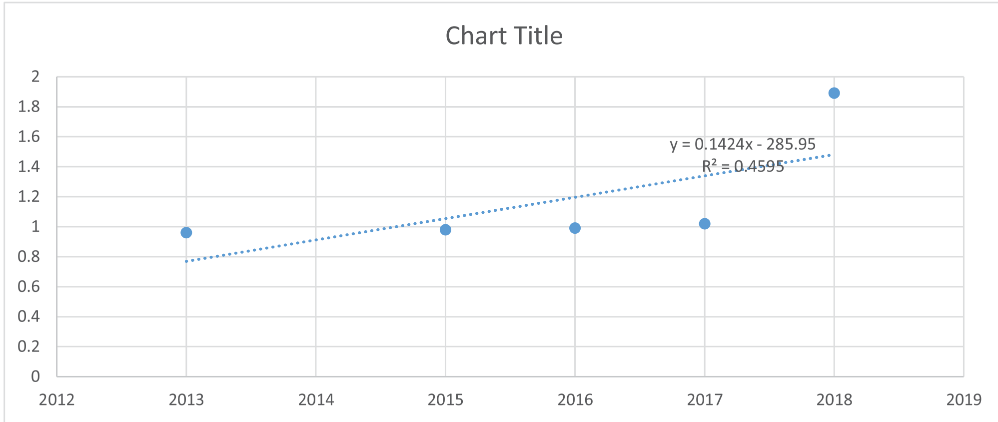
month	2013	2,014.00	2015	2016	2017	2018	2019
Jan			0.021	0.013	0.113	0.02	0.046
Feb			0.024	0.015	0.017	0.02	0.090
Mar			0.018	0.015	0.017	0.11	0.040
Apr			0.016	0.015	0.018	0.02	0.050
May			0.014	0.012	0.090	0.01	0.006
Jun			0.014	0.012	0.015	0.01	0.005
Jul		0.01	0.014	0.014	0.012	0.01	0.006
Aug		0.01	0.013	0.009	0.012	0.01	
Sep		0.01	0.014	0.009	0.012	0.02	
Oct		0.015	0.013	0.011	0.013	0.01	
Nov		0.018	0.015	0.017	0.100	0.021	
Dec		0.026	0.016	0.022	0.016	0.015	
Peak Load	0.000	0.026	0.024	0.022	0.113	0.112	0.090



	DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equationy = 0.0261x - 52.558											
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0	0.026	0.024	0.022	0.113	0.112	0.138	0.164	0.190	0.216	0.242	0.268	0.295	0.321	0.347	0.373	0.399	0.425
Load Growth in kW							0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	

11 kV College Feeder

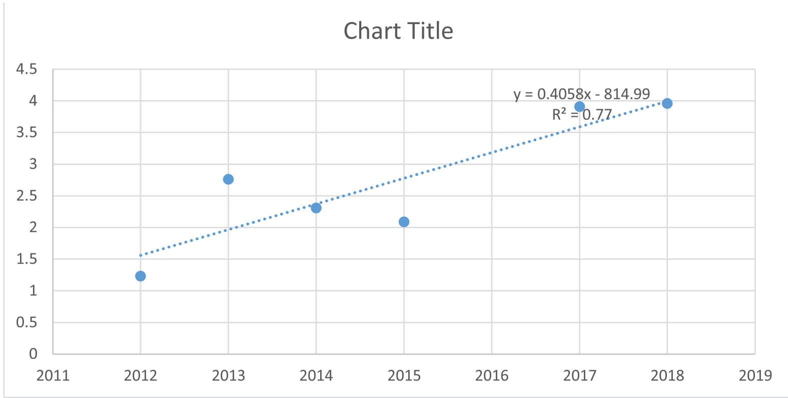
month	2013	2014	2015	2016	2017	2018	2019
Jan	0.33	0.32	0.26	0.42	0.45	0.85	0.44
Feb	0.46	0.46	0.44	0.57	0.52	0.86	0.70
Mar	0.96	0.58	0.42	0.48	0.60	0.65	0.63
Apr	0.40	0.36	0.47	0.46	0.50	0.52	0.56
May	0.88	0.34	0.37	0.49	0.48	0.47	1.40
Jun	0.36	0.30	0.98	0.39	0.96	0.91	0.482
Jul	0.36	0.34	0.34	0.38	0.88	1.89	0.434
Aug	0.36	0.46	0.38	0.99	1.02	0.46	
Sep	0.35	0.36	0.46	0.54	0.44	0.72	
Oct	0.38	0.36	0.56	0.43	0.51	0.58	
Nov	0.53	0.44	0.51	0.62	0.59	0.87	
Dec	0.46	0.52	0.50	0.57	0.59	0.63	
Peak Load	0.96	0.58	0.98	0.99	1.02	1.89	1.40



	DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equationy = 0.1424x - 285.95											
Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	0.96		0.98	0.99	1.02	1.89	1.556	1.698	1.840	1.983	2.125	2.268	2.410	2.552	2.695	2.837	2.980	3.122
Load Growth in kW							0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	0.1424	

Ratio 0.55 1.01

	2012	2013	2014	2015	2016	2017	2018	2019
Jan	0.12	1.86	1.98	1.39	1.90	2.54	2.30	2.67
Feb	0.12	2.12	2.29	1.42	1.94	2.38	2.00	2.161
Mar	0.110	1.28	2.31	1.43	1.64	2.38	2.43	2.32
Apr	0.100	2.28	1.55	1.37	1.89	2.80	2.44	2.193
May	0.001	1.93	2.24	1.33	1.82	2.13	2.12	1.986
Jun	0.003	2.13	1.75	1.62	1.92	2.03	2.21	2.823
Jul	0.35	2.44	1.72	1.92	2.09	2.14	3.96	3.380
Aug	0.490	2.1	1.83	2.09	4.00	2.06	2.24	
Sep	0.580	2.19	1.62	1.48	3.90	2.62	2.37	
Oct	1.230	2.30	1.88	1.40	4.02	3.91	1.85	
Nov		2.76	1.27	1.37	4.03	2.23	1.87	
Dec		2.54	2.25	1.92	2.38	2.56	2.817	
Peak Load	1.23	2.76	2.31	2.09	4.03	3.91	3.96	3.38



		DATA FOR ANALYSIS						Forecasted Peak Load Year Wise from 2019-2030 with derived equation (y = 0.3406x - 683.4)											
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Load	1.23	2.76	2.31	2.09		3.91	3.96	4.2714	4.612	4.9526	5.2932	5.6338	5.9744	6.315	6.6556	6.9962	7.3368	7.6774	8.018
Load Growth in kW								0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	0.3406	

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
Bus376	132.000													
Bus1	132.000										19.123	74.7	83.6	
Bus2 Khangma	33.000										12.075	79.1	234.1	
Bus3	33.000										8.628	81.0	167.3	
Bus4	132.000										9.561	74.7	41.8	
Bus5	11.000										1.419	84.9	85.1	
Bus6	11.000		0.007	0.004	0.020	0.012					0.031	85.0	1.9	
Bus7	11.000										1.610	84.7	96.5	
Bus8	11.000		0.009	0.005	0.027	0.017					0.491	85.2	29.6	
Bus9	11.000		0.006	0.004	0.017	0.011					0.448	85.2	27.0	
Bus10	11.000										0.421	85.2	25.4	
Bus11	11.000		0.015	0.009	0.045	0.028					0.729	85.1	44.1	
Bus12	11.000		0.006	0.003	0.017	0.010					0.356	85.2	21.5	
Bus13	11.000		0.007	0.004	0.021	0.013					0.421	85.2	25.4	
Bus14	11.000		0.009	0.006	0.028	0.017					0.330	85.2	20.0	
Bus15	33.000		0.723	0.448	2.312	1.433					3.570	85.0	69.9	
Bus16	11.000										0.658	85.1	39.9	
Bus17	11.000		0.027	0.017	0.081	0.050					0.285	85.1	17.3	
Bus18	11.000		0.013	0.008	0.038	0.024					0.060	85.0	3.6	
Bus19	11.000		0.001	0.001	0.004	0.003					0.098	85.2	5.9	
Bus20	11.000		0.008	0.005	0.024	0.015					0.038	85.0	2.3	
Bus21	11.000		0.011	0.007	0.034	0.021					0.091	85.2	5.6	
Bus22	11.000										0.644	85.2	39.0	
Bus23	11.000		0.007	0.004	0.017	0.011					1.037	85.0	66.9	
Bus24	11.000		0.003	0.002	0.009	0.006					0.014	85.0	0.9	
Bus25	11.000		0.016	0.010	0.049	0.030					0.076	85.0	4.6	
Bus26	33.000		0.003	0.002	0.009	0.006					0.119	98.2	2.3	
Bus27	11.000		0.051	0.032	0.153	0.095					0.568	85.2	34.4	
Bus28	11.000		0.005	0.003	0.015	0.009					0.140	85.2	8.5	
Bus29	11.000		0.040	0.024	0.118	0.073					0.328	85.3	19.9	
Bus30	11.000										1.004	85.1	65.1	
Bus31	11.000		0.003	0.002	0.009	0.006					0.116	85.2	7.1	
Bus32	11.000		0.012	0.007	0.031	0.019					0.050	85.0	3.2	
Bus33	11.000										0.102	85.1	6.2	
Bus34	11.000		0.014	0.009	0.043	0.026					0.067	85.0	4.1	
Bus35	11.000		0.008	0.005	0.023	0.014					0.036	85.0	2.2	
Bus36	11.000		0.052	0.032	0.116	0.072					0.198	85.0	13.9	
Bus36 Chenary SS	33.000										6.373	73.9	127.1	
Bus37	11.000		0.000	0.000	0.001	0.001					0.002	85.0	0.1	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus38	11.000										1.608	84.8	96.5	
Bus39	11.000		0.031	0.019	0.095	0.059					0.149	85.0	8.9	
Bus40	11.000		0.013	0.008	0.039	0.024					1.445	84.8	87.6	
Bus41	11.000		0.004	0.003	0.013	0.008					0.021	85.0	1.3	
Bus42	11.000										1.374	84.9	84.0	
Bus43	11.000										0.949	85.1	61.9	
Bus44	11.000										1.349	84.9	82.7	
Bus45	11.000		0.006	0.003	0.016	0.010					0.026	85.0	1.6	
Bus46	11.000		0.001	0.000	0.001	0.001					0.002	85.0	0.1	
Bus47	11.000										1.316	84.9	81.1	
Bus48	11.000		0.000	0.000	0.001	0.001					0.002	85.0	0.1	
Bus49	33.000		0.005	0.003	0.017	0.011					0.116	90.9	2.2	
Bus50	11.000		0.002	0.001	0.006	0.004					1.305	85.0	81.0	
Bus51	11.000		0.003	0.002	0.010	0.006					0.074	86.7	4.6	
Bus52	11.000										0.942	85.1	61.7	
Bus53	11.000		0.001	0.001	0.004	0.002					0.059	86.7	3.6	
Bus54	11.000										0.053	86.2	3.3	
Bus55	11.000		0.019	0.012	0.048	0.030					0.079	85.0	5.2	
Bus56	11.000		0.000	0.000	0.001	-					0.005	92.0	0.3	
Bus57	11.000		0.001	0.001	0.003	0.002					0.004	85.0	0.3	
Bus58	11.000										2.681	77.8	172.4	
Bus58 at Chenary	33.000										4.075	84.9	80.0	
Bus59	11.000										0.049	85.2	3.0	
Bus60	11.000		0.006	0.003	0.016	0.010					0.025	85.0	1.6	
Bus61	11.000		0.005	0.003	0.015	0.009					0.024	85.0	1.5	
Bus62	11.000		0.009	0.006	0.024	0.015					0.860	85.2	56.6	
Bus63	11.000										1.208	84.9	75.9	
Bus64	33.000		0.009	0.006	0.029	0.018					0.073	86.9	1.4	
Bus65	11.000										0.143	85.5	9.0	
Bus66	11.000		0.001	0.001	0.003	0.002					0.005	85.0	0.3	
Bus67	11.000		0.010	0.006	0.024	0.015					0.816	85.2	54.0	
Bus68	11.000		0.001	0.001	0.002	0.001					0.138	85.4	8.7	
Bus69	33.000		0.005	0.003	0.017	0.011					0.026	85.0	0.5	
Bus70	11.000										0.135	85.3	8.5	
Bus71	11.000		0.008	0.005	0.022	0.013					0.035	85.0	2.2	
Bus72	11.000		0.013	0.008	0.034	0.021					0.060	85.2	3.9	
Bus73	11.000		0.002	0.001	0.005	0.003					0.100	85.2	6.3	
Bus74	33.000										0.003	95.8	0.1	
Bus75	11.000										0.093	85.1	5.9	
Bus76	11.000		0.011	0.007	0.030	0.019					0.049	85.0	3.1	
Bus77	11.000		0.010	0.006	0.027	0.017					0.044	85.0	2.8	
Bus78	11.000										0.772	85.2	51.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus79	11.000		0.024	0.015	0.060	0.037					0.098	85.0	6.5	
Bus80	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus81	11.000		0.040	0.024	0.097	0.060					0.669	85.3	44.9	
Bus82	11.000		0.007	0.005	0.018	0.011					0.029	85.0	2.0	
Bus83	11.000										0.503	85.5	34.1	
Bus84	33.000		0.000	0.000	0.000	-					0.000	85.0	-	
Bus85	11.000										0.466	85.5	32.2	
Bus86	11.000										2.723	64.7	175.1	
Bus87	11.000		0.036	0.022	0.082	0.051					0.139	85.0	9.6	
Bus88	33.000		0.001	0.001	0.003	0.002					0.029	62.9	0.6	
Bus89	11.000										0.327	85.5	22.7	
Bus90	11.000		0.009	0.006	0.021	0.013					0.036	85.0	2.5	
Bus91	11.000		0.007	0.004	0.017	0.011					0.599	85.1	38.5	
Bus92	11.000										0.290	85.5	20.2	
Bus93	33.000										0.025	57.3	0.5	
Bus94	11.000		0.010	0.006	0.024	0.015					0.060	85.2	4.2	
Bus95	11.000		0.005	0.003	0.012	0.007					0.020	85.0	1.4	
Bus96	11.000		0.001	0.001	0.003	0.002					0.004	85.0	0.3	
Bus97	11.000		0.009	0.005	0.020	0.012					0.230	85.6	16.0	
Bus98	33.000		0.001	0.000	0.002	0.001					0.025	58.0	0.5	
Bus99	11.000		0.002	0.001	0.004	0.002					0.197	85.7	13.7	
Bus100	11.000		0.001	0.001	0.004	0.002					0.569	85.1	36.7	
Bus101	33.000		0.000	0.000	0.001	-					0.009	27.2	0.2	
Bus102	11.000										0.190	85.6	13.3	
Bus103	11.000		0.011	0.007	0.024	0.015					0.041	85.0	2.8	
Bus104	11.000		0.055	0.034	0.146	0.090					0.562	85.1	36.3	
Bus105	11.000		0.004	0.003	0.010	0.006					0.149	85.6	10.5	
Bus106	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus107	11.000		0.008	0.005	0.017	0.011					0.132	85.6	9.3	
Bus108	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus109	11.000										0.103	85.7	7.2	
Bus110	11.000		0.003	0.002	0.007	0.004					0.012	85.0	0.8	
Bus111	11.000		0.004	0.003	0.008	0.005					1.766	42.4	130.0	
Bus112	11.000		0.001	0.000	0.001	0.001					0.091	85.6	6.4	
Bus113	33.000		0.001	0.001	0.003	0.002					0.011	62.6	0.2	
Bus114	11.000										0.089	85.6	6.3	
Bus115	11.000										0.018	88.5	1.1	
Bus116	11.000		0.003	0.002	0.007	0.004					0.023	85.5	1.6	
Bus117	33.000		0.000	0.000	0.002	0.001					0.004	94.1	0.1	
Bus118	11.000		0.003	0.002	0.007	0.004					0.011	85.0	0.8	
Bus119	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus120	11.000										0.067	85.4	4.7	

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
Bus121	11.000		0.003	0.002	0.006	0.004					0.011	85.0	0.7	
Bus122	11.000										0.325	85.2	21.1	
Bus123	11.000		0.002	0.001	0.005	0.003					0.056	85.3	4.0	
Bus124	11.000		0.003	0.002	0.007	0.004					0.012	85.0	0.8	
Bus125	11.000										0.048	85.1	3.4	
Bus126	11.000		0.003	0.002	0.008	0.005					0.013	85.0	0.9	
Bus127	11.000		0.031	0.019	0.081	0.050					0.154	85.1	10.0	
Bus128	11.000		0.003	0.002	0.007	0.005					0.035	85.1	2.4	
Bus129	11.000		0.006	0.004	0.013	0.008					0.022	85.0	1.6	
Bus130	33.000										3.732	85.8	72.6	
Bus131	33.000		0.002	0.002	0.008	0.005					3.610	85.2	70.6	
Bus132	11.000			0.000							1.683	40.0	127.8	
Bus133	33.000										3.599	85.1	70.4	
Bus134	33.000		0.003	0.002	0.010	0.006					0.016	85.0	0.3	
Bus135	33.000										3.586	85.0	70.1	
Bus136	33.000		0.003	0.002	0.009	0.005					0.014	85.0	0.3	
Bus137	11.000		0.003	0.002	0.008	0.005					0.171	85.1	11.1	
Bus138	11.000		0.005	0.003	0.014	0.009					0.022	85.0	1.4	
Bus139	11.000		0.037	0.023	0.097	0.060					0.158	85.0	10.3	
Bus140	11.000		0.001	0.000	0.002	0.001					0.006	91.0	0.4	
Bus141	11.000		0.065	0.040	0.174	0.108					1.855	84.9	119.3	
Bus142	11.000		0.001	0.001	0.002	0.001					0.004	85.0	0.2	
Bus143	11.000										1.547	85.0	101.2	
Bus144	11.000		0.087	0.054	0.223	0.138					0.365	85.0	23.9	
Bus145	11.000		0.006	0.004	0.015	0.009					0.024	85.0	1.6	
Bus146	11.000										1.179	85.0	77.4	
Bus147	11.000		0.008	0.005	0.020	0.012					0.049	85.1	3.2	
Bus148	11.000		0.004	0.002	0.010	0.006					0.017	85.0	1.1	
Bus149	11.000		0.006	0.004	0.012	0.008					0.022	85.0	1.6	
Bus150	11.000		0.167	0.103	0.424	0.263					1.126	85.0	74.1	
Bus151	11.000										0.180	85.4	11.7	
Bus152	11.000										0.432	85.0	28.4	
Bus153	11.000		0.026	0.016	0.066	0.041					0.108	85.0	7.1	
Bus154	11.000		0.078	0.048	0.197	0.122					0.324	85.0	21.3	
Bus155	11.000		0.001	0.000	0.002	0.001					0.003	85.0	0.2	
Bus156	11.000		0.001	0.001	0.002	0.001					0.004	85.0	0.3	
Bus157	11.000		0.011	0.007	0.030	0.018					0.356	85.6	23.0	
Bus158	11.000										0.307	85.6	19.9	
Bus159	11.000										0.177	85.4	11.5	
Bus160	11.000										0.204	85.4	13.2	
Bus161	11.000										0.103	86.0	6.7	
Bus162	11.000										1.673	39.7	127.5	

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
Bus163	11.000										0.077	86.3	5.0	
Bus164	11.000		0.006	0.004	0.016	0.010					0.026	85.0	1.7	
Bus165	11.000		0.022	0.013	0.057	0.035					0.101	85.2	6.5	
Bus166	11.000		0.011	0.007	0.021	0.013					0.037	85.0	2.8	
Bus167	11.000		0.002	0.001	0.005	0.003					0.009	85.0	0.6	
Bus168	11.000		0.009	0.005	0.014	0.008					0.069	85.2	5.7	
Bus169	11.000										0.076	85.4	4.9	
Bus170	11.000		0.003	0.002	0.009	0.005					0.014	85.0	0.9	
Bus171	11.000		0.013	0.008	0.033	0.020					0.054	85.0	3.5	
Bus172	11.000		0.002	0.001	0.005	0.003					0.009	85.0	0.6	
Bus173	11.000			0.000							2.024	48.9	141.9	
Bus174	11.000		0.008	0.005	0.015	0.009					1.632	38.2	125.2	
Bus175	11.000		0.014	0.008	0.023	0.014					0.109	85.3	8.9	
Bus176	11.000		0.005	0.003	0.009	0.006					1.482	31.6	115.9	
Bus177	11.000										0.127	85.5	9.7	
Bus178	11.000		0.019	0.012	0.036	0.022					0.112	85.4	8.6	
Bus179	11.000		0.009	0.006	0.015	0.009					0.412	85.4	34.2	
Bus180	11.000										0.015	85.6	1.2	
Bus181	11.000		0.002	0.002	0.005	0.003					0.008	85.0	0.6	
Bus182	11.000		0.002	0.001	0.004	0.002					0.007	85.0	0.5	
Bus183	11.000		0.003	0.002	0.005	0.003					0.047	85.6	3.7	
Bus184	11.000										0.043	85.3	3.6	
Bus185	11.000										0.039	85.6	3.0	
Bus186	11.000		0.007	0.004	0.012	0.008					0.022	85.0	1.7	
Bus187	11.000		0.004	0.002	0.007	0.004					0.017	85.7	1.3	
Bus188	11.000		0.002	0.001	0.003	0.002					0.005	85.0	0.4	
Bus189	11.000		0.010	0.006	0.017	0.010					0.032	85.0	2.6	
Bus190	11.000		0.004	0.003	0.007	0.004					1.441	29.7	114.9	
Bus191	11.000		0.004	0.002	0.006	0.004					0.011	85.0	0.9	
Bus192	11.000		0.005	0.003	0.009	0.005					1.411	28.3	114.1	
Bus194	11.000										1.293	20.2	105.5	
Bus195	11.000										0.768	85.2	64.1	
Bus196	11.000		0.007	0.004	0.012	0.007					0.132	85.3	10.7	
Bus197	11.000		0.004	0.002	0.007	0.004					0.067	85.3	5.4	
Bus198	11.000		0.019	0.012	0.030	0.019					0.059	85.0	4.9	
Bus199	11.000		0.005	0.003	0.008	0.005					0.054	85.3	4.4	
Bus200	11.000		0.005	0.003	0.009	0.005					0.016	85.0	1.3	
Bus201	11.000		0.007	0.005	0.012	0.008					0.023	85.0	1.9	
Bus202	11.000		0.098	0.061	0.162	0.100					0.305	85.0	24.9	
Bus203	11.000										1.103	6.7	90.4	
Bus204	11.000										0.382	85.4	31.9	
Bus205	11.000		0.017	0.010	0.028	0.017					0.083	85.1	6.8	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus206	11.000		0.002	0.001	0.003	0.002					0.005	85.0	0.4	
Bus207	11.000		0.008	0.005	0.013	0.008					0.031	85.1	2.5	
Bus208	11.000		0.013	0.008	0.021	0.013					0.705	85.3	59.2	
Bus209	11.000		0.006	0.004	0.010	0.006					1.054	9.6	87.0	
Bus210	33.000		0.001	0.001	0.004	0.002					1.211	91.4	24.2	
Bus211	11.000		0.052	0.032	0.084	0.052					1.064	22.5	88.0	
Bus212	132.000										2.366	84.0	10.3	
Bus213	33.000										1.205	91.3	24.2	
Bus214	33.000		0.005	0.003	0.016	0.010					0.024	85.0	0.5	
Bus215	11.000		0.050	0.031	0.077	0.047					0.659	85.3	55.9	
Bus216	11.000		0.005	0.003	0.008	0.005					0.214	85.3	17.9	
Bus216/Rangjung	33.000										1.187	90.4	24.0	
Bus217	33.000										0.190	97.3	3.8	
Bus218	11.000			0.000							0.509	85.4	43.3	
Bus219	11.000										0.042	85.3	3.6	
Bus220	11.000		0.008	0.005	0.013	0.008					0.025	85.0	2.1	
Bus221	33.000										1.027	86.1	20.8	
Bus222	11.000		0.006	0.004	0.009	0.005					0.017	85.0	1.5	
Bus223	33.000		0.003	0.002	0.009	0.006					0.038	87.3	0.8	
Bus224	33.000		0.005	0.003	0.016	0.010					0.025	85.0	0.5	
Bus225	33.000										2.340	84.7	41.4	
Bus226	33.000										0.989	86.0	20.1	
Bus227	33.000		0.009	0.005	0.026	0.016					0.041	85.0	0.8	
Bus228	11.000		0.015	0.009	0.022	0.014					0.464	85.4	39.7	
Bus229	33.000										0.950	85.8	19.3	
Bus230	33.000		0.008	0.005	0.023	0.014					0.037	85.0	0.7	
Bus231	11.000										0.133	85.3	11.1	
Bus232	33.000		0.013	0.008	0.038	0.023					0.099	87.3	2.0	
Bus233	11.000										0.419	85.4	36.0	
Bus234	33.000		0.005	0.003	0.014	0.009					0.041	88.7	0.8	
Bus235	33.000		0.004	0.003	0.013	0.008					0.021	85.0	0.4	
Bus236	11.000		0.011	0.007	0.016	0.010					0.031	85.0	2.7	
Bus237	33.000		0.006	0.004	0.018	0.011					0.814	85.7	16.5	
Bus238	11.000		0.017	0.010	0.025	0.016					0.049	85.0	4.2	
Bus239	33.000										0.786	85.6	16.0	
Bus240/Rangjung 33kV Bus	33.000													
Bus241	33.000		0.020	0.012	0.060	0.037					0.094	85.0	1.9	
Bus242	11.000		0.003	0.002	0.005	0.003					0.026	85.2	2.2	
Bus243	33.000										0.694	85.4	14.1	
Bus244	11.000		0.005	0.003	0.008	0.005					0.016	85.0	1.4	
Bus245	33.000										0.605	85.3	12.3	
Bus246	33.000		0.019	0.012	0.058	0.036					0.090	85.0	1.8	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
Bus247	33.000		0.121	0.075	0.359	0.222					0.565	85.0	11.5	
Bus248	33.000		0.009	0.006	0.027	0.017					0.042	85.0	0.9	
Bus249	11.000		0.006	0.004	0.010	0.006					0.035	85.6	2.9	
Bus250	33.000		0.002	0.001	0.005	0.003					0.142	92.6	2.9	
Bus251	11.000										0.309	85.4	26.9	
Bus252	33.000		0.007	0.004	0.020	0.012					0.145	86.0	2.9	
Bus253	33.000										0.054	98.0	1.1	
Bus254	11.000		0.002	0.002	0.004	0.002					0.007	85.0	0.6	
Bus255	33.000		0.025	0.015	0.074	0.046					0.116	85.0	2.3	
Bus256	33.000		0.001	0.000	0.002	0.001					0.003	85.0	0.1	
Bus257	11.000		0.001	0.001	0.002	0.001					0.004	85.0	0.3	
Bus258	33.000		0.000	0.000	0.001	0.001					0.052	98.4	1.0	
Bus259	11.000										0.301	85.3	26.3	
Bus260	33.000		0.000	0.000	0.001	0.001					0.050	98.2	1.0	
Bus261	11.000		0.008	0.005	0.012	0.007					0.040	85.3	3.5	
Bus262	33.000		0.001	0.000	0.002	0.001					0.048	97.6	1.0	
Bus263	33.000										1.170	84.7	20.7	
Bus264	33.000		0.000	0.000	0.001	0.001					0.045	99.1	0.9	
Bus265	33.000		0.000	0.000	0.001	0.001					0.002	85.0	-	
Bus266	11.000		0.003	0.002	0.005	0.003					0.016	85.4	1.4	
Bus267	33.000		0.000	0.000	0.001	-					0.041	99.6	0.8	
Bus268	11.000		0.002	0.001	0.003	0.002					0.006	85.0	0.5	
Bus269	33.000		0.000	0.000	0.001	0.001					0.040	99.4	0.8	
Bus270	11.000		0.002	0.001	0.004	0.002					0.128	85.2	10.8	
Bus271	33.000		0.000	0.000	0.001	0.001					0.038	99.3	0.8	
Bus272	11.000										0.259	85.3	22.8	
Bus273	33.000										0.040	90.0	0.8	
Bus274	33.000		0.001	0.000	0.002	0.001					0.009	87.5	0.2	
Bus275	33.000		0.001	0.001	0.004	0.002					0.006	85.0	0.1	
Bus276	11.000		0.008	0.005	0.011	0.007					0.022	85.0	1.9	
Bus277	33.000		0.000	0.000	0.001	0.001					0.033	87.1	0.7	
Bus278	33.000										2.339	84.6	41.4	
Bus279	33.000		0.003	0.002	0.008	0.005					0.032	86.7	0.6	
Bus280	11.000		0.031	0.019	0.044	0.027					0.175	85.0	15.5	
Bus281	33.000		0.001	0.000	0.002	0.001					0.019	86.8	0.4	
Bus282	11.000										0.122	85.2	10.2	
Bus283	33.000		0.003	0.002	0.008	0.005					0.016	85.7	0.3	
Bus284	33.000		0.001	0.001	0.002	0.001					0.004	85.0	0.1	
Bus285	11.000										0.087	85.1	7.7	
Bus286	6.600		0.000	0.000							0.800	100.0	109.4	
Bus287	11.000		0.006	0.004	0.009	0.005					0.017	85.0	1.5	
Bus288	6.600		0.000	0.000							0.800	100.0	109.4	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus289	11.000		0.025	0.015	0.035	0.022					0.070	85.0	6.2	
Bus290	11.000										1.234	63.9	102.3	
Bus291	11.000		0.082	0.051	0.131	0.081					0.380	85.1	31.5	
Bus292	11.000										1.222	82.8	101.2	
Bus293	11.000		0.036	0.023	0.057	0.035					0.110	85.0	9.2	
Bus294	11.000		0.020	0.012	0.032	0.020					0.130	85.2	10.8	
Bus295	11.000										0.062	85.7	5.5	
Bus296	11.000		0.002	0.001	0.003	0.002					0.006	85.0	0.5	
Bus297	33.000		0.003	0.002	0.013	0.008					0.020	85.0	0.4	
Bus298	11.000										0.057	85.7	5.0	
Bus299	11.000		0.002	0.001	0.002	0.002					0.005	85.0	0.4	
Bus300	11.000		0.002	0.002	0.003	0.002					0.007	85.0	0.6	
Bus301	11.000										0.012	86.4	1.0	
Bus302	11.000										0.045	85.6	4.0	
Bus303	11.000		0.001	0.001	0.002	0.001					0.004	85.0	0.4	
Bus305	11.000										0.041	85.4	3.6	
Bus306	11.000		0.002	0.001	0.002	0.002					0.005	85.0	0.4	
Bus307	11.000		0.002	0.001	0.004	0.002					0.012	85.4	1.0	
Bus308	11.000		0.005	0.003	0.007	0.004					0.036	85.4	3.2	
Bus309	11.000		0.002	0.001	0.002	0.001					0.005	85.0	0.4	
Bus310	11.000										0.022	85.6	2.0	
Bus311	11.000		0.002	0.002	0.003	0.002					0.011	85.7	1.0	
Bus312	11.000		0.002	0.001	0.002	0.001					0.004	85.0	0.4	
Bus313	33.000		0.003	0.002	0.012	0.008					2.319	84.2	41.3	
Bus314	11.000		0.002	0.001	0.003	0.002					0.011	85.2	1.0	
Bus315	11.000		0.002	0.001	0.002	0.002					0.005	85.0	0.4	
Bus316	11.000		0.003	0.002	0.004	0.003					0.017	85.4	1.4	
Bus317	11.000		0.003	0.002	0.004	0.003					0.008	85.0	0.7	
Bus319	11.000		0.008	0.005	0.012	0.008					0.198	85.3	16.6	
Bus320	33.000										2.300	84.1	41.0	
Bus321	11.000										0.173	85.2	14.6	
Bus322	11.000		0.010	0.006	0.015	0.009					0.029	85.0	2.4	
Bus324	11.000		0.012	0.007	0.019	0.012					0.144	85.2	12.2	
Bus325	11.000										1.872	85.2	102.2	
Bus326	11.000										0.102	85.2	8.7	
Bus327	11.000		0.010	0.006	0.015	0.009					0.028	85.0	2.4	
Bus328	11.000										1.127	85.3	61.5	
Bus329	11.000		0.002	0.001	0.003	0.002					0.108	85.2	9.1	
Bus330	11.000										0.536	85.3	29.3	
Bus331	11.000										0.074	85.2	6.3	
Bus332	11.000		0.009	0.006	0.014	0.008					0.027	85.0	2.2	
Bus333	11.000		0.017	0.011	0.063	0.039					0.094	85.0	5.2	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus334	11.000		0.007	0.005	0.011	0.007					0.047	85.2	4.0	
Bus335	11.000		0.002	0.001	0.003	0.002					0.006	85.0	0.5	
Bus336	11.000		0.007	0.004	0.010	0.006					0.020	85.0	1.7	
Bus338	11.000		0.007	0.004	0.025	0.016					0.442	85.4	24.2	
Bus339	11.000										0.404	85.4	22.1	
Bus340	11.000		0.016	0.010	0.059	0.037					0.089	85.0	4.9	
Bus342	11.000		0.021	0.013	0.076	0.047					0.315	85.4	17.3	
Bus343	11.000		0.001	0.000	0.003	0.002					0.045	85.5	2.5	
Bus345	11.000		0.003	0.002	0.009	0.006					0.041	85.4	2.3	
Bus346	11.000		0.003	0.002	0.011	0.007					0.027	85.5	1.5	
Bus347	11.000		0.002	0.001	0.007	0.004					0.011	85.0	0.6	
Bus349	11.000		0.007	0.004	0.025	0.016					0.156	85.5	8.6	
Bus351	11.000										0.118	85.4	6.5	
Bus352	11.000		0.004	0.002	0.013	0.008					0.020	85.0	1.1	
Bus354	11.000		0.010	0.007	0.038	0.024					0.099	85.1	5.4	
Bus355	11.000		0.008	0.005	0.028	0.017					0.042	85.0	2.3	
Bus356	11.000										1.263	85.4	70.5	
Bus357	11.000		0.008	0.005	0.030	0.018					1.321	85.3	72.9	
Bus359	11.000										0.189	85.5	10.6	
Bus360	11.000		0.011	0.007	0.040	0.025					0.060	85.0	3.3	
Bus362	11.000		0.015	0.009	0.052	0.032					0.130	85.4	7.3	
Bus365	11.000		0.002	0.001	0.007	0.005					1.073	85.3	59.9	
Bus367	11.000		0.024	0.015	0.085	0.053					1.056	85.4	59.3	
Bus369	11.000		0.019	0.012	0.066	0.041					0.919	85.5	52.0	
Bus371	11.000										0.819	85.5	46.4	
Bus373	11.000		0.011	0.007	0.039	0.024					0.244	85.3	13.8	
Bus374	33.000		0.837	0.519	2.593	1.607					4.035	85.0	80.2	
Bus375	11.000										0.572	85.6	32.6	
Bus377	11.000		0.009	0.005	0.030	0.019					0.184	85.3	10.5	
Bus378	33.000										4.035	85.0	80.2	
Bus379	11.000										0.138	85.3	7.9	
Bus381	11.000		0.007	0.004	0.024	0.015					0.074	85.2	4.2	
Bus382	11.000		0.007	0.004	0.024	0.015					0.037	85.0	2.1	
Bus384	11.000		0.011	0.007	0.037	0.023					0.065	85.1	3.7	
Bus385	11.000		0.002	0.001	0.006	0.003					0.009	85.0	0.5	
Bus387	11.000										0.569	85.6	32.6	
Bus388	11.000		0.001	0.001	0.005	0.003					0.007	85.0	0.4	
Bus390	11.000		0.001	0.001	0.003	0.002					0.156	85.4	9.0	
Bus392	11.000										0.151	85.3	8.7	
Bus393	11.000		0.001	0.001	0.005	0.003					0.007	85.0	0.4	
Bus395	11.000										0.144	85.3	8.3	
Bus396	11.000		0.010	0.006	0.034	0.021					0.052	85.0	3.0	

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus398	11.000		0.010	0.006	0.032	0.020					0.092	85.1	5.3	
Bus399	11.000		0.008	0.005	0.028	0.017					0.043	85.0	2.5	
Bus401	11.000		0.003	0.002	0.010	0.006					0.405	85.6	23.3	
Bus403	11.000		0.007	0.004	0.024	0.015					0.390	85.6	22.4	
Bus405	11.000		0.003	0.002	0.009	0.006					0.353	85.6	20.4	
Bus407	11.000										0.339	85.7	19.5	
Bus409	11.000										0.048	85.2	2.8	
Bus410	11.000		0.005	0.003	0.015	0.009					0.023	85.0	1.3	
Bus411	11.000		0.005	0.003	0.016	0.010					0.025	85.0	1.4	
Bus413	11.000		0.010	0.007	0.035	0.021					0.290	85.7	16.8	
Bus415	11.000		0.007	0.005	0.025	0.015					0.237	85.7	13.7	
Bus417	11.000		0.008	0.005	0.026	0.016					0.199	85.8	11.5	
Bus419	11.000										0.159	86.0	9.2	
Bus420	11.000										0.094	85.9	5.5	
Bus422	11.000		0.002	0.001	0.006	0.004					0.065	85.6	3.8	
Bus423	11.000		0.003	0.002	0.009	0.005					0.056	85.4	3.3	
Bus426	11.000		0.005	0.003	0.015	0.009					0.043	85.1	2.5	
Bus428	11.000		0.004	0.002	0.013	0.008					0.045	85.6	2.6	
Bus430	11.000										0.049	85.7	2.9	
Bus432	11.000		0.003	0.002	0.009	0.005					0.024	85.2	1.4	
Bus433	11.000		0.002	0.001	0.007	0.004					0.011	85.0	0.6	
Bus435	11.000		0.003	0.002	0.009	0.006					0.025	85.2	1.5	
Bus437	11.000		0.002	0.001	0.008	0.005					0.025	85.7	1.5	
Bus440	11.000		0.003	0.002	0.009	0.005					0.013	85.0	0.8	
Bus441	11.000		0.002	0.001	0.007	0.005					0.011	85.0	0.7	
Bus442	11.000		0.004	0.002	0.013	0.008					0.020	85.0	1.2	
Bus443	11.000		0.001	0.000	0.003	0.002					0.381	85.6	20.9	
Bus445	11.000										0.376	85.6	20.7	
Bus446	11.000		0.001	0.001	0.005	0.003					0.007	85.0	0.4	
Bus448	11.000										0.368	85.5	20.3	
Bus450	11.000		0.003	0.002	0.010	0.006					0.033	85.2	1.8	
Bus453	11.000		0.003	0.002	0.012	0.008					0.018	85.0	1.0	
Bus455	11.000		0.003	0.002	0.012	0.007					0.334	85.5	18.5	
Bus457	11.000		0.003	0.002	0.011	0.007					0.317	85.5	17.5	
Bus459	11.000		0.011	0.007	0.040	0.025					0.300	85.5	16.6	
Bus461	11.000		0.004	0.002	0.014	0.009					0.239	85.6	13.2	
Bus463	11.000										0.218	85.6	12.1	
Bus465	11.000		0.001	0.001	0.004	0.003					0.043	85.4	2.4	
Bus467	11.000		0.001	0.001	0.004	0.003					0.037	85.2	2.1	
Bus469	11.000		0.002	0.002	0.009	0.005					0.030	85.2	1.7	
Bus470	11.000		0.003	0.002	0.012	0.007					0.017	85.0	1.0	
Bus472	11.000		0.004	0.002	0.013	0.008					0.174	85.5	9.7	

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
Bus474	11.000										0.155	85.5	8.6	
Bus475	11.000		0.004	0.003	0.015	0.009					0.023	85.0	1.3	
Bus477	11.000		0.005	0.003	0.016	0.010					0.132	85.5	7.3	
Bus479	11.000		0.004	0.002	0.014	0.009					0.108	85.5	6.0	
Bus481	11.000		0.004	0.002	0.013	0.008					0.086	85.5	4.8	
Bus483	11.000		0.004	0.002	0.014	0.009					0.067	85.4	3.7	
Bus485	11.000										0.046	85.6	2.5	
Bus486	11.000		0.007	0.004	0.024	0.015					0.036	85.0	2.0	
Bus487	11.000		0.002	0.001	0.007	0.004					0.010	85.0	0.6	
Bus489	11.000		0.006	0.004	0.020	0.013					0.052	85.5	2.9	
Bus490	11.000		0.004	0.003	0.014	0.009					0.022	85.0	1.2	

* 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	%
* Chenary T1	Transformer				2.500	2.621	104.8	2.439	97.6
* Chenary T2	Transformer				2.500	2.621	104.8	2.439	97.6
Rangjung 33/11 SS	Transformer				3.000				
Rangjung T1	Transformer				1.500	0.800	53.3	0.792	52.8
Rangjung T2	Transformer				1.500	0.800	53.3	0.792	52.8
* T1	Transformer				5.000	9.561	191.2	8.628	172.6
* T2	Transformer				5.000	9.561	191.2	8.628	172.6
T3	Transformer				2.500	1.463	58.5	1.419	56.8
T4	Transformer				2.500	1.463	58.5	1.419	56.8
T6	Transformer				5.000	1.183	23.7	1.170	23.4
T7	Transformer				5.000	1.183	23.7	1.170	23.4
Wamrong T1	Transformer				2.500	1.150	46.0	1.127	45.1
Wamrong T2	Transformer				2.500	1.150	46.0	1.127	45.1

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

Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
T1	7.142	6.357	-6.989	-5.059	152.8	1298.4	100.0	90.2	9.76
Line40	4.845	4.395	-4.708	-4.294	136.6	100.1	90.2	87.7	2.50
Line331	3.493	2.175	-3.462	-2.151	31.6	24.5	90.2	89.1	1.11
T3	1.216	0.814	-1.205	-0.749	10.8	64.8	90.2	87.5	2.73
Line133	3.209	1.919	-3.203	-1.915	6.7	4.2	90.2	90.0	0.26
T2	-6.989	-5.059	7.142	6.357	152.8	1298.4	90.2	100.0	9.76
T4	1.216	0.814	-1.205	-0.749	10.8	64.8	90.2	87.5	2.73
Line1	0.420	0.258	-0.419	-0.257	1.0	0.6	87.5	87.3	0.24
Line11	0.626	0.386	-0.621	-0.383	5.2	3.9	87.5	86.7	0.81
Line5	-0.026	-0.016	0.026	0.016	0.0	-0.2	86.9	86.9	0.02
Line39	1.364	0.854	-1.363	-0.854	1.0	0.8	87.5	87.4	0.07
Line2	0.383	0.235	-0.382	-0.235	0.9	0.5	87.3	87.0	0.23
Line4	0.359	0.221	-0.359	-0.220	0.4	0.1	87.0	86.9	0.10
Line7	0.359	0.220	-0.359	-0.220	0.2	0.1	86.9	86.9	0.05
Line15	0.561	0.345	-0.560	-0.345	0.2	0.1	86.7	86.7	0.03
Line6	-0.304	-0.187	0.304	0.187	0.1	0.0	86.8	86.9	0.04
Line8	0.281	0.173	-0.281	-0.173	0.7	0.1	86.8	86.7	0.20
Line10	0.243	0.150	-0.243	-0.150	0.8	0.1	86.7	86.4	0.28
Line145	-3.035	-1.881	3.036	1.882	1.4	0.8	89.4	89.4	0.06
Line18	0.548	0.338	-0.548	-0.338	0.1	0.0	86.7	86.7	0.01
Line20	0.012	0.007	-0.012	-0.007	0.0	0.0	86.7	86.7	0.00
Line12	0.051	0.031	-0.051	-0.031	0.0	-0.2	86.4	86.3	0.02
Line13	0.083	0.051	-0.083	-0.051	0.0	-0.1	86.4	86.3	0.03
Line14	0.078	0.048	-0.078	-0.048	0.0	-0.1	86.3	86.3	0.02
Line16	-0.032	-0.020	0.032	0.020	0.0	-0.3	86.3	86.3	0.04
Line22	0.065	0.040	-0.065	-0.040	0.0	0.0	86.7	86.7	0.00
Line24	0.484	0.298	-0.484	-0.298	0.1	0.0	86.7	86.6	0.01
Line9	-0.882	-0.546	0.903	0.563	21.0	17.4	81.4	83.6	2.17
Line19	0.858	0.531	-0.854	-0.528	4.1	3.4	81.4	81.0	0.43
Line17	0.105	0.015	-0.105	-0.024	0.0	-8.4	90.0	90.0	0.01
Line147	-0.117	-0.023	0.117	0.015	0.0	-7.5	90.0	90.0	0.01
Line26	0.280	0.171	-0.279	-0.171	0.2	0.1	86.6	86.6	0.07
Line27	-0.119	-0.073	0.120	0.073	0.1	-0.2	86.5	86.6	0.06
Line29	0.099	0.061	-0.099	-0.061	0.0	-0.2	86.5	86.5	0.04

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
Line36	0.002	0.000	-0.002	0.000	0.0	-0.4	86.6	86.6	0.00
Line23	0.042	0.026	-0.042	-0.026	0.0	-0.2	81.0	80.9	0.04
Line28	0.812	0.502	-0.808	-0.499	4.0	3.3	81.0	80.5	0.45
Line31	0.087	0.053	-0.087	-0.054	0.0	-0.2	86.5	86.4	0.04
Line33	0.057	0.035	-0.057	-0.035	0.0	-0.2	86.4	86.4	0.02
Line35	0.030	0.019	-0.030	-0.019	0.0	-0.1	86.4	86.4	0.01
Line44	-0.168	-0.104	0.168	0.104	0.2	0.0	74.8	74.9	0.08
Line219	1.110	0.482	-1.107	-0.491	3.0	-8.8	87.7	87.5	0.27
Line354	0.000	0.000	0.000	0.000	0.0	-0.1	87.7	87.7	0.00
Chenary T1	1.799	1.906	-1.762	-1.686	36.7	220.1	87.7	81.6	6.09
Chenary T2	1.799	1.906	-1.762	-1.686	36.7	220.1	87.7	81.6	6.09
Line38	0.000	-0.001	0.000	0.000	0.0	-0.8	86.6	86.6	0.00
Line41	0.126	0.078	-0.126	-0.078	0.0	0.0	87.4	87.4	0.00
Line43	1.237	0.775	-1.226	-0.766	11.2	9.5	87.4	86.6	0.88
Line45	1.174	0.734	-1.166	-0.727	8.3	7.0	86.6	85.9	0.69
Line46	-0.018	-0.011	0.018	0.011	0.0	-0.2	85.9	85.9	0.01
Line48	1.148	0.716	-1.145	-0.713	2.9	2.5	85.9	85.6	0.24
Line32	0.002	0.001	-0.002	-0.001	0.0	-0.1	80.5	80.5	0.00
Line37	0.806	0.497	-0.802	-0.494	4.0	3.3	80.5	80.1	0.45
Line50	0.022	0.014	-0.022	-0.014	0.0	-0.1	85.6	85.6	0.00
Line52	1.123	0.700	-1.118	-0.695	5.5	4.6	85.6	85.2	0.47
Line54	0.002	0.001	-0.002	-0.001	0.0	-0.1	85.2	85.2	0.00
Line56	1.116	0.694	-1.109	-0.688	7.1	5.9	85.2	84.6	0.60
Line25	0.064	0.034	-0.064	-0.034	0.0	-0.1	90.0	90.0	0.00
Line71	0.019	-0.025	-0.019	0.020	0.0	-4.2	90.0	90.0	0.00
Line58	0.064	0.037	-0.064	-0.037	0.0	-0.1	84.6	84.5	0.03
Line72	1.037	0.647	-1.026	-0.637	11.1	9.3	84.6	83.6	1.01
Line60	0.051	0.029	-0.051	-0.029	0.1	-0.5	84.5	84.4	0.11
Line42	0.067	0.041	-0.067	-0.042	0.1	-0.2	80.1	80.0	0.06
Line47	0.735	0.453	-0.733	-0.451	1.8	1.5	80.1	79.8	0.22
Line61	0.046	0.026	-0.046	-0.027	0.1	-0.8	84.4	84.3	0.15
Line63	0.004	0.002	-0.004	-0.002	0.0	-0.2	84.3	84.3	0.00
Line67	0.042	0.025	-0.042	-0.025	0.0	-0.1	84.3	84.3	0.02
Line65	0.003	0.001	-0.003	-0.002	0.0	-0.8	84.3	84.3	0.01
Line49	0.510	0.315	-0.510	-0.314	0.3	0.2	81.6	81.6	0.05
Line131	1.575	0.982	-1.575	-0.981	0.3	0.3	81.6	81.6	0.02
Line227	3.462	2.151	-3.430	-2.125	32.0	25.3	89.1	88.0	1.12

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
Line69	0.021	0.013	-0.021	-0.013	0.0	-0.2	84.3	84.2	0.02
Line70	0.020	0.012	-0.020	-0.012	0.0	-0.1	84.3	84.3	0.01
Line51	0.700	0.431	-0.695	-0.427	4.4	3.5	79.8	79.3	0.55
Line74	0.123	0.074	-0.123	-0.074	0.2	-0.1	83.6	83.4	0.11
Line34	0.023	0.013	-0.023	-0.014	0.0	-1.4	90.0	90.0	0.00
Line57	0.003	-0.002	-0.003	0.000	0.0	-1.8	90.0	90.0	0.00
Line76	0.004	0.002	-0.004	-0.002	0.0	-0.1	83.4	83.4	0.00
Line78	0.119	0.072	-0.118	-0.072	0.3	-0.3	83.4	83.2	0.21
Line55	0.662	0.406	-0.658	-0.404	3.2	2.5	79.3	78.9	0.42
Line80	0.115	0.070	-0.115	-0.070	0.1	-0.1	83.2	83.2	0.07
Line82	0.029	0.018	-0.029	-0.018	0.0	-0.4	83.2	83.1	0.04
Line83	0.086	0.052	-0.086	-0.053	0.0	-0.1	83.2	83.1	0.04
Line66	-0.051	-0.031	0.051	0.031	0.0	-0.3	80.9	80.9	0.04
Line95	0.004	0.002	-0.004	-0.002	0.0	-0.3	80.9	80.9	0.00
Line85	0.079	0.048	-0.079	-0.049	0.1	-0.2	83.1	83.0	0.08
Line53	0.003	0.001	-0.003	-0.002	0.0	-0.9	90.0	90.0	0.00
Line62	0.000	-0.001	0.000	0.000	0.0	-1.2	90.0	90.0	0.00
Line87	0.041	0.026	-0.041	-0.026	0.0	-0.1	83.0	83.0	0.03
Line89	0.037	0.023	-0.037	-0.023	0.0	0.0	83.0	83.0	0.01
Line59	0.084	0.052	-0.084	-0.052	0.0	-0.1	78.9	78.8	0.03
Line64	0.575	0.352	-0.571	-0.349	4.2	3.3	78.9	78.2	0.64
Line68	0.434	0.264	-0.430	-0.261	4.6	3.2	78.2	77.3	0.92
Line73	-0.025	-0.016	0.025	0.015	0.0	0.0	77.3	77.3	0.00
Line77	0.405	0.246	-0.399	-0.242	5.9	4.1	77.3	76.0	1.26
Line81	0.118	0.071	-0.118	-0.072	0.3	-0.3	76.0	75.8	0.20
Line86	0.281	0.170	-0.279	-0.169	1.3	0.7	76.0	75.6	0.40
Line156	0.306	0.185	-0.305	-0.184	1.2	0.6	81.6	81.3	0.37
Line179	1.134	1.891	-0.989	-1.766	144.8	125.5	81.6	74.9	6.75
Line132	0.000	-0.001	0.000	0.000	0.0	-1.3	75.8	75.8	0.00
Line79	0.014	-0.023	-0.014	0.021	0.0	-2.2	90.0	90.0	0.00
Line90	0.031	0.019	-0.031	-0.019	0.0	-0.1	75.6	75.6	0.01
Line92	0.249	0.151	-0.248	-0.150	0.5	0.2	75.6	75.5	0.17
Line75	0.486	0.300	-0.485	-0.299	1.3	1.0	81.6	81.3	0.25
Line94	0.051	0.031	-0.051	-0.032	0.0	-0.2	75.5	75.4	0.06
Line98	0.197	0.119	-0.197	-0.119	0.0	0.0	75.5	75.5	0.01
Line88	0.014	-0.021	-0.014	0.018	0.0	-2.9	90.0	90.0	0.00
Line96	0.017	0.010	-0.017	-0.011	0.0	-0.2	75.4	75.4	0.02

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line100	0.169	0.101	-0.168	-0.101	0.2	0.0	75.5	75.4	0.08
Line93	0.003	-0.012	-0.003	0.008	0.0	-3.5	90.0	90.0	0.00
Line101	0.003	0.001	-0.003	-0.002	0.0	-0.5	90.0	90.0	0.00
Line105	0.007	-0.008	-0.007	0.007	0.0	-1.8	90.0	90.0	0.00
Line102	0.163	0.098	-0.163	-0.098	0.4	-0.1	75.4	75.2	0.20
Line91	0.479	0.296	-0.478	-0.295	1.0	0.7	81.3	81.1	0.20
Line97	0.002	-0.009	-0.002	-0.001	0.0	-10.0	90.0	90.0	0.00
Line104	0.035	0.021	-0.035	-0.021	0.0	-0.1	75.2	75.2	0.01
Line106	0.128	0.077	-0.128	-0.077	0.3	-0.3	75.2	75.0	0.22
Line99	0.278	0.170	-0.277	-0.170	0.3	0.1	81.1	81.1	0.09
Line108	0.113	0.068	-0.113	-0.068	0.1	-0.1	75.0	74.9	0.09
Line110	0.088	0.053	-0.088	-0.053	0.0	-0.1	74.9	74.8	0.04
Line112	0.010	0.006	-0.010	-0.006	0.0	-0.2	74.8	74.8	0.01
Line113	0.078	0.047	-0.078	-0.047	0.1	-0.2	74.8	74.8	0.07
Line84	-0.749	-1.599	0.821	1.662	71.9	62.3	71.3	74.9	3.55
Line103	0.718	1.581	-0.674	-1.542	44.3	38.4	71.3	69.1	2.20
Line119	0.019	0.011	-0.019	-0.011	0.0	-0.3	71.3	71.3	0.04
Line115	0.077	0.046	-0.077	-0.046	0.0	-0.1	74.8	74.7	0.02
Line109	0.003	-0.009	-0.003	-0.001	0.0	-9.4	90.0	90.0	0.00
Line117	0.057	0.035	-0.057	-0.035	0.0	-0.1	74.7	74.7	0.02
Line118	0.020	0.012	-0.020	-0.012	0.0	-0.2	74.7	74.7	0.02
Line111	-0.016	-0.008	0.016	0.008	0.0	-0.2	80.9	80.9	0.01
Line124	0.010	0.006	-0.010	-0.006	0.0	-0.2	80.9	80.9	0.00
Line150	0.006	0.002	-0.006	-0.003	0.0	-0.4	80.9	80.9	0.00
Line120	0.009	0.006	-0.009	-0.006	0.0	-0.3	74.7	74.7	0.01
Line114	0.001	-0.001	-0.001	-0.001	0.0	-1.5	90.0	90.0	0.00
Line122	0.009	0.005	-0.009	-0.006	0.0	-0.1	74.7	74.7	0.00
Line123	0.048	0.029	-0.048	-0.029	0.0	-0.2	74.7	74.7	0.03
Line107	0.146	0.090	-0.145	-0.090	0.6	-0.2	81.1	80.8	0.30
Line116	0.131	0.081	-0.131	-0.081	0.2	-0.3	81.1	80.9	0.16
Line125	0.041	0.025	-0.041	-0.025	0.0	-0.2	74.7	74.7	0.02
Line127	0.011	0.007	-0.011	-0.007	0.0	0.0	74.7	74.7	0.00
Line129	0.030	0.018	-0.030	-0.018	0.0	-0.1	74.7	74.7	0.00
Line121	0.019	0.011	-0.019	-0.012	0.0	-0.5	80.9	80.9	0.02
Line130	0.019	0.012	-0.019	-0.012	0.0	-0.1	74.7	74.7	0.00
Line135	3.085	1.900	-3.074	-1.893	11.6	6.8	90.0	89.5	0.46
Line137	3.064	1.886	-3.063	-1.886	0.5	0.3	89.5	89.5	0.02

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line140	0.004	0.002	-0.004	-0.002	0.0	-0.2	69.1	69.1	0.00
Line144	0.670	1.540	-0.665	-1.535	5.3	4.6	69.1	68.9	0.26
Line139	0.014	-0.004	-0.014	-0.008	0.0	-12.0	89.5	89.5	0.01
Line141	3.049	1.890	-3.048	-1.889	1.6	0.9	89.5	89.4	0.06
Line143	0.012	0.007	-0.012	-0.007	0.0	-0.1	89.4	89.4	0.00
Line126	0.134	0.083	-0.134	-0.083	0.2	-0.1	80.8	80.7	0.11
Line154	0.003	0.001	-0.003	-0.002	0.0	-0.9	80.9	80.9	0.01
Line134	1.335	0.833	-1.315	-0.815	20.6	17.6	81.6	80.2	1.40
Line136	0.310	0.192	-0.310	-0.192	0.0	0.0	80.2	80.2	0.00
Line138	1.005	0.623	-1.002	-0.621	2.8	2.4	80.2	80.0	0.25
Line157	-0.021	-0.013	0.021	0.013	0.0	0.0	81.0	81.0	0.00
Line142	0.042	0.025	-0.042	-0.026	0.0	-0.3	80.0	79.9	0.04
Line146	0.960	0.595	-0.957	-0.593	2.5	2.1	80.0	79.7	0.24
Line148	0.014	0.009	-0.014	-0.009	0.0	-0.2	79.9	79.9	0.01
Line149	0.367	0.227	-0.367	-0.227	0.2	0.1	79.7	79.7	0.05
Line162	-0.153	-0.093	0.154	0.093	0.1	-0.1	80.9	81.0	0.08
Line166	0.002	0.001	-0.002	-0.002	0.0	-0.2	80.9	80.9	0.00
Line168	0.151	0.092	-0.151	-0.092	0.0	0.0	80.9	80.9	0.02
Line151	0.092	0.057	-0.092	-0.057	0.0	-0.1	79.7	79.7	0.02
Line153	0.275	0.171	-0.275	-0.171	0.1	0.0	79.7	79.6	0.04
Line158	0.264	0.159	-0.263	-0.158	0.8	0.3	81.3	81.0	0.28
Line159	0.089	0.052	-0.089	-0.053	0.0	-0.2	81.0	80.9	0.04
Line161	0.174	0.106	-0.174	-0.106	0.0	0.0	81.0	81.0	0.02
Line170	0.065	0.039	-0.065	-0.040	0.0	-0.2	80.9	80.8	0.03
Line172	0.086	0.053	-0.086	-0.053	0.0	-0.2	80.9	80.8	0.04
Line30	0.066	0.039	-0.066	-0.039	0.0	0.0	80.9	80.9	0.01
Line163	0.022	0.014	-0.022	-0.014	0.0	0.0	80.9	80.9	0.00
Line152	0.032	0.020	-0.032	-0.020	0.0	0.0	68.9	68.9	0.00
Line160	0.633	1.516	-0.624	-1.508	9.4	8.1	68.9	68.4	0.47
Line174	0.008	0.004	-0.008	-0.005	0.0	-0.4	80.8	80.8	0.01
Line3	-0.059	-0.036	0.059	0.036	0.1	-0.1	62.9	62.9	0.07
Line155	0.037	0.022	-0.037	-0.022	0.0	-0.1	62.9	62.9	0.02
Line176	0.012	0.007	-0.012	-0.007	0.0	-0.1	80.8	80.8	0.00
Line178	0.046	0.028	-0.046	-0.028	0.0	-0.3	80.8	80.8	0.03
Line181	0.008	0.004	-0.008	-0.005	0.0	-0.4	80.8	80.8	0.01
Line165	0.493	1.428	-0.468	-1.406	25.2	21.8	68.4	67.1	1.31
Line167	0.109	0.066	-0.109	-0.066	0.1	0.0	68.4	68.4	0.04

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
Line128	0.057	0.035	-0.057	-0.035	0.1	-0.1	64.6	64.5	0.09
Line203	-0.093	-0.057	0.093	0.057	0.1	0.0	64.6	64.7	0.09
Line195	0.453	1.397	-0.428	-1.376	24.6	21.3	67.1	65.8	1.28
Line171	0.013	0.008	-0.013	-0.008	0.0	-0.1	68.4	68.4	0.01
Line175	0.096	0.058	-0.095	-0.058	0.1	-0.1	68.4	68.3	0.09
Line186	0.041	0.024	-0.041	-0.025	0.0	-0.2	68.3	68.2	0.06
Line177	-0.351	-0.214	0.353	0.215	1.4	0.6	63.1	63.3	0.24
Line190	0.327	0.199	-0.326	-0.199	1.0	0.4	63.1	62.9	0.18
Line182	0.007	0.004	-0.007	-0.004	0.0	-0.1	68.4	68.4	0.00
Line183	0.006	0.004	-0.006	-0.004	0.0	-0.1	68.4	68.3	0.01
Line187	0.033	0.020	-0.033	-0.020	0.0	-0.2	68.2	68.2	0.04
Line184	0.027	0.017	-0.027	-0.017	0.0	-0.1	62.9	62.8	0.02
Line188	0.010	0.006	-0.010	-0.006	0.0	-0.2	62.9	62.8	0.02
Line189	0.019	0.012	-0.019	-0.012	0.0	-0.1	68.2	68.2	0.01
Line191	0.015	0.009	-0.015	-0.009	0.0	-0.2	68.2	68.2	0.02
Line193	0.004	0.003	-0.004	-0.003	0.0	-0.3	68.2	68.1	0.01
Line197	0.417	1.369	-0.399	-1.353	17.9	15.5	65.8	64.9	0.93
Line199	0.272	1.276	-0.262	-1.266	10.6	9.1	64.9	64.3	0.56
Line201	0.113	0.069	-0.113	-0.069	0.4	0.0	64.9	64.7	0.19
Line205	0.260	0.161	-0.259	-0.161	0.1	0.1	64.3	64.3	0.02
Line207	0.002	1.106	0.003	-1.101	5.5	4.8	64.3	64.0	0.28
Line192	-0.654	-0.402	0.659	0.406	4.3	3.7	62.9	63.3	0.46
Line196	0.050	0.031	-0.050	-0.031	0.1	-0.1	62.9	62.8	0.07
Line200	0.604	0.371	-0.601	-0.368	3.6	3.0	62.9	62.4	0.42
Line164	0.046	0.028	-0.046	-0.028	0.0	-0.1	64.5	64.5	0.05
Line173	0.020	0.012	-0.020	-0.012	0.0	-0.1	64.5	64.4	0.03
Line180	0.014	0.008	-0.014	-0.008	0.0	-0.2	64.5	64.4	0.02
Line209	-0.074	1.057	0.084	-1.049	10.1	8.7	64.0	63.6	0.49
Line211	0.071	0.043	-0.071	-0.044	0.1	-0.1	64.0	63.9	0.12
Line198	0.183	0.112	-0.182	-0.112	0.5	0.1	62.9	62.8	0.16
Line206	0.113	0.069	-0.113	-0.069	0.2	0.0	62.9	62.8	0.08
Line217	0.030	0.018	-0.030	-0.018	0.0	-0.1	62.9	62.9	0.03
Line213	0.026	0.016	-0.026	-0.016	0.0	-0.1	63.9	63.9	0.02
Line214	-0.004	-0.003	0.004	0.003	0.0	-0.1	63.9	63.9	0.00
Line204	0.567	0.347	-0.563	-0.344	3.9	3.2	62.4	62.0	0.48
Line216	-0.101	1.038	0.103	-1.037	1.7	1.5	63.6	63.5	0.08
Line221	1.102	0.488	-1.100	-0.493	1.8	-5.2	87.5	87.3	0.16

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	
Line218	-0.239	0.952	0.243	-0.949	3.8	3.3	63.5	63.3	0.15
T6	0.993	0.642	-0.991	-0.622	2.3	19.9	100.0	98.9	1.07
T7	0.993	0.642	-0.991	-0.622	2.3	19.9	100.0	98.9	1.07
Line223	0.021	0.012	-0.021	-0.013	0.0	-0.5	87.3	87.3	0.00
Line224	1.079	0.481	-1.073	-0.501	6.6	-20.1	87.3	86.7	0.62
Line208	0.436	0.266	-0.435	-0.265	1.3	1.0	62.0	61.8	0.20
Line294	0.169	0.104	-0.169	-0.103	0.6	0.2	62.8	62.5	0.22
Line228	0.185	-0.007	-0.185	-0.020	0.4	-27.3	86.7	86.5	0.18
Line234	0.887	0.508	-0.884	-0.523	3.5	-14.9	86.7	86.3	0.39
Line267	0.132	0.044	-0.132	-0.054	0.1	-9.7	86.5	86.4	0.05
Line272	0.053	-0.024	-0.053	0.010	0.0	-13.7	86.5	86.5	0.02
Line212	0.036	0.022	-0.036	-0.022	0.0	-0.1	61.8	61.8	0.01
Line226	0.399	0.243	-0.396	-0.241	3.1	1.3	61.8	61.3	0.45
Line215	0.021	0.013	-0.021	-0.013	0.0	-0.1	61.8	61.7	0.02
Line222	0.015	0.009	-0.015	-0.009	0.0	-0.1	61.8	61.7	0.02
Line236	0.033	0.017	-0.033	-0.019	0.0	-1.3	86.3	86.3	0.00
Line238	0.850	0.505	-0.850	-0.505	0.0	-0.2	86.3	86.3	0.00
Line240	0.021	0.011	-0.021	-0.013	0.0	-2.1	86.3	86.3	0.00
Line185	1.982	1.244	-1.979	-1.247	2.8	-2.2	98.9	98.8	0.16
Line242	0.035	0.020	-0.035	-0.021	0.0	-1.3	86.3	86.3	0.00
Line244	0.816	0.485	-0.815	-0.488	0.5	-2.2	86.3	86.2	0.05
Line229	0.359	0.218	-0.358	-0.218	1.6	0.7	61.3	61.1	0.25
Line246	0.031	0.019	-0.031	-0.019	0.0	-0.1	86.2	86.2	0.00
Line247	0.698	0.420	-0.698	-0.420	0.0	-0.1	86.2	86.2	0.00
Line248	0.087	0.048	-0.087	-0.048	0.0	-0.1	86.2	86.2	0.00
Line225	0.003	0.002	-0.003	-0.002	0.0	-0.1	62.8	62.8	0.00
Line230	0.110	0.067	-0.109	-0.067	0.3	0.0	62.8	62.7	0.16
Line250	0.037	0.017	-0.037	-0.019	0.0	-1.7	86.2	86.2	0.00
Line231	0.042	0.026	-0.042	-0.026	0.0	-0.1	61.1	61.0	0.05
Line233	0.026	0.016	-0.026	-0.016	0.0	-0.1	61.1	61.0	0.02
Line237	0.022	0.014	-0.022	-0.014	0.0	-0.1	61.1	61.0	0.02
Line245	0.267	0.162	-0.264	-0.161	3.2	1.3	61.1	60.4	0.69
Line252	0.017	0.007	-0.017	-0.011	0.0	-3.6	86.2	86.2	0.00
Line254	0.673	0.405	-0.673	-0.406	0.1	-1.0	86.2	86.2	0.02
Line256	0.080	0.049	-0.080	-0.049	0.0	-0.2	86.2	86.2	0.00
Line258	0.593	0.357	-0.593	-0.361	0.4	-4.3	86.2	86.1	0.07
Rangjung 33/11 SS	0.000	0.000	0.000	0.000			63.3	63.3	

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
Line241	0.013	0.008	-0.013	-0.008	0.0	-0.1	61.0	61.0	0.02
Line260	0.516	0.314	-0.516	-0.316	0.2	-2.2	86.1	86.1	0.03
Line262	0.077	0.047	-0.077	-0.048	0.0	-0.2	86.1	86.1	0.00
Line264	0.480	0.295	-0.480	-0.298	0.2	-2.4	86.1	86.1	0.03
Line266	0.036	0.021	-0.036	-0.022	0.0	-1.2	86.1	86.1	0.00
Line279	0.014	0.008	-0.014	-0.009	0.0	-0.3	62.9	62.8	0.05
Line269	0.125	0.049	-0.125	-0.074	0.2	-24.7	86.4	86.3	0.13
Line251	0.006	0.004	-0.006	-0.004	0.0	-0.1	60.4	60.4	0.01
Line255	0.258	0.157	-0.256	-0.157	1.6	0.6	60.4	60.0	0.36
Line271	0.098	0.058	-0.098	-0.061	0.0	-3.1	86.3	86.3	0.01
Line274	0.003	0.001	-0.003	-0.002	0.0	-0.5	86.5	86.5	0.00
Line276	0.051	-0.011	-0.051	0.008	0.0	-2.7	86.5	86.5	0.00
Line278	0.049	-0.009	-0.049	0.008	0.0	-1.1	86.5	86.5	0.00
Line259	0.034	0.021	-0.034	-0.021	0.0	0.0	60.0	60.0	0.01
Line273	0.223	0.136	-0.221	-0.135	2.0	0.7	60.0	59.5	0.49
Line280	0.047	-0.009	-0.047	0.009	0.0	-0.6	86.5	86.5	0.00
Line263	0.013	0.008	-0.013	-0.008	0.0	-0.1	60.0	60.0	0.02
Line282	0.044	-0.010	-0.044	0.005	0.0	-5.7	86.5	86.5	0.01
Line284	0.002	0.000	-0.002	-0.001	0.0	-1.0	86.5	86.5	0.00
Line286	0.041	-0.006	-0.041	0.003	0.0	-2.9	86.5	86.5	0.00
Line268	0.005	0.003	-0.005	-0.003	0.0	-0.1	60.0	60.0	0.01
Line288	0.040	-0.004	-0.040	-0.004	0.0	-8.0	86.5	86.4	0.01
Line290	0.038	0.003	-0.038	-0.004	0.0	-1.1	86.4	86.4	0.00
Line235	0.104	0.064	-0.104	-0.064	0.2	0.0	62.7	62.6	0.09
Line292	0.036	0.003	-0.036	-0.018	0.0	-14.2	86.4	86.4	0.02
Line277	0.018	0.011	-0.018	-0.011	0.0	0.0	59.5	59.5	0.01
Line281	0.149	0.092	-0.149	-0.092	0.1	0.0	59.5	59.5	0.04
Line296	0.053	0.032	-0.053	-0.032	0.1	-0.2	59.5	59.5	0.07
Line295	0.008	0.003	-0.008	-0.004	0.0	-1.0	86.4	86.4	0.00
Line299	0.029	0.014	-0.029	-0.016	0.0	-1.8	86.4	86.4	0.00
Line297	0.005	0.003	-0.005	-0.003	0.0	-0.5	86.4	86.4	0.00
Line301	0.027	0.015	-0.027	-0.016	0.0	-0.3	86.4	86.4	0.00
Line202	0.017	0.003	-0.017	-0.010	0.0	-7.6	98.8	98.8	0.00
Line220	1.963	1.244	-1.951	-1.253	11.3	-8.9	98.8	98.1	0.63
Line303	0.017	0.009	-0.017	-0.010	0.0	-0.5	86.4	86.4	0.00
Line285	0.074	0.046	-0.074	-0.046	0.0	0.0	59.5	59.5	0.03
Line305	0.014	0.008	-0.014	-0.008	0.0	-0.5	86.4	86.4	0.00

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	
Line243	0.094	0.058	-0.093	-0.058	0.1	0.0	62.6	62.5	0.08
Line253	0.010	0.006	-0.010	-0.006	0.0	-0.1	62.6	62.6	0.01
Line309	0.003	0.002	-0.003	-0.002	0.0	-0.3	86.4	86.4	0.00
Line289	0.015	0.009	-0.015	-0.009	0.0	-0.1	59.5	59.4	0.01
Line293	0.059	0.037	-0.059	-0.037	0.0	0.0	59.5	59.4	0.04
Rangjung T1	0.800	0.000	-0.789	0.064	10.7	64.3	64.0	63.3	0.65
Rangjung T2	0.800	0.000	-0.789	0.064	10.7	64.3	64.0	63.3	0.65
Line307	0.324	0.200	-0.323	-0.199	0.5	0.2	63.3	63.2	0.09
Line310	0.111	0.068	-0.111	-0.068	0.6	0.0	63.2	62.9	0.30
Line300	0.005	0.003	-0.005	-0.003	0.0	0.0	59.5	59.5	0.00
Line304	0.048	0.029	-0.048	-0.029	0.0	0.0	59.5	59.4	0.02
Line308	0.004	0.003	-0.004	-0.003	0.0	0.0	59.4	59.4	0.00
Line312	0.006	0.004	-0.006	-0.004	0.0	0.0	59.4	59.4	0.00
Line314	0.038	0.023	-0.038	-0.023	0.1	-0.2	59.4	59.3	0.10
Line261	0.010	0.006	-0.010	-0.006	0.0	-0.3	62.6	62.5	0.02
Line316	0.004	0.002	-0.004	-0.002	0.0	-0.2	59.3	59.3	0.00
Line318	0.035	0.021	-0.035	-0.021	0.0	-0.1	59.3	59.3	0.02
Line320	0.004	0.003	-0.004	-0.003	0.0	0.0	59.3	59.3	0.00
Line322	0.031	0.019	-0.031	-0.019	0.0	0.0	59.3	59.3	0.00
Line270	0.004	0.002	-0.004	-0.002	0.0	-0.1	62.5	62.5	0.00
Line324	0.019	0.011	-0.019	-0.011	0.0	0.0	59.3	59.3	0.01
Line326	0.009	0.006	-0.009	-0.006	0.0	0.0	59.3	59.3	0.00
Line330	0.009	0.006	-0.009	-0.006	0.0	0.0	59.3	59.3	0.00
Line328	0.004	0.002	-0.004	-0.002	0.0	-0.2	59.3	59.3	0.01
Line232	1.936	1.243	-1.934	-1.244	1.2	-1.0	98.1	98.1	0.07
Line332	0.004	0.003	-0.004	-0.003	0.0	-0.1	59.3	59.3	0.00
Line287	0.007	0.004	-0.007	-0.004	0.0	-0.1	62.8	62.8	0.01
Line302	0.148	0.091	-0.148	-0.091	0.4	0.1	62.5	62.4	0.17
Wamrong T1	0.967	0.622	-0.962	-0.588	5.7	33.9	98.1	96.1	1.94
Wamrong T2	0.967	0.622	-0.962	-0.588	5.7	33.9	98.1	96.1	1.94
Line311	0.123	0.076	-0.123	-0.075	0.3	0.0	62.4	62.2	0.14
Line315	0.025	0.015	-0.025	-0.015	0.0	-0.1	62.4	62.3	0.02
Line319	0.092	0.057	-0.092	-0.057	0.1	0.0	62.2	62.2	0.07
Line249	0.458	0.280	-0.458	-0.280	0.8	0.4	96.1	95.9	0.19
Line357	1.138	0.699	-1.126	-0.689	11.3	9.3	96.1	95.1	1.07
Line323	0.024	0.015	-0.024	-0.015	0.0	0.0	62.1	62.0	0.01
Line327	-0.087	-0.054	0.087	0.054	0.1	0.0	62.1	62.2	0.10

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line329	0.063	0.039	-0.063	-0.039	0.0	0.0	62.1	62.0	0.04
Line355	0.327	0.197	-0.326	-0.197	0.8	0.2	96.1	95.9	0.28
Line265	0.080	0.050	-0.080	-0.050	0.0	-0.1	95.9	95.9	0.02
Line283	0.377	0.230	-0.377	-0.230	0.1	0.0	95.9	95.9	0.03
Line333	0.023	0.014	-0.023	-0.014	0.0	0.0	62.0	62.0	0.01
Line335	0.040	0.025	-0.040	-0.025	0.0	-0.1	62.0	62.0	0.05
Line337	0.005	0.003	-0.005	-0.003	0.0	-0.1	62.0	62.0	0.00
Line339	0.017	0.010	-0.017	-0.010	0.0	-0.1	62.0	62.0	0.01
Line298	0.345	0.210	-0.345	-0.210	0.4	0.1	95.9	95.8	0.12
Line313	0.075	0.047	-0.075	-0.047	0.0	-0.2	95.8	95.7	0.04
Line321	0.269	0.164	-0.269	-0.164	0.3	0.0	95.8	95.7	0.12
Line325	0.039	0.023	-0.039	-0.023	0.0	-0.5	95.7	95.6	0.06
Line343	0.133	0.081	-0.133	-0.081	0.1	-0.2	95.7	95.6	0.06
Line334	0.035	0.021	-0.035	-0.021	0.0	-0.1	95.6	95.6	0.01
Line338	0.023	0.014	-0.023	-0.014	0.0	-0.1	95.6	95.6	0.01
Line341	0.009	0.005	-0.009	-0.006	0.0	-0.3	95.6	95.6	0.01
Line345	0.101	0.061	-0.101	-0.061	0.1	-0.6	95.6	95.5	0.10
Line347	0.017	0.010	-0.017	-0.010	0.0	-0.7	95.5	95.5	0.02
Line351	0.084	0.052	-0.084	-0.052	0.0	0.0	95.5	95.5	0.01
Line353	0.035	0.022	-0.035	-0.022	0.0	-0.3	95.5	95.5	0.03
Line356	-1.078	-0.658	1.088	0.666	9.8	8.0	94.1	95.1	0.96
Line359	0.162	0.098	-0.162	-0.098	0.3	-0.2	94.1	93.9	0.16
Line367	0.916	0.560	-0.916	-0.559	0.6	0.5	94.1	94.0	0.07
Line361	0.051	0.031	-0.051	-0.032	0.0	-0.4	93.9	93.9	0.06
Line363	0.111	0.067	-0.111	-0.067	0.1	-0.3	93.9	93.8	0.11
Line365	0.045	0.026	-0.044	-0.027	0.0	-0.6	93.8	93.8	0.08
Line369	0.906	0.553	-0.902	-0.550	4.4	3.5	94.0	93.5	0.52
Line371	0.792	0.482	-0.786	-0.477	5.9	4.6	93.5	92.7	0.78
Line373	0.701	0.425	-0.701	-0.424	0.5	0.4	92.7	92.7	0.07
Line375	0.208	0.127	-0.208	-0.127	0.5	-0.1	92.7	92.4	0.22
Line377	0.492	0.297	-0.490	-0.296	2.5	1.5	92.7	92.1	0.52
Line379	0.157	0.096	-0.157	-0.096	0.1	-0.1	92.4	92.4	0.05
Line391	0.490	0.296	-0.487	-0.294	2.5	1.5	92.1	91.6	0.52
Line381	0.118	0.072	-0.118	-0.072	0.1	-0.2	92.4	92.3	0.10
Line383	0.063	0.038	-0.063	-0.039	0.0	-0.3	92.3	92.2	0.06
Line387	0.055	0.034	-0.055	-0.034	0.0	-0.3	92.3	92.2	0.05
Line385	0.032	0.019	-0.032	-0.020	0.0	-0.3	92.2	92.2	0.03

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Line389	0.007	0.004	-0.007	-0.005	0.0	-0.2	92.2	92.2	0.00
Line393	0.006	0.004	-0.006	-0.004	0.0	-0.2	91.6	91.6	0.00
Line395	0.134	0.081	-0.133	-0.081	0.4	-0.5	91.6	91.4	0.26
Line411	0.347	0.210	-0.347	-0.209	0.5	0.2	91.6	91.5	0.13
Line397	0.129	0.079	-0.129	-0.079	0.2	-0.2	91.4	91.3	0.11
Line399	0.006	0.004	-0.006	-0.004	0.0	-0.1	91.3	91.3	0.00
Line401	0.123	0.075	-0.123	-0.075	0.1	-0.1	91.3	91.2	0.06
Line403	0.044	0.027	-0.044	-0.028	0.0	-0.2	91.2	91.2	0.02
Line407	0.078	0.048	-0.078	-0.048	0.1	-0.4	91.2	91.1	0.10
Line409	0.037	0.022	-0.037	-0.023	0.0	-0.2	91.1	91.1	0.03
Line413	0.334	0.202	-0.334	-0.201	0.7	0.2	91.5	91.3	0.23
Line415	0.303	0.182	-0.302	-0.182	0.9	0.2	91.3	91.0	0.29
Line417	0.290	0.175	-0.290	-0.175	0.1	0.0	91.0	90.9	0.05
Line419	0.041	0.025	-0.041	-0.025	0.0	-0.1	90.9	90.9	0.02
Line425	0.249	0.150	-0.249	-0.150	0.1	0.0	90.9	90.9	0.06
Line421	0.020	0.012	-0.020	-0.012	0.0	-0.2	90.9	90.9	0.01
Line423	0.021	0.013	-0.021	-0.013	0.0	-0.1	90.9	90.9	0.00
Line427	0.204	0.122	-0.203	-0.122	0.7	-0.1	90.9	90.6	0.29
Line429	0.171	0.102	-0.171	-0.102	0.3	-0.1	90.6	90.5	0.13
Line431	0.137	0.081	-0.137	-0.081	0.1	-0.1	90.5	90.4	0.03
Line433	0.081	0.048	-0.081	-0.048	0.1	-0.4	90.4	90.3	0.12
Line435	0.056	0.033	-0.056	-0.034	0.0	-0.3	90.4	90.4	0.06
Line440	0.039	0.023	-0.038	-0.023	0.0	-0.4	90.3	90.3	0.05
Line442	0.042	0.025	-0.042	-0.025	0.0	-0.1	90.3	90.3	0.01
Line436	0.048	0.029	-0.048	-0.029	0.0	-0.4	90.4	90.3	0.05
Line438	0.036	0.022	-0.036	-0.022	0.0	-0.4	90.3	90.3	0.04
Line456	0.017	0.010	-0.017	-0.011	0.0	-0.1	90.3	90.3	0.01
Line450	0.021	0.013	-0.021	-0.013	0.0	-0.2	90.3	90.2	0.01
Line444	0.021	0.013	-0.021	-0.013	0.0	0.0	90.3	90.3	0.00
Line448	0.022	0.013	-0.022	-0.013	0.0	-0.5	90.3	90.3	0.03
Line446	0.009	0.006	-0.009	-0.006	0.0	-0.1	90.3	90.3	0.00
Line454	0.010	0.006	-0.010	-0.006	0.0	-0.1	90.3	90.3	0.00
Line452	0.011	0.007	-0.011	-0.007	0.0	-0.4	90.2	90.2	0.01
Line457	0.323	0.195	-0.322	-0.195	1.0	0.2	95.9	95.5	0.33
Line459	0.006	0.004	-0.006	-0.004	0.0	-0.1	95.5	95.5	0.00
Line461	0.316	0.191	-0.315	-0.191	0.8	0.1	95.5	95.3	0.27
Line463	0.029	0.017	-0.029	-0.018	0.0	-0.1	95.3	95.2	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
Line467	0.286	0.173	-0.286	-0.173	0.6	0.0	95.3	95.0	0.21
Line465	0.016	0.010	-0.016	-0.010	0.0	-0.1	95.2	95.2	0.00
Line469	0.271	0.164	-0.271	-0.164	0.1	0.0	95.0	95.0	0.05
Line471	0.256	0.155	-0.256	-0.155	0.2	0.0	95.0	94.9	0.09
Line473	0.205	0.124	-0.205	-0.124	0.1	-0.1	94.9	94.9	0.04
Line475	0.187	0.112	-0.186	-0.113	0.2	-0.3	94.9	94.7	0.13
Line477	0.037	0.022	-0.037	-0.023	0.0	-0.1	94.7	94.7	0.01
Line486	0.149	0.090	-0.149	-0.090	0.3	-0.3	94.7	94.6	0.18
Line479	0.032	0.019	-0.032	-0.019	0.0	-0.2	94.7	94.7	0.02
Line481	0.026	0.016	-0.026	-0.016	0.0	-0.1	94.7	94.7	0.01
Line484	0.015	0.009	-0.015	-0.009	0.0	-0.1	94.7	94.7	0.00
Line488	0.132	0.080	-0.132	-0.080	0.0	0.0	94.6	94.5	0.02
Line490	0.019	0.011	-0.019	-0.012	0.0	-0.4	94.5	94.5	0.02
Line492	0.113	0.069	-0.113	-0.069	0.0	0.0	94.5	94.5	0.01
Line494	0.092	0.056	-0.092	-0.056	0.0	-0.1	94.5	94.5	0.02
Line496	0.074	0.044	-0.074	-0.045	0.1	-0.4	94.5	94.4	0.08
Line498	0.057	0.034	-0.057	-0.035	0.0	-0.2	94.4	94.4	0.04
Line500	0.039	0.024	-0.039	-0.024	0.0	0.0	94.4	94.4	0.00
Line502	0.030	0.019	-0.030	-0.019	0.0	-0.2	94.4	94.4	0.02
Line504	0.009	0.005	-0.009	-0.005	0.0	-0.4	94.4	94.4	0.01
Line505	0.018	0.011	-0.018	-0.011	0.0	-0.6	93.8	93.7	0.03
					1301.4	3729.1			

Alert Summary Report

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

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus10	Bus	Under Voltage	11.000	kV	9.563	86.9	3-Phase
Bus100	Bus	Under Voltage	11.000	kV	8.95	81.3	3-Phase
Bus101	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus102	Bus	Under Voltage	11.000	kV	8.27	75.2	3-Phase
Bus103	Bus	Under Voltage	11.000	kV	8.27	75.2	3-Phase
Bus104	Bus	Under Voltage	11.000	kV	8.93	81.1	3-Phase
Bus105	Bus	Under Voltage	11.000	kV	8.24	75.0	3-Phase
Bus106	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus107	Bus	Under Voltage	11.000	kV	8.23	74.9	3-Phase
Bus108	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus109	Bus	Under Voltage	11.000	kV	8.23	74.8	3-Phase
Bus11	Bus	Under Voltage	11.000	kV	9.54	86.7	3-Phase
Bus110	Bus	Under Voltage	11.000	kV	8.23	74.8	3-Phase
Bus111	Bus	Under Voltage	11.000	kV	7.85	71.3	3-Phase
Bus112	Bus	Under Voltage	11.000	kV	8.22	74.8	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus113	Bus	Under Voltage	33.000	kV	29.687	90.0	3-Phase
Bus114	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus115	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus116	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus117	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus118	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus119	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus12	Bus	Under Voltage	11.000	kV	9.55	86.8	3-Phase
Bus120	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus121	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus122	Bus	Under Voltage	11.000	kV	8.92	81.1	3-Phase
Bus123	Bus	Under Voltage	11.000	kV	8.22	74.7	3-Phase
Bus124	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus125	Bus	Under Voltage	11.000	kV	8.21	74.7	3-Phase
Bus126	Bus	Under Voltage	11.000	kV	8.21	74.7	3-Phase
Bus127	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus128	Bus	Under Voltage	11.000	kV	8.21	74.7	3-Phase
Bus129	Bus	Under Voltage	11.000	kV	8.21	74.7	3-Phase
Bus13	Bus	Under Voltage	11.000	kV	9.56	86.9	3-Phase
Bus130	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus131	Bus	Under Voltage	33.000	kV	29.54	89.5	3-Phase
Bus132	Bus	Under Voltage	11.000	kV	7.61	69.1	3-Phase
Bus133	Bus	Under Voltage	33.000	kV	29.53	89.5	3-Phase
Bus134	Bus	Under Voltage	33.000	kV	29.53	89.5	3-Phase
Bus135	Bus	Under Voltage	33.000	kV	29.51	89.4	3-Phase
Bus136	Bus	Under Voltage	33.000	kV	29.51	89.4	3-Phase
Bus137	Bus	Under Voltage	11.000	kV	8.88	80.8	3-Phase
Bus138	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus139	Bus	Under Voltage	11.000	kV	8.87	80.7	3-Phase
Bus14	Bus	Under Voltage	11.000	kV	9.53	86.7	3-Phase
Bus140	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus141	Bus	Under Voltage	11.000	kV	8.98	81.6	3-Phase
Bus142	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus143	Bus	Under Voltage	11.000	kV	8.82	80.2	3-Phase
Bus144	Bus	Under Voltage	11.000	kV	8.82	80.2	3-Phase
Bus145	Bus	Under Voltage	11.000	kV	8.91	81.0	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus146	Bus	Under Voltage	11.000	kV	8.796	80.0	3-Phase
Bus147	Bus	Under Voltage	11.000	kV	8.79	79.9	3-Phase
Bus148	Bus	Under Voltage	11.000	kV	8.79	79.9	3-Phase
Bus149	Bus	Under Voltage	11.000	kV	7.84	71.3	3-Phase
Bus15	Bus	Under Voltage	33.000	kV	29.50	89.4	3-Phase
Bus150	Bus	Under Voltage	11.000	kV	8.77	79.7	3-Phase
Bus151	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus152	Bus	Under Voltage	11.000	kV	8.76	79.7	3-Phase
Bus153	Bus	Under Voltage	11.000	kV	8.76	79.7	3-Phase
Bus154	Bus	Under Voltage	11.000	kV	8.76	79.6	3-Phase
Bus155	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus156	Bus	Under Voltage	11.000	kV	7.60	69.1	3-Phase
Bus157	Bus	Under Voltage	11.000	kV	8.94	81.3	3-Phase
Bus158	Bus	Under Voltage	11.000	kV	8.91	81.0	3-Phase
Bus159	Bus	Under Voltage	11.000	kV	8.89	80.9	3-Phase
Bus16	Bus	Under Voltage	11.000	kV	9.53	86.7	3-Phase
Bus160	Bus	Under Voltage	11.000	kV	8.91	81.0	3-Phase
Bus161	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus162	Bus	Under Voltage	11.000	kV	7.58	68.9	3-Phase
Bus163	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus164	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus165	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus166	Bus	Under Voltage	11.000	kV	7.58	68.9	3-Phase
Bus167	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus168	Bus	Under Voltage	11.000	kV	6.92	62.9	3-Phase
Bus169	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus17	Bus	Under Voltage	11.000	kV	9.50	86.4	3-Phase
Bus170	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus171	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus172	Bus	Under Voltage	11.000	kV	8.89	80.8	3-Phase
Bus173	Bus	Under Voltage	11.000	kV	8.24	74.9	3-Phase
Bus174	Bus	Under Voltage	11.000	kV	7.52	68.4	3-Phase
Bus175	Bus	Under Voltage	11.000	kV	7.11	64.6	3-Phase
Bus176	Bus	Under Voltage	11.000	kV	7.38	67.1	3-Phase
Bus177	Bus	Under Voltage	11.000	kV	7.52	68.4	3-Phase
Bus178	Bus	Under Voltage	11.000	kV	7.51	68.3	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus179	Bus	Under Voltage	11.000	kV	6.940	63.1	3-Phase
Bus18	Bus	Under Voltage	11.000	kV	9.50	86.3	3-Phase
Bus180	Bus	Under Voltage	11.000	kV	7.52	68.4	3-Phase
Bus181	Bus	Under Voltage	11.000	kV	7.52	68.4	3-Phase
Bus182	Bus	Under Voltage	11.000	kV	7.52	68.3	3-Phase
Bus183	Bus	Under Voltage	11.000	kV	7.50	68.2	3-Phase
Bus184	Bus	Under Voltage	11.000	kV	6.91	62.9	3-Phase
Bus185	Bus	Under Voltage	11.000	kV	7.50	68.2	3-Phase
Bus186	Bus	Under Voltage	11.000	kV	7.50	68.2	3-Phase
Bus187	Bus	Under Voltage	11.000	kV	7.50	68.2	3-Phase
Bus188	Bus	Under Voltage	11.000	kV	7.50	68.1	3-Phase
Bus189	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus19	Bus	Under Voltage	11.000	kV	9.50	86.3	3-Phase
Bus190	Bus	Under Voltage	11.000	kV	7.24	65.8	3-Phase
Bus191	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus192	Bus	Under Voltage	11.000	kV	7.14	64.9	3-Phase
Bus194	Bus	Under Voltage	11.000	kV	7.08	64.3	3-Phase
Bus195	Bus	Under Voltage	11.000	kV	6.91	62.9	3-Phase
Bus196	Bus	Under Voltage	11.000	kV	7.12	64.7	3-Phase
Bus197	Bus	Under Voltage	11.000	kV	7.10	64.5	3-Phase
Bus198	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus199	Bus	Under Voltage	11.000	kV	7.09	64.5	3-Phase
Bus20	Bus	Under Voltage	11.000	kV	9.49	86.3	3-Phase
Bus200	Bus	Under Voltage	11.000	kV	7.09	64.4	3-Phase
Bus201	Bus	Under Voltage	11.000	kV	7.09	64.4	3-Phase
Bus202	Bus	Under Voltage	11.000	kV	7.07	64.3	3-Phase
Bus203	Bus	Under Voltage	11.000	kV	7.04	64.0	3-Phase
Bus204	Bus	Under Voltage	11.000	kV	6.92	62.9	3-Phase
Bus205	Bus	Under Voltage	11.000	kV	7.03	63.9	3-Phase
Bus206	Bus	Under Voltage	11.000	kV	7.03	63.9	3-Phase
Bus207	Bus	Under Voltage	11.000	kV	7.03	63.9	3-Phase
Bus208	Bus	Under Voltage	11.000	kV	6.87	62.4	3-Phase
Bus209	Bus	Under Voltage	11.000	kV	6.99	63.6	3-Phase
Bus21	Bus	Under Voltage	11.000	kV	9.50	86.3	3-Phase
Bus210	Bus	Under Voltage	33.000	kV	28.86	87.5	3-Phase
Bus211	Bus	Under Voltage	11.000	kV	6.98	63.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus213	Bus	Under Voltage	33.000	kV	28.808	87.3	3-Phase
Bus214	Bus	Under Voltage	33.000	kV	28.81	87.3	3-Phase
Bus215	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus216	Bus	Under Voltage	11.000	kV	6.90	62.8	3-Phase
Bus216/Rangjung	Bus	Under Voltage	33.000	kV	28.60	86.7	3-Phase
Bus217	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus218	Bus	Under Voltage	11.000	kV	6.79	61.8	3-Phase
Bus219	Bus	Under Voltage	11.000	kV	6.79	61.8	3-Phase
Bus22	Bus	Under Voltage	11.000	kV	9.53	86.7	3-Phase
Bus220	Bus	Under Voltage	11.000	kV	6.79	61.7	3-Phase
Bus221	Bus	Under Voltage	33.000	kV	28.47	86.3	3-Phase
Bus222	Bus	Under Voltage	11.000	kV	6.79	61.7	3-Phase
Bus223	Bus	Under Voltage	33.000	kV	28.47	86.3	3-Phase
Bus224	Bus	Under Voltage	33.000	kV	28.47	86.3	3-Phase
Bus226	Bus	Under Voltage	33.000	kV	28.47	86.3	3-Phase
Bus227	Bus	Under Voltage	33.000	kV	28.47	86.3	3-Phase
Bus228	Bus	Under Voltage	11.000	kV	6.74	61.3	3-Phase
Bus229	Bus	Under Voltage	33.000	kV	28.46	86.2	3-Phase
Bus23	Bus	Under Voltage	11.000	kV	8.95	81.4	3-Phase
Bus230	Bus	Under Voltage	33.000	kV	28.46	86.2	3-Phase
Bus231	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus232	Bus	Under Voltage	33.000	kV	28.46	86.2	3-Phase
Bus233	Bus	Under Voltage	11.000	kV	6.72	61.1	3-Phase
Bus234	Bus	Under Voltage	33.000	kV	28.45	86.2	3-Phase
Bus235	Bus	Under Voltage	33.000	kV	28.45	86.2	3-Phase
Bus236	Bus	Under Voltage	11.000	kV	6.71	61.0	3-Phase
Bus237	Bus	Under Voltage	33.000	kV	28.45	86.2	3-Phase
Bus238	Bus	Under Voltage	11.000	kV	6.71	61.0	3-Phase
Bus239	Bus	Under Voltage	33.000	kV	28.45	86.2	3-Phase
Bus24	Bus	Under Voltage	11.000	kV	9.53	86.7	3-Phase
Bus240/Rangjung 33kV Bus	Bus	Under Voltage	33.000	kV	20.90	63.3	3-Phase
Bus241	Bus	Under Voltage	33.000	kV	28.45	86.2	3-Phase
Bus242	Bus	Under Voltage	11.000	kV	6.71	61.0	3-Phase
Bus243	Bus	Under Voltage	33.000	kV	28.43	86.1	3-Phase
Bus244	Bus	Under Voltage	11.000	kV	6.71	61.0	3-Phase
Bus245	Bus	Under Voltage	33.000	kV	28.42	86.1	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus246	Bus	Under Voltage	33.000	kV	28.425	86.1	3-Phase
Bus247	Bus	Under Voltage	33.000	kV	28.41	86.1	3-Phase
Bus248	Bus	Under Voltage	33.000	kV	28.42	86.1	3-Phase
Bus249	Bus	Under Voltage	11.000	kV	6.92	62.9	3-Phase
Bus25	Bus	Under Voltage	11.000	kV	9.53	86.7	3-Phase
Bus250	Bus	Under Voltage	33.000	kV	28.53	86.4	3-Phase
Bus251	Bus	Under Voltage	11.000	kV	6.64	60.4	3-Phase
Bus252	Bus	Under Voltage	33.000	kV	28.48	86.3	3-Phase
Bus253	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus254	Bus	Under Voltage	11.000	kV	6.64	60.4	3-Phase
Bus255	Bus	Under Voltage	33.000	kV	28.48	86.3	3-Phase
Bus256	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus257	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus258	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus259	Bus	Under Voltage	11.000	kV	6.60	60.0	3-Phase
Bus26	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus260	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus261	Bus	Under Voltage	11.000	kV	6.60	60.0	3-Phase
Bus262	Bus	Under Voltage	33.000	kV	28.54	86.5	3-Phase
Bus264	Bus	Under Voltage	33.000	kV	28.53	86.5	3-Phase
Bus265	Bus	Under Voltage	33.000	kV	28.53	86.5	3-Phase
Bus266	Bus	Under Voltage	11.000	kV	6.60	60.0	3-Phase
Bus267	Bus	Under Voltage	33.000	kV	28.53	86.5	3-Phase
Bus268	Bus	Under Voltage	11.000	kV	6.60	60.0	3-Phase
Bus269	Bus	Under Voltage	33.000	kV	28.53	86.4	3-Phase
Bus27	Bus	Under Voltage	11.000	kV	9.53	86.6	3-Phase
Bus270	Bus	Under Voltage	11.000	kV	6.89	62.7	3-Phase
Bus271	Bus	Under Voltage	33.000	kV	28.53	86.4	3-Phase
Bus272	Bus	Under Voltage	11.000	kV	6.55	59.5	3-Phase
Bus273	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus274	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus275	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus276	Bus	Under Voltage	11.000	kV	6.55	59.5	3-Phase
Bus277	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus279	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus28	Bus	Under Voltage	11.000	kV	9.52	86.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus280	Bus	Under Voltage	11.000	kV	6.543	59.5	3-Phase
Bus281	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus282	Bus	Under Voltage	11.000	kV	6.88	62.6	3-Phase
Bus283	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus284	Bus	Under Voltage	33.000	kV	28.52	86.4	3-Phase
Bus285	Bus	Under Voltage	11.000	kV	6.54	59.5	3-Phase
Bus286	Bus	Under Voltage	6.600	kV	4.22	64.0	3-Phase
Bus287	Bus	Under Voltage	11.000	kV	6.54	59.4	3-Phase
Bus288	Bus	Under Voltage	6.600	kV	4.22	64.0	3-Phase
Bus289	Bus	Under Voltage	11.000	kV	6.53	59.4	3-Phase
Bus29	Bus	Under Voltage	11.000	kV	9.52	86.6	3-Phase
Bus290	Bus	Under Voltage	11.000	kV	6.97	63.3	3-Phase
Bus291	Bus	Under Voltage	11.000	kV	6.96	63.2	3-Phase
Bus292	Bus	Under Voltage	11.000	kV	6.97	63.3	3-Phase
Bus293	Bus	Under Voltage	11.000	kV	6.87	62.5	3-Phase
Bus294	Bus	Under Voltage	11.000	kV	6.92	62.9	3-Phase
Bus295	Bus	Under Voltage	11.000	kV	6.54	59.5	3-Phase
Bus296	Bus	Under Voltage	11.000	kV	6.54	59.5	3-Phase
Bus298	Bus	Under Voltage	11.000	kV	6.54	59.4	3-Phase
Bus299	Bus	Under Voltage	11.000	kV	6.54	59.4	3-Phase
Bus30	Bus	Under Voltage	11.000	kV	8.91	81.0	3-Phase
Bus300	Bus	Under Voltage	11.000	kV	6.54	59.4	3-Phase
Bus301	Bus	Under Voltage	11.000	kV	6.88	62.6	3-Phase
Bus302	Bus	Under Voltage	11.000	kV	6.53	59.3	3-Phase
Bus303	Bus	Under Voltage	11.000	kV	6.53	59.3	3-Phase
Bus305	Bus	Under Voltage	11.000	kV	6.53	59.3	3-Phase
Bus306	Bus	Under Voltage	11.000	kV	6.53	59.3	3-Phase
Bus307	Bus	Under Voltage	11.000	kV	6.88	62.5	3-Phase
Bus308	Bus	Under Voltage	11.000	kV	6.53	59.3	3-Phase
Bus309	Bus	Under Voltage	11.000	kV	6.88	62.5	3-Phase
Bus31	Bus	Under Voltage	11.000	kV	9.51	86.5	3-Phase
Bus310	Bus	Under Voltage	11.000	kV	6.52	59.3	3-Phase
Bus311	Bus	Under Voltage	11.000	kV	6.52	59.3	3-Phase
Bus312	Bus	Under Voltage	11.000	kV	6.52	59.3	3-Phase
Bus314	Bus	Under Voltage	11.000	kV	6.52	59.3	3-Phase
Bus315	Bus	Under Voltage	11.000	kV	6.52	59.3	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus316	Bus	Under Voltage	11.000	kV	6.912	62.8	3-Phase
Bus317	Bus	Under Voltage	11.000	kV	6.91	62.8	3-Phase
Bus319	Bus	Under Voltage	11.000	kV	6.88	62.5	3-Phase
Bus32	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus321	Bus	Under Voltage	11.000	kV	6.86	62.4	3-Phase
Bus322	Bus	Under Voltage	11.000	kV	6.86	62.3	3-Phase
Bus324	Bus	Under Voltage	11.000	kV	6.84	62.2	3-Phase
Bus326	Bus	Under Voltage	11.000	kV	6.83	62.1	3-Phase
Bus327	Bus	Under Voltage	11.000	kV	6.83	62.0	3-Phase
Bus329	Bus	Under Voltage	11.000	kV	6.84	62.2	3-Phase
Bus33	Bus	Under Voltage	11.000	kV	9.51	86.4	3-Phase
Bus331	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus332	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus334	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus335	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus336	Bus	Under Voltage	11.000	kV	6.82	62.0	3-Phase
Bus34	Bus	Under Voltage	11.000	kV	9.50	86.4	3-Phase
Bus35	Bus	Under Voltage	11.000	kV	9.51	86.4	3-Phase
Bus36	Bus	Under Voltage	11.000	kV	8.23	74.8	3-Phase
Bus36 Chenary SS	Bus	Under Voltage	33.000	kV	28.95	87.7	3-Phase
Bus37	Bus	Under Voltage	11.000	kV	9.52	86.6	3-Phase
Bus374	Bus	Under Voltage	33.000	kV	29.04	88.0	3-Phase
Bus378	Bus	Under Voltage	33.000	kV	29.04	88.0	3-Phase
Bus38	Bus	Under Voltage	11.000	kV	9.62	87.4	3-Phase
Bus39	Bus	Under Voltage	11.000	kV	9.62	87.4	3-Phase
Bus40	Bus	Under Voltage	11.000	kV	9.52	86.6	3-Phase
Bus41	Bus	Under Voltage	11.000	kV	9.44	85.9	3-Phase
Bus42	Bus	Under Voltage	11.000	kV	9.45	85.9	3-Phase
Bus43	Bus	Under Voltage	11.000	kV	8.86	80.5	3-Phase
Bus44	Bus	Under Voltage	11.000	kV	9.42	85.6	3-Phase
Bus45	Bus	Under Voltage	11.000	kV	9.42	85.6	3-Phase
Bus46	Bus	Under Voltage	11.000	kV	8.86	80.5	3-Phase
Bus47	Bus	Under Voltage	11.000	kV	9.37	85.2	3-Phase
Bus48	Bus	Under Voltage	11.000	kV	9.37	85.2	3-Phase
Bus49	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus5	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus50	Bus	Under Voltage	11.000	kV	9.302	84.6	3-Phase
Bus51	Bus	Under Voltage	11.000	kV	9.30	84.5	3-Phase
Bus52	Bus	Under Voltage	11.000	kV	8.81	80.1	3-Phase
Bus53	Bus	Under Voltage	11.000	kV	9.29	84.4	3-Phase
Bus54	Bus	Under Voltage	11.000	kV	9.27	84.3	3-Phase
Bus55	Bus	Under Voltage	11.000	kV	8.80	80.0	3-Phase
Bus56	Bus	Under Voltage	11.000	kV	9.27	84.3	3-Phase
Bus57	Bus	Under Voltage	11.000	kV	9.27	84.3	3-Phase
Bus58	Bus	Under Voltage	11.000	kV	8.98	81.6	3-Phase
Bus58 at Chenary	Bus	Under Voltage	33.000	kV	29.41	89.1	3-Phase
Bus59	Bus	Under Voltage	11.000	kV	9.27	84.3	3-Phase
Bus6	Bus	Under Voltage	11.000	kV	9.56	86.9	3-Phase
Bus60	Bus	Under Voltage	11.000	kV	9.27	84.2	3-Phase
Bus61	Bus	Under Voltage	11.000	kV	9.27	84.3	3-Phase
Bus62	Bus	Under Voltage	11.000	kV	8.78	79.8	3-Phase
Bus63	Bus	Under Voltage	11.000	kV	9.19	83.6	3-Phase
Bus64	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus65	Bus	Under Voltage	11.000	kV	9.18	83.4	3-Phase
Bus66	Bus	Under Voltage	11.000	kV	9.18	83.4	3-Phase
Bus67	Bus	Under Voltage	11.000	kV	8.72	79.3	3-Phase
Bus68	Bus	Under Voltage	11.000	kV	9.16	83.2	3-Phase
Bus69	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus7	Bus	Under Voltage	11.000	kV	9.63	87.5	3-Phase
Bus70	Bus	Under Voltage	11.000	kV	9.15	83.2	3-Phase
Bus71	Bus	Under Voltage	11.000	kV	9.14	83.1	3-Phase
Bus72	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus73	Bus	Under Voltage	11.000	kV	9.14	83.1	3-Phase
Bus74	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus75	Bus	Under Voltage	11.000	kV	9.14	83.0	3-Phase
Bus76	Bus	Under Voltage	11.000	kV	9.13	83.0	3-Phase
Bus77	Bus	Under Voltage	11.000	kV	9.13	83.0	3-Phase
Bus78	Bus	Under Voltage	11.000	kV	8.68	78.9	3-Phase
Bus79	Bus	Under Voltage	11.000	kV	8.67	78.8	3-Phase
Bus8	Bus	Under Voltage	11.000	kV	9.60	87.3	3-Phase
Bus80	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus81	Bus	Under Voltage	11.000	kV	8.60	78.2	3-Phase

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus82	Bus	Under Voltage	11.000	kV	8.502	77.3	3-Phase
Bus83	Bus	Under Voltage	11.000	kV	8.50	77.3	3-Phase
Bus84	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus85	Bus	Under Voltage	11.000	kV	8.36	76.0	3-Phase
Bus86	Bus	Under Voltage	11.000	kV	8.98	81.6	3-Phase
Bus87	Bus	Under Voltage	11.000	kV	8.34	75.8	3-Phase
Bus88	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus89	Bus	Under Voltage	11.000	kV	8.32	75.6	3-Phase
Bus9	Bus	Under Voltage	11.000	kV	9.57	87.0	3-Phase
Bus90	Bus	Under Voltage	11.000	kV	8.32	75.6	3-Phase
Bus91	Bus	Under Voltage	11.000	kV	8.97	81.6	3-Phase
Bus92	Bus	Under Voltage	11.000	kV	8.30	75.5	3-Phase
Bus93	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus94	Bus	Under Voltage	11.000	kV	8.30	75.4	3-Phase
Bus95	Bus	Under Voltage	11.000	kV	8.29	75.4	3-Phase
Bus96	Bus	Under Voltage	11.000	kV	8.90	80.9	3-Phase
Bus97	Bus	Under Voltage	11.000	kV	8.30	75.5	3-Phase
Bus98	Bus	Under Voltage	33.000	kV	29.69	90.0	3-Phase
Bus99	Bus	Under Voltage	11.000	kV	8.29	75.4	3-Phase
Chenary T1	Transformer	Overload	2.500	MVA	2.62	104.8	3-Phase
Chenary T2	Transformer	Overload	2.500	MVA	2.62	104.8	3-Phase
T1	Transformer	Overload	5.000	MVA	9.56	191.2	3-Phase
T2	Transformer	Overload	5.000	MVA	9.56	191.2	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus2 Khangma	Bus	Under Voltage	33.000	kV	29.778	90.2	3-Phase
Bus3	Bus	Under Voltage	33.000	kV	29.78	90.2	3-Phase
Bus356	Bus	Under Voltage	11.000	kV	10.35	94.1	3-Phase
Bus359	Bus	Under Voltage	11.000	kV	10.33	93.9	3-Phase
Bus360	Bus	Under Voltage	11.000	kV	10.33	93.9	3-Phase
Bus362	Bus	Under Voltage	11.000	kV	10.32	93.8	3-Phase
Bus365	Bus	Under Voltage	11.000	kV	10.34	94.0	3-Phase
Bus367	Bus	Under Voltage	11.000	kV	10.29	93.5	3-Phase
Bus369	Bus	Under Voltage	11.000	kV	10.20	92.7	3-Phase
Bus371	Bus	Under Voltage	11.000	kV	10.19	92.7	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus373	Bus	Under Voltage	11.000	kV	10.169	92.4	3-Phase
Bus375	Bus	Under Voltage	11.000	kV	10.14	92.1	3-Phase
Bus377	Bus	Under Voltage	11.000	kV	10.16	92.4	3-Phase
Bus379	Bus	Under Voltage	11.000	kV	10.15	92.3	3-Phase
Bus381	Bus	Under Voltage	11.000	kV	10.15	92.2	3-Phase
Bus382	Bus	Under Voltage	11.000	kV	10.14	92.2	3-Phase
Bus384	Bus	Under Voltage	11.000	kV	10.15	92.2	3-Phase
Bus385	Bus	Under Voltage	11.000	kV	10.15	92.2	3-Phase
Bus387	Bus	Under Voltage	11.000	kV	10.08	91.6	3-Phase
Bus388	Bus	Under Voltage	11.000	kV	10.08	91.6	3-Phase
Bus390	Bus	Under Voltage	11.000	kV	10.05	91.4	3-Phase
Bus392	Bus	Under Voltage	11.000	kV	10.04	91.3	3-Phase
Bus393	Bus	Under Voltage	11.000	kV	10.04	91.3	3-Phase
Bus395	Bus	Under Voltage	11.000	kV	10.03	91.2	3-Phase
Bus396	Bus	Under Voltage	11.000	kV	10.03	91.2	3-Phase
Bus398	Bus	Under Voltage	11.000	kV	10.02	91.1	3-Phase
Bus399	Bus	Under Voltage	11.000	kV	10.02	91.1	3-Phase
Bus401	Bus	Under Voltage	11.000	kV	10.06	91.5	3-Phase
Bus403	Bus	Under Voltage	11.000	kV	10.04	91.3	3-Phase
Bus405	Bus	Under Voltage	11.000	kV	10.01	91.0	3-Phase
Bus407	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus409	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus410	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus411	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus413	Bus	Under Voltage	11.000	kV	10.00	90.9	3-Phase
Bus415	Bus	Under Voltage	11.000	kV	9.96	90.6	3-Phase
Bus417	Bus	Under Voltage	11.000	kV	9.95	90.5	3-Phase
Bus419	Bus	Under Voltage	11.000	kV	9.95	90.4	3-Phase
Bus420	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus422	Bus	Under Voltage	11.000	kV	9.94	90.4	3-Phase
Bus423	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus426	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus428	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus430	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus432	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus433	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase

Marginal Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus435	Bus	Under Voltage	11.000	kV	9.928	90.3	3-Phase
Bus437	Bus	Under Voltage	11.000	kV	9.93	90.2	3-Phase
Bus440	Bus	Under Voltage	11.000	kV	9.92	90.2	3-Phase
Bus441	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus442	Bus	Under Voltage	11.000	kV	9.93	90.3	3-Phase
Bus457	Bus	Under Voltage	11.000	kV	10.45	95.0	3-Phase
Bus459	Bus	Under Voltage	11.000	kV	10.44	94.9	3-Phase
Bus461	Bus	Under Voltage	11.000	kV	10.43	94.9	3-Phase
Bus463	Bus	Under Voltage	11.000	kV	10.42	94.7	3-Phase
Bus465	Bus	Under Voltage	11.000	kV	10.42	94.7	3-Phase
Bus467	Bus	Under Voltage	11.000	kV	10.42	94.7	3-Phase
Bus469	Bus	Under Voltage	11.000	kV	10.42	94.7	3-Phase
Bus470	Bus	Under Voltage	11.000	kV	10.42	94.7	3-Phase
Bus472	Bus	Under Voltage	11.000	kV	10.40	94.6	3-Phase
Bus474	Bus	Under Voltage	11.000	kV	10.40	94.5	3-Phase
Bus475	Bus	Under Voltage	11.000	kV	10.40	94.5	3-Phase
Bus477	Bus	Under Voltage	11.000	kV	10.40	94.5	3-Phase
Bus479	Bus	Under Voltage	11.000	kV	10.39	94.5	3-Phase
Bus481	Bus	Under Voltage	11.000	kV	10.39	94.4	3-Phase
Bus483	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus485	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus486	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus487	Bus	Under Voltage	11.000	kV	10.38	94.4	3-Phase
Bus489	Bus	Under Voltage	11.000	kV	10.31	93.8	3-Phase
Bus490	Bus	Under Voltage	11.000	kV	10.31	93.7	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	16.271	13.998	21.464	75.81 Lagging
Source (Non-Swing Buses):	1.600	0.000	1.600	100.00 Lagging
Total Demand:	17.871	13.998	22.701	78.72 Lagging
Total Motor Load:	4.442	2.753	5.226	85.00 Lagging
Total Static Load:	12.128	7.516	14.268	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	1.301	3.729		
System Mismatch:	0.000	0.000		

Number of Iterations: 4

Annexure 5- Feeder Wise Reliability Indices

Feeder Name: 33kV Chenary Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line													0
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire					1								1
12	Preventive Maintenance of Line/LBS/GO/ARCB													0
13	Preventive Maintenance of substation/Switchyard							2						2
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown													0
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault			2	3	1								6
19	Trace of fault on line													0
20	Because of Bird/Animals							1						1
21	Close and Open of GO/LBS													0
	SAIFI			**0.021**	**0.445**	**0.742**		**0.741**						**1.948**
	SAIDI			**0.156**	**0.156**	**1.295**		**0.456**						**2.064**

Feeder Name: 33kV Chenary Feeder													FY:	2017
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage							1						1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line													0
9	RoW Clearing								5					5
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB											1		1
13	Preventive Maintenance of substation/Switchyard				2									2
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown			1										1
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault						1							1
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI			**0.380**	**0.380**		**0.380**	**0.380**	**0.760**			**0.380**		**2.660**
	SAIDI			**0.090**	**0.410**		**0.090**	**0.090**	**1.460**			**0.090**		**2.230**

Feeder Name: 33kV Udzrong Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	3	1	2	2	1								9
2	Line Jumpering													0
3	Collaps of Pole-Breakdown						1							1
4	Snap of Conductor													0
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance	1		1										2
7	Ligtining & Strom/Rain													0
8	Tree/branch fall on line	1												1
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire					1			1					2
12	Preventive Maintenance of Line/LBS/GO/ARCB						3							3
13	Preventive Maintenance of substation/Switchyard											1		1
14	Breakdown Maintenance of Line/LBS/GO/ARCB		1											1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown		1											1
17	Adhoc Shutdown (Tapping, Emergency request)				1	1	1							3
18	Momentary/Traisent fault						1							1
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**0.150**	**0.110**	**0.160**	**0.160**	**0.160**	**0.260**		**0.050**			**0.050**		**1.1**
	SAIDI	**0.037**	**0.025**	**0.168**	**0.059**	**0.140**	**0.829**		**0.027**			**0.296**		**1.581**

Feeder Name: 33kV Udzrong Feeder													FY:	2017
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	2		3	7		2	4	4	6	4	1	5	38
2	Line Jumpering	2		3			6	2	1		5	1		20
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage				3							2	1	6
6	Puncture of LA/LA Maintenance			1			1		1			1		4
7	Ligtining & Strom							2						2
8	Tree/branch fall on line						1	2	1	1				5
9	RoW Clearing						9				5			14
10	Land Slide													0
11	Forest fire	1	1											2
12	Preventive Maintenance of Line/LBS/GO/ARCB		1			1		5	3				2	12
13	Preventive Maintenance of substation/Switchyard						1		1					2
14	Breakdown Maintenance of Line/LBS/GO/ARCB									1		1		2
15	Breakdown Maintenance of Substation/Switchyard				2									2
16	SMD Planned shutdown			1										1
17	Adhoc Shutdown (Tapping, Emergency request)	2	1							4	4	3		14
18	Momentary/Traisent fault					1		2						3
19	Trace of fault on line					1	1							2
20	Because of Bird/Animals							1						1
21	Close and Open of GO/LBS							2						2
	SAIFI	**0.061**	**0.060**	**0.770**	**0.650**	**0.170**	**1.340**	**0.370**	**0.170**	**0.300**	**0.640**	**0.440**	**0.290**	**5.261**
	SAIDI	**0.043**	**0.025**	**2.830**	**0.535**	**0.372**	**2.803**	**0.636**	**0.646**	**0.880**	**1.053**	**1.296**	**0.283**	**11.402**

Feeder Name: 11kV Younphula Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace											1		1
2	Line Jumpering				1									1
3	Collaps of Pole-Breakdown							1						1
4	Snap of Conductor							1						1
5	Puncture of insulator/Leakage							1						1
6	Puncture of LA/LA Maintenance											2		2
7	Ligtining /Strom/Rain						1							1
8	Tree/branch fall on line							1						1
9	RoW Clearing			1	1									2
10	Land Slide								1					1
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB								1		2			3
13	Preventive Maintenance of substation/Switchyard								1					1
14	Breakdown Maintenance of Line/LBS/GO/ARCB										1			1
15	Breakdown Maintenance of Substation/Switchyard										1			1
16	SMD Planned shutdown		1											1
17	Adhoc Shutdown (Tapping, Emergency request)										1			1
18	Momentary/Traisent fault						1							1
19	Trace of fault on line								1					1
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS										1			1
	SAIFI		**0.058**	**0.058**	**0.116**		**0.058**	**0.058**	**0.116**		**0.088**	**0.078**		**0.632**
	SAIDI		**0.139**	**0.139**	**0.153**		**0.139**	**0.139**	**0.153**		**0.057**	**0.033**		**0.9514**

Feeder Name: 11kV Younphula Feeder													FY:	2017
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering		1											1
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain							1						1
8	Tree/branch fall on line				1									1
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB				1		1			7	5			14
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown			1										1
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault					1								1
19	Trace of fault on line	1												1
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**0.050**	**0.010**	**0.010**	**0.100**	**0.060**	**0.060**	**0.060**		**0.060**	**0.350**			**0.76**
	SAIDI	**0.020**	**0.007**	**0.007**	**0.177**	**0.020**	**0.023**	**0.137**		**0.137**	**1.240**			**1.768**

Feeder Name: 11kV Khaling Feeder													FY:	2018
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	2	4	8	4	2	1		1	1	1			24
2	Line Jumpering			1	2	3								6
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage					1								1
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain			1	1				2					4
8	Tree/branch fall on line			1										1
9	RoW Clearing					1	2	10						13
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB	2												2
13	Preventive Maintenance of substation/Switchyard				1						1	3		5
14	Breakdown Maintenance of Line/LBS/GO/ARCB													0
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown		1											1
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault													0
19	Trace of fault on line									2				2
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**0.140**	**0.160**	**0.320**	**3.420**	**0.280**	**0.118**	**0.276**	**0.118**	**0.118**	**0.088**	**0.078**		**5.1153**
	SAIDI	**0.040**	**0.040**	**0.100**	**0.465**	**0.103**	**0.033**	**0.268**	**0.026**	**0.041**	**0.057**	**0.033**		**1.206**

Feeder Name: 11kV Khaling Feeder													FY:	2017
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace	2	2	1	3	5	2	2	3	3		2		25
2	Line Jumpering		1	1	3	1	1				5	1	3	16
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage				2									2
6	Puncture of LA/LA Maintenance					2		3						5
7	Ligtining /Strom/Rain			10	4									14
8	Tree/branch fall on line		1							1				2
9	RoW Clearing						1	1	1					3
10	Land Slide													0
11	Forest fire											1		1
12	Preventive Maintenance of Line/LBS/GO/ARCB		1			1			1	1	2			6
13	Preventive Maintenance of substation/Switchyard										2	2		4
14	Breakdown Maintenance of Line/LBS/GO/ARCB							1					2	3
15	Breakdown Maintenance of Substation/Switchyard									1				1
16	SMD Planned shutdown			1										1
17	Adhoc Shutdown (Tapping, Emergency request)													0
18	Momentary/Traisent fault													0
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI	**0.110**	**0.460**	**0.330**	**0.040**	**0.090**	**0.080**	**0.300**	**0.240**	**0.200**	**0.510**	**0.310**	**0.290**	**2.96**
	SAIDI	**0.042**	**0.730**	**0.980**	**0.076**	**0.620**	**0.027**	**0.235**	**0.557**	**0.100**	**0.980**	**0.115**	**0.280**	**4.742**

Feeder Name: 11kV Chenary Feeder													FY:	2019
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain													0
8	Tree/branch fall on line													0
9	RoW Clearing													0
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB													0
13	Preventive Maintenance of substation/Switchyard													0
14	Breakdown Maintenance of Line/LBS/GO/ARCB								1					1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown		1											1
17	Adhoc Shutdown (Tapping, Emergency request)	1												1
18	Momentary/Traisent fault													0
19	Trace of fault on line													0
20	Because of Bird/Animals									1				1
21	Close and Open of GO/LBS													0
	SAIFI	**0.023**	**0.023**						**0.107**	**0.122**				**0.2744**
	SAIDI	**0.053**	**0.053**						**0.073**	**0.113**				**0.2907**

Feeder Name: 11kV Chenary Feeder													FY:	2017
Sl.No.	Cause of Outages	Frequency of Interuption (Times)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	HT fuse Replace													0
2	Line Jumpering													0
3	Collaps of Pole-Breakdown													0
4	Snap of Conductor													0
5	Puncture of insulator/Leakage													0
6	Puncture of LA/LA Maintenance													0
7	Ligtining /Strom/Rain			1										1
8	Tree/branch fall on line													0
9	RoW Clearing									1	1			2
10	Land Slide													0
11	Forest fire													0
12	Preventive Maintenance of Line/LBS/GO/ARCB										1	1		2
13	Preventive Maintenance of substation/Switchyard										1			1
14	Breakdown Maintenance of Line/LBS/GO/ARCB										1			1
15	Breakdown Maintenance of Substation/Switchyard													0
16	SMD Planned shutdown			1										1
17	Adhoc Shutdown (Tapping, Emergency request)											1	2	3
18	Momentary/Traisent fault													0
19	Trace of fault on line													0
20	Because of Bird/Animals													0
21	Close and Open of GO/LBS													0
	SAIFI			**0.040**						**0.120**	**1.930**	**0.250**	**0.290**	**2.63**
	SAIDI			**0.330**						**0.052**	**0.206**	**0.184**	**0.283**	**1.055**

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 of substation location	Capacity (	Existing		2025		2030		Remarks
			Peak Load (kVA)	% Loading	Peak Load(kVA)	% Loading	Peak Load(kVA)	% Loading	
O140	**11 kV Khaling-Wangrong Feeder**	**2965.00**	**664.43**		**1476.81**		**2153.80**	**7260.03**	
1	Transformer-Thrizor	25.00	3.03	12.14%	6.75	26.98%	9.84	39.35%	
2	Transformer-Chamzor	16.00	1.50	9.35%	3.33	20.79%	4.85	30.31%	
3	Transformer-Jeri School	16.00	3.13	19.59%	6.97	43.54%	10.16	63.50%	
4	Transformer-Jeri	63.00	14.23	22.59%	31.64	50.22%	46.14	73.24%	
5	Transformer-Lower Lemi	63.00	18.06	28.67%	40.15	63.72%	58.55	92.94%	
6	Transformer-Upper Lemi	63.00	20.00	31.75%	44.46	70.57%	64.84	102.91%	Over loaded
7	Transformer-Barshong I	63.00	11.82	18.77%	26.28	41.71%	38.33	60.83%	
8	Transformer-Barshong Gonpa (KTD)	125.00	42.09	33.67%	93.55	74.84%	136.43	109.14%	Over loaded
9	Transformer-Barshong II	16.00	0.99	6.21%	2.21	13.79%	3.22	20.12%	
10	Transformer-Gomchu	100.00	34.33	34.33%	76.31	76.31%	111.29	111.29%	Over loaded
11	Transformer-Dewang	50.00	16.83	33.66%	37.41	74.81%	54.55	109.11%	Over loaded
12	Transformer-Kholdung	63.00	17.58	27.90%	39.07	62.02%	56.98	90.44%	
13	Transformer-Dawzor	150.00	43.46	28.97%	96.60	64.40%	140.89	93.92%	
14	Transformer-KHSS Khaling	250.00	71.80	28.72%	159.58	63.83%	232.74	93.10%	
15	Transformer-Monangkhola	63.00	13.42	21.30%	29.82	47.34%	43.50	69.04%	
16	Transformer-Kharphu	63.00	16.87	26.78%	37.50	59.53%	54.70	86.82%	
17	Transformer-Lower Kurechelo	63.00	18.91	30.02%	42.04	66.73%	61.31	97.32%	
18	Transformer-Upper Kurechelo	63.00	15.79	25.07%	35.10	55.72%	51.19	81.26%	
19	Transformer-Darung	25.00	2.91	11.63%	6.46	25.84%	9.42	37.69%	
20	Transformer-Drupkhang	63.00	19.19	30.46%	42.65	67.69%	62.20	98.72%	
21	Transformer-Shachari	63.00	8.22	13.05%	18.28	29.01%	26.65	42.31%	
22	Transformer-Lumang	63.00	13.81	21.91%	30.69	48.71%	44.75	71.04%	
23	Transformer-Wamrong Bazzar	250.00	64.43	25.77%	143.21	57.29%	208.86	83.55%	
24	Transformer-Darna	63.00	9.59	15.22%	21.32	33.84%	31.09	49.35%	
25	Transformer-Gangzor Rubsey	25.00	5.64	22.57%	12.54	50.16%	18.29	73.15%	
26	Transformer-Dekhi	10.00	0.95	9.49%	2.11	21.10%	3.08	30.77%	
27	Transformer-Bemrey	25.00	5.69	22.78%	12.66	50.63%	18.46	73.84%	
28	Transformer-Chengrey	25.00	5.30	21.20%	11.78	47.12%	17.18	68.72%	
29	Transformer-Bamshing	25.00	4.07	16.28%	9.05	36.20%	13.20	52.79%	
30	Transformer-Dungmanma B	25.00	6.18	24.73%	13.74	54.97%	20.04	80.16%	
31	Transformer-Dungmanma A	25.00	5.93	23.70%	13.17	52.69%	19.21	76.84%	
32	Transformer-Dungmanma School	25.00	10.71	42.85%	23.81	95.24%	34.72	138.90%	Over loaded

33	Transformer-Regay	16.00	5.02	31.39%	11.16	69.76%	16.28	101.74%	Over loaded
34	Transformer-Leeza	16.00	1.63	10.19%	3.62	22.66%	5.29	33.04%	
35	Transformer-Ashamdelo	150.00	56.37	37.58%	125.29	83.53%	182.73	121.82%	Over loaded
36	Transformer-Khangma	125.00	23.64	18.91%	52.55	42.04%	76.64	61.31%	
37	Transformer-L/Yongphu Pam	63.00	8.19	13.00%	18.20	28.89%	26.55	42.14%	
38	Transformer-U/Yongphu Pam	63.00	10.08	16.00%	22.40	35.56%	32.68	51.87%	
39	Transformer-BBSC Yongphula	25.00	0.75	3.00%	1.67	6.67%	2.43	9.72%	
40	Transformer-Air Port	63.00	3.78	6.00%	8.40	13.34%	12.25	19.45%	
41	Transformer-K/mani	16.00	6.25	39.04%	13.88	86.77%	20.25	126.55%	Over loaded
42	Transformer-Bolphay	25.00	2.32	9.26%	5.15	20.59%	7.51	30.03%	
43	Transformer-Upper Cheya	63.00	9.45	15.00%	21.00	33.34%	30.63	48.62%	
44	Transformer-Lower Cheya	63.00	10.08	16.00%	22.40	35.56%	32.68	51.87%	
45	Transformer-Cheya Stone Quarry	250.00	0.38	0.15%	0.85	0.34%	1.25	0.50%	
O150	**11kV Younphul feeder**	**2065.00**	**371.07**		**501.88**		**610.89**		
1	Transformer-RLDC	63.00	31.37	49.80%	42.43	67.35%	51.65	81.98%	
2	Transformer-Imtrat	63.00	20.13	31.96%	27.23	43.22%	33.15	52.61%	
3	Transformer-S/Gonpa -I	63.00	25.34	40.23%	34.28	54.41%	41.72	66.23%	
4	Transformer-S/Gonpa -II	125.00	23.75	19.00%	32.12	25.70%	39.10	31.28%	
5	Transformer-Centenary College, Younphula	250.00	20.22	8.09%	27.35	10.94%	33.29	13.32%	
6	Transformer-B/Gonpa	63.00	33.31	52.87%	45.05	71.51%	54.84	87.04%	
7	Transformer-U/ Market,Kanglung	250.00	97.56	39.02%	131.95	52.78%	160.61	64.24%	
8	Transformer-Kanglung BHU	63.00	5.11	8.11%	6.91	10.97%	8.41	13.35%	
9	Transformer-Thragom	250.00	41.74	16.70%	56.46	22.58%	68.72	27.49%	
10	Transformer-Pangthang	125.00	28.75	23.00%	38.89	31.11%	47.33	37.87%	
11	Transformer-Girls Hostel,Campus-II, Kanglung College	750.00	43.77	5.84%	59.21	7.89%	72.07	9.61%	
O10	**11kV College/Chenary feeder**	**2020.00**	**481.24**		**745.56**		**965.82**		
1	Transformer-Manthong	250.00	115.74	46.30%	179.31	71.72%	232.29	92.92%	
2	Transformer-Jampheling	125.00	14.79	11.84%	22.92	18.34%	29.69	23.75%	
3	Transformer-Namla	63.00	8.78	13.93%	13.60	21.58%	17.61	27.96%	
4	Transformer-Tongmetong	63.00	22.18	35.21%	34.37	54.55%	44.52	70.67%	
5	Transformer-Rongthong	125.00	41.95	33.56%	64.99	51.99%	84.19	67.35%	
6	Transformer-College -I	750.00	149.38	19.92%	231.42	30.86%	299.79	39.97%	
7	Transformer-College -II	315.00	70.73	22.46%	109.59	34.79%	141.96	45.07%	
8	Transformer-Jargardung	16.00	1.28	8.00%	1.98	12.39%	2.57	16.06%	
9	Transformer-Telecome,Kanglung	250.00	47.53	19.01%	73.64	29.45%	95.39	38.16%	
10	Transformer-Kanglung Shadra	63.00	8.87	14.09%	13.75	21.82%	17.81	28.27%	
O170	**33kV Udzrong Feeder**	**8507.00**	**2360.77**		**3537.09**		**4517.37**		

1	Transformer-Jomtshang	63.00	7.56	12.00%	11.33	17.98%	14.47	22.96%	
2	Transformer-Bimshingmo	63.00	8.82	14.00%	13.21	20.98%	16.88	26.79%	
3	Transformer-Monka	63.00	16.39	26.02%	24.56	38.98%	31.36	49.78%	
4	Transformer-Phungchelo	63.00	2.91	4.62%	4.36	6.92%	5.57	8.84%	
5	Transformer-Gamtey	63.00	27.80	44.13%	41.66	66.12%	53.20	84.45%	
6	Transformer-Udzorong School	125.00	16.57	13.26%	24.83	19.86%	31.71	25.37%	
7	Transformer-U/Udzorong	63.00	1.91	3.03%	2.86	4.54%	3.65	5.80%	
8	Transformer-L/ Udzorong S/s.	63.00	0.29	0.46%	0.43	0.69%	0.55	0.88%	
9	Transformer-Drothphu	25.00	1.61	6.42%	2.41	9.62%	3.07	12.29%	
10	Transformer-U/Beypam	63.00	2.52	4.00%	3.78	5.99%	4.82	7.65%	
11	Transformer-L/Beypam	63.00	1.89	3.00%	2.83	4.49%	3.62	5.74%	
12	Transformer-Lhenchi	25.00	0.50	2.00%	0.75	3.00%	0.96	3.83%	
13	Transformer-Mankhar	25.00	1.25	5.00%	1.87	7.49%	2.39	9.57%	
14	Transformer-Gangkhar-A	25.00	1.50	6.00%	2.25	8.99%	2.87	11.48%	
15	Transformer-Gangkhar-B	25.00	1.00	4.00%	1.50	5.99%	1.91	7.65%	
16	Transformer-Domthi	125.00	8.75	7.00%	13.11	10.49%	16.74	13.39%	
17	Rolong Substation	100.00	20.00	20.00%	29.97	29.97%	38.27	38.27%	
18	Dremitse Lump Load, Mongar	7465.00	2239.50	30.00%	3355.40	44.95%	4285.32	57.41%	
O200	**11kV Town Feeder**	**3653.00**	**785.24**		**2962.08**		**3197.54**		
1	Transformer-KIPL Substation, Chenary	315.00	94.50	30.00%	356.47	113.17%	384.81	122.16%	Over loaded
2	Transformer-Dejung	500.00	125.00	25.00%	471.52	94.30%	509.01	101.80%	Over loaded
3	Transformer-Chazam Substation, Trashigang	25.00	11.25	45.00%	42.44	169.75%	45.81	183.24%	Over loaded
4	Transformer-Nongzor Substation, Trashigang	63.00	14.49	23.00%	54.66	86.76%	59.00	93.66%	
5	Transformer-T/gang Town	1000.00	240.00	24.00%	905.33	90.53%	977.29	97.73%	
6	Transformer-Royal Guest House	750.00	112.50	15.00%	424.37	56.58%	458.11	61.08%	
7	Transformer-TMS Package substation	750.00	150.00	20.00%	565.83	75.44%	610.81	81.44%	
8	Transformer-Dzong, Trashigang	250.00	37.50	15.00%	141.46	56.58%	152.70	61.08%	
O60	**11kV Pam Rangshikhar**	**839.00**	**202.17**		**762.62**		**823.25**		
1	Transformer-Colony Substation, Chenary	63.00	9.45	15.00%	35.65	56.58%	38.48	61.08%	
2	Transformer-Lower Pam	25.00	2.00	8.00%	7.54	30.18%	8.14	32.58%	
3	Transformer-Upper Pam	250.00	80.00	32.00%	301.78	120.71%	325.76	130.31%	Over loaded
4	Transformer-Bamridang	63.00	4.41	7.00%	16.64	26.41%	17.96	28.50%	
5	Transformer-Lengkhar	125.00	53.75	43.00%	202.76	162.20%	218.87	175.10%	Over loaded
6	Transformer-Rangshikhar	250.00	45.00	18.00%	169.75	67.90%	183.24	73.30%	
7	Transformer-Rangshikhar Gonpa	63.00	7.56	12.00%	28.52	45.27%	30.78	48.86%	
O30	**11kV Chenary-Rangjung**	**2893.00**	**439.83**		**1410.27**		**1791.03**		
1	Transformer-Samkhar	50.00	6.00	12.00%	19.24	38.48%	24.43	48.86%	

2	Transformer-Samcholing	63.00	8.82	14.00%	28.28	44.89%	35.92	57.01%	
3	Transformer-Bikhar	125.00	27.50	22.00%	88.17	70.54%	111.98	89.59%	
4	Transformer-Khabti Kadam	63.00	11.34	18.00%	36.36	57.71%	46.18	73.30%	
5	Transformer-Shachaphu Substation	25.00	3.00	12.00%	9.62	38.48%	12.22	48.86%	
6	Transformer-Phinary Pam Substation	25.00	3.50	14.00%	11.22	44.89%	14.25	57.01%	
7	Transformer-Khabti Village Substation	63.00	15.75	25.00%	50.50	80.16%	64.13	101.80%	Over loaded
8	Transformer-Lungten Zampa Substation	63.00	7.56	12.00%	24.24	38.48%	30.78	48.86%	
9	Transformer-Bikhar Gonpa Substation	63.00	9.45	15.00%	30.30	48.10%	38.48	61.08%	
10	Transformer-Yanang Brangsa Substation	63.00	5.04	8.00%	16.16	25.65%	20.52	32.58%	
11	Transformer-Patpa Gonpa Substation	63.00	3.78	6.00%	12.12	19.24%	15.39	24.43%	
12	Transformer-Taling Gonpa Substation	25.00	1.75	7.00%	5.61	22.44%	7.13	28.50%	
13	Transformer-Tamlung Substation	25.00	2.25	9.00%	7.21	28.86%	9.16	36.65%	
14	Transformer-Dramang	50.00	6.06	12.13%	19.44	38.89%	24.69	49.39%	
15	Transformer-Lower Galing	100.00	10.35	10.35%	33.17	33.17%	42.13	42.13%	
16	Transformer-Upper Galing	250.00	19.90	7.96%	63.81	25.52%	81.03	32.41%	
17	Transformer-Chutung	16.00	5.76	35.99%	18.47	115.41%	23.45	146.57%	Over loaded
18	Transformer-Thongphu	25.00	7.40	29.60%	23.73	94.92%	30.14	120.55%	Over loaded
19	Transformer-Gonsiphama	63.00	8.76	13.91%	28.09	44.59%	35.68	56.63%	
20	Transformer-Yobenang	50.00	10.67	21.34%	34.22	68.44%	43.46	86.91%	
21	Transformer-VTI, Buna	500.00	141.45	28.29%	453.54	90.71%	575.99	115.20%	Over loaded
22	Transformer-VTI, Buna	500.00	0.00	0.00%	0.00	0.00%	0.00	0.00%	
23	Transformer-Changmey	160.00	24.45	15.28%	78.39	49.00%	99.56	62.22%	
24	Transformer-Kharmi	63.00	11.94	18.96%	38.29	60.78%	48.63	77.19%	
25	Transformer-Intake/Renang	125.00	2.53	2.02%	8.10	6.48%	10.29	8.23%	
26	Transformer-BHU/PWD	25.00	9.34	37.34%	29.93	119.74%	38.02	152.07%	Over loaded
27	Transformer-Lower Market/FCB	250.00	75.49	30.19%	242.03	96.81%	307.38	122.95%	Over loaded
O40	**11kV Gongthung**	**693.00**	**122.37**		**392.36**		**498.30**		
	Transformer-Lifu,Gongthung	125.00	16.25	13.00%	52.10	41.68%	66.17	52.94%	
	Transformer-Drupdhey Substation, Gongthung	63.00	18.90	30.00%	60.60	96.19%	76.96	122.16%	Over loaded
	Transformer-Kharza,Gongthung	63.00	8.82	14.00%	28.28	44.89%	35.92	57.01%	
	Transformer-Ngambinang Substation, Gongthung	25.00	1.25	5.00%	4.01	16.03%	5.09	20.36%	
	Transformer-Aringtang Substation, Gongthung	25.00	1.00	4.00%	3.21	12.83%	4.07	16.29%	
	Transformer-Durung Substation, Gongthung	25.00	4.00	16.00%	12.83	51.30%	16.29	65.15%	
	Transformer-Shockhang Substation, Gongthung.	63.00	8.19	13.00%	26.26	41.68%	33.35	52.94%	
	Transformer-RNR Substation, Yangneer	25.00	2.25	9.00%	7.21	28.86%	9.16	36.65%	
	Transformer-Baynang Substation, Yangneer	25.00	4.75	19.00%	15.23	60.92%	19.34	77.37%	

	Transformer-Daliphangma Substation, Yangneer	63.00	18.27	29.00%	58.58	92.98%	74.40	118.09%	Over loaded
	Transformer-Khardung	25.00	3.00	12.00%	9.62	38.48%	12.22	48.86%	
	Transformer-Darjeeling	125.00	31.25	25.00%	100.20	80.16%	127.25	101.80%	Over loaded
	Transformer-Khari,Yangneer	25.00	3.00	12.00%	9.62	38.48%	12.22	48.86%	
	Transformer-Tshowong-Poktor	16.00	1.44	9.00%	4.62	28.86%	5.86	36.65%	
O80	**33kV Rangjung/Bartsham**	**2343.00**	**419.91**		**1346.37**		**1709.89**		
1	Transformer-Satshalu Substation, Trashigang	63.00	1.89	3.00%	6.06	9.62%	7.70	12.22%	
2	Transformer-Godhi Substation, Trashigang	250.00	7.50	3.00%	24.05	9.62%	30.54	12.22%	
3	Transformer-Kumung Substation, Bartsham	25.00	4.50	18.00%	14.43	57.71%	18.32	73.30%	
4	Transformer-Yangkhar Substation, Bartsham	63.00	7.56	12.00%	24.24	38.48%	30.78	48.86%	
5	Transformer-Mentshang Substation, Bartsham	63.00	12.60	20.00%	40.40	64.13%	51.31	81.44%	
6	Transformer-Masang Gorpo-I Substation, Bartsham	63.00	11.34	18.00%	36.36	57.71%	46.18	73.30%	
7	Transformer-Masang Gorpo-II Substation, Bartsham	63.00	8.82	14.00%	28.28	44.89%	35.92	57.01%	
8	Transformer-Chador Lhakang Substation, Bartsham	63.00	18.27	29.00%	58.58	92.98%	74.40	118.09%	Over loaded
9	Transformer-Baragonpa/Woosarang Substation, Bartsham	63.00	6.93	11.00%	22.22	35.27%	28.22	44.79%	
10	Transformer-Thangpoche/Zur Substation, Bartsham	63.00	6.30	10.00%	20.20	32.06%	25.65	40.72%	
11	Transformer-Bartsham Central School, Bartsham	250.00	72.50	29.00%	232.46	92.98%	295.22	118.09%	Over loaded
12	Transformer-SMCL Crusher	250.00	175.00	70.00%	561.11	224.45%	712.61	285.04%	Over loaded
13	Transformer-Dzongthung Substation, Bartsham	100.00	28.00	28.00%	89.78	89.78%	114.02	114.02%	Over loaded
14	Transformer-Ngalung Substation, Bartsham	100.00	13.00	13.00%	41.68	41.68%	52.94	52.94%	
15	Transformer-Cherbaling A	25.00	1.38	5.52%	4.42	17.70%	5.62	22.48%	
16	Transformer-Cherbaling B	25.00	1.15	4.60%	3.69	14.75%	4.68	18.73%	
17	Transformer-Gengo A	25.00	2.99	11.96%	9.59	38.35%	12.18	48.70%	
18	Transformer-Gengo B	25.00	2.77	11.09%	8.89	35.55%	11.29	45.15%	
19	Transformer-Gengo 3phase Xmer	63.00	3.69	5.85%	11.82	18.76%	15.01	23.82%	
20	Transformer-Gonorteng A	63.00	7.23	28.92%	23.18	92.73%	29.44	117.77%	Over loaded
21	Transformer-Gonorteng B	63.00	7.13	28.52%	22.86	91.46%	29.04	116.15%	Over loaded
22	Transformer-Murphey	25.00	0.92	3.68%	2.95	11.80%	3.75	14.99%	
23	Transformer-Bumlog	25.00	0.69	2.77%	2.22	8.89%	2.82	11.29%	
24	Transformer-Jhonkhar-A	25.00	0.69	2.76%	2.21	8.85%	2.81	11.24%	
25	Transformer-Jhonkhar-B	25.00	0.92	3.68%	2.95	11.80%	3.75	14.99%	
26	Transformer-Tholong	25.00	0.69	2.76%	2.21	8.85%	2.81	11.24%	
27	Transformer-Dhak	25.00	0.69	2.76%	2.21	8.85%	2.81	11.24%	
28	Transformer-Mandinang	25.00	0.23	0.92%	0.74	2.96%	0.94	3.76%	
29	Transformer-Lower Thrakthri	25.00	0.69	2.77%	2.22	8.89%	2.82	11.29%	
30	Transformer-Upper Thrakthri	25.00	0.69	2.76%	2.21	8.85%	2.81	11.24%	

31	Transformer-Lower Borangma	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
32	Transformer-Upper Borangma A	25.00	1.15	4.60%	3.69	14.75%	4.68	18.73%	
33	Transformer-Upper Borangma B	25.00	0.69	2.76%	2.21	8.85%	2.81	11.24%	
34	Transformer-Guest House	25.00	0.46	1.85%	1.48	5.93%	1.88	7.53%	
35	Transformer-Jabtsho A	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
36	Transformer-Jabtsho B	25.00	0.92	3.68%	2.95	11.80%	3.75	14.99%	
37	Transformer-Jabtsho C	25.00	1.15	4.60%	3.69	14.75%	4.68	18.73%	
38	Transformer-Jabtsho D	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
39	Transformer-Gyentsha	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
40	Transformer-Manirong A	25.00	1.15	4.60%	3.69	14.75%	4.68	18.73%	
41	Transformer-Manirong B	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
42	Transformer-Manirong C	25.00	0.92	3.70%	2.96	11.85%	3.76	15.05%	
43	Transformer-Manirong D	25.00	0.92	3.68%	2.95	11.80%	3.75	14.99%	
44	Transformer-Tengma	25.00	1.16	4.62%	3.70	14.81%	4.70	18.81%	
O100	**11kV Bidung feeder**	**1168.00**	**165.35**		**520.00**		**800.00**		
1	Transformer-RHSS	250.00	11.48	4.59%	36.12	14.45%	55.56	22.23%	
2	Transformer-Pamtem	16.00	6.01	37.55%	18.89	118.09%	29.07	181.67%	Over loaded
3	Transformer-Dogorom	50.00	9.74	19.48%	30.63	61.27%	47.13	94.25%	
4	Transformer-Khairey	63.00	11.73	18.62%	36.89	58.56%	56.75	90.08%	
5	Transformer-Saling	50.00	14.59	29.17%	45.87	91.74%	70.57	141.14%	Over loaded
6	Transformer-Saling Daza	16.00	2.30	14.40%	7.25	45.29%	11.15	69.67%	
7	Transformer-Lower Phuntsum	63.00	11.57	18.36%	36.37	57.74%	55.96	88.83%	
8	Transformer-Upper Phuntsum	63.00	10.84	17.21%	34.10	54.13%	52.47	83.28%	
9	Transformer-Yabrang	63.00	8.97	14.24%	28.21	44.77%	43.39	68.88%	
10	Transformer-Yabrangzor	63.00	8.05	12.78%	25.32	40.19%	38.96	61.84%	
11	Transformer-Yabrang Top	16.00	2.31	14.45%	7.27	45.44%	11.19	69.91%	
12	Transformer-Chiktuma	50.00	7.59	15.18%	23.88	47.75%	36.73	73.46%	
13	Transformer-Lempang	25.00	3.45	13.81%	10.86	43.42%	16.70	66.81%	
14	Transformer-Chema,Bidung	25.00	3.23	12.90%	10.14	40.57%	15.60	62.41%	
15	Transformer-Jalung	16.00	1.61	10.06%	5.06	31.64%	7.79	48.68%	
16	Transformer-Rezangpeg	63.00	2.71	4.61%	8.52	13.52%	13.11	20.81%	
17	Transformer-Kakaney	160.00	44.44	27.78%	139.77	87.36%	215.03	134.39%	Over loaded
18	Transformer-Tsekhar	100.00	2.88	2.88%	9.06	9.06%	13.94	13.94%	
19	Transformer-Bramung	16.00	1.84	11.49%	5.78	36.15%	8.90	55.61%	
O90	**11kV Shongphu feedr**	**475.00**	**102.36**		**83.58**		**115.11**		
1	Transformer-Upper Market, Rangjung	250.00	67.31	26.92%	54.96	21.98%	75.70	30.28%	
2	Transformer-Lower Shongphu	100.00	16.29	16.29%	13.30	13.30%	18.32	18.32%	

3	Transformer-Upper Shongphu	50.00	7.08	14.16%	5.78	11.57%	7.96	15.93%	
4	Transformer-Chaling	50.00	8.62	17.24%	7.04	14.08%	9.70	19.39%	
5	Transformer-Upper Dungye Gonpa	25.00	3.06	12.22%	2.49	9.98%	3.44	13.74%	
O110	**11kV Radhi feeder**	**1649.00**	**273.37**		**784.00**		**1500.00**		
1	Transformer-Tongling	125.00	20.75	16.60%	59.50	47.60%	113.83	91.07%	
2	Transformer-Jhonla	63.00	14.35	22.77%	41.15	65.31%	78.72	124.96%	Over loaded
3	Transformer-Pangthang	100.00	53.36	53.36%	153.03	153.03%	292.79	292.79%	Over loaded
4	Transformer-Bongman	50.00	6.22	12.44%	17.84	35.69%	34.14	68.28%	
5	Transformer-Khatay	63.00	8.97	14.23%	25.71	40.81%	49.20	78.09%	
6	Transformer-Langten	150.00	15.80	10.53%	45.30	30.20%	86.67	57.78%	
7	Transformer-Tshangkhar	100.00	18.13	18.13%	51.99	51.99%	99.46	99.46%	
8	Transformer-Pakaling	63.00	10.84	17.20%	31.08	49.33%	59.46	94.38%	
9	Transformer-Tokshingmang	25.00	3.75	15.01%	10.76	43.04%	20.59	82.35%	
10	Transformer-Phajo Gonpa	25.00	5.80	23.22%	16.65	66.58%	31.85	127.39%	Over loaded
11	Transformer-Karma Gonpa	25.00	2.59	10.36%	7.43	29.72%	14.22	56.87%	
12	Transformer-Lem	63.00	8.98	14.25%	25.75	40.87%	49.27	78.20%	
13	Transformer-Gazare	25.00	3.75	14.98%	10.74	42.96%	20.55	82.20%	
14	Transformer-Janjanma	16.00	2.12	13.24%	6.07	37.96%	11.62	72.63%	
15	Transformer-Momnangkhar	63.00	8.17	12.97%	23.42	37.18%	44.82	71.14%	
16	Transformer-Dorshing	63.00	33.15	52.62%	95.08	150.92%	181.91	288.75%	Over loaded
17	Transformer-Dungtsi School	250.00	26.55	10.62%	76.14	30.46%	145.68	58.27%	
18	Transformer-Shingroom	63.00	6.51	10.34%	18.68	29.65%	35.74	56.73%	
19	Transformer-Tabrang	25.00	2.08	8.32%	5.96	23.85%	11.41	45.63%	
20	Transformer-U.Shokhang	25.00	2.60	10.39%	7.45	29.79%	14.25	57.00%	
21	Transformer-L.Shokhang	25.00	1.89	7.54%	5.41	21.64%	10.35	41.39%	
22	Transformer-L.Thongrong	25.00	1.85	7.41%	5.31	21.25%	10.16	40.65%	
23	Transformer-M.Thongrong	63.00	5.14	8.17%	14.75	23.42%	28.23	44.80%	
24	Transformer-U.Thongrong	25.00	2.59	10.36%	7.43	29.72%	14.22	56.87%	
25	Transformer-Thongrong School	25.00	2.31	9.22%	6.61	26.45%	12.65	50.61%	
26	Transformer-Bremeteng	16.00	1.63	10.16%	4.66	29.13%	8.92	55.73%	
27	Transformer-zhabuteng	25.00	1.89	7.55%	5.41	21.66%	10.36	41.44%	
28	Transformer-Breng	63.00	1.63	2.59%	4.68	7.42%	8.95	14.21%	
O180	**33kV Nangkhor Incomer for Wamrong**	**3581.00**	**775.79**		**2041.18**		**2552.94**		
1	Transformer-Wakhar 33/0.415kV	30.00	6.19	20.64%	16.29	54.30%	20.37	67.91%	
2	Transformer-Kheshing 33/0.415kV	63.00	5.72	9.07%	15.04	23.88%	18.81	29.86%	
3	Wamrong 33/11 5MVA SS	3488.00	763.89	21.90%	2009.85	57.62%	2513.76	72.07%	
O30	**11kV Wamrong Local Feeder**	**922.00**	**175.35**		**461.35**		**577.02**		

1	Transformer-Tshozor	63.00	30.60	48.57%	80.52	127.80%	100.70	159.84%	Over loaded
2	Transformer-Ramzor	63.00	12.34	19.59%	32.46	51.53%	40.60	64.45%	
3	Transformer-Zookpola (Trashitshe)	250.00	29.03	11.61%	76.39	30.56%	95.54	38.22%	
4	Transformer-Reserboo Hospital	250.00	37.36	14.94%	98.30	39.32%	122.95	49.18%	
5	Transformer-Kosophu	63.00	12.42	19.71%	32.68	51.87%	40.87	64.87%	
6	Transformer-Moshi Market	63.00	18.69	29.67%	49.18	78.06%	61.51	97.63%	
7	Transformer-Moshi Village	63.00	13.67	21.69%	35.95	57.07%	44.97	71.38%	
8	Transformer-Phugayee	25.00	6.39	25.57%	16.82	67.29%	21.04	84.16%	
9	Transformer-Hapla	16.00	1.37	8.55%	3.60	22.49%	4.50	28.13%	
10	Transformer-Khairey A	25.00	4.61	18.44%	12.13	48.51%	15.17	60.67%	
11	Transformer-Khairey B	25.00	5.32	21.27%	13.99	55.97%	17.50	70.00%	
12	Transformer-Gaphu	16.00	3.55	22.18%	9.34	58.34%	11.68	72.97%	
O170	**11kV Kangpara Feeder**	**2014.00**	**463.56**		**1219.66**		**1525.45**		
1	Transformer-Saithang	63.00	14.68	23.31%	38.63	61.32%	48.32	76.70%	
2	Transformer-Trashiyangphu (Nublang Farm)	63.00	20.01	31.76%	52.64	83.56%	65.84	104.50%	Over loaded
3	Transformer-Phoyang	25.00	3.13	12.54%	8.25	32.98%	10.31	41.25%	
4	Transformer-Phakpari	125.00	43.57	34.86%	114.64	91.71%	143.38	114.70%	Over loaded
5	Transformer-Tshangpo	125.00	34.31	27.44%	90.26	72.21%	112.89	90.31%	
6	Transformer-Thrimshing A	63.00	20.55	32.62%	54.08	85.84%	67.64	107.36%	Over loaded
7	Transformer-Thrimshing B	63.00	15.67	24.87%	41.23	65.44%	51.57	81.85%	
8	Transformer-Breakha A	63.00	12.70	20.17%	33.43	53.06%	41.81	66.36%	
9	Transformer-Breakha B	63.00	12.74	20.22%	33.51	53.19%	41.91	66.52%	
10	Transformer-Sarong	25.00	2.50	10.02%	6.59	26.36%	8.24	32.97%	
11	Transformer-Gawong/Neeling	25.00	5.14	20.55%	13.51	54.06%	16.90	67.61%	
12	Transformer-Lamyoung	63.00	12.59	19.99%	33.13	52.59%	41.44	65.77%	
13	Transformer-Kheshing	63.00	5.00	7.93%	13.15	20.87%	16.44	26.10%	
14	Transformer-Kangpara School Top/ Wangthung	63.00	18.79	29.82%	49.43	78.46%	61.82	98.13%	
15	Transformer-Upper Zorthung	63.00	13.32	21.14%	35.04	55.62%	43.82	69.56%	
16	Transformer-Lower Zorthung	63.00	14.19	22.53%	37.35	59.28%	46.71	74.14%	
17	Transformer-Chemasharang	25.00	3.40	13.59%	8.94	35.76%	11.18	44.73%	
18	Transformer-Relam Ngapa/Kangpara Top	63.00	8.71	13.83%	22.92	36.38%	28.67	45.51%	
19	Transformer-Tawang/Upper Kangpara/ Shachama	63.00	8.21	13.03%	21.59	34.27%	27.01	42.87%	
20	Transformer-Brumshari	16.00	1.73	10.81%	4.55	28.44%	5.69	35.56%	
21	Transformer-Maduwa	63.00	18.39	29.19%	48.39	76.81%	60.52	96.07%	
22	Transformer-Lower Pasaphu	63.00	17.19	27.29%	45.23	71.80%	56.58	89.80%	
23	Transformer-Upper Pasaphu	63.00	15.10	23.97%	39.74	63.07%	49.70	78.89%	
24	Transformer-Paydung	16.00	2.49	15.57%	6.56	40.97%	8.20	51.24%	

25	Transformer-Drawangchema and Kosargang	25.00	2.97	11.89%	7.82	31.29%	9.78	39.13%	
26	Transformer-Lama Gongpa B	16.00	4.81	30.05%	12.65	79.06%	15.82	98.88%	
27	Transformer-Lama Gongpa A	25.00	3.78	15.11%	9.94	39.75%	12.43	49.72%	
28	Transformer-Martha A	25.00	5.02	20.07%	13.20	52.79%	16.51	66.03%	
29	Transformer-Martha B	16.00	4.05	25.33%	10.66	66.65%	13.34	83.36%	
30	Transformer-Baydangphu A	25.00	7.10	28.41%	18.69	74.76%	23.38	93.50%	
31	Transformer-Baydangphu B	16.00	4.25	26.56%	11.18	69.89%	13.99	87.42%	
32	Transformer-Shingmo/momla	25.00	4.80	19.21%	12.64	50.54%	15.80	63.21%	
33	Transformer-Threphu School	25.00	4.85	19.39%	12.75	51.01%	15.95	63.80%	
34	Transformer-Threphu A	25.00	8.03	32.13%	21.13	84.53%	26.43	105.72%	Over loaded
35	Transformer-Threphu B	25.00	7.11	28.45%	18.71	74.84%	23.40	93.61%	
36	Transformer-Bayphu pam	125.00	26.18	20.95%	68.89	55.11%	86.16	68.93%	
37	Transformer-Bayphu sari	63.00	10.37	16.45%	27.27	43.29%	34.11	54.15%	
38	Transformer-Drungtshopeg Befu	63.00	7.28	11.55%	19.14	30.38%	23.94	38.00%	
39	Transformer-Thrimshing CS	125.00	38.85	31.08%	102.20	81.76%	127.83	102.26%	Over loaded
O190	**11kV Thungkhar Feeder**	**552.00**	**124.98**		**328.84**		**411.29**		
1	Transformer-Tshangphu	16.00	1.41	8.83%	3.72	23.24%	4.65	29.07%	
2	Transformer-Nolapay	10.00	1.43	14.30%	3.76	37.62%	4.71	47.05%	
3	Transformer-Ramchongma B	25.00	5.01	20.06%	13.19	52.77%	16.50	66.00%	
4	Transformer-Ramchongma A	25.00	5.96	23.86%	15.69	62.76%	19.63	78.50%	
5	Transformer-Soko A	25.00	5.66	22.64%	14.89	59.58%	18.63	74.51%	
6	Transformer-Soko B	25.00	5.61	22.45%	14.76	59.06%	18.47	73.87%	
7	Transformer-Thungkhar School	63.00	19.98	31.72%	52.57	83.45%	65.75	104.37%	Over loaded
8	Transformer-Barpangthang	25.00	7.03	28.14%	18.51	74.03%	23.15	92.59%	
9	Transformer-Phungshing	25.00	2.11	8.43%	5.55	22.19%	6.94	27.75%	
10	Transformer-Yamkhar C	25.00	2.19	8.76%	5.76	23.05%	7.21	28.83%	
11	Transformer-Yamkhar B	25.00	4.31	17.23%	11.33	45.33%	14.17	56.70%	
12	Transformer-Yamkhar A	25.00	5.78	23.13%	15.21	60.85%	19.03	76.11%	
13	Transformer-Thungkhar A	25.00	6.64	26.55%	17.46	69.86%	21.84	87.37%	
14	Transformer-Thungkhar B	25.00	7.50	30.01%	19.74	78.95%	24.69	98.75%	
15	Transformer-Thungkhar C	25.00	8.15	32.60%	21.45	85.78%	26.82	107.29%	Over loaded
16	Transformer-Thungkhar D	25.00	7.13	28.51%	18.75	75.01%	23.46	93.82%	
17	Transformer-Lower Berdungma	25.00	6.65	26.59%	17.49	69.96%	21.87	87.50%	
18	Transformer-Berdungma School	25.00	7.01	28.03%	18.44	73.76%	23.06	92.25%	
19	Transformer-Upper Berdungma	63.00	11.97	18.99%	31.48	49.97%	39.37	62.50%	
20	Transformer-Berdungma top	25.00	3.45	13.79%	9.07	36.28%	11.34	45.38%	

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**