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ELECTRICITY REGULATORY AUTHORITY

Ministry of Energy and Natural Resources

Distribution Power Reliability and Transmission System Performance Report 2023

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ABBREVIATIONS

BPC	Bhutan Power Corporation Limited
CT	Current Transformer
HD	High Definition
ERA	Electricity Regulatory Authority
ESD	Electricity Services Division
ESSD	Electricity Services Sub Division
GO Switch	Gang Operating Switch
HT Fuse	High Tension Fuse
HV	High Voltage
ICT	Interconnecting Transformer
IPC	Insulation-piercing connector
KM	Kilometer
kV	Kilovolt
LA	Lightning Arrestor
LBS	Load Break Switch
LV	Low Voltage
MV	Medium Voltage
OPGW	Optical Ground Wire
PT	Potential Transformer
RoW	Right of Way
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
UG Cable	Underground Cable

EXECUTIVE SUMMARY

Ensuring the reliability of electricity supply is paramount, given its integral role in daily life and economic activities. From everyday household tasks to large-scale industrial operations, electricity plays a vital role. Any disruption in supply can have significant repercussions, affecting essential services and industrial activities, and ultimately impacting the economy. The persistent expansion of power systems, driven by increasing demand, poses ongoing challenges for grid operators in meeting reliability standards. Nevertheless, maintaining supply reliability remains essential and non-negotiable for transmission, distribution utilities and regulators.

In this regard, the ERA studied the power outages in the distribution and transmission system for 2023, aiming to enhance power reliability through strong regulatory interventions and benchmarking. The main root causes of the power outages were identified, and actions to be taken by the distribution licensee were outlined to ensure that similar power outages are avoided in the future.

Based on the study findings, the ERA has calculated a preliminary baseline of power reliability indices (SAIFI was 18.96 times/customer/year and SAIDI was 18.58 hours/customer/year) accounting only for the power outages within the control of the distribution licensee and transmission system performance of 96.06%. To enhance the power reliability hereafter, the ERA has set distribution reliability indices at 20% lower than the calculated preliminary baseline (SAIFI at 15.17 times/customer/year and SAIDI at 14.86 hours/customer/year) and the transmission system performance standard at 98% for the year 2024-2025.

1. BACKGROUND

The ERA studied the power reliability for the distribution and transmission system of BPC by assessing the daily power outage data available in the power outage information published by BPC in their website. The assessment was executed to understand the root cause for power outage in the BPC's distribution and transmission system and set preliminary baselines for power reliability indices as a standard of performance to be maintained hereafter.

Conducting such a system study will mandate the BPC to operate its business efficiently, aligning with the national objective of fostering sustainable economic transformation. Moreover, to make BPC go beyond its performance standards to ensure a dependable power supply for consumers.

To establish dependable and implementable standards, the ERA reviewed and analyzed the daily power outage data from January 2023 to December 2023. As per section 55 of the Distribution Code (Amendment) Regulation 2022, the reliability indices such as SAIDI and SAIFI were calculated excluding the following types of interruption that occurred in the system:

1) Schedule outages;
2) Momentary outages of duration of less than five (5) minutes;
3) Outages due to failure of the grid;
4) Cyclones, earthquakes, floods, storms, wars, riots, strikes, landslides, fire, or any other occurrences that are beyond the control of the Distribution Licensee; and
5) A Distribution licensee may disconnect supply to a Customer's premises if supply otherwise would potentially endanger or threaten to endanger the health or safety of any person or the environment or an element of the environment or if there is otherwise an emergency.

During the year 2023-2024, the ERA also conducted a study aimed at determining the transmission system performance standard. This involved assessing transmission power outage data provided by the BPC, covering the period from January 2023 to December 2023. Given that the Bhutan transmission system encompasses of transmission line and substation equipment, the performance standard for the transmission system was evaluated according to the voltage levels and benchmarked the overall transmission system performance standard.

Throughout the process of assessing distribution reliability indices and transmission performance, the ERA has engaged in over three (September 29, 2023, October 17, 2023 & January 15, 2024) face-to-face meetings and twice online meetings with senior officials of Distribution Department to improve/revise the power outage reporting format; with the focus on capturing the issues such as root cause and appropriate categorization of the outages for smooth analysis and determination of the reliability standards. Moreover, the ERA officials visited the ESD and ESSD of BPC to validate data and gain insights into the root causes of power outages. Furthermore, ERA conducted three (December 18, 2023, January 15, 2024 &

March 12, 2024) face to face meetings with the senior officials from the Transmission Department.

Analyzing these reliability indices and performance standards, the ERA will be able to uplift the power reliability, prioritize investment approval for infrastructure upgradation or maintenance, and implement strategies through regulatory interventions to improve the overall reliability and quality of service for customers.

2. DISTRIBUTION POWER RELIABILITY

The BPC has total length of 17,252.39 kms of distribution line across the country with total of 5583 installed transformers to serve 2,43,285 customers as of the year 2023. Considering the length of the distribution lines and consumers connected to the huge number of substations, there is a high number of power outages experienced by the consumers due to various faults occurring in the system equipment which are within and outside the control of the BPC. To understand the frequency and duration of the power outages, daily power outage records of all distribution feeders were analyzed for the year 2023 to determine the feeder-wise and overall annual reliability indices. The study also looked into the various contributors to power outages were categorized according to the nature of the fault related to the power outages. Moreover, root cause analysis for the power outages was conducted to uncover the problems in the distribution system and come up with appropriate solutions to fix the problems to reduce the undesired power outages.

2.1 Category for Cause of Power Outage

The causes of the power outage were identified and classified into four major categories based on the nature of the causes to determine the SAIFI and SAIDI as per the Distribution Code (Amendment) Regulation 2022. The definition of each major category is as outlined in figure 1 below.

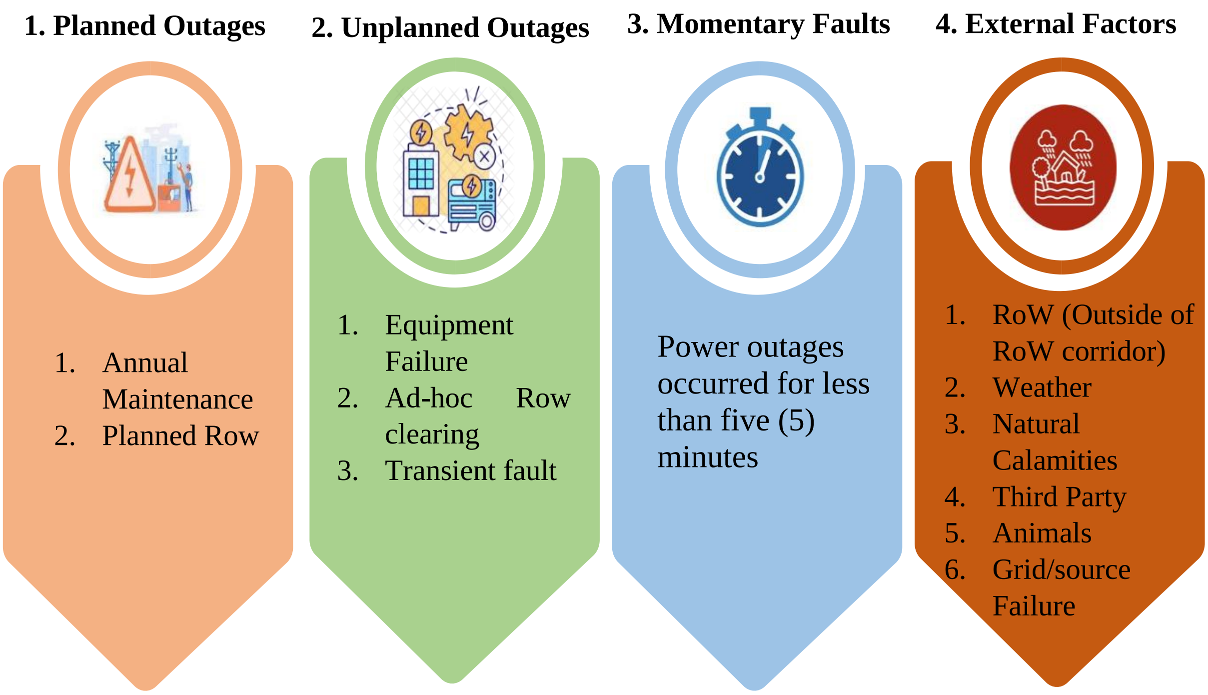


Figure 1: Category for Cause of Power Outages

The figure 2 shows the frequency and duration of outages caused by each category of power outages within the distribution network. Unplanned power outages caused the highest power interruptions in terms of both frequency and duration accounting for 44.0% and 40%.

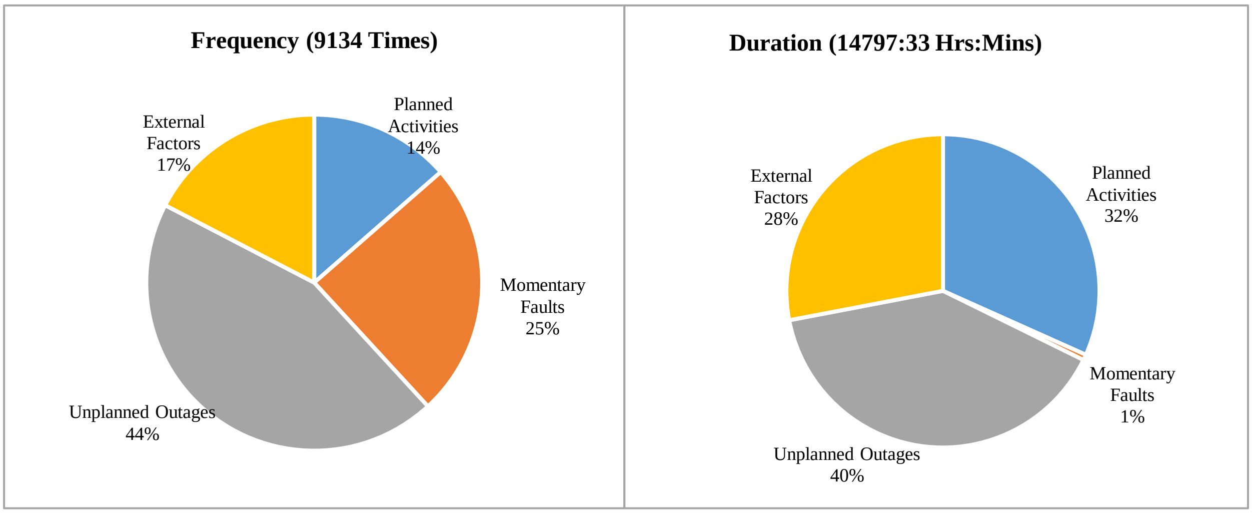


Figure 2: Cause of Overall Power Outages

As per Distribution Code (Amendment) Regulation 2022, the power outages due to external factors, planned activities and momentary fault were excluded from the calculation of SAIFI and SAIDI. However, the power outage caused by each category are detailed out as follows.

2.1.1 Planned Outages

Planned outages include planned shutdowns required for annual maintenance activities and RoW clearing activities. Annual maintenance involves various activities such as upgrading equipment/lines, maintaining substations, and installing new equipment or lines (new services).

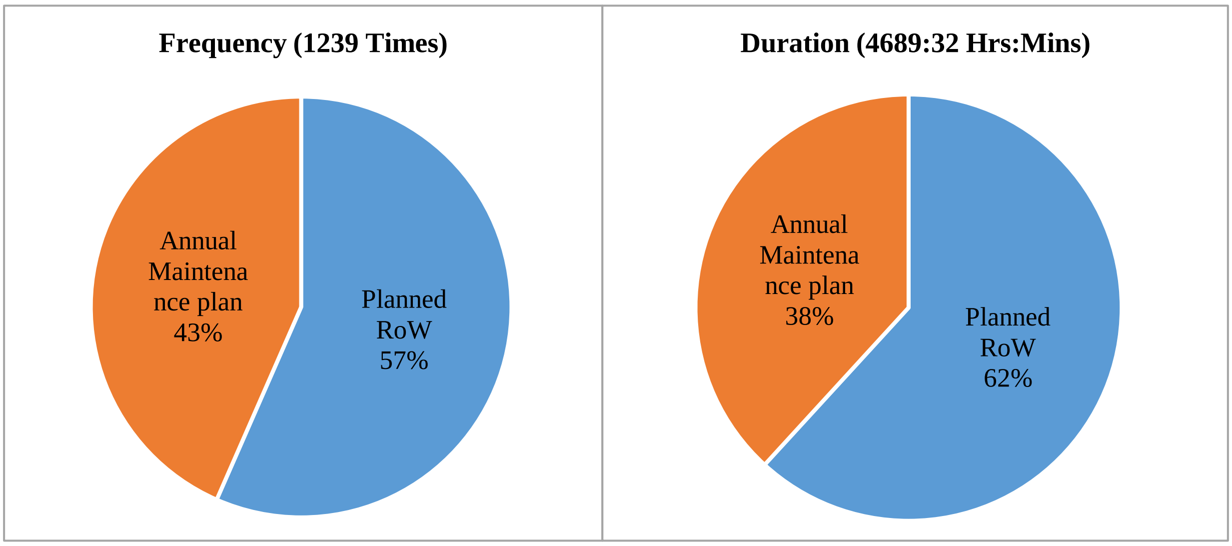


Figure 3: Contributors to Planned Outage

In terms of both frequency of power interruption and outage duration, planned RoW clearing was conducted more than the annual maintenance. BPC has total of 1239 times of power interruptions and 4689:32 (Hrs:Mins) outage duration in a year. The frequency and duration of power outages for each ESD caused by planned RoW clearing and annual maintenance is shown separately in figure 4 and figure 5 below.

i) Planned RoW

It was observed that ESD of P/Gatshel experienced the highest frequency of interruptions, totaling 195 times, with a cumulative outage duration of 817 hours and 8 minutes. ESD S/Jongkhar follows with 98 interruptions, accounting for 296 hours and 30 minutes of power outage. ESD Trongsa, despite having only 31 interruptions, records a substantial outage duration of 602 hours and 39 minutes, indicating longer downtime periods per interruption. Among all ESDs, Paro and Wangdue had less interruptions because of planned RoW clearing.

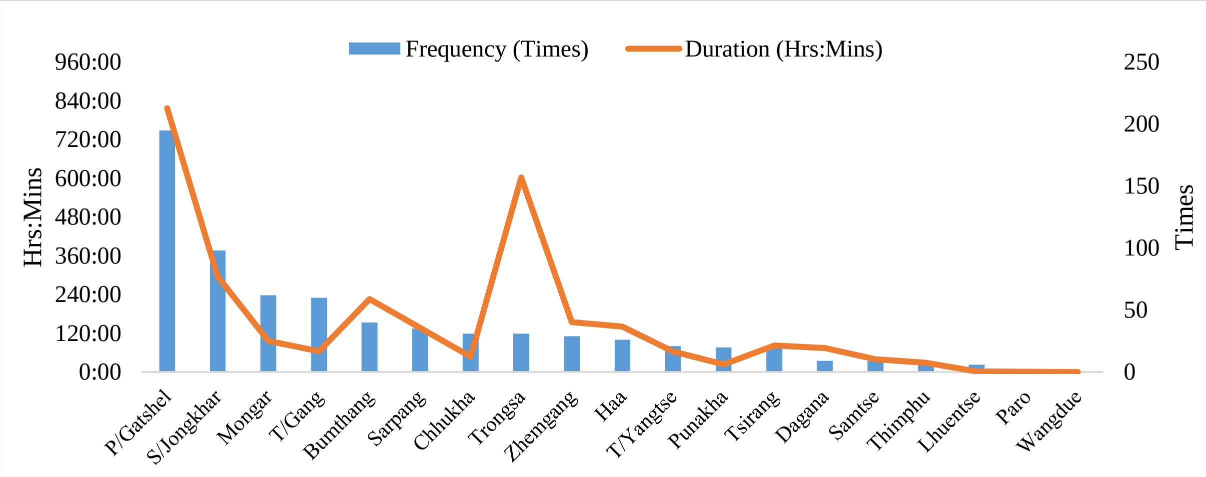


Figure 4: ESD Wise Frequency and Duration of Power Outages

ii) Annual Maintenance

The figure 5 below shows an analysis of planned power outages caused by annual maintenance activities across 19 ESDs. From the graph, it is observed that the ESD Chhukha experienced the highest frequency of annual maintenance outages followed by ESD Paro and S/Jongkhar. ESD Tsirang reported the minimum outages due to maintenance activities during the year 2023.

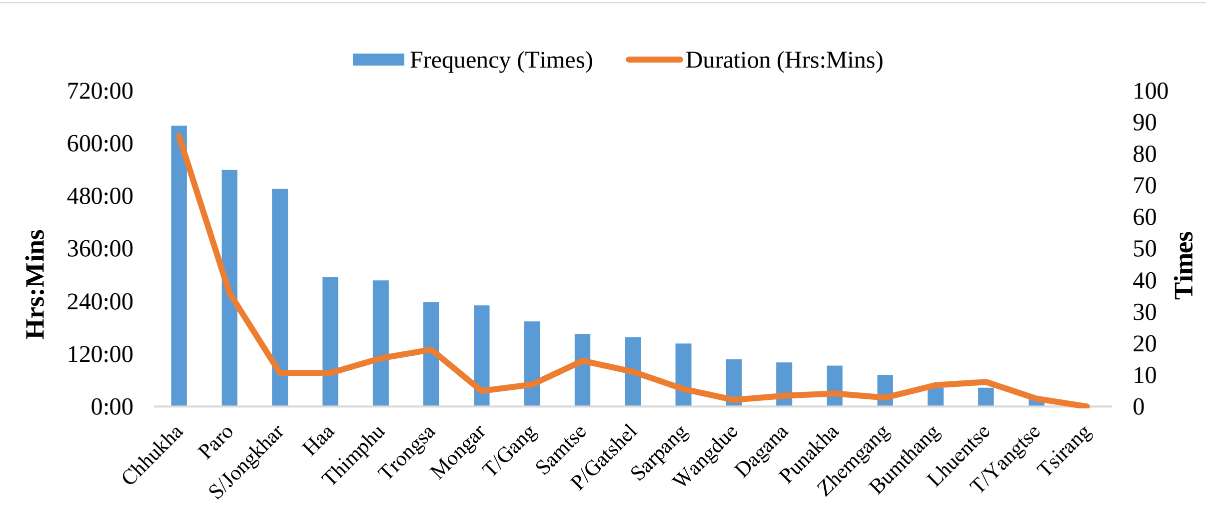


Figure 5: ESD Wise Frequency and Duration of Power Outages

2.1.2 External Factors

The primary cause for the external factor was weather accounting for 52.0% of the total outage frequency and 51.0% of the total outage duration, followed by RoW issues with 18% from total outage frequency and 27% from total outage duration as shown in the figure 6 below.

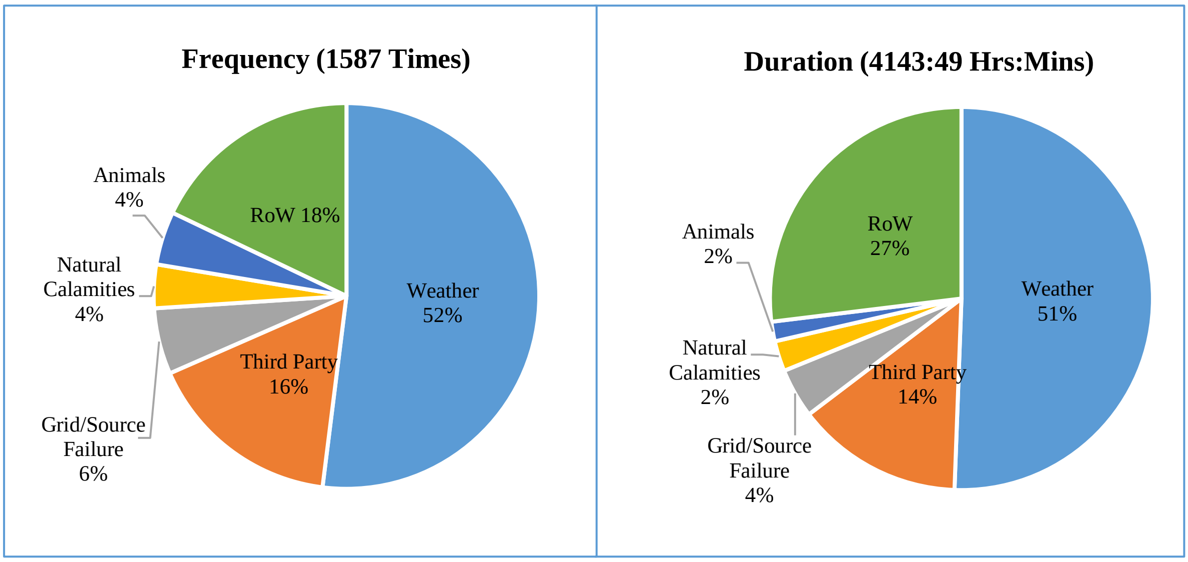


Figure 6: Various Contributors under External Factors

The RoW issues, in the context of external factors, refer to situation where trees fall from outside the RoW corridor onto power infrastructure, causing power outages. The remaining power outages were caused by the animals, natural calamities, third party and grid/source failure. The frequency and duration of power outages for each ESD caused by the remaining factors other than weather and RoW are shown in the Annexure I (figure 1 to figure 4).

The frequency of power interruption and outage duration of each ESD due to weather is shown in the figure 7. ESD Chhukha, P/Gatshel and Samtse experienced the most outages due to adverse weather conditions whereas Wangdue, T/Yangtse and Bumthang experienced the least number of outages. In comparison to other regions of the country, the ESDs of the southern part of the country reported more outages due to harsh weather conditions.

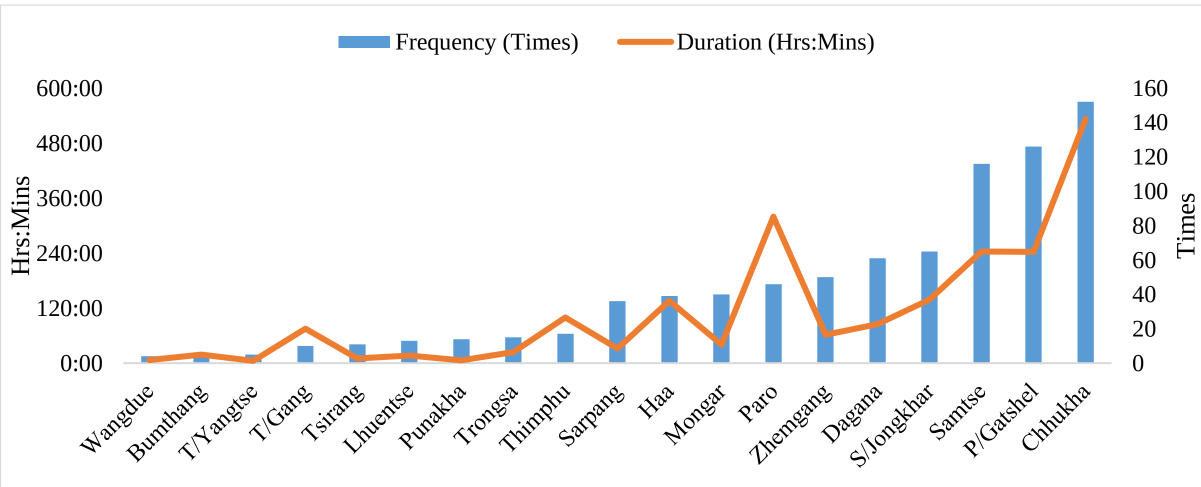


Figure 7: ESD Wise Frequency and Duration of Power Outages

The frequency of power interruption and outage duration of each ESD due to RoW are shown in the figure 8. ESD S/Jongkhar, Punakha, and Zhemgang experienced the highest number of outages due to trees falling from outside the RoW corridor, while ESD Trongsa, Bumthang, and Thimphu encountered the less outages.

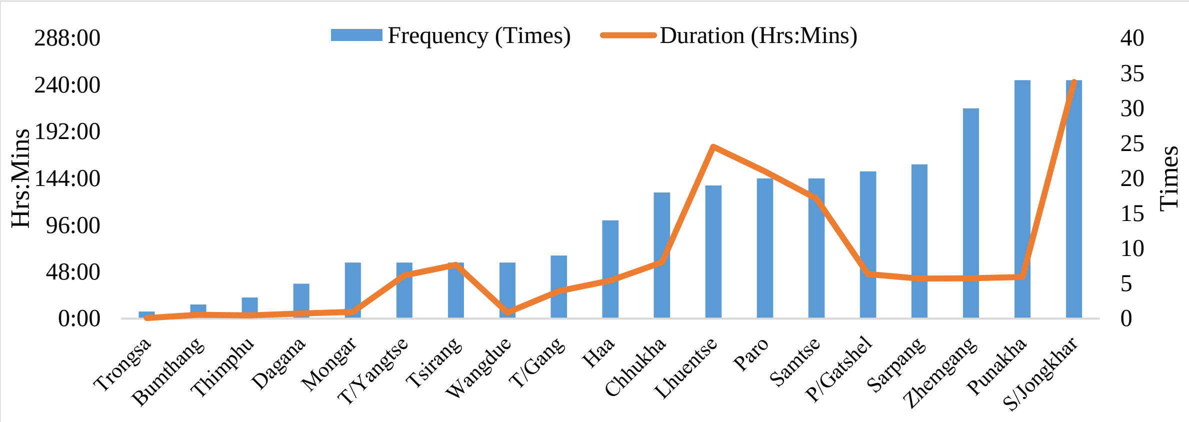


Figure 8: ESD Wise Frequency and Duration of Power Outages

2.1.3 Momentary

The momentary faults are the temporary power interruptions that occurs due to various factors such as lightning strikes, switching operations, or sudden power surges which is not more than five (5) minutes. Despite their short duration, momentary faults pose significant challenges to the reliability and stability of the electrical system.

Analyzing the outage frequency and duration of power outages due to momentary faults across the 19 ESD, S/Jongkhar experienced the highest frequency and duration of momentary faults, followed by Zhemgang and Punakha as shown in figure 9. It was observed that the region with the highest percentage of forest cover experiences the highest momentary faults. This geographical diversity highlights the need for frequent trimming of nearby tree branches, use of insulated conductors having resistance to tree contact and robust lightning protection measures to safeguard distribution feeders against lightning-induced momentary faults especially in the southern region.

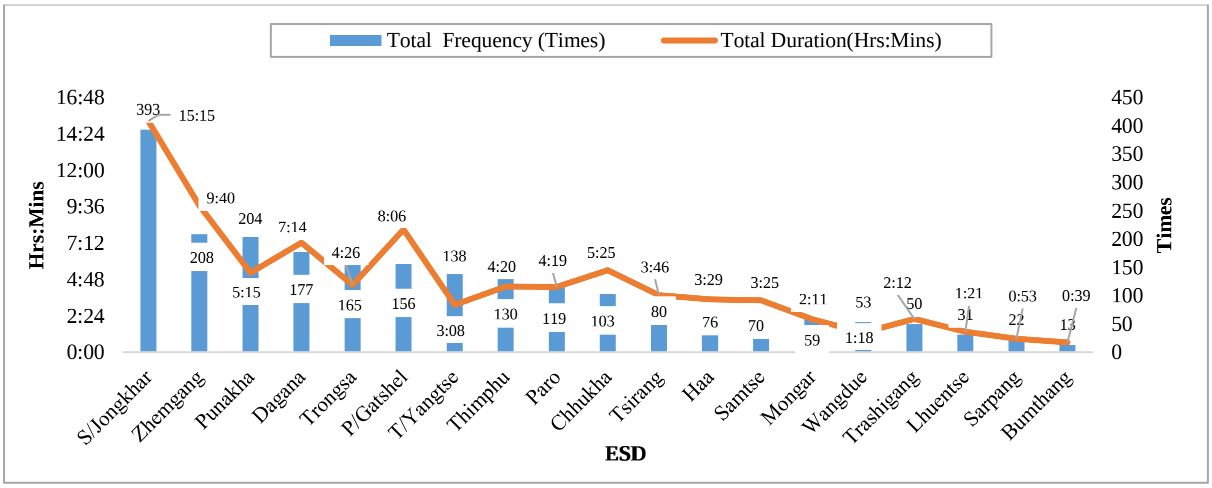


Figure 9: ESD Wise Frequency and Duration of Power Outages

2.1.4 Unplanned Outages

The figure 10 shows the frequency of power outages and figure 11 shows the duration of power outages due the various contributors to unplanned outages. The leading contributor was found to be HT fuse failures, accounting for 1443 outages, followed by the line/conductor with 844 outages. Regarding outage duration, the line/conductor was predominant, with a total duration of 1936 hours and 42 minutes. Moreover, for a significant portion of outages, the cause could not be identified by BPC and some line stood on test charge before locating the fault. These outages with unknown causes were grouped under unspecified causes, accounting for 427 outages and outage duration of 634 hours and 53 minutes.

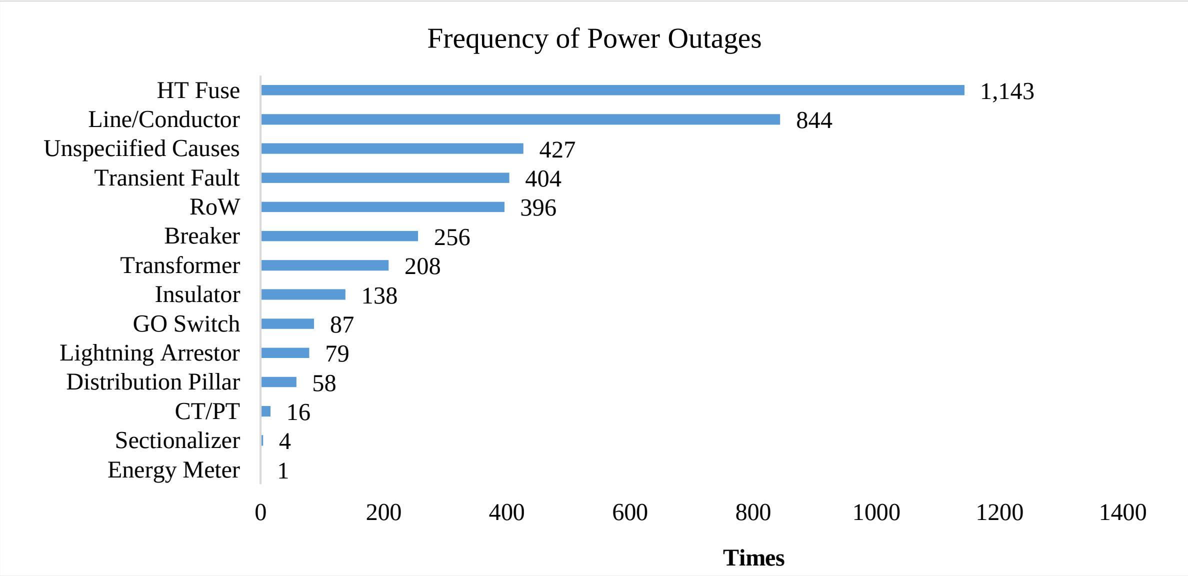


Figure 10: Frequency of Power Outages

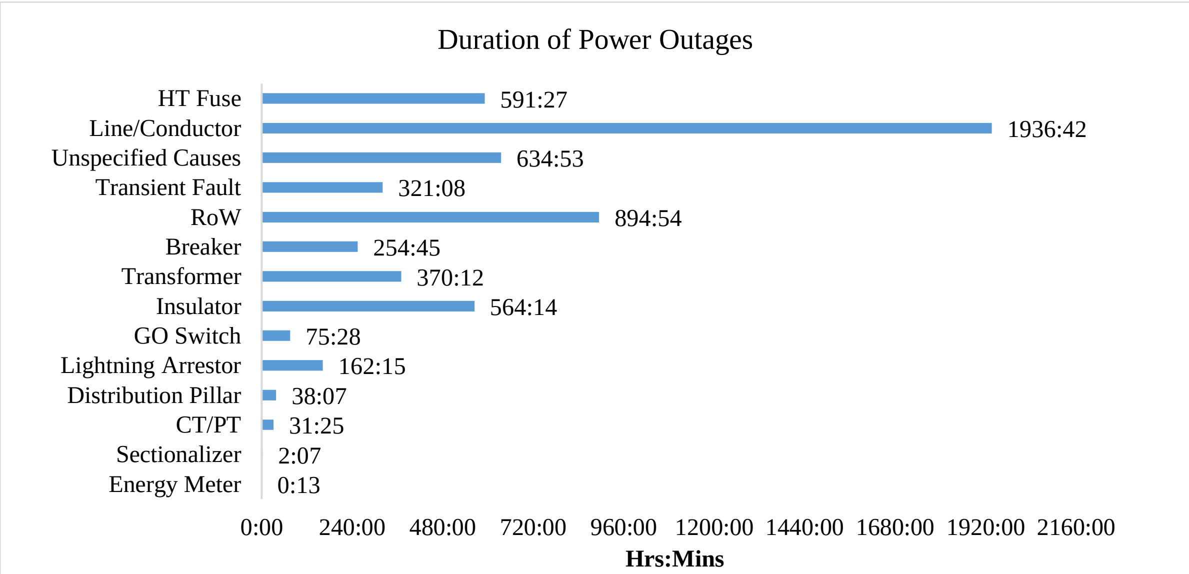


Figure 11: Duration of Power Outages

The other causes under unplanned outage were due to fault from electrical equipment, transient fault and RoW issues which is displayed in the graph above. Here, RoW issues refer to power outages caused by trees and branches falling from within the RoW corridor onto power infrastructure and if the nature of the tree fall is not clearly indicated in the power outage information.

The ESD wise outage frequency and duration due to the major causes like HT Fuse failure and line/conductor faults are shown in the figure 12 and 13 respectively. The outage frequency and duration of each ESD due to other factors are detailed out in Annexure II (Table 1 and Table 2).

i) HT Fuse Failure

The figure 12 shown below represents the frequency and duration of power interruption caused by the failure of HT fuses in each ESD. It can be seen that the ESD S/Jongkhar has the highest frequency of power interruption, while the ESD Paro experienced the highest duration of power outages due to the HT fuse failure.

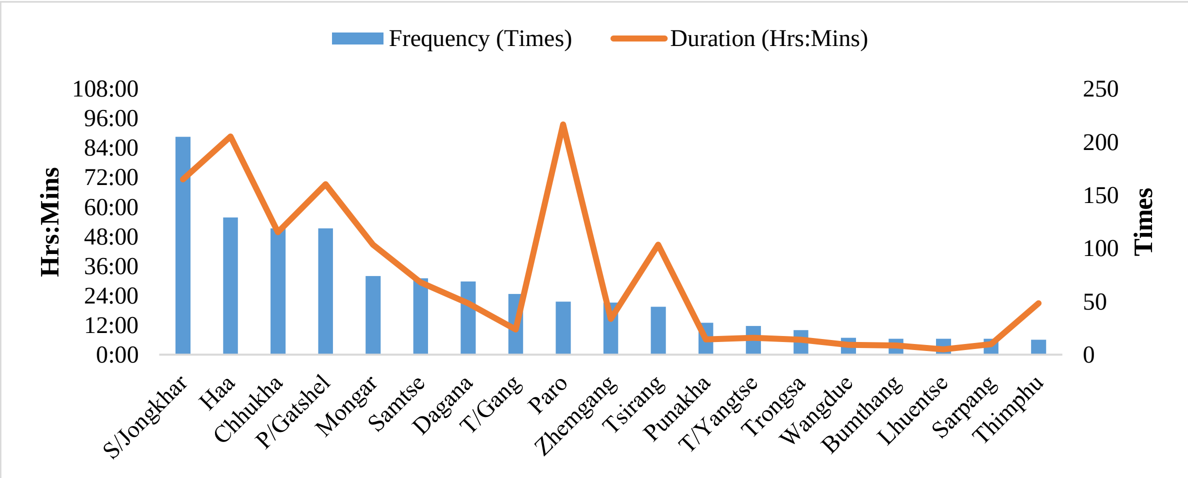


Figure 12: ESD Wise Frequency and Duration of Power Outages

ii) Line/Conductor faults

Line/conductor faults include the power outages caused by the fault such as snapping/sparking and low sagging of overhead lines, UG cable puncture, pole damage, jumper burnt out, IPC/service cable burnt out and others issues associated with the part of overhead and underground cable system. ESD Chhukha experienced the highest outages in terms of frequency and ESD Dagana experienced the highest cumulative outage duration due to the fault related to distribution line system.

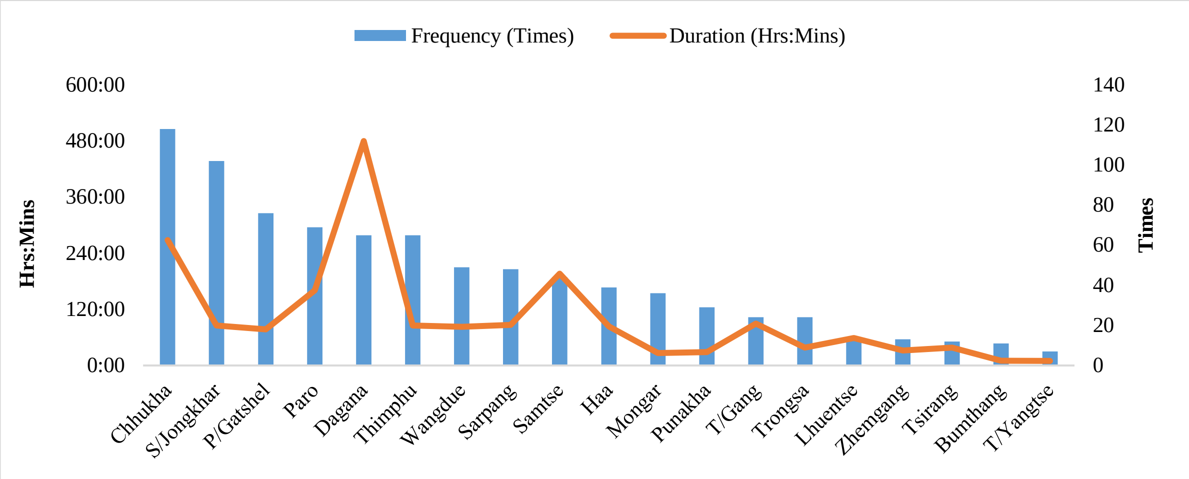


Figure 13: ESD Wise Frequency and Duration of Power Outages

2.2 Root Cause of Power Outages in Distribution System

The analysis of the power outages of the above-mentioned derived that the root causes of the power outages can be mainly categorized as follows

1. Maintenance/Inspection/Recording

   i) Transformer failures due to lack of timely transformer oil inspections, insulation problem (aging) and transformer loadings issues.

   ii) Loose connections of jumper and sparking in LBS and GO switch due to lack of regular maintenance/inspections.

   iii) Insulator failures caused by aging and weathering indicate a lack of proper routine inspection.

   iv) RoW issues such as tree falling on the line from within and outside RoW corridor.

   v) Inconsistent recording of power outages within the ESDs.

   vi) Lack of proper verifications/validation of data/records in the ESDs.

2. Inventory Management

Inadequate inventory management practices contribute to equipment failures by leading to delays in repairs, replacements of non-standard equipment, and unavailability of critical spare parts.

To mitigate these issues, organizations must implement robust inventory management systems. This includes maintaining accurate records of equipment and spare parts, establishing reorder points, and regularly auditing inventory levels to ensure availability when needed. Collaborating with reliable suppliers and establishing contingency plans for critical components can also help mitigate risks associated with inventory shortages.

3. Standard of Equipment/Procedures

   i) Low quality of earthing/grounding for the infrastructures.

   ii) Improper rating usage of fuse wire.

   iii) UG cable failures due to non-standard burial of UG cables and lack of appropriate signs displayed for indication of UG cables.

   iv) Improper function of safety equipment (hot stick).

4. Automation Progress of the Power System

Although the BPC has installed smart equipment for the enhancement of power supply, the usage of the automatic operation of the system has not achieved as desired and such equipment are manually operated and controlled. Moreover, there is need for more smart equipment to be installed at the earliest considering the size of the network to reduce the power outage duration in a significant manner, since manual operations consumes large amount of time for restoration.

2.3 Determination of Reliability Indices

As per the Distribution Code (Amendment) Regulation 2022, the following reliability indices were calculated:

1) "System Average Interruption Duration Index" or "SAIDI" means the average duration of sustained consumer interruptions (determined in accordance with Section 55 (i.) per consumer occurring during the reporting period, determined by dividing the sum of all sustained consumer interruption durations, in minutes, by the total number of consumers using the following equation:

$$SAIDI = \sum(Ri * Ni)/NT$$

where:

"Ri" is the restoration time for interruption event "i";

"Ni" is the number of consumers who experienced a sustained interruption in interruption event "i" during the reporting period; and

"NT" is the total number of consumers of the Distribution Licensee.

2) "System Average Interruption Frequency Index" or "SAIFI" means the average frequency of sustained interruptions determined in accordance with Section 55(i.) per consumer occurring during the reporting period, determined by dividing the total number of all sustained consumer interrupted by the total number of consumers using the following equation:

$$SAIFI = Ni/NT$$

where:

"Ni" is the number of consumers who experienced a sustained interruption in interruption event "i" during the reporting period; and

"NT" is the total number of consumers of the Distribution Licensee

While calculating these two reliability indices, only unplanned outages among the four general causes were considered for the calculation. The figure below shows that the ESD Zhemgang has the highest SAIDI of value 80.13 hrs/customer/year and ESD Dagana has the highest SAIFI of value 56.62 times/customer/year. ESD Thimphu has the lowest SAIDI and SAIFI with the values 1.64 hrs/customer/year and 2.95 times/customer/year respectively. BPC as overall has the SAIDI value of 18.58 hrs/customer/year and SAIFI value of 18.96 times/customer/year for year 2023. The monthly variation of SAIFI and SAIDI of each ESD are shown in the Annexure III.

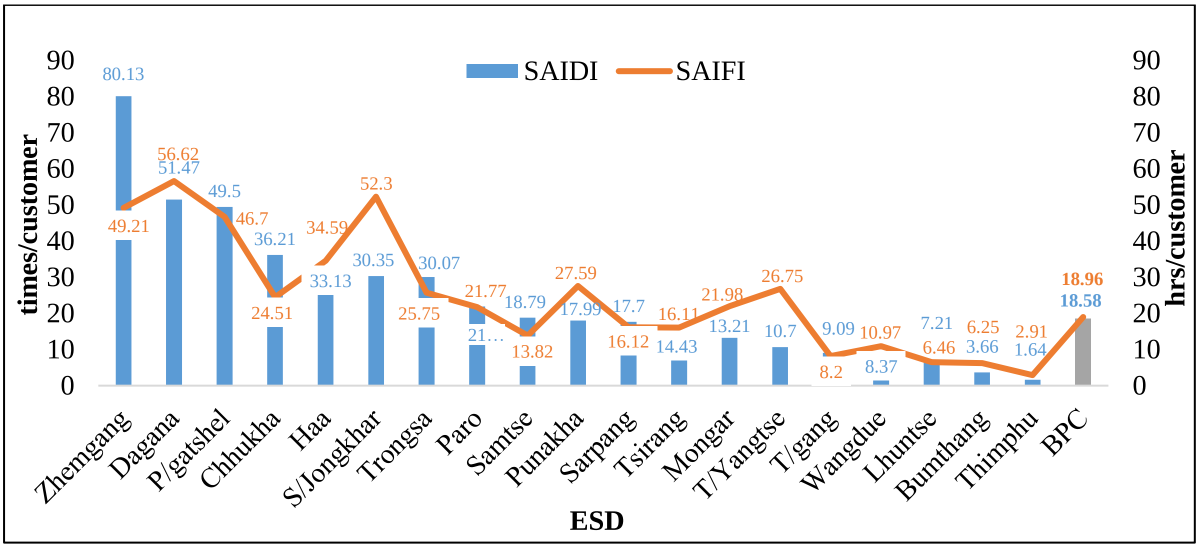


Figure 14: ESD Wise Annual Reliability Indices (2023)

3. TRANSMISSION SYSTEM PERFORMANCE STANDARD

The BPC has total number of seventy-one (71) transmission feeders in the country comprising of 400kV, 220kV, 132kV and 66kV, and total length of more than 1736.86 kms. Any failure in the transmission system will have cascading effect to the distribution systems power reliability and therefore it is very important to maintain a healthy transmission system. Considering the fact, it is equally crucial to derive common indicators that enable monitoring the performance of the transmission line services. Moreover, these indicators provide a platform to compare or benchmark the system performance for reflecting the operational problems/drawbacks and accordingly to take appropriate actions to enhance the performance. In this regard, the ERA determined the transmission system performance of different voltage levels (400kV, 220kV, 132kV and 66kV) for the year 2024-2025 using the transmission outage data for the year 2023.

3.1 General Causes of Transmission Outage

As indicated in figure 15, ERA considered the unplanned outages (transient faults, equipment malfunction, loading, and voltage issues) and domestic outages on the export feeders for the determination of the transmission system performance standard. Whereas the outages such as zero customer affected, momentary outages, export feeder outages and planned outages were excluded for calculation of system performance.

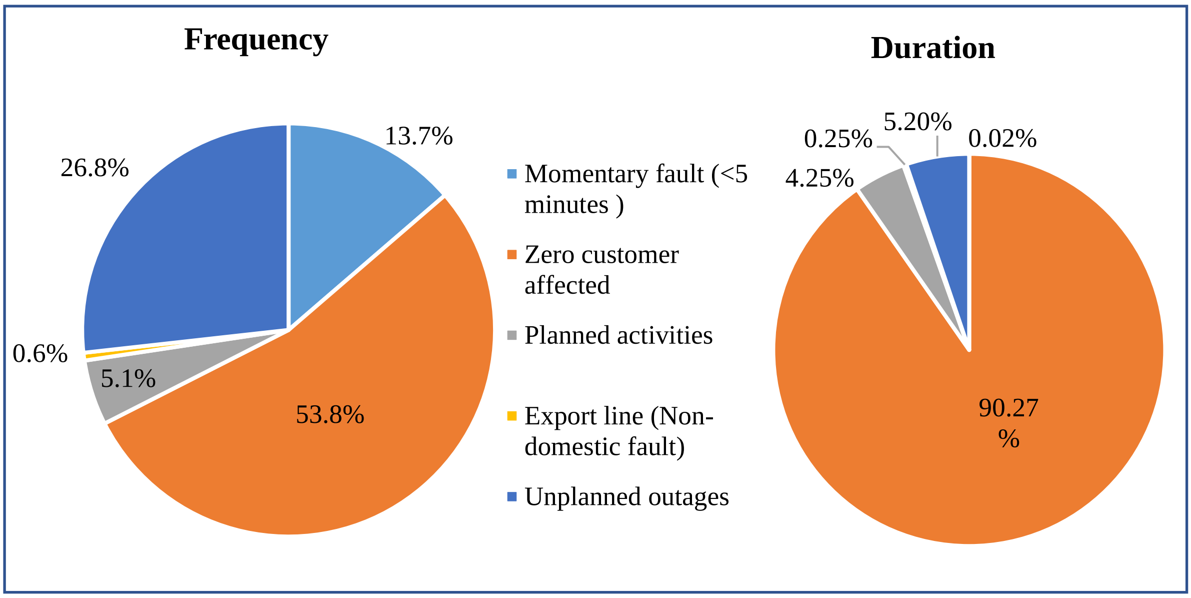


Figure 15: Cause of Transmission System Outage (2023)

3.2 Determination of Transmission System Performance

The performance of the transmission system can be determined by the percentage of transmission system availability during the period under consideration. The percentage of system availability is calculated based on the given formula.

$$\% \text{ Availability of Transmission System} = \sum_{i=1}^{O} \frac{Ti - Tnai}{Ti} \times 100$$

Where,

O = Total number of transmission system outage.

Ti = the total hours of the transmission system during the period under consideration.

Tnai = the non-availability hours for the transmission system.

3.3 400kV Transmission System Performance

The transmission system availability was 100% during February, May, July, November, and December 2023. The system availability in April was 65.95% which was mainly due to the blasting of LA at the Malbase ICT, and it took almost 10 days to replace. For the rest of the month, the system availability was above 95%. The figure 16 below shows the monthly variation in 400kV transmission system availability. The annual availability performance of a 400kV transmission system was 96.73 %.

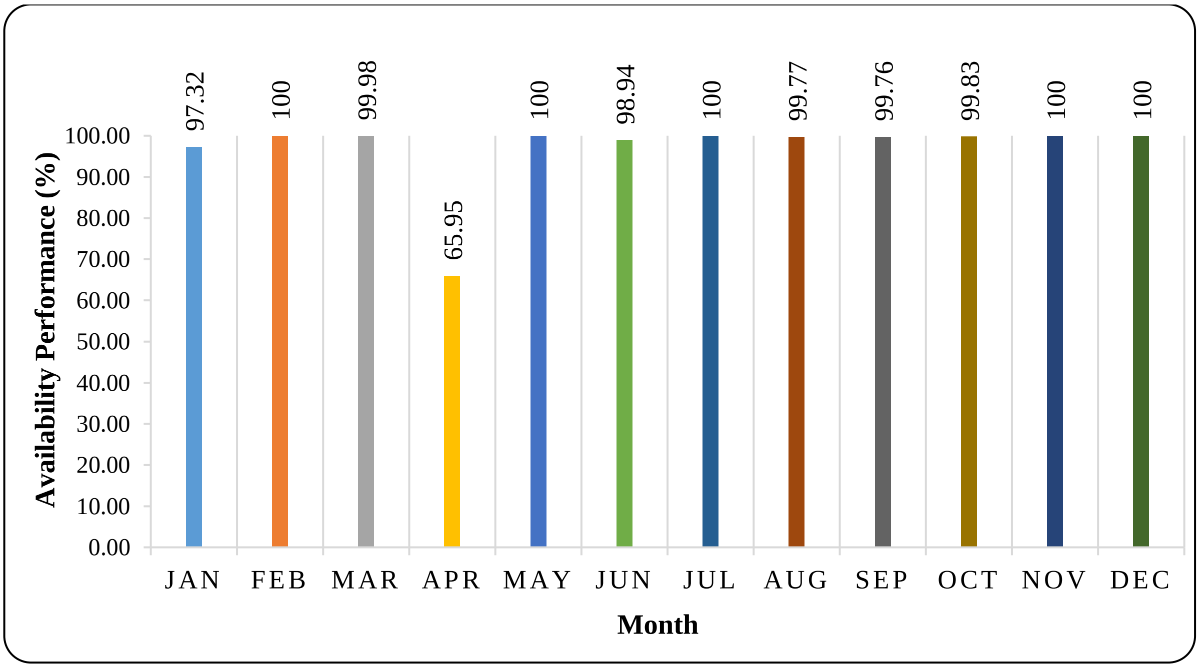


Figure 16: 400 kV Transmission System Availability – 2023

3.3.1 Causes of the Outage

Compared to other levels of voltage in the transmission system, the 400 kV transmission system experienced very minimum outages. The major cause of the frequent outages was the tripping of line and the collapse of the Capacitive Voltage Transformer. Although there was only one outage due to a LA puncture, almost 10 days have been taken to replace the LA and it can be concluded that it is very important to have enough spare equipment to reduce the time it takes to replace the damaged equipment. In addition, there is a requirement for timely inspection and monitoring of the equipment in the transmission system, as the failure of the transmission system affects all other transmission and distribution feeders connected to it.

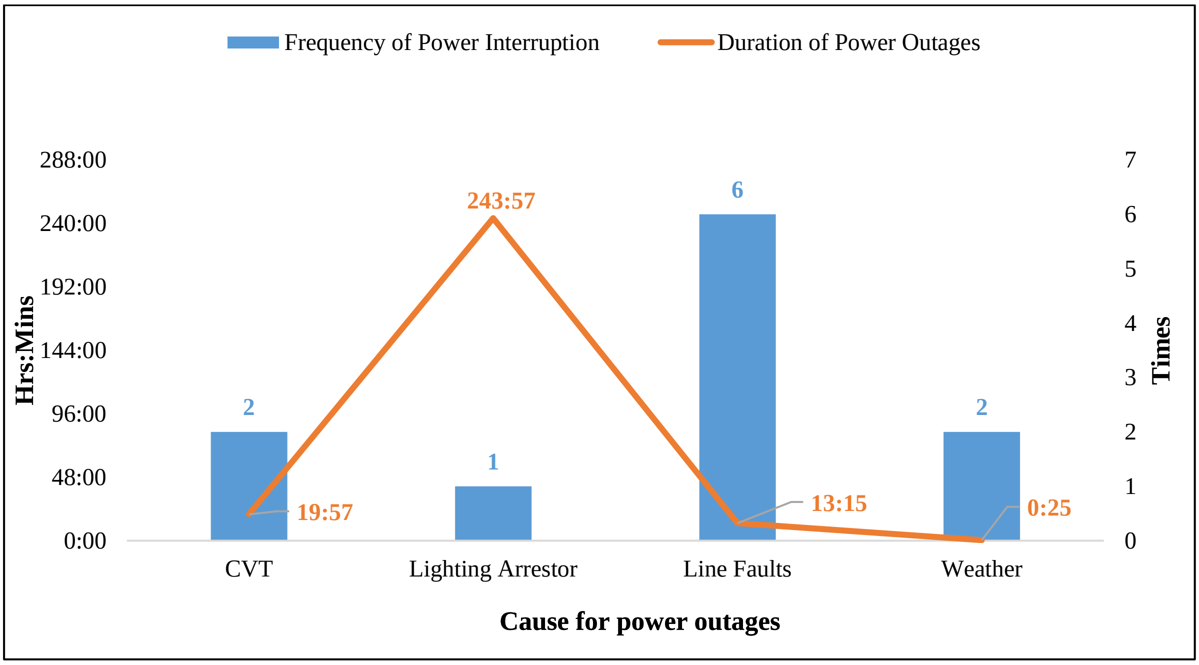


Figure 17: Cause of 400kV Transmission System Outage (2023)

3.4 220kV Transmission System Performance

The figure 18 below shows the monthly variation of 220kV transmission system availability. The transmission system availability for most of the month was above 98% and the minimum was in May and December, which is 96.46% and 96.01% respectively. That was due to the multiple trips of the line due to transient faults, voltage issues, and loading problems. The annual availability performance of the 220kV transmission system was 98.77%.

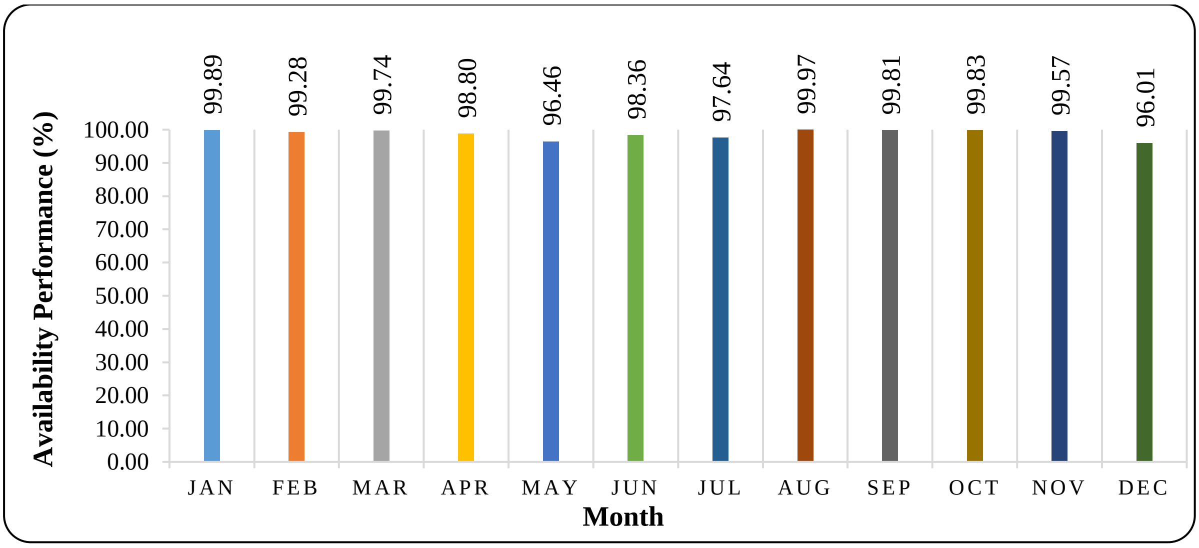


Figure 18: 220kV Transmission System Availability – 2023

3.4.1 Causes of the Outage

The causes of 220kV transmission system outages were broadly classified to unplanned outages and external factors. It can be observed from the following graph that 35% of the power interruptions were caused by external factors such as heavy rain, lightning, and third parties. The unplanned outages (65%) were mostly caused by equipment faults. Equipment faults were commonly from line faults, OPGW links breakages, and substation equipment faults such as transformers and isolators. The transmission line also tripped due to the transient fault, tall bamboo touching the line (RoW), and under voltage.

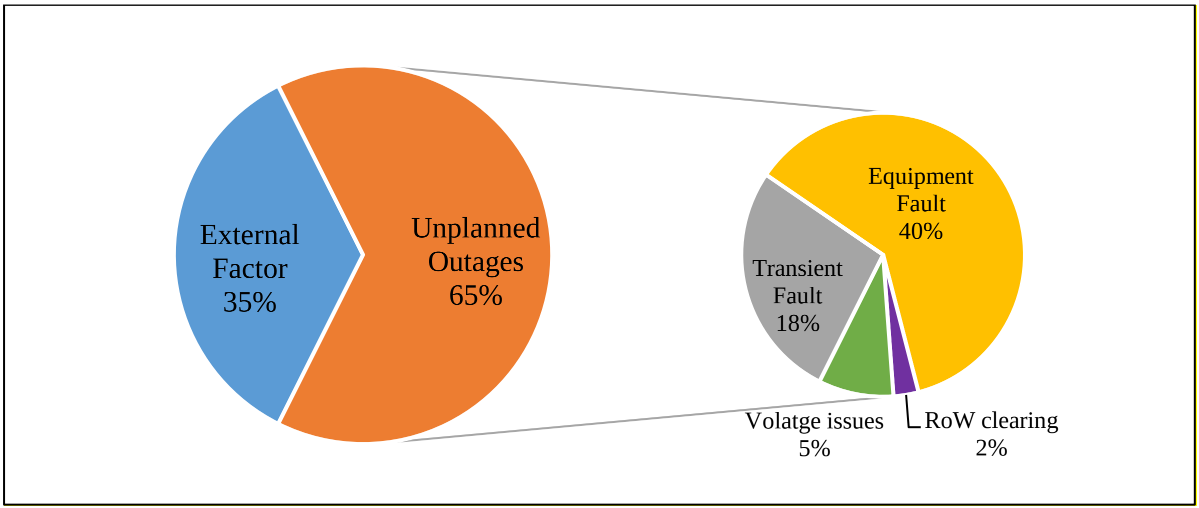


Figure 19: Cause of Power Interruptions in 220kV Transmission System (2023)

3.5 132kV Transmission System Performance

The figure 20 below shows the monthly variation of the 132kV transmission system availability. The minimum value was in June and July due to the frequent tripping of line on earth fault/over current and transient fault. The annual availability performance of the 132kV transmission system was 96.76%.

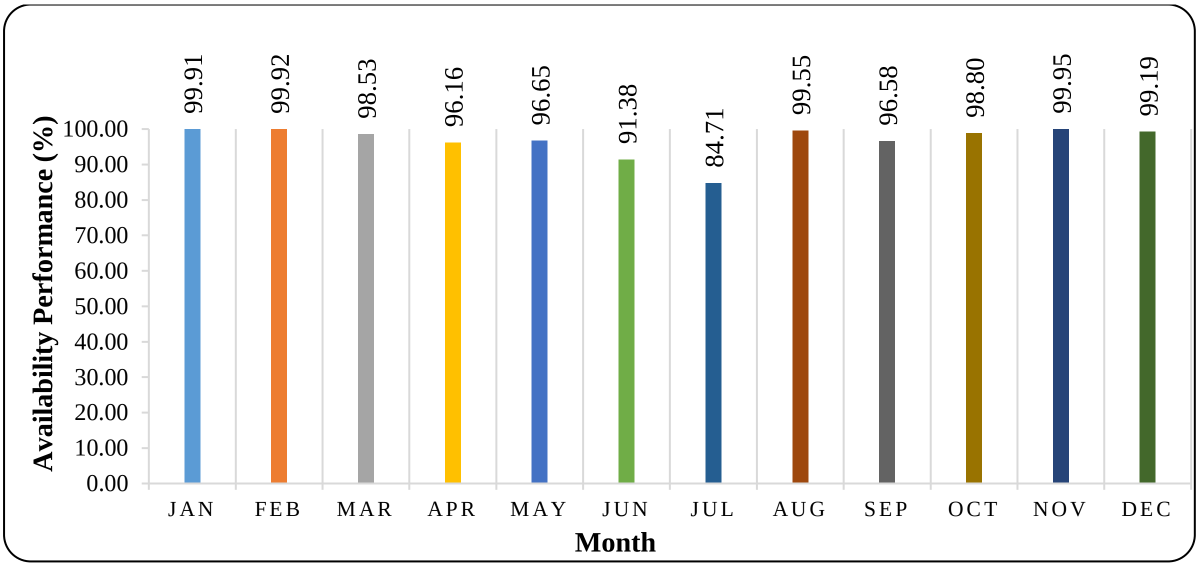


Figure 20: 132kV Transmission System Availability – 2023

3.5.1 Causes of the Outage

132kV power system experienced 119 times of interruptions and outage duration of 645 hours and 39 minutes in the year 2023 due to unplanned outages. External factors caused 22 times of power interruption and total outage duration of 56 hours and 42 minutes.

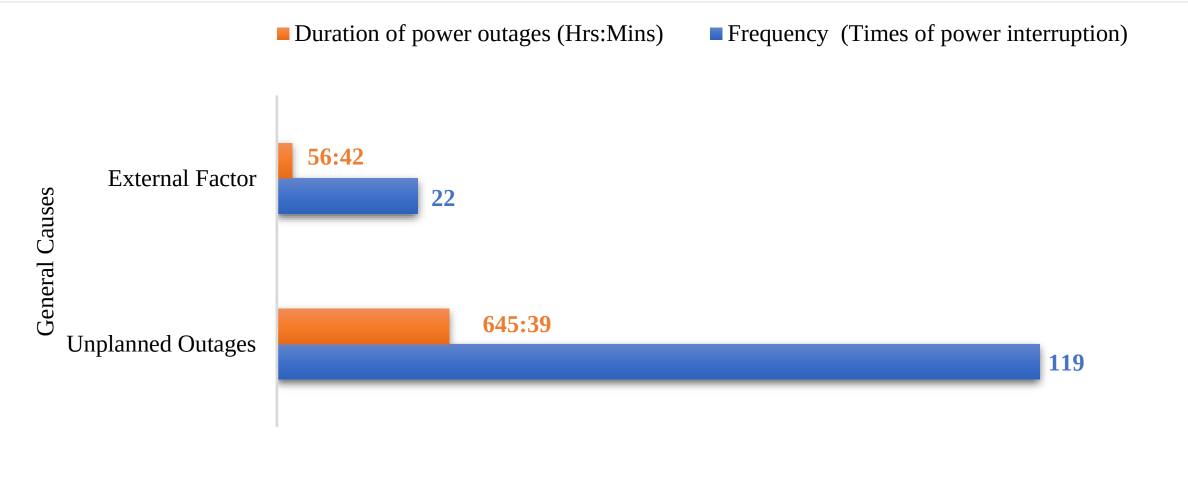


Figure 21: Cause of Power Interruptions in 132kV Transmission System (2023)

The various factors causing the unplanned outages were transient faults that caused 67 times of interruptions and shutdowns for 144 hours and 43 minutes in a year. Transient faults often happen due to bad weather and temporary touch on power line by external objects such as tree branches and animals. The 132kV transmission system tripped mostly due to line faults and the fault from substation equipment such as LA, transformer, CT, PT, and circuit breaker. Among all the equipment faults, it was observed that the replacement of the LA took a very long duration of almost 15 days. 132kV line has also been interrupted by the RoW issues and over/under voltage.

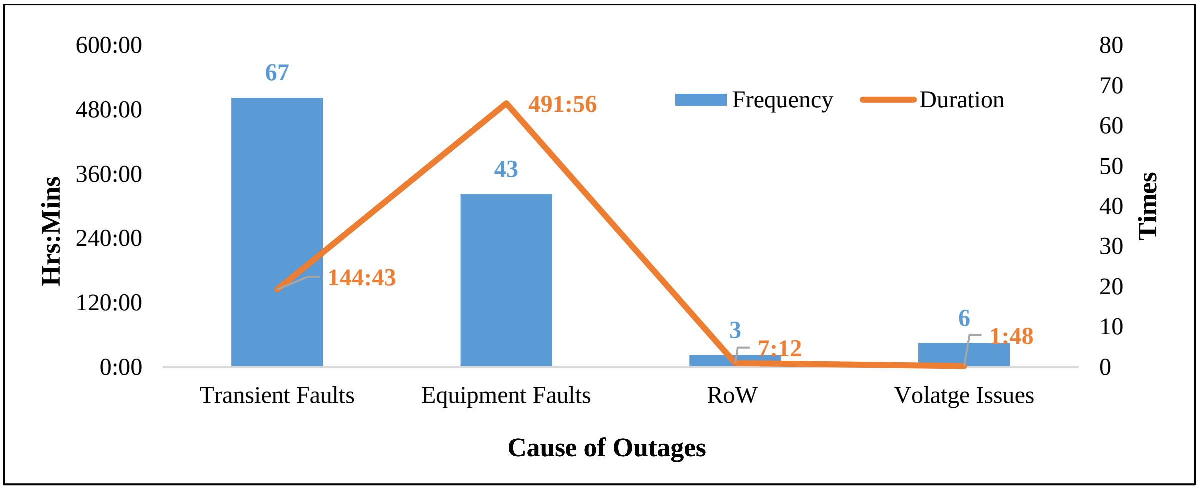


Figure 22: Cause of Power Interruptions in 132kV Transmission System (2023)

3.6 66kV Transmission System Performance

The figure 23 shows the monthly variation in the availability of the 66kV transmission system. The values were minimum for June and July. In June, there was an OPGW breakage at a multi-circuit tower in Pasakha, which took more than five days to rectify. In July, there were phase missing issues on the 66kV Malbase-Phuentsholing line, leading to a shutdown lasting more than 3 days. Due to these major breakdowns within the 66kV power system, the annual availability performance of the 66kV transmission system was 92%.

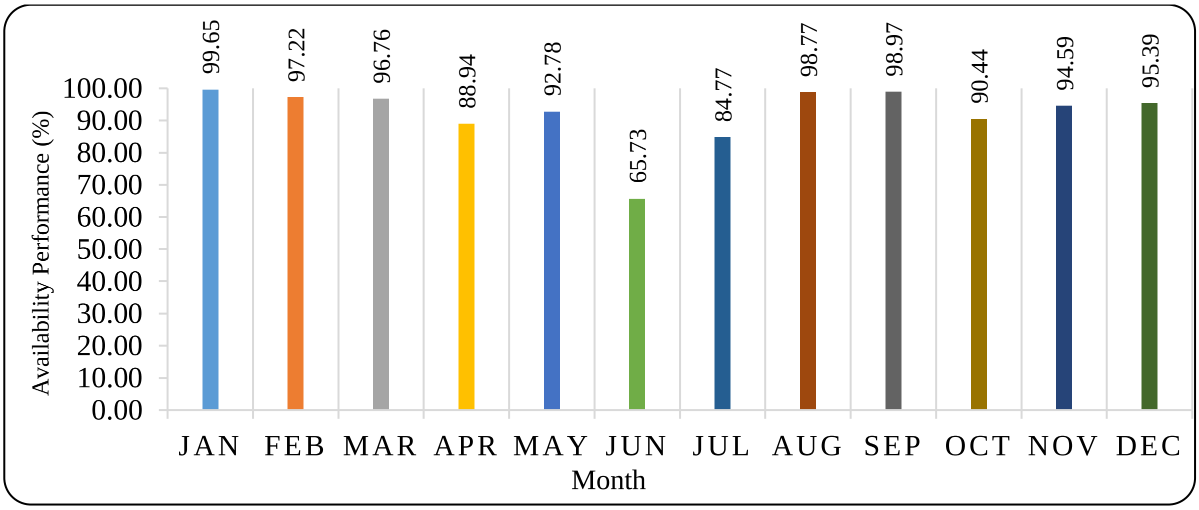


Figure 23: 66kV Transmission System Availability – 2023

3.6.1 Causes of the Outage

Apart from force majeure and planned shutdowns being excluded, the 66kV system experienced 25% of outages due to external factors, including harsh weather conditions, third-party interference, and grid source failures. The primary cause of frequent power interruptions, accounting for 75%, was unplanned outages. The major contributors to these unplanned outages were transient faults and equipment faults. The 66kV power line often failed due to the snapping of conductors, OPGW line breakages, and tripping of transformers. Other contributing factors to transmission system outages included overloading, voltage issues, and tree falls from within the RoW corridor on the line as shown in the pie chart below.

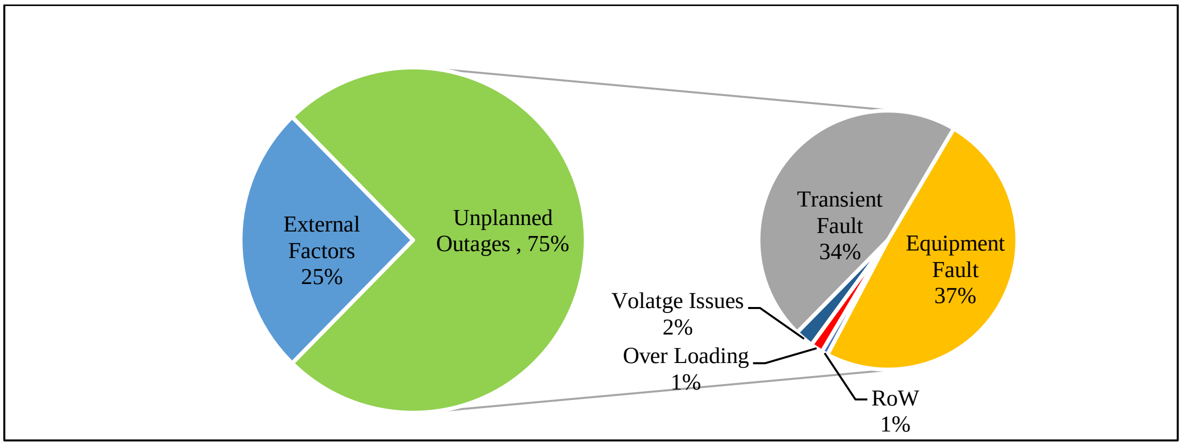


Figure 24: Cause of Power Interruptions in 66kV Transmission System (2023)

3.7 Overall Performance of Transmission System and Cause of Outage

In 2023, the 220kV transmission system has the highest annual system availability of 98.77% amongst the four (4) category voltage levels in the country. The 66kV has the lowest system availability due to faults associated with more number of 66kV circuits. The overall transmission system availability was 96.06%.

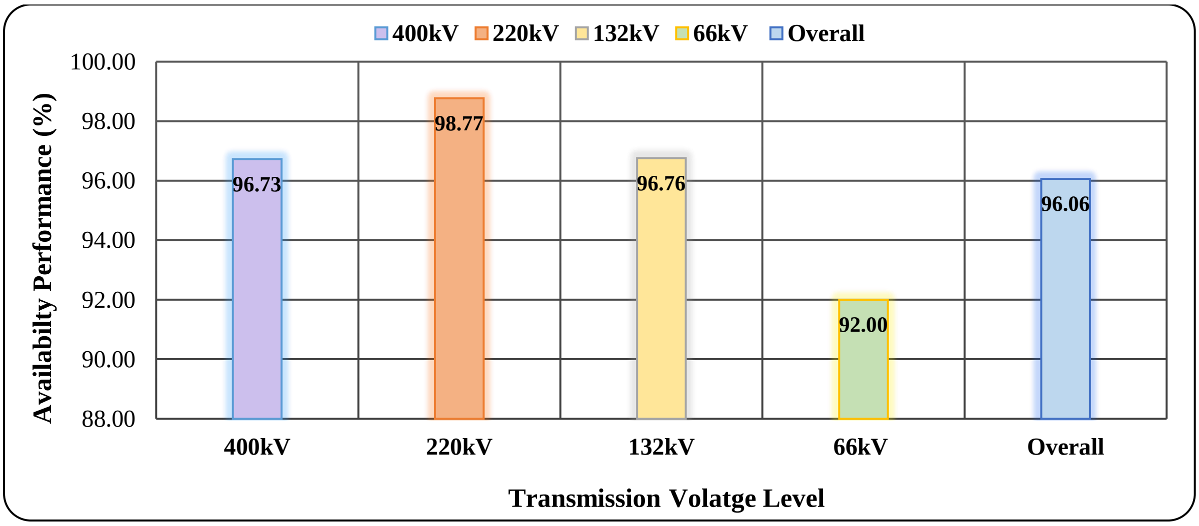


Figure 25: System Availability for Different Transmission Voltage Level (2023)

The transmission system faced outages mostly due to equipment faults, including the line snapping, OPGW breakages, and malfunctions in substation equipment. Therefore, regular inspection and maintenance of the transmission system's equipment, and adequate spare equipment in storage, can reduce outage durations and improving overall availability performance in Bhutan.

Another major cause of outages was transient faults, leading to 178 times of line interruptions with a total outage duration of 276 hours and 28 minutes. Transient faults commonly result from factors such as lightning strikes, momentary contact with the line by external objects like tree branches or animals, and sudden alterations in power demands, as well as faults in other equipment. Incorporating protective devices such as surge arrestors and protective relays becomes imperative in mitigating the impact of transient faults. These devices facilitate swift detection and resolution of transient faults, thereby minimizing both the duration and extent of power interruptions.

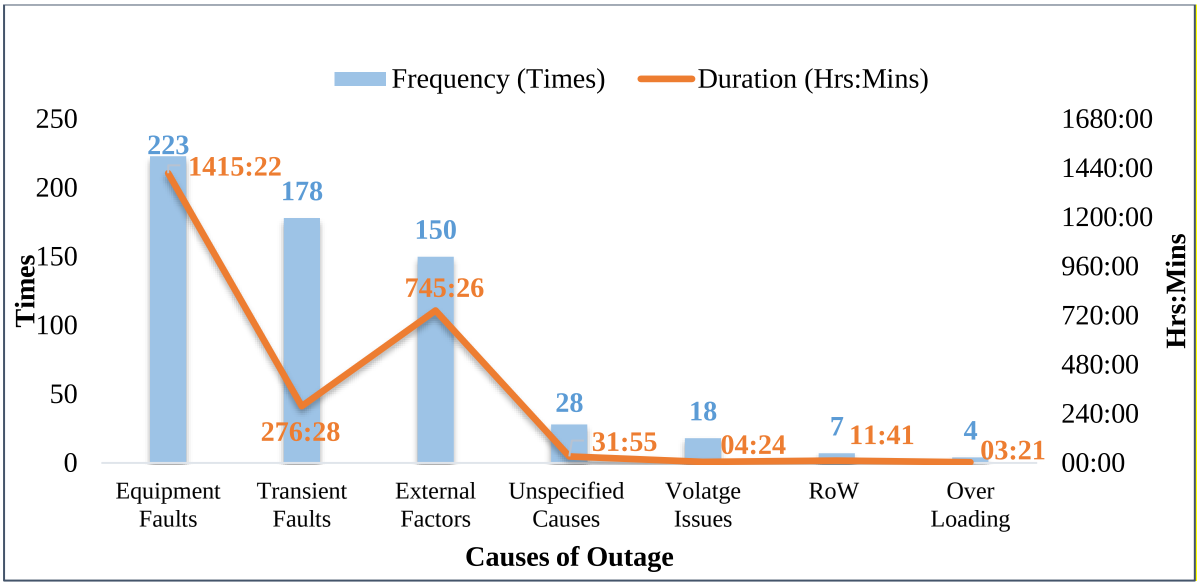


Figure 26:Factors Causing Transmission System Outage (2023)

External factors such as harsh weather conditions, third-party intervention, and grid/source failure have caused 150 times of system interruptions and a total outage duration of more than 745 hours. Since it is also a major cause disturbing the normal operation of the transmission system, it is very important to mitigate it through strategic measures improving the power system infrastructure enhancing the protective system, and giving an awareness to the third party on their intervention. System interruptions have also occurred due to other factors such as overloading, over or under voltage, tree fall on the line (RoW) and some causes of the outages were remained unspecified.

4. ACTIONS TO IMPROVE POWER OUTAGES BY BPC

1) Carry out condition-based and/or predictive maintenance works on all equipment such as Power Transformers, Distribution Transformers, Voltage Transformers, CT, Circuit Breaker, etc.

2) Carry out timely inspection of all HV, MV and LV lines using advanced technologies such as drones, HD camera, infrared thermal imagers, etc.

3) Coordinate and match its planned outages within Distribution and Transmission department to minimize outage impact to the Consumers.

4) Collect all users' tentative outage plans to synchronize their schedule works to reduce power outage.

5) Adhere to UG cable burial standards and install signs where necessary to indicate the presence of UG cables for easy detection of cable during fault finding/maintenance and minimizing destruction caused by third parties. Use good quality safety equipment.

6) Accelerate the installation of the Distribution Transformer metering systems for accurate reporting and recording of the power outages in the system.

7) Devise innovative methods for protecting or minimizing equipment damage caused by natural calamities such as lightning and landslides.

8) Accelerate smartening of the system to enhance the power reliability.

9) Improve earthing and grounding system.

10) Maintain adequate inventories for swift replacement to minimize power outages.

5. DISTRIBUTION RELIABILITY AND TRANSMISSION SYSTEM PERFORMANCE TARGET

1) Distribution Reliability Indices.

The ERA analyzed the power outages data of BPC for the year 2023 and determined the reliability of distribution system on the basis of number and duration of unplanned interruptions. The annual SAIFI calculated was 18.96 times/customer/year and SAIDI was 18.58 hours/customer/year for the year 2023. However, the ERA has set the target for SAIFI at 15.17 times/customer/year and SAIDI at 14.86 hours/customer/year for the year 2024-2025, which is 20 percent lower than the year 2023 mainly to achieve the SAIDI and SAIFI less than 1.00 in next five (5) years.

2) Transmission System Performance Standard

The ERA also analyzed the Transmission System outages of BPC for the year 2023 and determined the overall transmission system performance standard considering the total hours of the transmission system and the non-availability hours for the transmission system during the period under consideration. The annual average transmission system performance of 2023 was 96.06%. However, the ERA has set the target for annual average transmission system performance standard at 98% for the year 2024-2025, which is 2% higher than the year 2023 mainly to improve the transmission performance above 99% in next two (2) years.

ANNEXURE I

External Factors

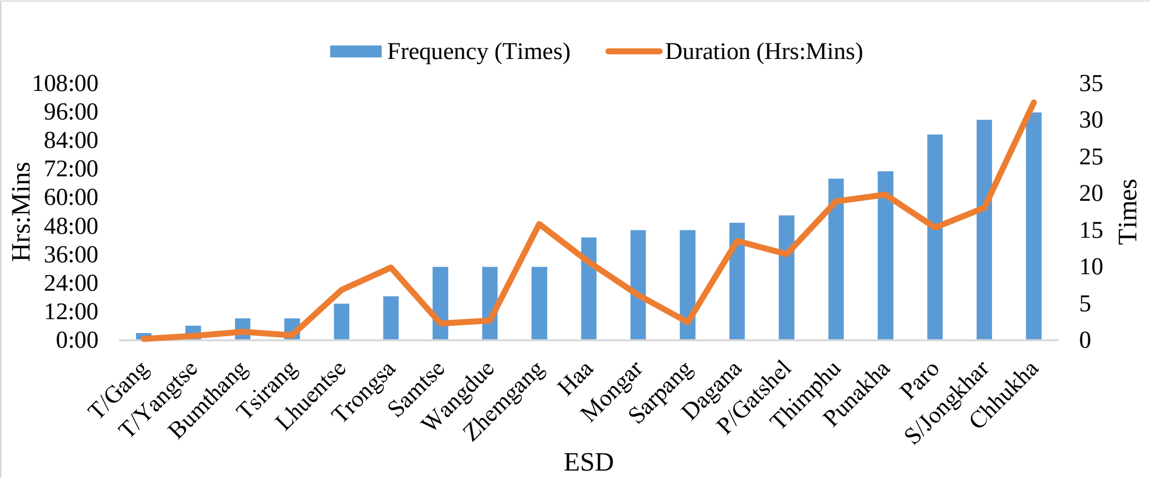


Figure 1: ESD Wise Frequency and Duration of Power Outages due to Third Party

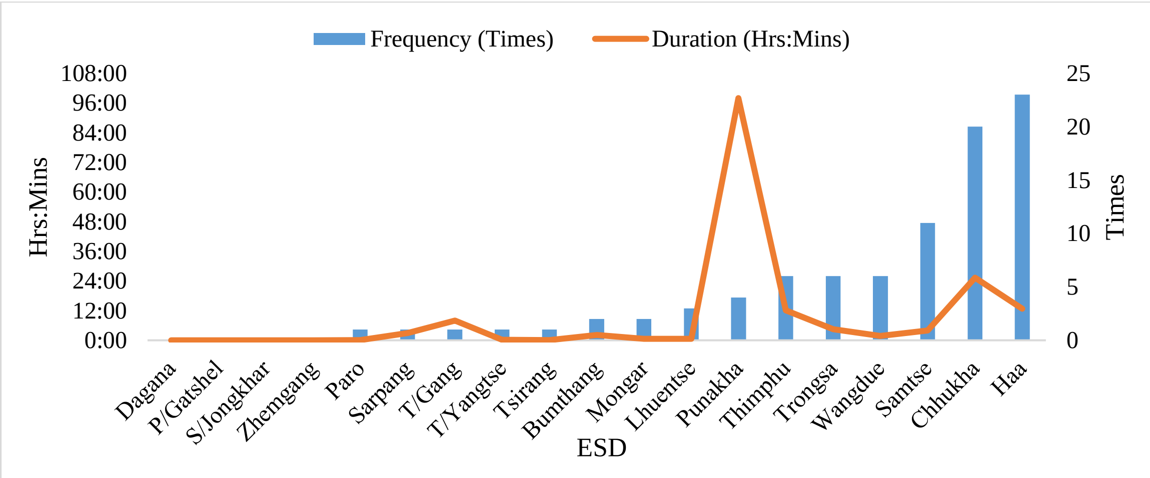


Figure 2:ESD Wise Frequency and Duration of Power Outages due to Grid/Source failure

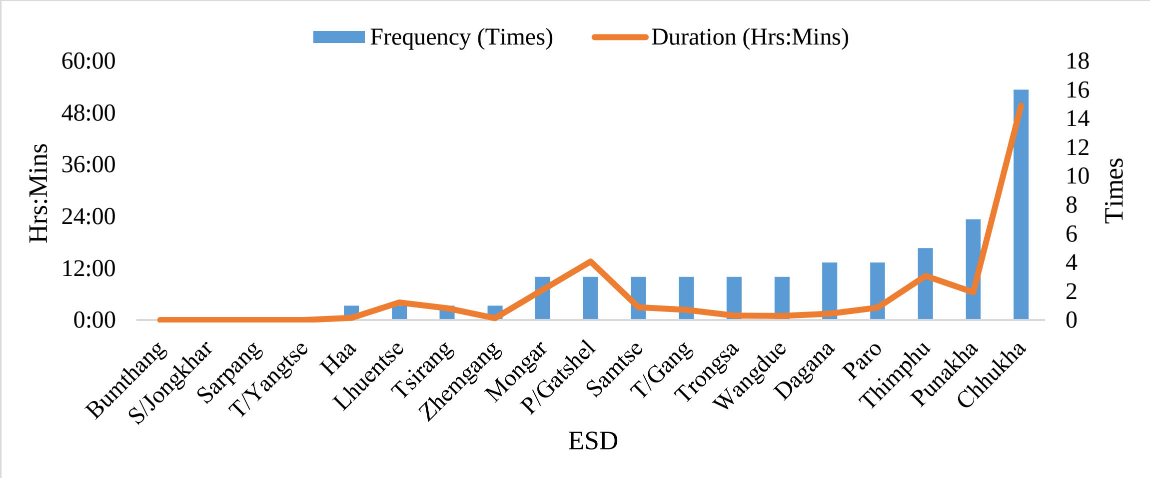


Figure 3: ESD Wise Frequency and Duration of Power Outages due to Natural Calamities

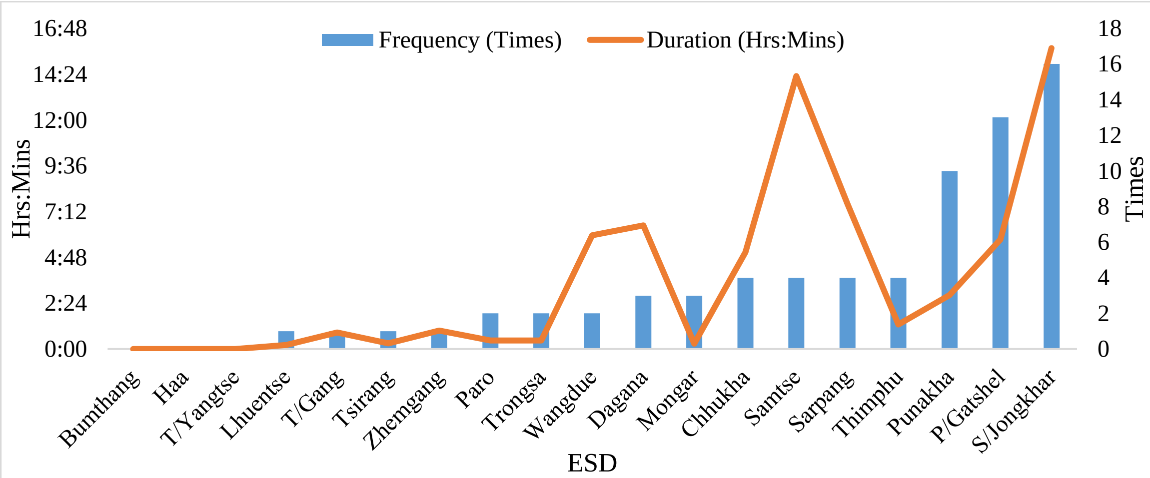


Figure 4: ESD Wise Frequency and Duration of Power Outages due to Animals

ANNEXURE II

Contributors to Unplanned Outages.

Table 1: Frequency of interruption (Times)

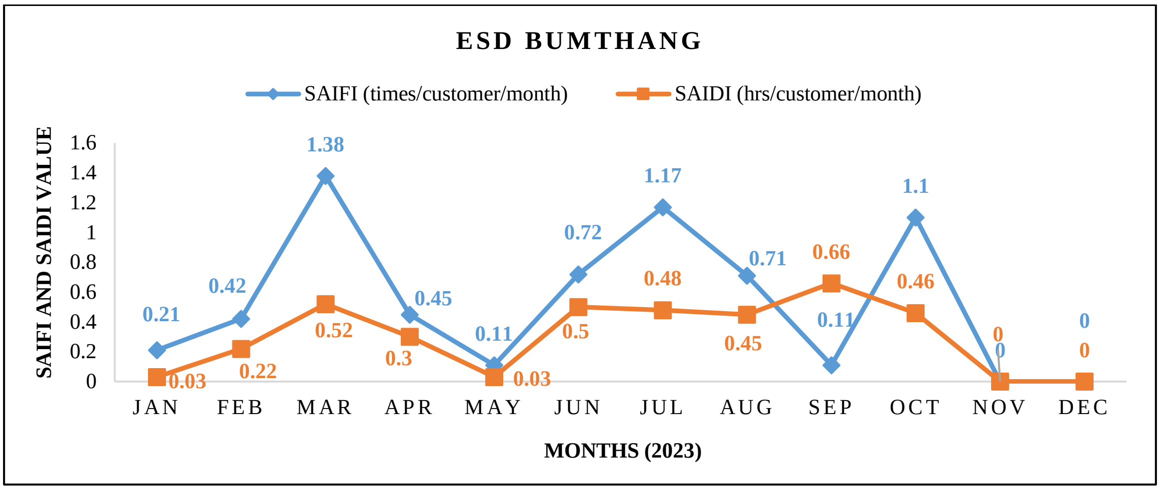
Factors	ESD																		
	Bumthang	Chukha	Dagana	Haa	Lhuentse	Mongar	Paro	P/Gatshel	Punakha	S/Jongkhar	Samtse	Sarpang	Thimphu	Trashigang	T/Yangtse	Trongsa	Tsirang	Wangdue	Zhemgang
HT Fuse	15	119	69	129	15	74	50	119	30	205	72	15	14	57	27	23	45	16	49
Transient Fault	22	45	8	17	0	16	57	54	12	23	32	3	38	13	16	7	4	8	29
Line/Conductor	11	118	65	39	13	36	69	76	29	102	44	48	65	24	7	24	12	49	13
RoW	4	27	21	18	17	15	2	59	26	39	34	21	13	8	19	13	5	13	42
Transformer	1	13	9	12	4	7	19	15	25	24	14	7	15	7	5	9	10	5	7
Breaker	5	20	44	18	2	15	12	33	21	23	17	3	2	3	2	8	11	5	12
Insulator	4	26	13	1	2	4	3	11	6	6	24	13	6	4	1	2	6	6	0
GO Switch	1	32	0	3	0	3	3	2	8	0	1	4	9	5	0	0	0	4	12
LA	1	14	3	3	1	10	0	9	4	5	12	3	3	8	2	0	1	0	0
Distribution Pillars	0	4	1	4	0	0	2	6	1	36	0	0	0	4	0	0	0	0	0
CT and PT	0	0	2	0	0	1	0	3	0	2	4	0	1	0	0	3	0	0	0
Cause Unknown	8	6	95	49	5	0	17	100	2	40	0	29	3	7	4	9	8	10	35
Sectionalizer	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Energy Meter	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

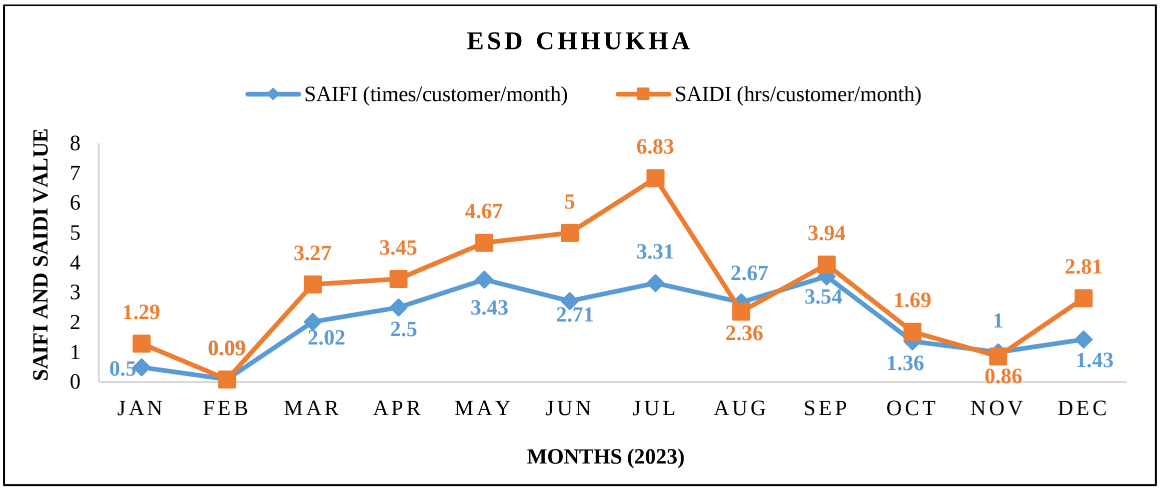
Table 2: Duration of Outages (Hrs:Mins)

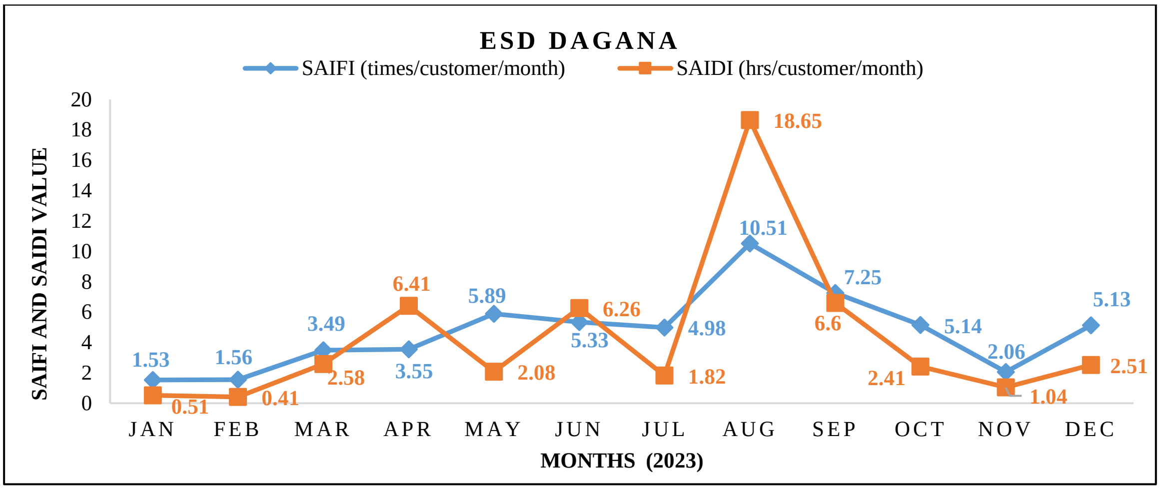
Factors	ESD																		
	Bumthang	Chukha	Dagana	Haa	Lhuentse	Mongar	Paro	P/Gatshel	Punakha	S/Jongkhar	Samtse	Sarpang	Thimphu	Trashigang	T/Yangtse	Trongsa	Tsirang	Wangdue	Zhemgang
HT Fuse	3:44	49:47	20:54	88:40	2:10	44:46	93:36	69:17	6:12	71:15	29:21	4:14	20:57	10:17	6:55	6:05	44:42	4:00	14:35
Transient Fault	8:25	45:50	1:53	16:00	0:00	4:32	29:36	58:12	4:39	14:26	65:19	8:12	6:12	2:35	3:24	14:25	0:31	1:44	35:13
Line/Conductor	9:56	267:59	479:45	83:01	58:57	26:54	160:36	77:30	28:31	85:21	196:18	86:43	85:44	89:36	9:46	38:01	37:57	82:23	31:44
RoW	4:53	34:43	31:24	11:01	30:32	16:00	1:37	158:36	20:44	29:06	76:00	46:05	16:14	15:15	41:40	120:43	34:20	14:01	192:00
Transformer	0:25	9:47	3:20	17:17	57:46	3:54	22:54	12:34	18:47	29:03	47:41	6:01	8:42	84:02	2:35	10:48	29:03	1:16	4:17
Breaker	17:28	24:47	22:48	16:57	0:21	30:14	8:43	40:53	12:21	16:17	30:32	3:12	2:22	0:51	0:22	2:12	7:30	3:07	13:48
Insulator	3:05	115:49	67:05	0:19	33:24	13:24	2:20	22:38	12:31	22:41	70:53	63:52	5:16	38:04	0:52	56:14	6:11	29:36	0:00
GO Switch	6:36	40:01	0:00	0:59	0:00	3:18	0:30	2:56	2:38	0:00	0:00	1:21	5:58	2:26	0:00	0:00	0:00	2:49	5:56
LA	0:00	29:28	3:11	2:42	1:20	7:59	0:00	8:37	4:54	4:01	82:48	5:10	6:39	3:37	1:37	0:00	0:12	0:00	0:00
Distribution Pillars	0:00	1:38	0:32	2:08	0:00	0:00	6:11	2:49	0:17	22:05	0:00	0:00	0:00	2:27	0:00	0:00	0:00	0:00	0:00
CT and PT	0:00	0:00	4:48	0:00	0:00	0:05	0:00	2:42	0:00	11:42	9:31	0:00	0:34	0:00	0:00	2:03	0:00	0:00	0:00
Cause unknown	2:28	25:22	143:22	81:25	6:37	0:00	18:00	118:02	5:48	50:23	0:00	36:41	3:50	8:31	1:42	5:11	40:33	13:04	73:54
Sectionalizer	0:00	0:56	0:00	0:52	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:19	0:00
Energy Meter	0:00	0:00	0:00	0:13	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00

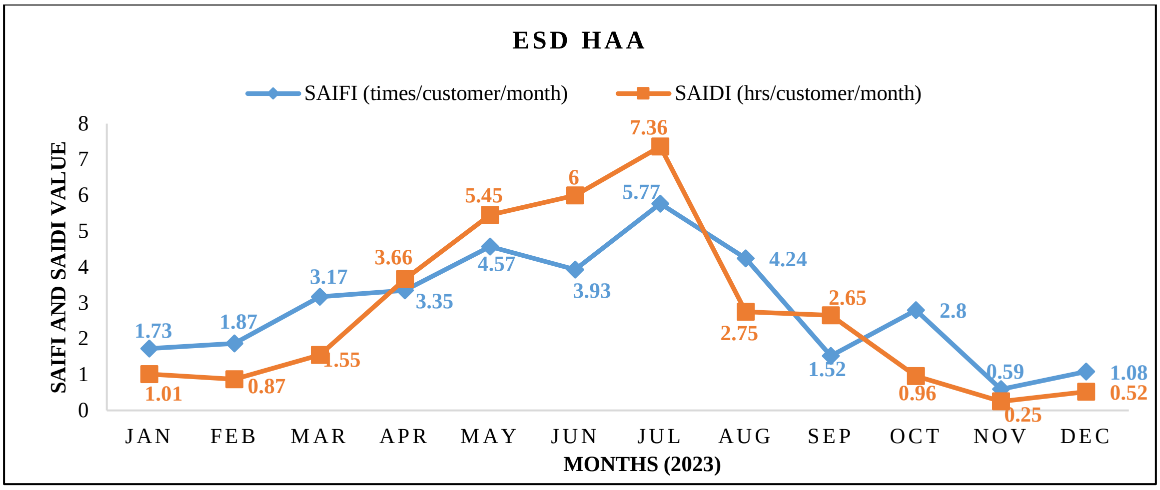
ANNEXURE III

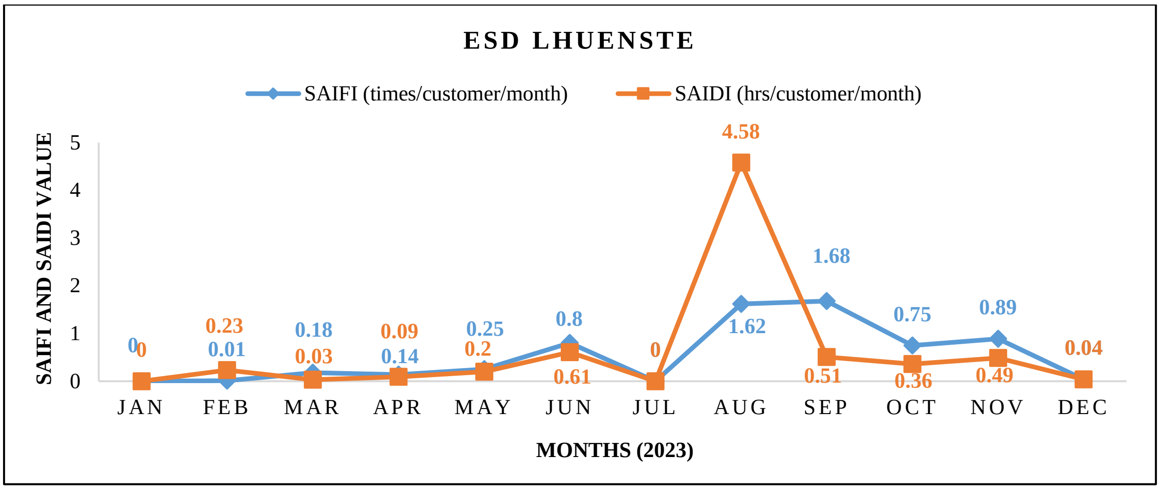
ESD Wise - Monthly SAIFI and SAIDI

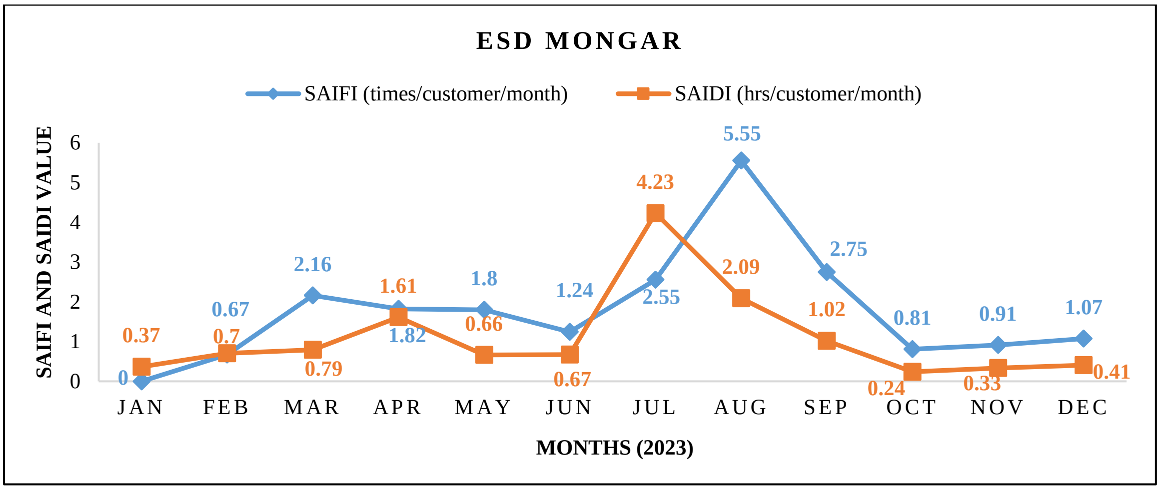


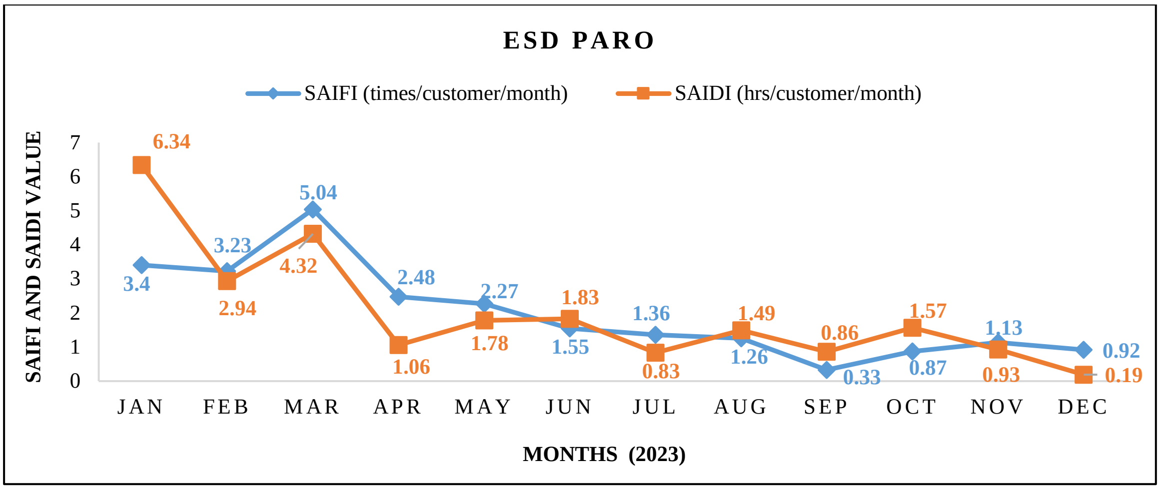


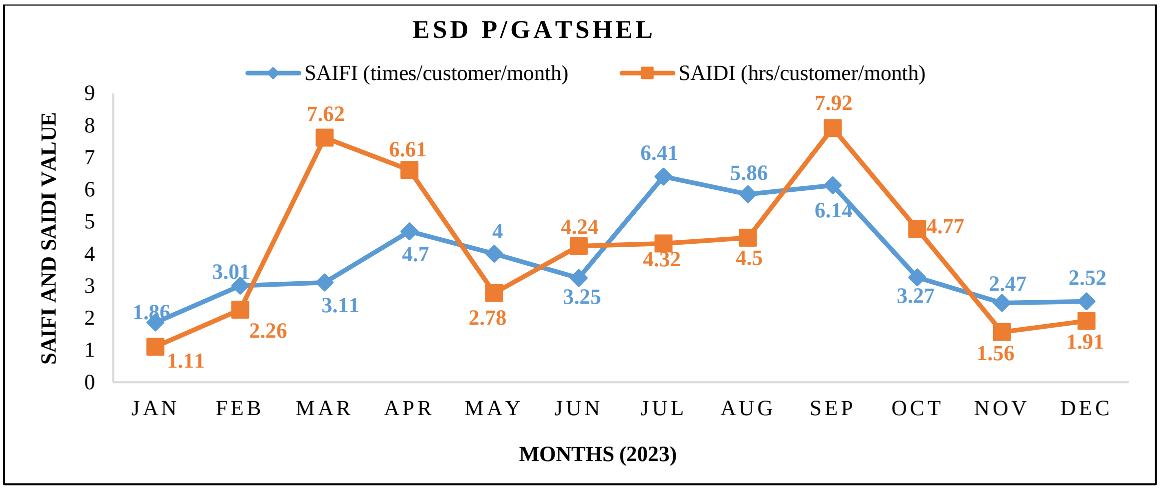


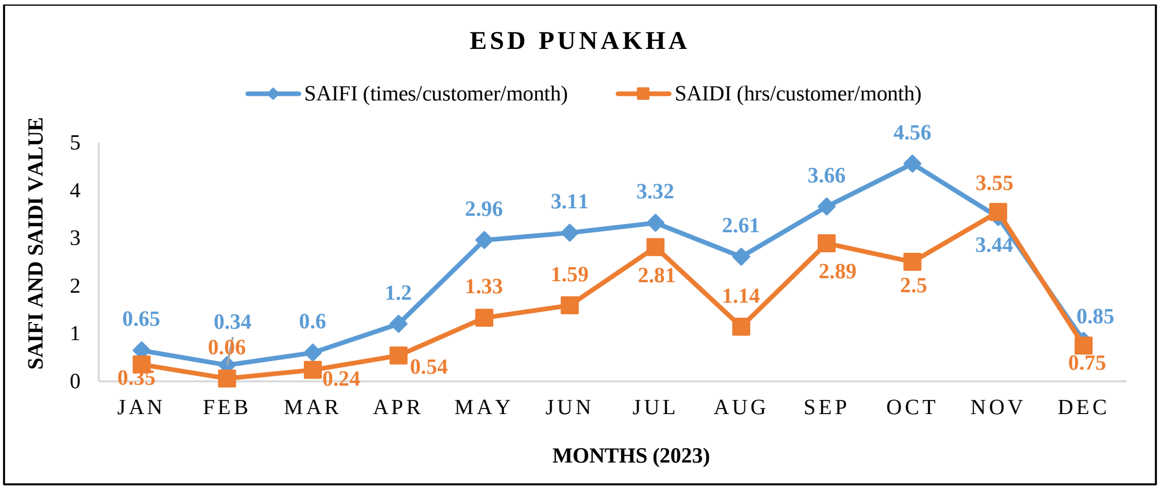

ESD HAA
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1.73 1.87 3.17 3.35 4.57 3.93 5.77 4.24 1.52 2.8 0.59 1.08
1.01 0.87 1.55 3.66 5.45 6 7.36 2.75 2.65 0.96 0.25 0.52

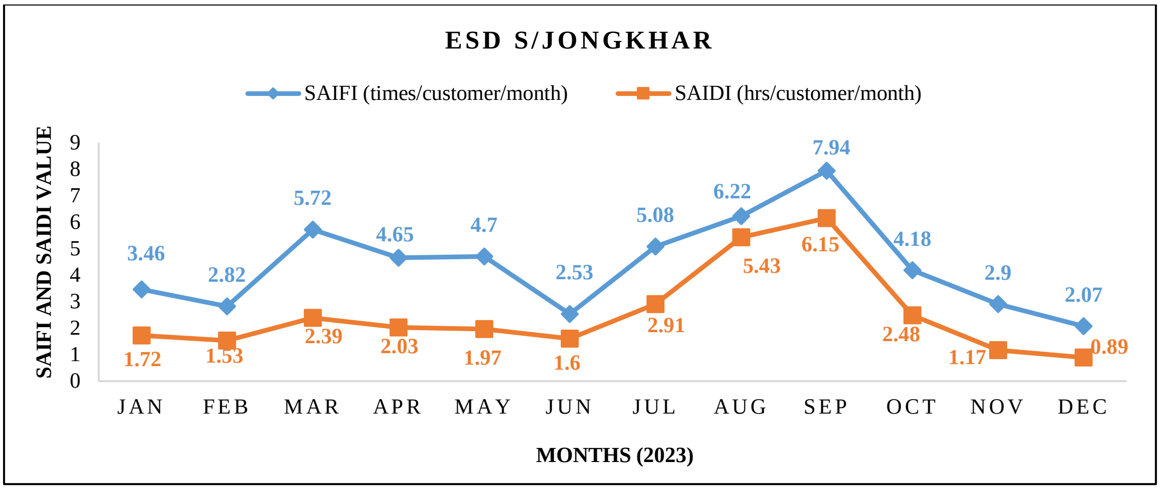

ESD LHUENSTE
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 0.01 0.18 0.14 0.25 0.8 1.62 1.68 0.75 0.89
0 0.23 0.03 0.09 0.2 0.61 0 4.58 0.51 0.36 0.49 0.04

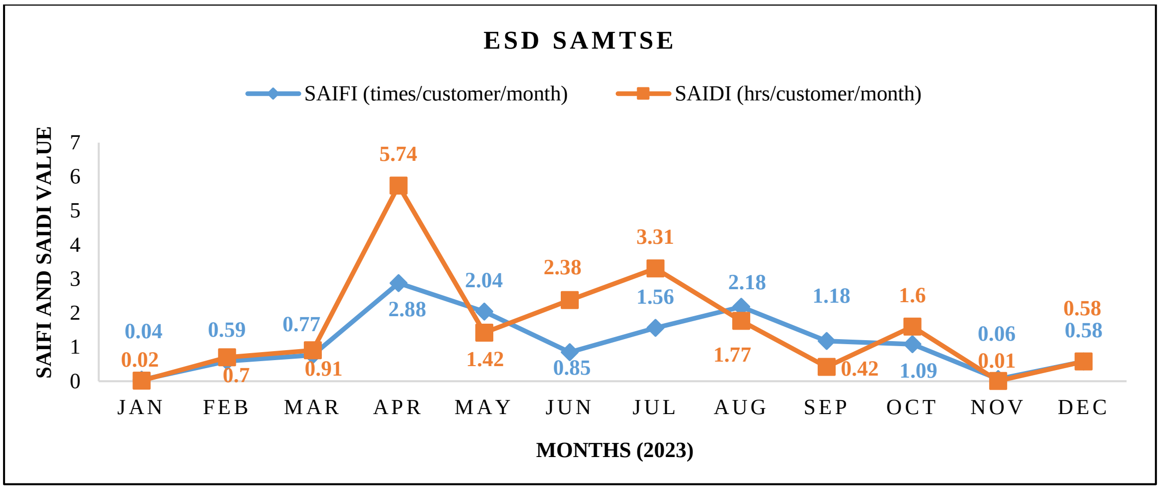

ESD MONGAR
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 0.67 2.16 1.82 1.8 1.24 2.55 5.55 2.75 0.81 0.91 1.07
0.37 0.7 0.79 1.61 0.66 0.67 4.23 2.09 1.02 0.24 0.33 0.41

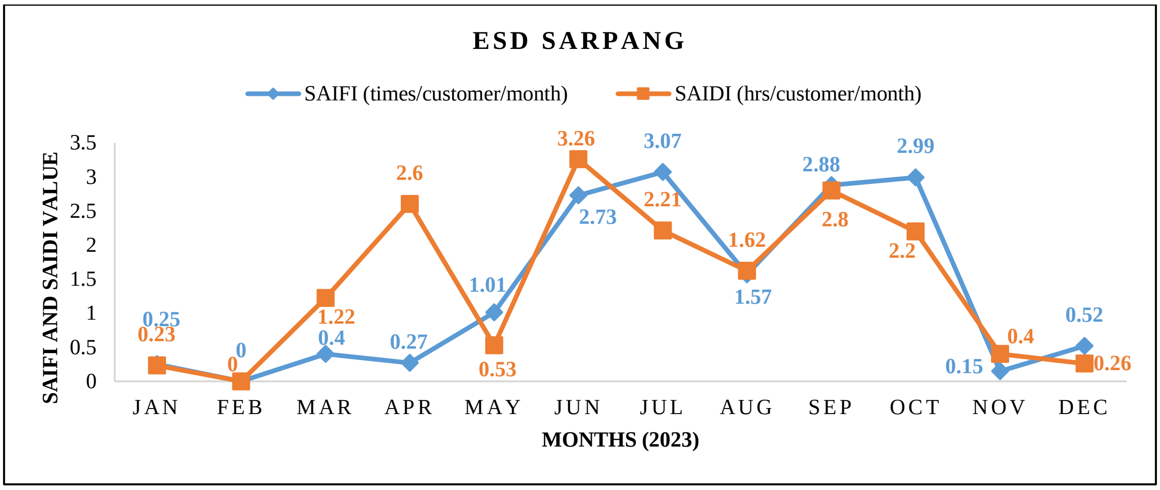

ESD PARO
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
6.34
3.4
3.23
2.94
5.04
4.32
2.48
1.06
2.27
1.78
1.83
1.55
1.36
0.83
1.49
1.26
0.86
0.33
1.57
0.87
1.13
0.93
0.92
0.19

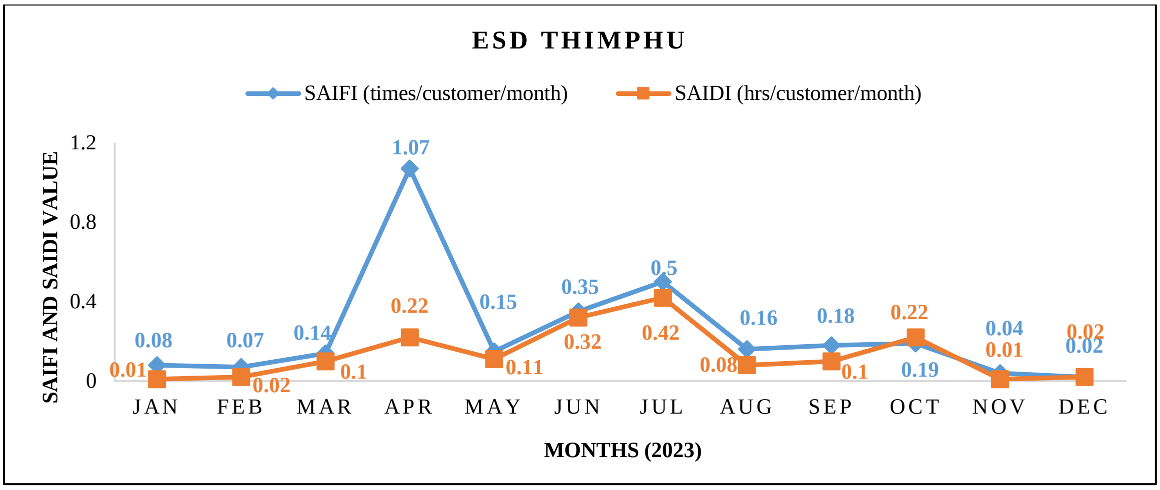

ESD P/GATSHEL
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1.86
1.11
3.01
2.26
7.62
3.11
6.61
4.7
4
2.78
4.24
3.25
6.41
4.32
5.86
4.5
7.92
6.14
4.77
3.27
2.47
1.56
2.52
1.91

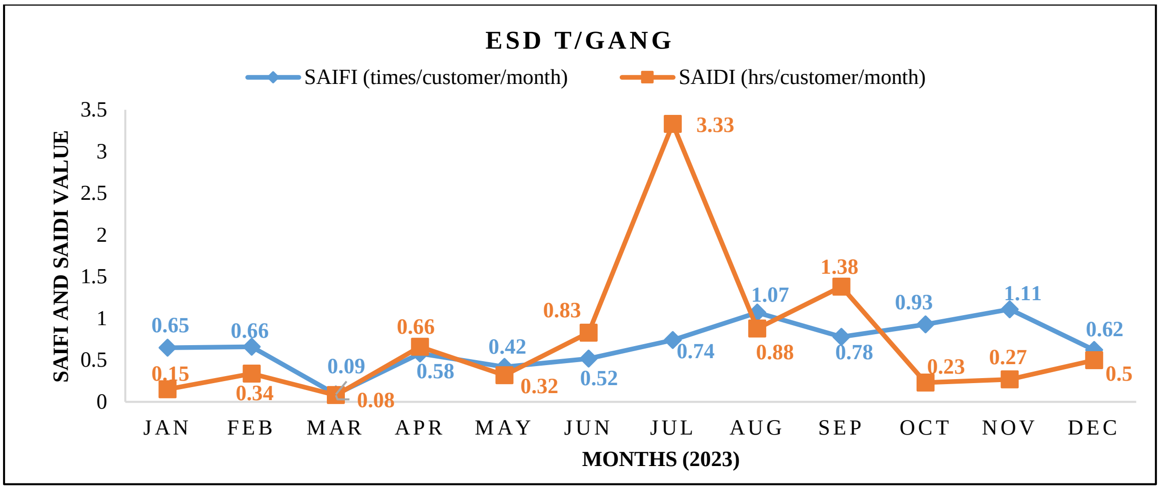

ESD PUNAKHA
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0.65
0.35
0.34
0.06
0.6
0.24
1.2
0.54
2.96
1.33
3.11
1.59
3.32
2.81
2.61
1.14
3.66
2.89
4.56
2.5
3.55
3.44
0.85
0.75

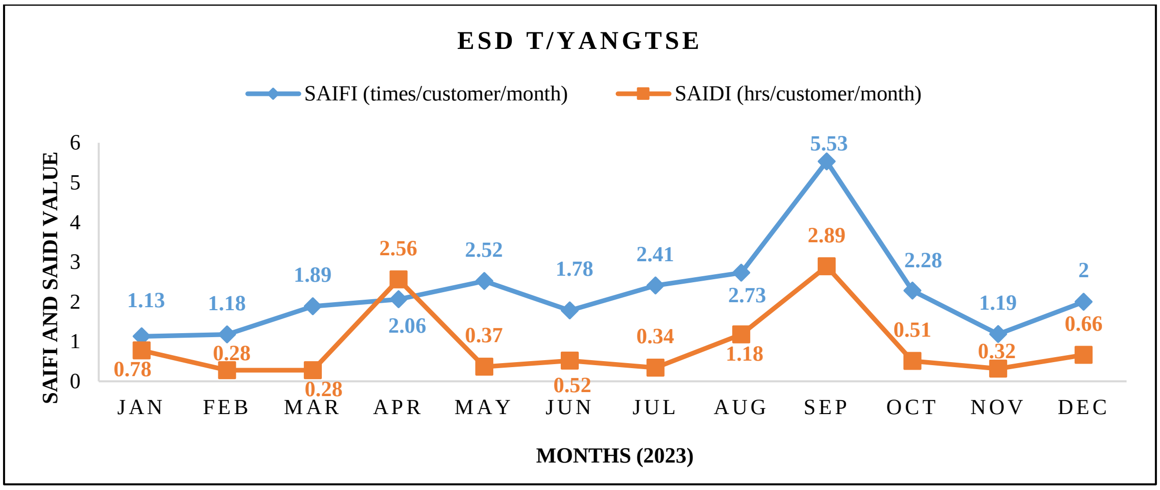

ESD S/JONGKHAR
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTHS (2023)
3.46 2.82 5.72 4.65 4.7 2.53 5.08 6.22 7.94 4.18 2.9 2.07
1.72 1.53 2.39 2.03 1.97 1.6 2.91 5.43 6.15 2.48 1.17 0.89

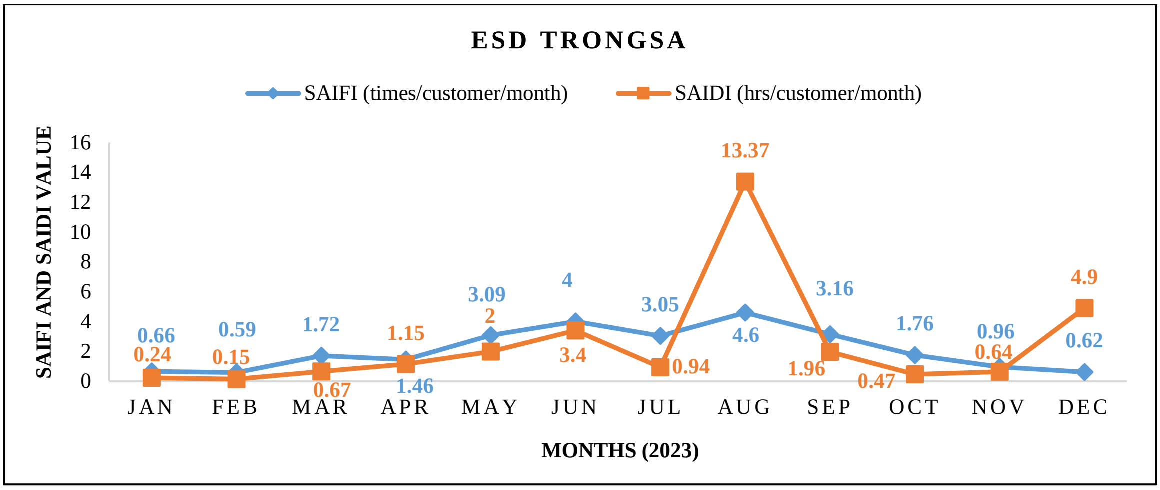

ESD SAMTSE
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTHS (2023)
0.04 0.59 0.77 2.88 2.04 0.85 1.56 2.18 1.18 1.09 0.06 0.58
0.02 0.7 0.91 5.74 1.42 2.38 3.31 1.77 0.42 1.6 0.01 0.58

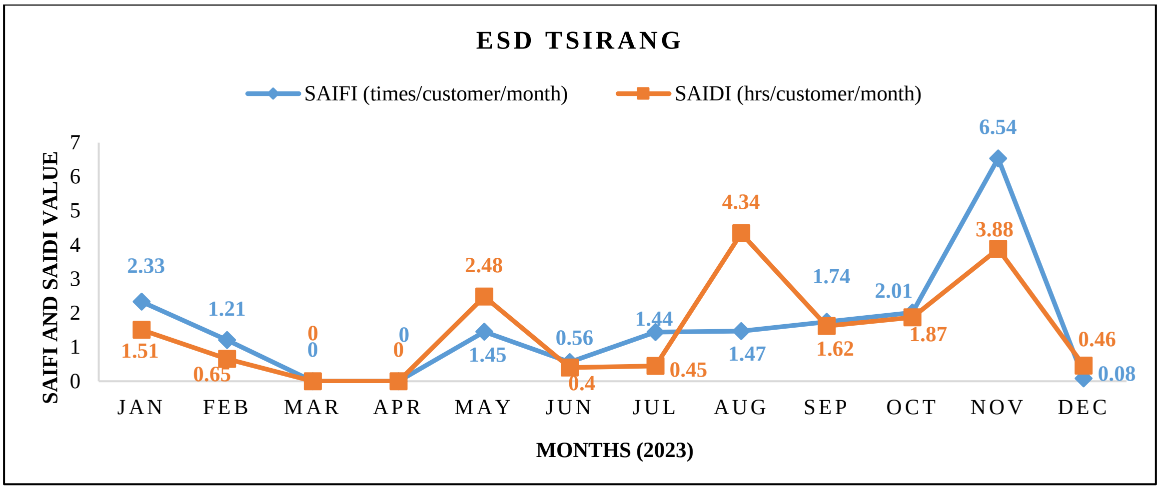

ESD SARPANG
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTHS (2023)
0.25 0 0.4 0.27 1.01 2.73 3.07 1.57 2.88 2.99 0.15 0.52
0.23 0 1.22 2.6 0.53 3.26 2.21 1.62 2.8 2.2 0.4 0.26

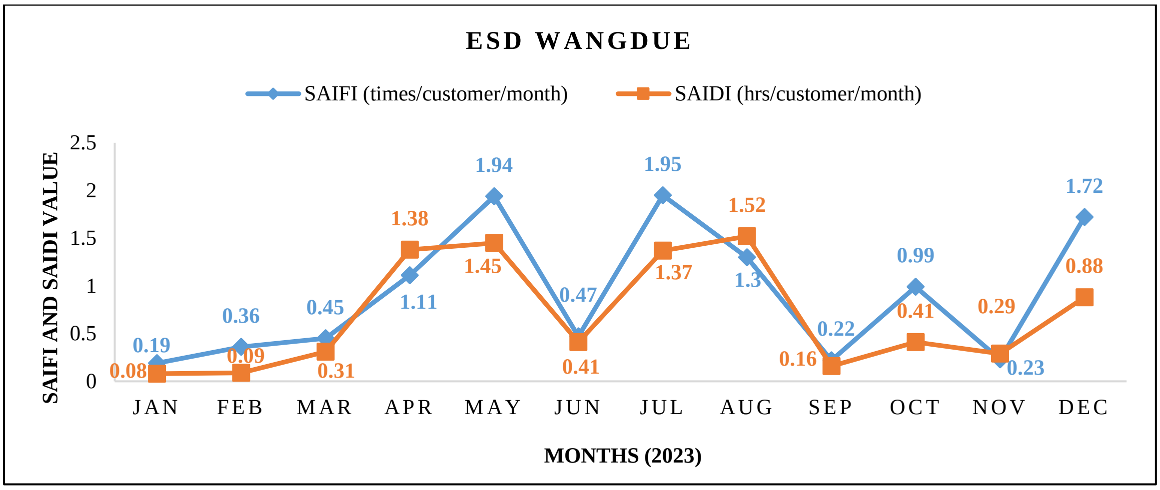

ESD THIMPHU
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
SAIFI: 0.08 0.07 0.14 1.07 0.15 0.35 0.5 0.16 0.18 0.19 0.04 0.02
SAIDI: 0.01 0.02 0.1 0.22 0.11 0.32 0.42 0.08 0.1 0.22 0.01 0.02

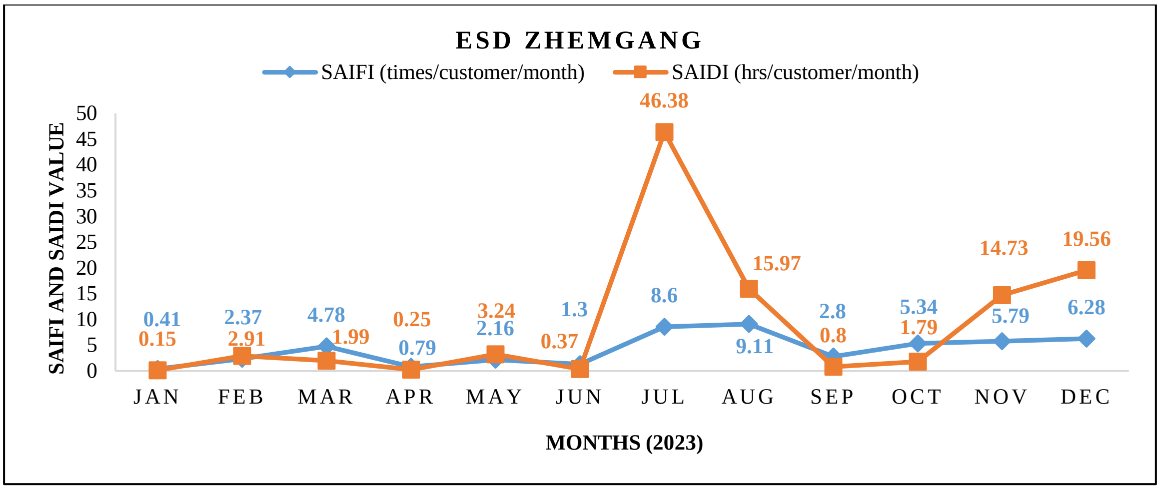

ESD T/GANG
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
SAIFI: 0.65 0.66 0.09 0.58 0.42 0.52 0.74 1.07 0.78 0.93 1.11 0.62
SAIDI: 0.15 0.34 0.08 0.66 0.32 0.83 3.33 0.88 1.38 0.23 0.27 0.5


ESD T/YANGTSE
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
SAIFI: 1.13 1.18 1.89 2.06 2.52 1.78 2.41 2.73 5.53 2.28 1.19 2
SAIDI: 0.78 0.28 0.28 2.56 0.37 0.52 0.34 1.18 2.89 0.51 0.32 0.66


ESD TRONGSA
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0.66 0.59 1.72 1.46 3.09 4 3.05 4.6 3.16 1.76 0.96 0.62
0.24 0.15 0.67 1.15 2 3.4 0.94 13.37 1.96 0.47 0.64 4.9


ESD TSIRANG
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
2.33 1.21 0 0 1.45 0.56 1.44 1.47 1.74 2.01 6.54 0.08
1.51 0.65 0 0 2.48 0.4 0.45 4.34 1.62 1.87 3.88 0.46


ESD WANGDUE
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
MONTHS (2023)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0.19 0.36 0.45 1.11 1.94 0.47 1.95 1.3 0.22 0.99 0.23 1.72
0.08 0.09 0.31 1.38 1.45 0.41 1.37 1.52 0.16 0.41 0.29 0.88


ESD ZHEMGANG
SAIFI (times/customer/month)
SAIDI (hrs/customer/month)
SAIFI AND SAIDI VALUE
50
45
40
35
30
25
20
15
10
5
0
0.41
0.15
2.37
2.91
4.78
1.99
0.25
0.79
3.24
2.16
1.3
0.37
46.38
8.6
15.97
9.11
2.8
0.8
5.34
1.79
14.73
5.79
19.56
6.28
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHS (2023)

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