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Assessment of Reliability Indices in Albania Distribution System

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Introduction



This paper is focused on the evaluation of the quality of supply, referring to the continuity of the supply as an important issue.



An analytical approach is used to calculate reliability indices such as SAIDI, SAIFI, CAIDI, and ENS according to IEEE Standard 1366



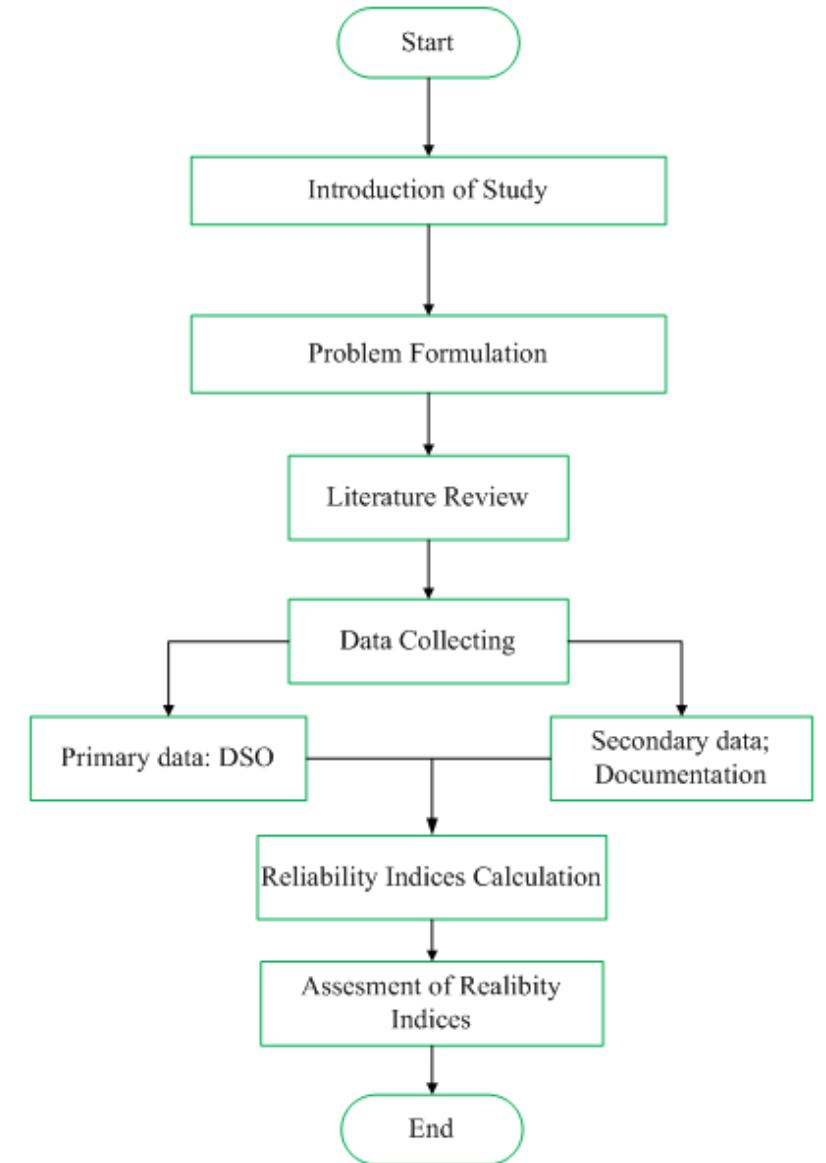
Reliability indices are ben used measuring system performance, service quality and the appropriate orientation of investments and technical measures for improvement.




In addition, is evaluated the impact of connection of distributed generation (HPPs, PVs), considering their connection point, as aged network components, energy demand in various areas of DSO.


Methodology of the Study


- In this paper, a **quantitative assessment of the reliability** of the Albanian Distribution System is estimated by measuring performance, **providing a clearly reliability profile of the existing system**
- Reliability indices **have been assessed for various voltage levels and geographical areas (urban, rural, and deep rural area), as well as by different distributions areas** to evaluate the impact of changes, new investments, depreciation, and the typology of the distribution network

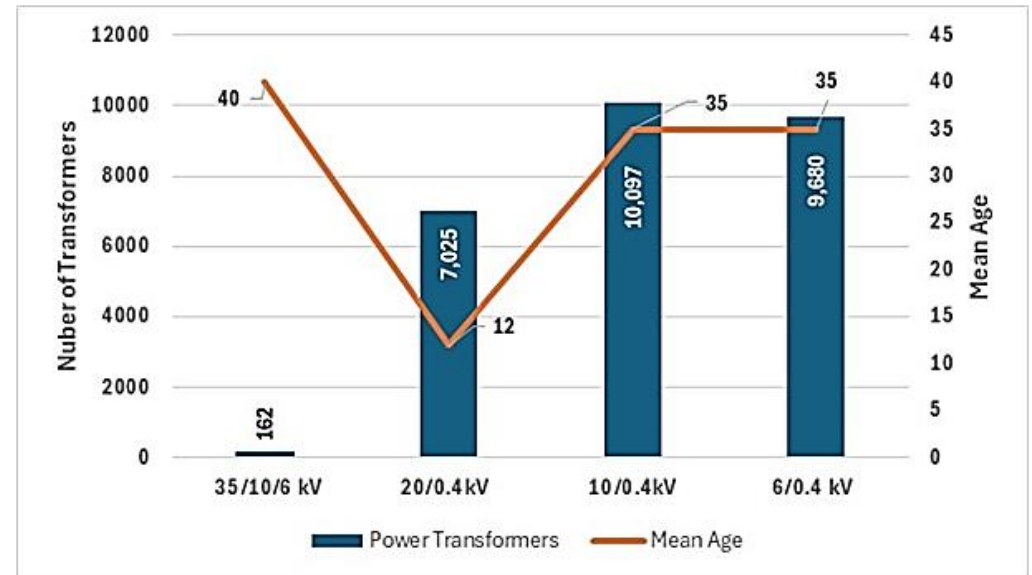
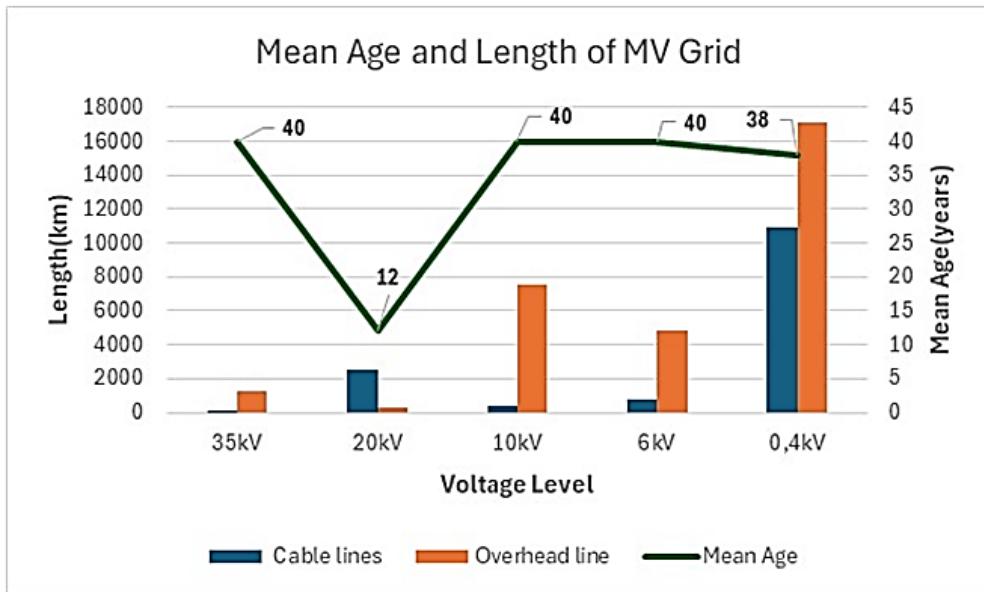


Albania Distribution System

 The Electricity Distribution System Operator in Albania is organized in **11 distribution areas** and **42 agencies** managed by a **single utility**

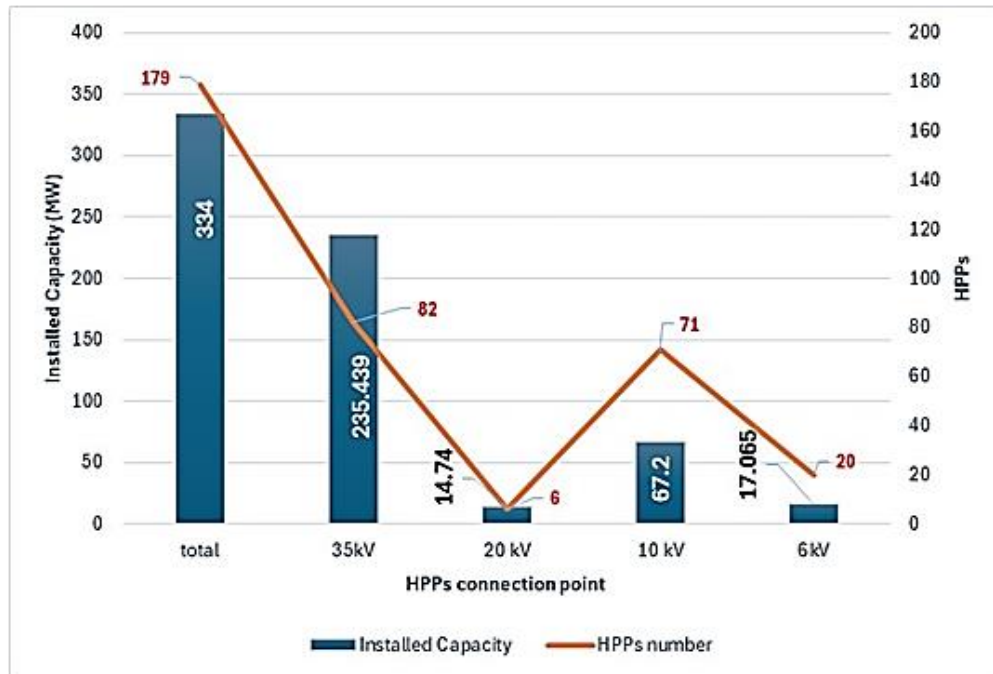
 Electricity distribution system includes all network elements at voltage levels of **35, 20, 10, 6, and 0.4 kV**, as well as substations that transform from 110 kV to them.

 The **aging** of distribution network (DN) components is one of the main factors for the **increased outages**, longer restoration times, **reduced performance** and **increased maintenance costs**



Albania Distribution System

- The penetration of small hydropower plants in Albania and PVs, connected to DN is increased significantly
- Most of HPPs are concentrated in the regions of the **Northeast and southeast of the country**, specifically the highest number it's located in **Kukës, Burrel, and Korça** area
- High penetration of Renewable Energy Sources (RESs) can have both positive and negative impacts on the local electrical network, especially when installed at high levels and when the network has low capacity for transmitting electricity



□ **179 HPPs** are connected at different voltage levels of the distribution network, with a total installed capacity **334 MW**

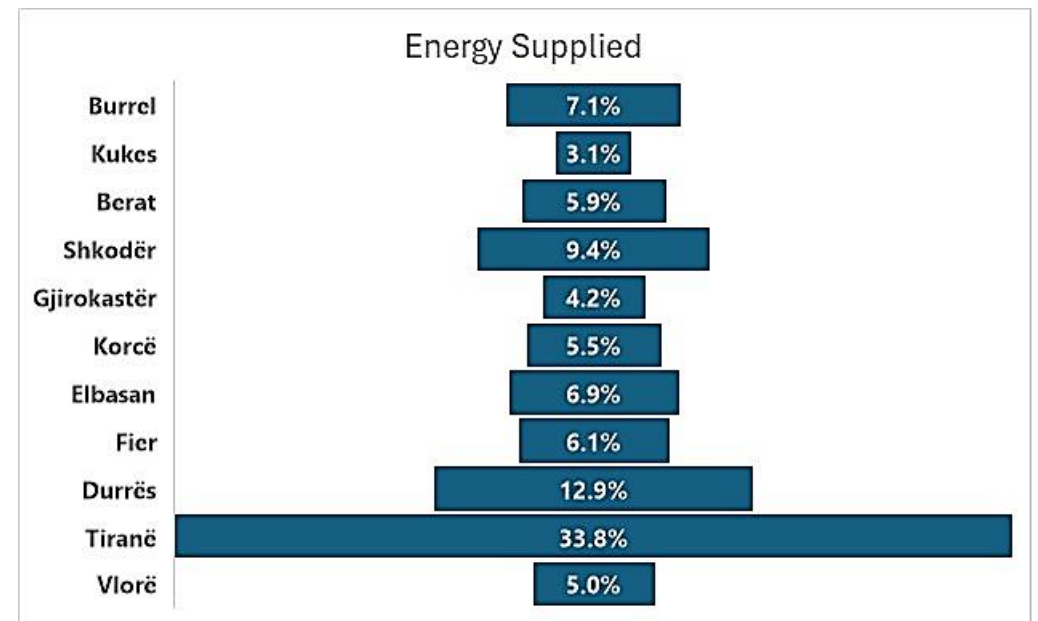
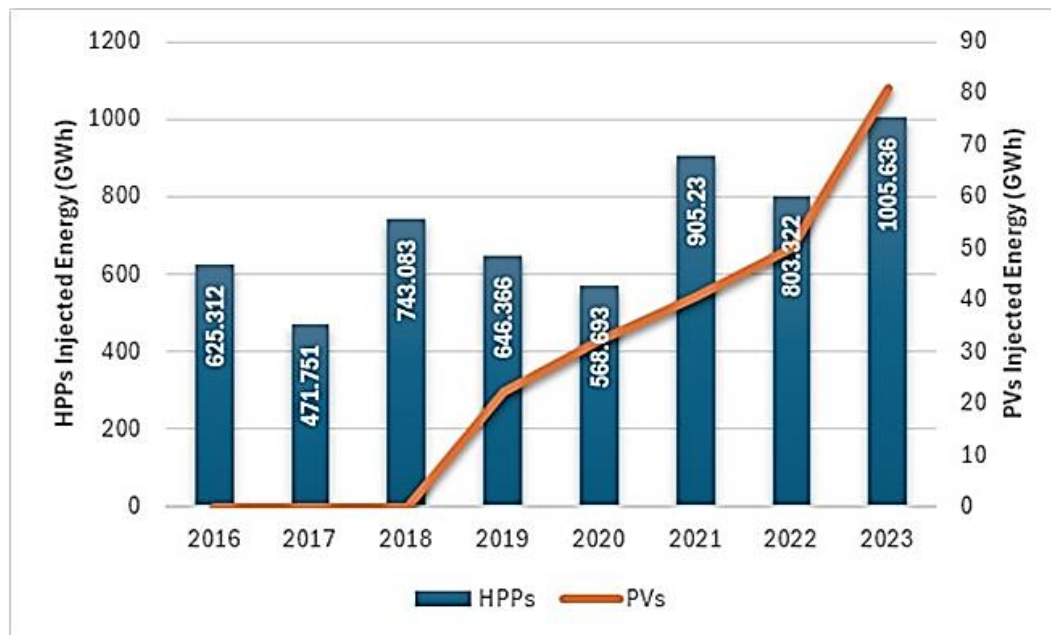
□ Currently, **21 PVs** are connected, with a total installed capacity of **48 MW**, almost all connected at the **35 kV** voltage level.

HPPs installed capacity by connection point

Albania Distribution System

In 2023, the total energy injected into the distribution network from hydroelectric power plants (HPPs) and photovoltaic systems (PVs) is **1,086,510 MWh**, with an increasing trend in the coming years

Energy consumption is concentrated in the main cities such as Tirana, Durrës, Fier, Shkodër and Vlora (about 70% of the electricity consumption), and less in rural and deep rural areas



- Total energy injected into the distribution network during the last 8 years

- The consumption of electric energy in the electric distribution network by Distribution Areas during the year 2023

Overview of Distribution Reliability Indices

Customer-orientated indices

- ❑ System Average Interruption Frequency Index, (**SAIFI**)

$$SAIFI = \frac{\sum \text{Total Number of Customer Interruptions}}{\text{Total Number of Customers Served}} = \frac{\sum N_i}{N_T}$$

N_i – Number of Interrupted Customers for each Sustained Interruption event during the reporting Period

N_T – Total Number of Customers Served

- ❑ System Average Interruption Duration Index, (**SAIDI**)

$$SAIDI = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customers Served}} = \frac{\sum r_i N_i}{N_T}$$

r_i – Restoration Time for each Interruption Event

- ❑ Customer Average Interruption Duration Index (**CAIDI**)

$$CAIDI = \frac{\sum \text{Customer Interruption Durations}}{\text{Total Number of Customers Interrupted}} = \frac{\sum r_i N_i}{\sum N_i}$$

Load- and energy-orientated indices

- ❑ Energy not supplied index, **ENS (MWh)**

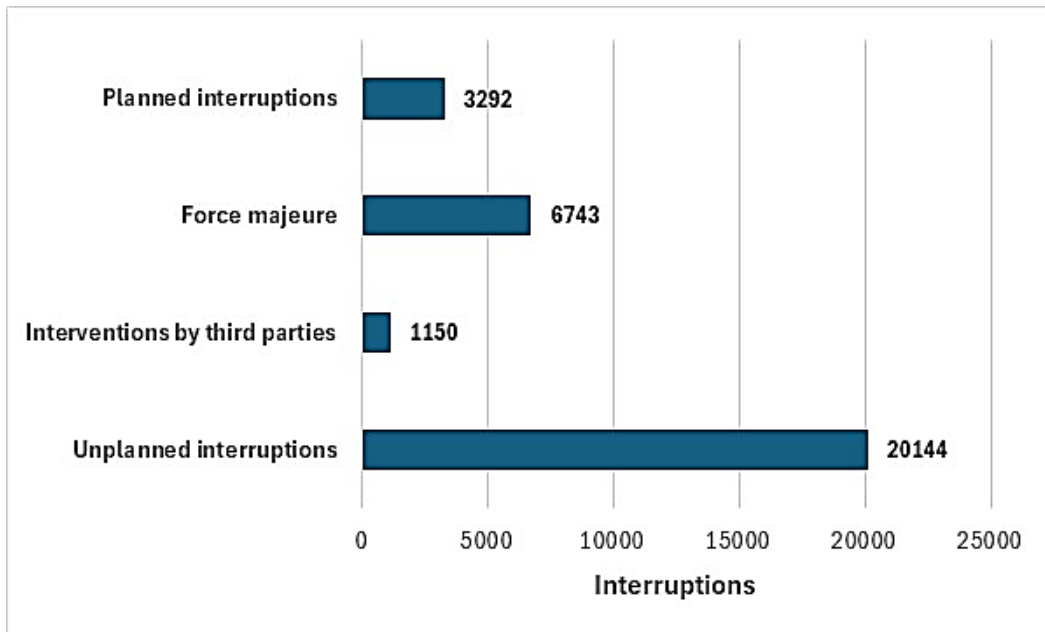
$$ENS = \text{total energy not supplied by the system} = \sum_{i=1}^n L_i \times U_i$$

L_i – Load demand during the interruption for the i^{th} event

U_i – Duration of interruption for the i^{th} event

Data collecting

Large data has been collected regarding the interruption that occurred throughout the year 2023, according to number of interruptions, duration and number of customers affected by the interruptions. **Classification of failure is done according to voltage levels HV, MV and LV, Distribution Areas and according to geographical location** i.e urban, rural and deep rural areas

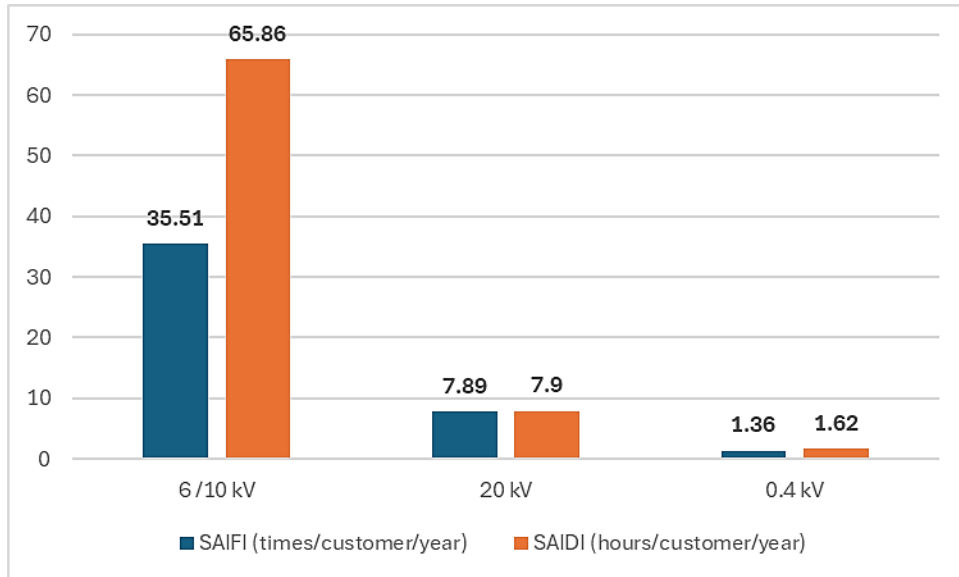


- The data considered are unplanned interruptions lasting more than 10 minutes.

- The classification of number of power interruptions in the distribution system by cause

Results and discussions

- ❑ The latest criteria set by Albanian Energy Regulatory Entity on distribution system reliability indices:
- ❑ **SAIFI 25.08** times\consumer\year and **SAIDI** of **47.17** hours\consumer\year



- ❑ Reliability indices according to HV, MV, LV classification and for the total distribution network(**SAIFI,SAIDI,CAIDI**)

| Network | SAIFI(times/customer/year) | SAIDI(hours/customer/year) | CAIDI(hours/interruption) |
|--------------|----------------------------|----------------------------|---------------------------|
| HV | 7.86 | 11.87 | 1.51 |
| MV | 21.6 | 36.7 | 1.7 |
| LV | 1.37 | 1.61 | 1.18 |
| Total | 30.86 | 50.18 | 1.63 |

- ❑ In the 6 and 10 kV networks, which account for almost 80% of the network's capacity, the installed equipment is very unstable despite maintenance

- ❑ Reliability indices for the 6/10 kV network (including all interruptions in the 6 kV and 10 kV systems), as well as for the 20 kV and 0.4 kV networks

Results and discussions

- SAIFI and SAIDI in distribution areas.

| Distribution Area | SAIFI (times/customer/year) | SAIDI (hours/customer/year) |
|-------------------|--------------------------------|--------------------------------|
| Tirane | 19.4 | 22.28 |
| Shkoder | 40.53 | 85 |
| Burrel | 40.61 | 115.56 |
| Kukes | 73.62 | 149.81 |
| Elbasan | 40.66 | 69.96 |
| Korce | 34.31 | 52.32 |
| Berat | 48.86 | 63.52 |
| Gjirokaster | 54.6 | 74.28 |
| Vlore | 20.43 | 36.85 |
| Durres | 15.52 | 24.34 |
| Fier | 27.21 | 44.06 |
| Total | 30.86 | 50.18 |
| Max | 73.62 | 149.81 |
| Min | 15.52 | 22.28 |

A significant part of the electric lines are radial and in rural and deep rural areas with very long lengths.

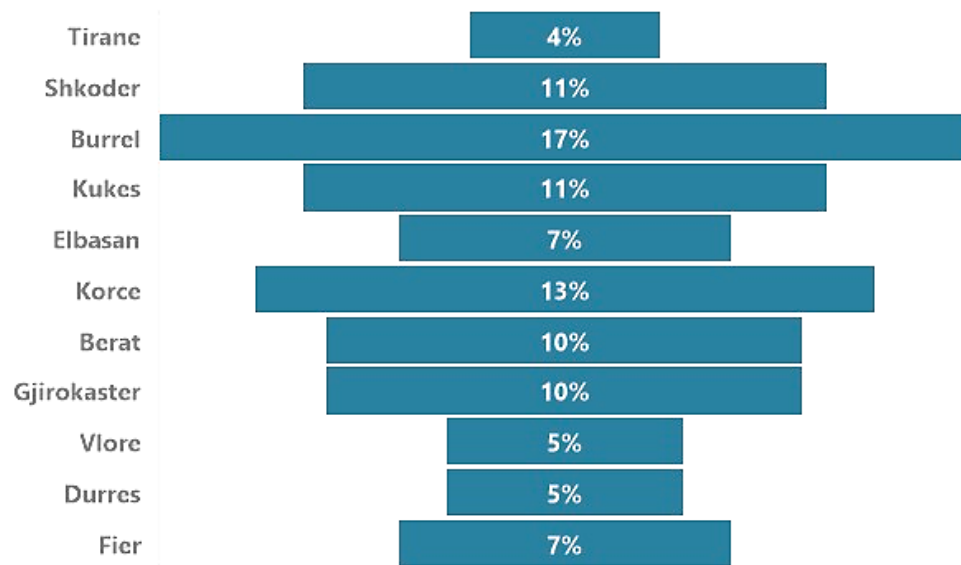
- Reliability indices values according to classification urban, rural, and deep rural areas of distribution network (DN)

| Total | | Urban Area | | Rural Area | | Deep Rural Area | |
|--------------------------------|--------------------------------|------------|-------|------------|-------|-----------------|--------|
| SAIFI (times/customer/year) | SAIDI (hours/customer/year) | SAIFI | SAIDI | SAIFI | SAIDI | SAIFI | SAIDI |
| 30.86 | 50.18 | 14.55 | 17.25 | 44.5 | 77.53 | 71.77 | 133.14 |

- The distribution network in urban and deep rural areas primarily consists of an aging overhead system operating at voltage levels of 35/10/6 kV
- Electricity consumption in some distribution area is low while the main HPPs are connected in this part of DN
- The HPPs suffer from the high frequency interruption of the generation due to failures happened in the distribution network and the situation become more critical during the rain seasons.

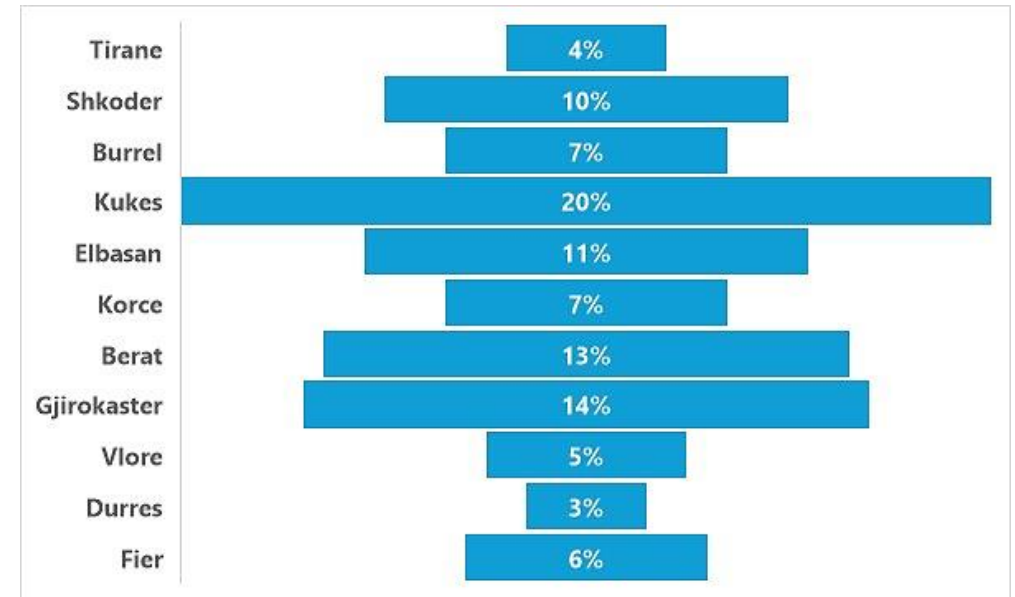
Results and discussions

- Weight of Power Interruptions in the **HV** network by Distribution Area (%)



The distribution network in Tirana, Durrës, Fieri and Vlora is more reliable, this is also due to more investments towards the transition to the 20 kV network.

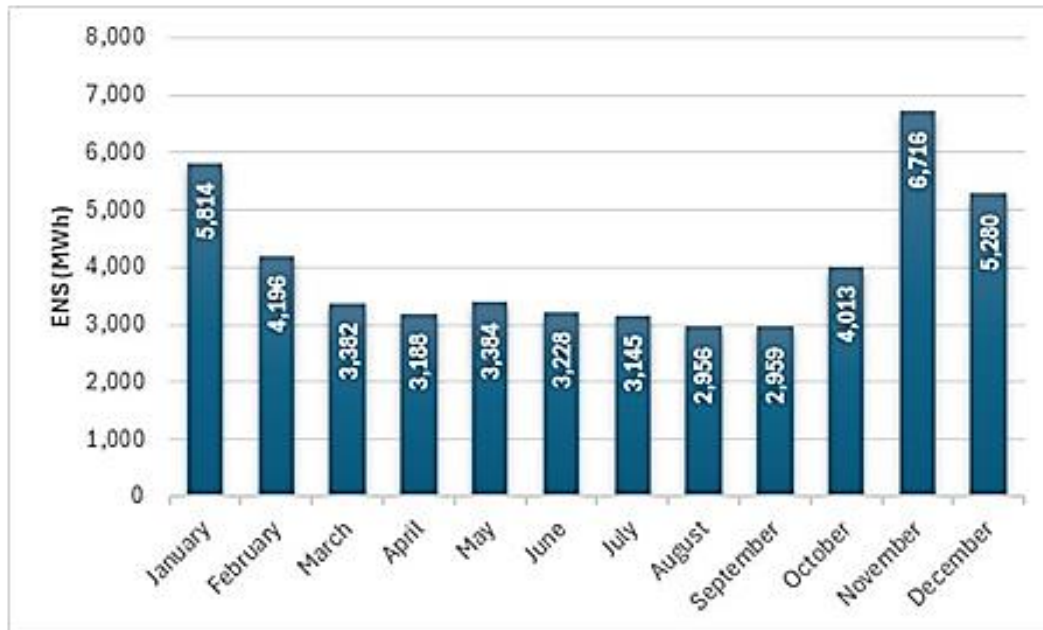
- Weight of Power Interruptions in the **MV** network by Distribution Area (%)



The Kukës distribution area comprises the highest percentage of interruptions in the MV, accounting for 17% of the total.

Results and discussions

The amount of energy not supplied to all consumers of the distribution network results in high values of **48,260.6 MWh**.



Energy not supplied due to interruptions, January-December 2023

- This value of unsupplied energy is an indicator of the financial cost that the company have due to unsold energy.
- Also, the damage that the customer may have suffered because of not being able to use electrical energy.
- An analysis of the economic impact for both sides would be appropriate.
- A negative impact is also observed in the HPPs connected to distribution network resulting to the reduction of energy produced and financial costs.

Conclusion

- ❑ This paper evaluates the reliability indices of the Albanian distribution system. The assessment of the indices was carried out for HV, MV, LV electrical network for all regions of the distribution network and according to the categorization by areas, considering the consumers included in the interruption.
- ❑ The analysis performed indicates that the large number of interruptions and their duration in rural and deep rural areas in certain regions reach maximum values several times higher than the values for total distribution network
- ❑ The distribution network in these areas, originally designed as a passive network for low energy consumption, is now being used as a transmission network due to the high penetration of HPPs in these areas.
- ❑ Investment planning to renew, strengthen the distribution network in areas with high potential for electricity production from distributed generators, should be a priority for the distribution operator to increase the reliability of the distribution system by ensuring minimal power interruptions for the final consumers and hydro producers.

Thank you for your attention!
