CLIMATE CHANGE IN BRAZIL AND ITS REFLECTIONS IN THE RELIABILITY OF CELESC DISTRIBUTION OVERHEAD LINES

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ABSTRACT

Extreme climatic events cause serious damage to electric utilities and their customers, with high number of occurrences simultaneously and more time spent on recovery of the entire electrical system. Such events have been more frequent in southern Brazil and this study aims to identify opportunities for improvement in projects of distribution overhead lines, aiming to reduce not only the number of occurrences in such events as well as its impact and recovery time.

INTRODUCTION

The change in the climate system of Brazil is already a reality, presenting significant effects on reliability indicators of major Brazilian utilities and in particular for CELESC, a power utility located in southern Brazil which serves about 2.5 million customers.

Due to its geographical position and accentuated relief, the Santa Catarina state suffers strongly the influence of cold fronts, tropical and polar masses that invade their territory routinely. Climatic effects are felt on the population by the constant extreme phenomena such as heavy rains, high winds, tornadoes, floods, frost, drought and intense seasonal temperature variations, resulting constant outages in the electrical system, including the disruption of conductors and poles, causing severe socioeconomic consequences.

The electric utilities should be concerned with phenomena that, until recently, Brazilians thought did not happen in your region: tornadoes and hurricanes. This last had only one to touch the ground in 2004 and was named Catarina, reaching full in the southern state of Santa Catarina. The phenomenon came to coast with winds up to 180 km/h, which puts him in the category 2 Saffir-Simpson scale, which goes up to category 5.

In 2008, the state was hit by three violent storms, the worst in November, mainly in the region of Blumenau, which prompted the company to invest in projects to minimize the impacts of these events.

This paper aims to better identify the climatic phenomena and analyze their impact on the electricity distribution lines, evaluating the number of occurrences and their direct impact on the CELESC continuity indicators (SAIDI and SAIFI).

The work also shows actions that are being studied and implemented to reduce the impacts of extreme events in the system and reduce the recovery time.

CLIMATIC PHENOMENA THAT AFFECT DISTRIBUTION LINES

Main climatic phenomena

The main climatic phenomena that affect electricity distribution grids can be defined as:

- Extratropical cyclones
- Thunderstorms
- Tornadoes
- Tropical Cyclones

There are even records of occurrence of tropical cyclones along with thunderstorms. The wind speed at a height of 30 to 40 meters can easily exceed 140 km/h.

A study[1] led by National Severe Storms Laboratory (NSSL) in the United States reveals that the territorial extension between northern Argentina, Paraguay, Rio Grande do Sul, Santa Catarina and Paraná west is the second largest area of tornado occurrence in the world. The region is second only to the U.S. central plains, along the Rockies.

In Brazil, the most critical event that started as a tropical cyclone and became a hurricane was Catarina, which struck the southern coast of the state of Santa Catarina and northern Rio Grande do Sul in 2004. The cyclone winds reached around 180 km/h, reaching over 11 thousand people and destroyed structures, transmission lines, distribution lines, among others. A task force took about two days to restore the power supply to the affected regions.

Evolution of Adverse Climatic Conditions in the State of Santa Catarina

Major climatic events that influence the state of Santa Catarina are the following phenomena:

- Frequent occurrence of cyclones;
- Storms associated with cold fronts;
- Thunderstorms associated with the low pressure coming from the region of Paraguay;
- Storms associated with orographic effect.

In the months from April to September, occurs 2-3 cyclones per month, always associated with high intensity winds, which affect the whole state of Santa Catarina. Due to the significant extension of the distribution grid along the coast, the result of high population density in the Santa Catarina coast and perpendicular arrangement of Santa Catarina state, the Celesc distribution lines is exposed directly to strong winds and cyclones.

Storms associated with cold fronts occur 3-4 times per month, and in the months from April to September their intensities are stronger.

The storms originates from the low pressure region of Paraguay and reach the western state of Santa Catarina with greater intensity in the months from September to March, as is the high ceraunic level in this region, with significant amount of days with thunderstorms. The correlation between the months with predominantly high winds and storms and interruptions in the distribution system becomes clear when it evaluates the interrupt distribution, as can be seen in the graph of Figure 1.

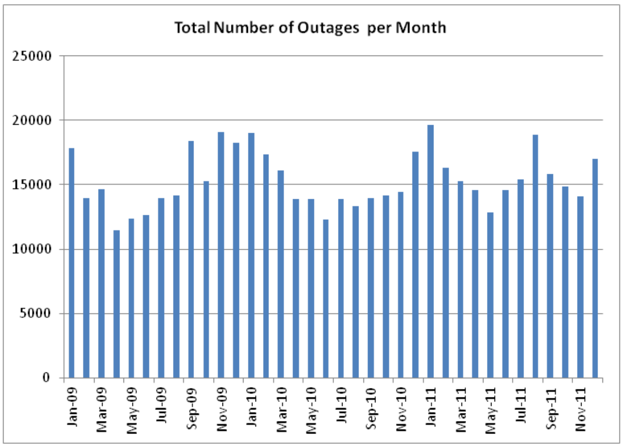


Figure 1 – Celesc total number of outages per month (2009 - 2011)

For the period between 1980 and 2003 were recorded in Santa Catarina 3373 natural disasters, 2881 is associated with severe atmospheric instability, which represents 85% of total disaster occurred. However, it is believed that the number of disasters caused by atmospheric instability is much greater, since the disaster were computed only the more stringent levels.

The mean disaster for this period was 120 events per year. Importantly, the average jumped from 109.5 to 127.4 events/year for decades 1984-1993 and 1994-2003, respectively.

Figure 2 shows a graph with the annual frequency of tornadoes recorded in Santa Catarina, which shows an increase of incidence and the record of this phenomenon in almost every year from the late 1990s. The most common tornadoes that have happened in Santa Catarina are the category F0 (winds 64-116 km / h) and F1 (winds 117-180 km / h) on the Fujita Scale. In addition to the tornadoes, the state of Santa Catarina suffer from other phenomena such as extratropical cyclones, tropical cyclones (most common) and thunderstorms.

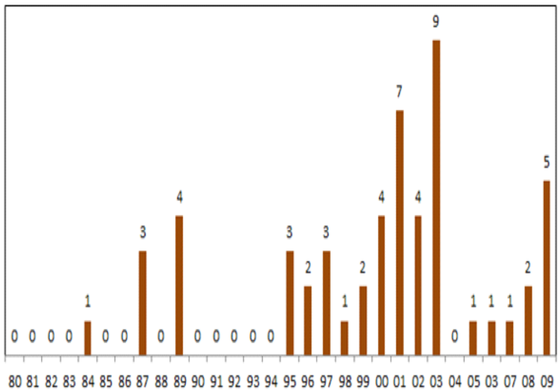


Figure 2 - Annual frequency of tornadoes in Santa Catarina (1980 - 2009)

More recent data show an increasing number of extreme weather events such translated amounts of emergency situations decrees caused by windstorms, floods, cyclones, flood, hail recorded by the Civil Defense of Santa Catarina:

- 2008 - 223 decrees
- 2009 - 419 decrees
- 2010 - 411 decrees
- 2011 - 626 decrees

CHARACTERIZATION OF CELESC DISTRIBUTION LINES

The Celesc electricity distribution grid has about 78,000 km of medium voltage networks (13.8kV to 34.5kV) and 47,800 km of low secondary networks (220/380V), distributed in the following patterns:

- Medium Voltage Lines: Overhead lines using crossarms and conventional bare conductors (above 90% - Figure 3);

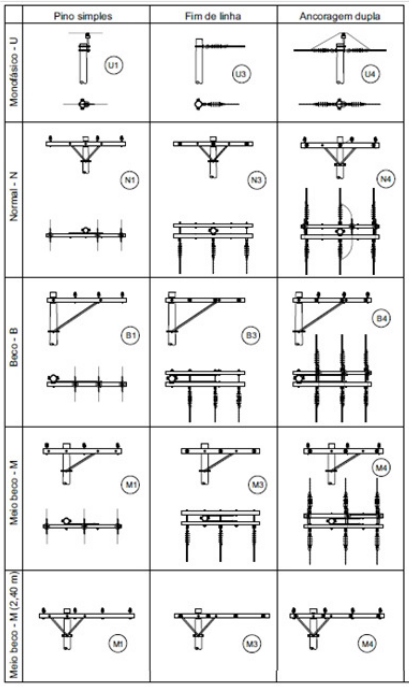


Figure 3- Medium voltage overhead lines with bared conductors

Other: spacer cable lines and insulated cables, most used close to substations and bigger urban areas.
- Low Voltage Lines: Overhead lines with bare conductors (greater than or equal to 80%);
Other: Insulated conductors, multiplexed lines.
The distribution lines are projected and constructed using the Brazilian standards, NBR15688 for overhead distribution lines with bared conductors and NBR 15992 for spacer cable distribution lines.

INFLUENCE OF CLIMATIC ADVERSITIES IN THE PERFORMANCE OF DISTRIBUTION LINES

Registered Historical Causes of Outages

Overhead lines with bared conductors
The most common causes of outages in medium and low voltage lines, when occurs gales and storms, are caused by falling trees and objects (plates, tiles, structures, tree branches, etc.) launched to the bare lines, causing the breakage of conductors, short circuits and in some cases, breaking poles. In medium voltage lines, in some situations, the conductor rupture also causes the rupture of the pole.

Figure 4 - Windstorm - Rural area

Spacer cable lines
The company's experience with the use of spacer cable lines has proved extremely positive contributing to the reduction of shutdowns due to objects and branches thrown over the line, lacking, however improvements aimed at not breaking the conductors and the pole when trees falls over lines.

Insulated lines
The company's experience with this type of line is greatly contributing to the significant reduction in disconnections due to objects and branches thrown over the net, lacking, however improvements aimed at not breaking the conductors and the pole when the tree falls over lines.

Evolution of CELESC reliability indicators due to climate conditions

The improving indicators of continuity is a challenge for Brazilian utilities, with about 30% of the indicators calculated are due to occurrences of windstorms or storms, and another part of indicator is expurgated (as rules of the Brazilian regulatory agency), about 20%, which is largely due to the occurrence of critical climatic events.
In recent years the number of occurrences related to climatic events has been significant, with more than 30,000 events per year, most of them related to vegetation or objects thrown in the distribution lines.
In the critical events, the most difficult and time spent for recovery the system are the work of replacement of damaged poles, high time-consuming and involve the work of special teams. Normally occurrences with breaking pole are not isolated, a pole in poor condition that damages will break with its weight adjacent poles, further hindering the recovery of the system and indicating a mechanical coordination problem of the distribution lines.

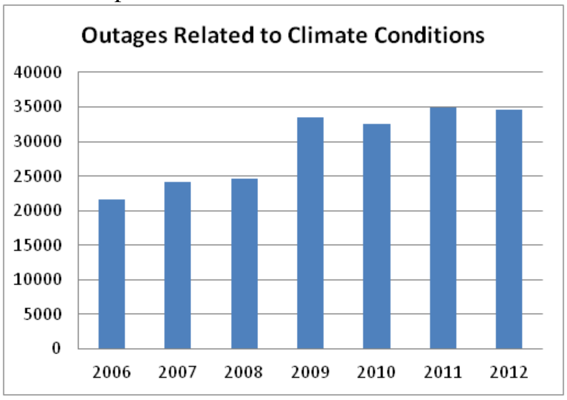


Figure 5 - Outages related to climate conditions at CELESC

SAIDI value has grown and it is also significant, as can be seen in figure 7. The value of SAIDI is divided into two main parts, the first concerning the time until the team is sent to solve the problem and the second part refers to the time of execution of work, where there is opportunity for improvement with the development of new components and tools for working on distribution lines. Causes can be seen on figure 5.

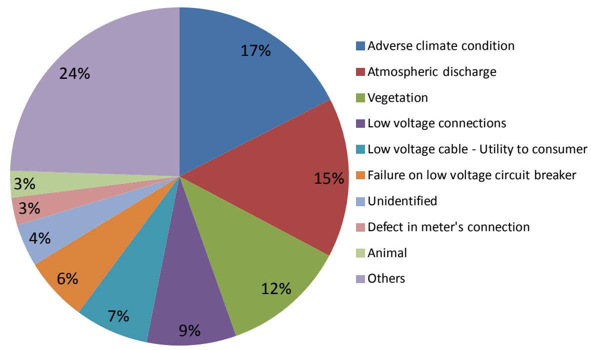


Figure 5 – Main causes of outages during critical storms (2008-2011)

Figure 6 represents the number of outages during climatic events per region and month, where can be seen high peaks during the summer, months with most part of the storms and high winds.

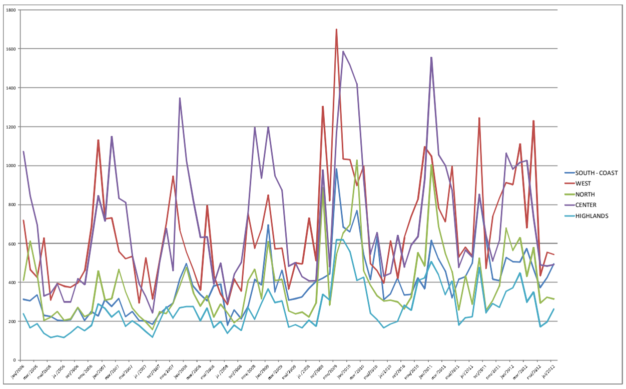
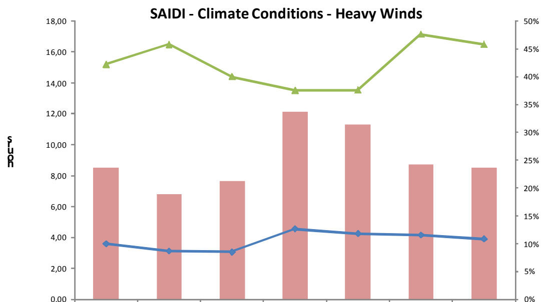


Figure 6 – Outages caused by climatic events by region of the state and month (2006-2012)

Figure 7 show the relation between total SAIDI and that one caused by climatic events. It is possible to notice that these occurrences are really representative for the utility.



	2006	2007	2008	2009	2010	2011	2012
% SAIDI Climate/Total	24%	19%	21%	34%	31%	24%	24%
SAIDI - Climate (hours)	3,60	3,12	3,07	4,56	4,25	4,15	3,91
SAIDI - Total (hours)	15,20	16,49	14,40	13,51	13,53	17,14	16,50

Figure 7 – Causes of outages on critical storms (2006-2012)

Associated with elevated indicators of continuity is the difficulty in attending these events, which occur largely simultaneously and exceed the capacity of teams. In these cases the waiting time for solving each occurrence increases, and usually acts CELESC calling more teams to assist in the restoration work of the electrical system.

CONCLUSIONS AND ONGOING STUDIES AIMED TO FRONT NEW SOLICITATIONS CAUSED BY CHANGING CLIMATE IN BRAZIL

The evolution of the historical data of outages in overhead distribution lines clearly shows the climate changes that are occurring in Brazil, bringing severe socioeconomic consequences for the population and for Celesc.

Diagnosis of problems occurred in areas of Celesc lines due to these adverse phenomena presented the following main reasons:

a) Today's distribution lines are mechanically dimensioned based on past data, the maximum and minimum temperature and maximum wind speeds, and these values were used at least 30 years, which are totally different intensities that occur today;
b) The standards for project and construction of distribution lines are unique to every region of the state of Santa Catarina, both for the most critical places that need more reinforced structures, as for the historically lower request;
c) The current distribution lines when installed at critical locations, have low reliability and restoration in outages caused by disruptions of conductors or broken poles, caused by objects on the network, it is very time consuming.

The sequence of work will find solutions to reduce the impacts of these events to the utility and its customers, as well as may increase security for system operation and for the population during the critical climatic events. The main topics being treated in the sequence of the studies are as follows:

a) Redefinition of meteorological parameters (maximum and minimum temperature and maximum winds) to be adopted in the calculations of mechanical sizing conductors and structures to meet the critical demands, considering the projected increase in intensity during the expected useful life of distribution lines;
b) Develop networking standards for use in areas subject to wind gusts of high intensity, such as those that have occurred in the state of Santa Catarina, which must have mechanical coordination with focus on minimizing the occurrence and impact;
c) Define the critical regions should be deployed where new patterns by mapping the concession area Celesc, using historical data on occurrences, identifying critical regions subject to more severe weather phenomena;
d) Development of project criteria and methodologies calculations that consider these new structures adverse requests;
e) Standardization and use of new components in the construction of distribution lines that meet the requirements better weather. Like for example in improving connections in low voltage lines, which are largely occurrences in windstorms, or use of polymeric poles to reduce the impact on adjacent poles of their break when requested beyond the specified limit.

The work, in addition to the topics mentioned, will perform laboratory tests and a pilot project in the field to verify the effectiveness of the proposed solutions.

Acknowledgments

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