THE PROVIDING AND RESTORATION OF THE POWER DISTRIBUTION IN MAJOR CLIMATIC DISTURBANCES

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Abstract:
During the year of 2005, unprecedented weather conditions occurred and affected in successive waves, from April to September, all the company's regions and a great part of the power distribution network.

ELECTRICA – Muntenia Nord provides the electricity distribution and supply in the center and east of Romania, on a geographical surface of 29,765 square kilometers, for approximately 1,300,000 customers in 6 counties. The 110 kV power distribution network of the company has 2200 km overhead lines and 121 substations of 110/Medium Voltage. Likewise, there is a number of 88 Medium Voltage substations (most of them being 20/6 kV) and 9500 substations Medium Voltage/Low Voltage or MV connection points.

The massive quantities of rain with storms and high intensity lightning, were followed by floods, streams, and the 20-30 time rising of the average water flow on rivers. These climatic challenges affected the power network normal operation very seriously. Some of the 110 kV overhead line piles felled in the riverbed and a great number of power substations and also the 20 kV and low voltage network were damaged.

The paper present the company's expertise in the management of this type of crisis. In order to restore the company's network and the power distribution for our customers in reliable solutions, we acted in different stages, presented in the paper. In some areas, it was necessary to co-ordinate many work teams and firms to restore the power network. The pictures offer the views of the initial state, the various stages and the achieved solutions. We analyzed future possible scenarios with their technical and economical implications, and new design solutions were applied, in some cases. The paper presents both the occurred events and the achieved solutions. The vulnerability of the electrical infrastructure during various climatic stress was a main concerns for the company and, during the years, a set of procedures and solutions was applied. The environment challenges in our area led us to requirements for the equipment and the main issues in this matter are specified in the paper. Last but not least, the paper overviews the emergency communications and the partnership with the public and the local authorities during major climatic disturbances.

Keywords: disturbances, emergency plans, resource management, technical solutions

1. INTRODUCTION.

ELECTRICA – Muntenia Nord provides the electricity distribution and supply in the center and east of Romania, on a geographical surface of 29,765 square kilometers, for approximately 1,300,000 customers in 6 counties (3,300,000 inhabitants). The 110 kV power distribution network of the company has 2300 km overhead lines and 121 substations of 110/Medium Voltage. Likewise, there is

a number of 88 Medium Voltage substations (most of them being 20/6 kV) and 9500 substations Medium Voltage/Low Voltage or MV connection points.

Geographically, the responsibility area covered by the company includes all the types of relief, from plane, the Danube and other important rivers, to the hills and mountains up to 2500 m high. We supply power for 6 relatively important towns and various industrial activities, agriculture and tourism (fig.1).

Fig. 1. Geographical map with the relief types in the company's responsibility area

Amount of the disasters

We'll not present just a phenomenon and its consequences, a storm or a flood, but the consequences of a 6 months period with important climatic challenges, a period that required important decisions and actions from the company. In this period, two 110/20 kV substations and 750 pc of MV/LV power substations were damaged and about 720 hundreds MV and LV pillars.

Mostly in Vrancea and Galati areas, 1200 customer houses were destroyed. River bank erosion led to the breaking of nine 110 kV pillars and the corresponding electricity wires (6.5 km). In some places, after floods and slide erosion, the ground configuration changed. More than four hundred villages and towns were affected in all the area. Other important losses were caused by the power supplied but unbilled with the destruction of the meters, also, with other various commercial or technical losses. For example, huge water-pumps were used to drain the flooded areas, with no recorded consumption. The tents and the container modules for the victims were power supplied but impossible to make an invoice. A high-pressure methane gas pipe was broken, and in a 400 000 inhabitants area the electricity remained the only power source for a week. The total amount of energy losses was estimated about 4 GWh.

First meetings and actions

To surpass the disturbances, the company had to mobilize both its financial, technological and labour resources. In the first moments, it was very important to know exactly the affected areas and installations. In the days after the events, the emergency meetings of the top and middle management staff established the primary goals:

I. Selecting the most adequate emergency repair solutions;
II. Restarting as urgent as possible the power supply for the customers;
III. The biding and the achievement of the necessary technical designs in the new conditions;
IV. The hiring of a number of specialized network builders for the great volume of activity;
V. The service planning and the resource management for the achievement of reliable solution power supply.

In Figure 2, we present a drawing of the company's 110 kV power network and the single-line diagram of an affected area (Figure 3). Presented bellow is the normal operation state, before the series of events.
The 110 kV is marked with black, the 220 kV lines and busbars are red, and 400 kV – blue.

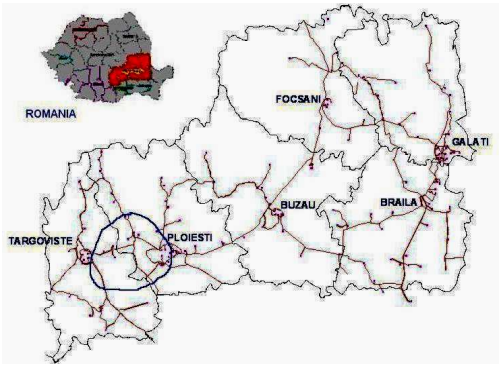

Fig. 2 The company's area of activity and the most afected 110 kV power network

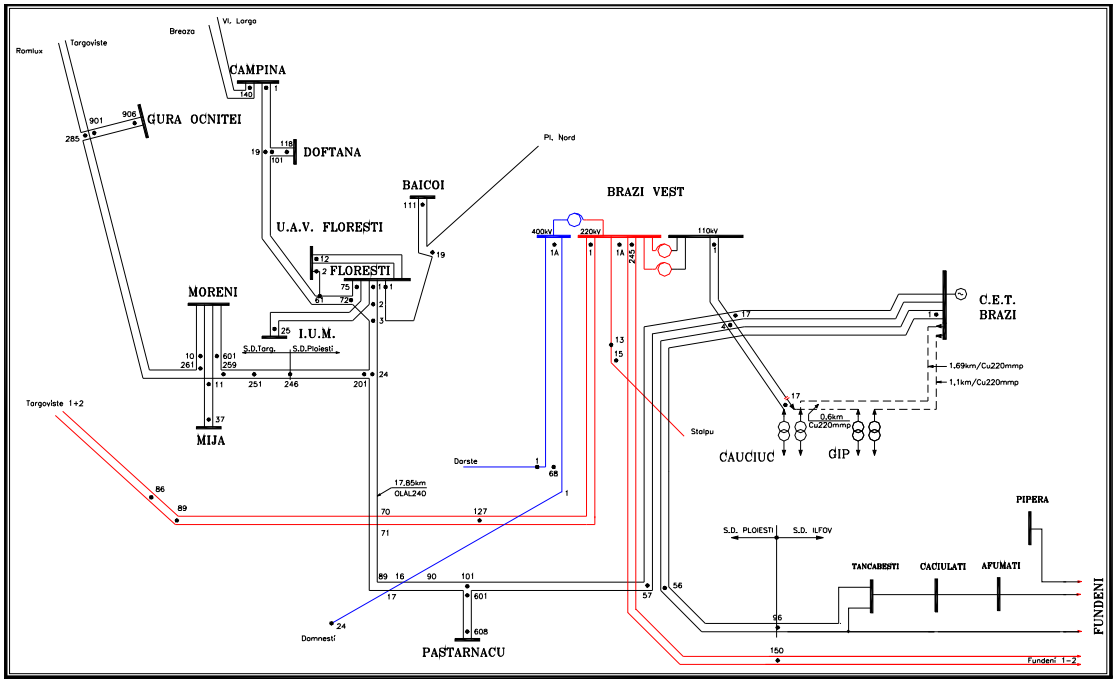

Figure 3. Single-line diagram of the 110 kV network area before floods in Prahova area

Fig. 4. 110 kV broken pillar fallen in Prahova river. The bank erosion caused by the abnormal water flow is visible

Figure 4 shows the picture of a 110 kV broken pillar, taken shortly after the floods. We can also see a pillar of 220 kV in danger due to the river bank erosion. Figure 3 and 10 present the network single-line diagram in normal conditions and after the floods.

Due to ground erosion, the foundation was destroyed and the both pillars collapsed in the end. A visual inspection of the network revealed also numerous minor deterioration which cannot be ignored on long term.

Fig. 5. Massive ground slide that damaged 110 kV and MV overhead lines

2. THE CRISIS MANAGEMENT

In the present organization form the company has very limited work-teams, only for maneuvers, inspections and secondary circuits maintenance and relay settings, the primary installations maintenance and repair service being fulfilled on a contractual basis by specialized companies. The same applies to the designing capacities of the firm. The transportation for the repair teams had to be done either by the means of our partners or, in some cases, with military caterpillar vehicles and army helicopters.

The company and its partners mobilized in the most affected subsidiary 34 work team (Vrancea Subsidiary). Even if difficult to coordinate, the work safety was satisfactory and labour injuries didn't took place. Only few of the repair teams were from the area, so they didn't know the local power network. Therefore, a special attention was paid to the safety measurements checking and, also, to the rest periods of the staff during long-time disturbances.

One of the multiple concerns in this period was to maintain and develop a positive communication with the media and the local authorities.

Figure 6. Bank erosion with MV affected cables

Unfortunately, it is not always a direct connection between responsible actions and a good media or public image. Every day, at 7,30 a.m., the company sends to the media a "press communiqué", so they might find in their editorial offices and boards up-dated information about the events. The spokesman of the firm or from one of the 6 subsidiaries can be solicited at any hour by the radio or television stations. All this selected personnel received proper media training and their interventions must provide always pertinent details. Often, the TV stations make pictures in the affected areas and interview the locals. The public image of the company must remain at least equal to its effective implication.

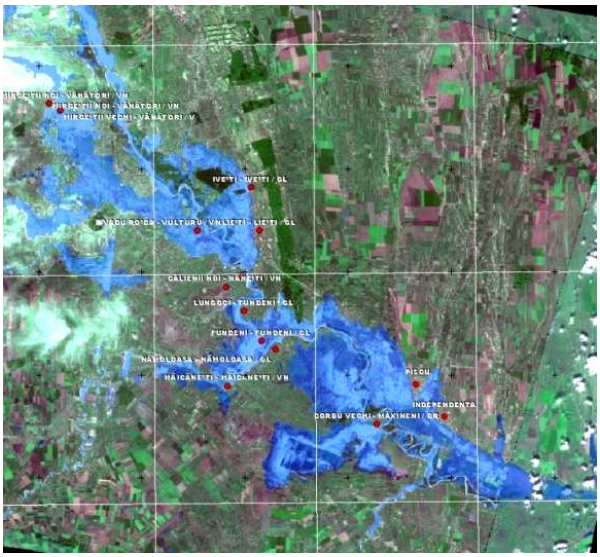

Figure 7. Satellite surveillance photo with a flooded area (Vrancea – Galati, 19th july, 2005, resolution 10 m)

The company has written agreements with the local authorities, also with the Romanian Water Authority, the fire brigades and the Police, for mutual announcement of the important events. It is not out of the order for the company's top managers to be convoked for meetings with local or government officials, or to offer details in press conferences.

3. TECHNICAL SOLUTIONS

The solutions varied from temporary repair to long-time results in different technical approaches. One of the most complex problems, both in design, network building and operation, appeared in the cases of river crossings and power line parallel with river banks (Figure 6) or/and with other lines or utilities.

The usual way to achieve a strong fundament in river beds for the power line pillars was to build a caisson, the depth being specified by a geological study (for example 10 m). A better solution offered by the designers, first time applied in our area, was the use of Benoto type drill piles (14 m depth). From technological point of view, the Benoto columns represent the best known type of drilled piles, allowing to reduce twice or four times the building period, at a lower price (Figure 8). Another solution tested, was the use of nine micro-piles, 9 m depth, for a 110 kV overhead line pillar. The micro-piles were not so effective as the Benoto piles, taking into account both the labour-time and the cost.

Figure 8. Benoto piles and river bank consolidation

The construction business knows a very fast growth this days in Romania and the ballast pits are often located to close from the infrastructure objectives such as bridge piles, pillars, etc.. This was a source of an important erosion, and the new settlements in the field hardens their authorization. Our company has done official notification against the ballast pits which endangered the power network.

As climatic conditions, the Romanian territory divided into 5 zones. The main climatic stresses, like the wind, hoar frost, air-temperature, are considered with different average in these zones. In some areas, on a statistical base, local conditions can be considered more severe than the rated ones. One of the toughest rated zone in our responsibility area is the “C” one, with average values of the climatic stress presented bellow.

- Dynamic pressure:
- Maximal wind: 55 daN/m^2 ;
- Wind with hoar frost: 20 daN/m^2 ;
- Hoar frost thickness: 22 mm;

As minimal temperature, – 30 C degrees frost in the winter is not unusual. A number of overhead line “de-frost” procedures and diagrams are established, so they can be activated under the dispatcher control when it is necessary. In the lightning period, 44 storm-days/year are rated in our area. Of course, the floods were, until now, an aleatory phenomenon, they are not rated as calculation values. The climatic stresses, in the last years, seems to have an increased impact on power network operation.

The 110 kV wood pillars were practically forgotten. After almost 40 years, the company and its partners designed, manufactured and used 110 kV portal wood pillars (Figure 9). The wood pillars proved to be reliable and cost-effective at least as temporary solution, so it will be applied again when necessary.

Figure 9. 110 kV portal wooden pillar

As we can see in Figure 10, some of the 110 kV system interconnections are still interrupted, due to unfinished works to the pillars. The Romanian HV system has an important redundancy, and other connections were rapidly made for reconfiguration. We did not experienced a lack of stability or the increase of the power losses up until now, but only a reduced operational flexibility of the diagram.
The daily withdrawals for maintenance are now more difficult to fulfill. The technical specifications, as the power overhead lines specification, are periodically reexamined under ANRE authority (ANRE – The Romanian Regulatory Authority) consequently to operators notifications, but in the last years exceptionally severe climatic challenges took place.

The climatic calamities caused about 10 millions € financial losses. The possibility to recover these expenses from distribution tariff is uncertain and not effective.

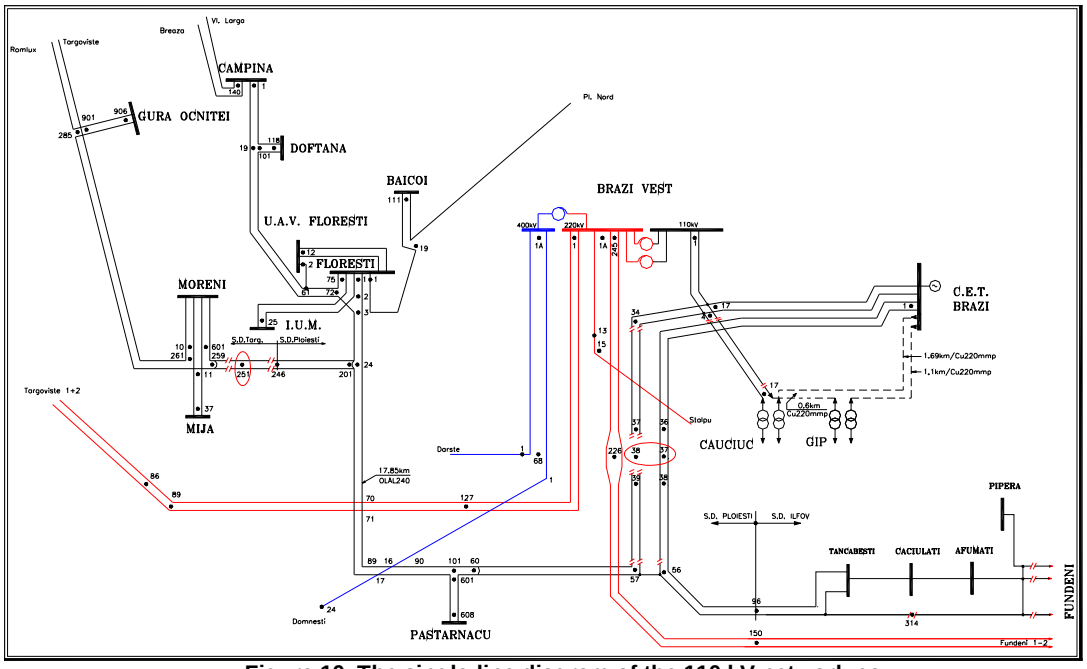

Figure 10. The single-line diagram of the 110 kV network now

4. CONCLUSIONS

In the last years, the company's power networks faced very severe climatic challenges. The climatic disturbances seems to be more important than ever before. Even if the power networks belongs to the utility company, the power supply is an essential aspect of the public life, so their vulnerability is a justified concern that outruns the company's borders. The technologies and the procedures for a better reliability and response in this field are improving with each event. Technical specifications and operational plans are subject to re-examination for this purpose. The public communication is also very important to get positive response from the authorities, officials and public.

For the pillars foundation, in rivers bed, the Benoto piles proved optimal as building-time and cost-effectiveness, the caisson will be no longer put in work. The wooden piles are also reliable and cost-effective as a temporary solution.

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