LOGISTIC COMPERATIVE ANALYSIS OF RELIABILITY IN REGIONS OF A DISTRIBUTION COMPANY

Jerzy SZKUTNIK
Faculty of Electrical Engineering, Technical University of Częstochowa, Poland

SUMMARY

In the report, I depicted the new outlook on the problem of reliability of the network. It is the logistic point of view, taking into consideration the form of the terrain and infrastructure of the communication network, which is crucial for the time needed for the emergency forces to get to the place of breakdown. The presented logistic ratios describing reliability can constitute an additional tool aimed at decreasing the time of shortage of energy supply. The report contains also analyses conducted on the basis of data of the chosen distribution company. The final part of the research is correlation analysis being a basis for presentation of general dependencies.

Keywords: *energy distribution, reliability of the network*

1. INTRODUCTION

The evaluation of the functioning of the energy network can be done taking into account different aspects. One of the most important is the analysis of efficiency of energy distribution – estimation of energy losses in all types of network of a distribution company. Such an analysis can be conducted with usage of special software [1]. It is the starting point for broader comparisons of efficiency, which are made to find the relations among distribution companies [2].

The second important element characterising the functioning of distribution companies and their energy regions is the breakdown ratio of the network and its elements. In this respect, the distribution companies make the current reporting, which include the following:

Power energy lines, transformer stations

- absolute number of disturbances
- number of disturbances for 100 km of line
- absolute number of breakdowns
- number of breakdowns for 100 km of line
- total time of fixing the disturbances
- total time of fixing the breakdowns
- average time of fixing the disturbances
- average time of fixing the breakdowns

The analysis comprises all voltage levels i.e. 110k, medium and low voltage. There is also a split into aerial and cable lines.

It is also conducted the detailed documentation of breakdowns of the particular elements of energy lines e.g. isolators, constructions, bridges, equipment, wires, poles, earth, joints.

For power energy stations, detailed analysis of breakdowns refers to buildings, isolators, separators, surge limiters, collective rails, transformers, switches and additional equipment.

The most authoritative ratio of the network functioning, as far as its reliability is concerned, is the average time of fixing the disturbances. The times for aerial network of medium voltage and additional characteristics of regions for a chosen distribution company are depicted in the table 1 below.

Table 1. Breakdown ratio of energy regions

Energy region	Area [km^2]	Number of disturbances for 100 km of line [items/km]	Average time of fixing the disturbances [h]
Region 1	1213	8,5	6,2
Region 2	1532	7,3	5,7
Region 3	1920	8,7	9,1
Region 4	921	6,8	7,4
Region 5	1519	7,4	3,6
Region 6	1554	6,8	7,1

Source*: Data received from a distribution company for the year 2001*

The results of breakdowns are analysed very carefully. The main objective is to identify regularities and tendencies, which may be a basis for certain forecasts.

2. LOGISTIC ANALYSIS OF ENERGY REGIONS

The analysis may constitute a supplementary element enabling to include additional factors, which may have impact on the final average time of fixing the disturbances. The time consists of the following elements: time of receiving information, time of segment location, time of point location, time of fixing, time of supply recovery. Most of these elements depend on the communication infrastructure of regions, because the possibility for the emergency forces to get quickly to place of breakdown determines how fast the breakdown is fixed.

I propose to use the following logistic ratios[1], which are based on parameters depicted on Figure 1 and refer to one energy region.

[1] Own research

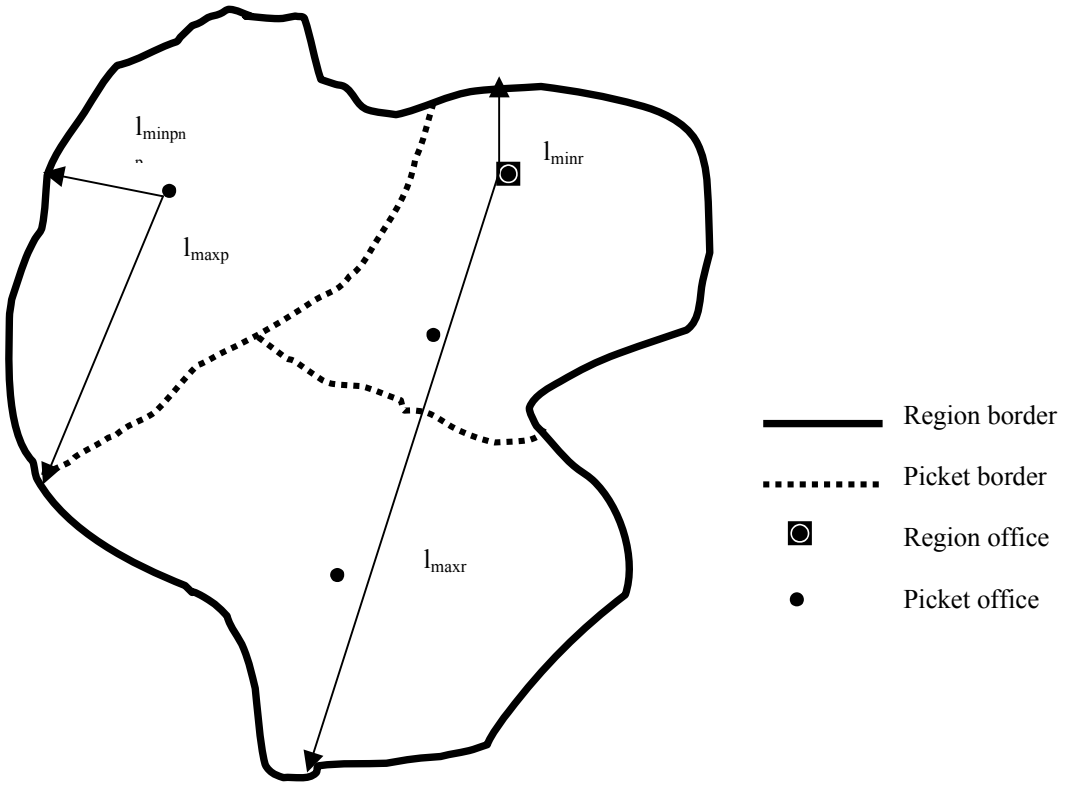

Figure. 1 The parameters of logistic evaluation of energy region
***Source**: Own research*

The network is serviced by the emergency forces located in the office of energy region or picket. The shape of the region or area of the emergency forces determines the efficiency of supply recoveries after breakdowns.

The following ratios are recommended for evaluation of breakdowns:

$$w_{lder} = \frac{l_{\min r}}{l_{\max r}} \tag{1}$$

$$w_{ldep} = \frac{l_{\min p}}{l_{\max p}} \tag{2}$$

where:

w_{lder} - logistic adjustment of exploitation of the region network

w_{ldep} - logistic adjustment of exploitation of the picket network

$l_{\min r}$ - min. distance between the picket office and the picket border

$l_{\max r}$ - max. distance between the picket office and the picket border

$l_{\min p}$ - min. distance between the region office and the region border

$l_{\max p}$ - max. distance between the region office and the region border

The average ratio w_{ldep} for region, which has n pickets in its area is as follows:

$$w_{rldep} = \frac{\sum_{1}^{n} w_{ldpi}}{n_p} \tag{3}$$

where:

w_{rldep} - logistic adjustment of exploitation of the picket network in the energy region

n_p - number of pickets in the energy region

The breakdowns, which occur in the networks, can be of different importance. There can be small damages or serious breakdowns that require substantial expenditures to recover the energy supply. In such cases greater number of emergency forces are necessary, including specialist working in the region office. This fact is included in the function below, where engagement of regional forces in the total fixing of disturbances has been estimated at k=0.25

$$w_{klderp} = k \bullet w_{lder} + (k-1) \bullet w_{jddep} \tag{4}$$

where:

w_{klderp} - complex ratio of logistic adjustment of exploitation of the energy region

k - ratio of engagement of regional forces in the total fixing of disturbances

In the table 2, all the ratios described above have been presented for a chosen distribution company. Figure 2 depicts changes of ratios.

Table 2. Ratios of the logistic adjustment of exploitation in regions of a distribution company

Energy region	w_{lder}	w_{ldep}	w_{lderp}
Region 1	0,428	0,562	0,5286
Region 2	0,2	0,582	0,4765
Region 3	0,25	0,436	0,3895
Region 4	0,17	0,596	0,4895
Region 5	0,52	0,482	0,4915
Region 6	0,15	0,382	0,3240

w_{klderp} - complex ratio of logistic adjustment of exploitation of the energy region as a function w_{lder} and w_{rldep}

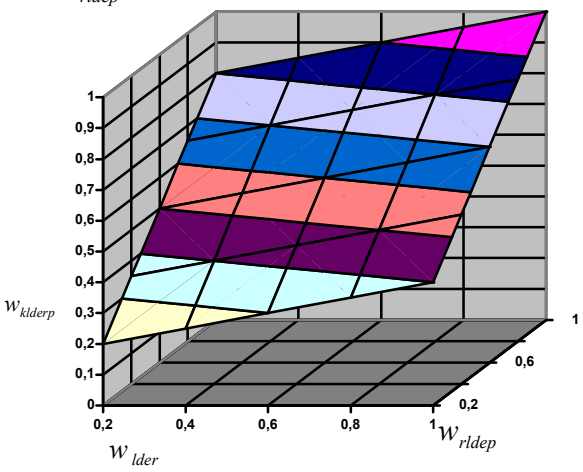

Figure. 2 Function $w_{klderp} = f(w_{lder}, w_{rldep})$

Source: *Own research*

The research related also to dependencies between the average time of fixing the disturbances in regions of the analysed company and the complex ratio of logistic adjustment of exploitation of the energy region w_{klderp}. This function presents figure 3.

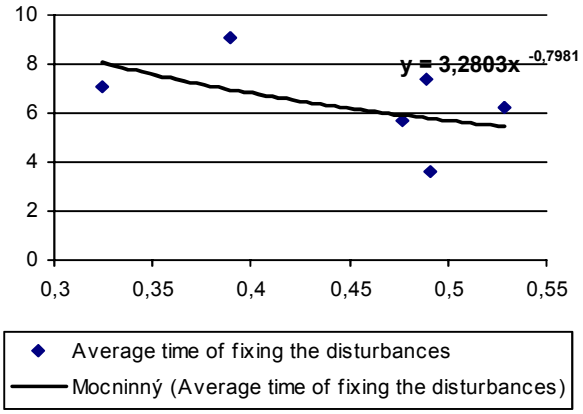

Figure. 3 Function $t_{zakl} = f(w_{klderp})$

Source*: Own research*

The research indicates a dependency between these parameters as the correlation co-efficient amounts to r_{xy} = 0,785. The correlation may be substantially improved after introduction of an additional ratio w_{ldikr} - the ratio of the logistic adjustment of communication infrastructure of energy region. It is described as the following function[2]:

$$w_{ldikr} = \frac{L_{dk}}{L_s} \bullet (1 - \frac{L_p}{L_s}) \qquad (5)$$

where:

w_{ldikr} - the ratio of the logistic adjustment of communication infrastructure of energy region

L_{dk} - total length of roads in the energy region

L_s - total length of the network of medium voltage in the energy region

L_p - distance between the centre of gravity of the road and energy networks

3. SUMMARY

The presented methodology of the logistic evaluation of reliability can find the application as an additional tool in the analysis of reasons and possibilities of reduction of energy supply shortages. The presented analysis refers to one of the domestic distribution companies. Results are promising, because quite high correlation between ratios and the time of fixing the disturbances has been achieved.

The ratio w_{ldikr}, presented in the equation 5, will be analysed thoroughly in the next research, where bitmapped model of the network [3] will be used for evaluation of the most important parameter of the ratio i.e. L_p. The results of this research will be presented in the next publication.

REFERENCES

[1] J. Szkutnik: System just in time a dystrybucja energii elektrycznej w zakładach energetycznych V Międzynarodowa Konferencja Naukowa KOMPLEKSOWE ZARZĄDZANIE LOGISTYCZNE – TOTAL LOGISTYK MANAGEMENT październik 2001

[2] J. Szkutnik: Benchmarking w sektorze dystrybucji energii elektrycznej VI Konferencja PE 2002 Prognozowanie w Elektroenergetyce Prognozowanie, efektywność energetyczna Częstochowa wrzesień 2002

[3] Kolcun, M. and team: Operation Control of Electric Power System, Košice 2002, ISBN-80-89061-57-5

BIOGRAPHY

Jerzy Szkutnik, for biography see Acta Electrotechnica et Informatica journal No. 2, Vol. 3, 2003, page 48.

[2] Own research