ANALYSIS OF PENALIZATION COSTS IN DISTRIBUTION NETWORK

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ABSTRACT

This article deals with problems connected with reliability of electrical energy distribution. Problems involves penalization system of power supply interruption in Czech Republic according to Public Notices to Act No. 540/2005 Coll [1]. Following text is focused on most frequent failures which results in electrical power outage. Causes of power failure are sorted by frequency of longest power outages.

1. INTRODUCTION

The article is based on Public Notices to Act No. 540/2005 Coll [1] that sets values of financial compensation for customers and specifies the conditions of the compensation application. According to the standards stated in this document, one type of the penalty is set to large customers and the other value penalization is applied to small customers for power supply interruption. Dividing between large and small customers depends on voltage level where they are connected to distribution network. Small customers are connected to LV network and large customers are supplied directly from MV or HV level. Distribution network operator gives the finance compensation to customers if duration of supply restoration after failure exceeded the limit. The rate of financial compensation is given as 10 percent of annual payment for distribution according to the current price for a previous year. The value of compensation is restricted by following maximal values: 5 000 CZK for LV, 10 000 CZK for MV and 100 000 CZK for HV. The following calculation methods were used for the analysis presented in this article:

- supply interruption in LV network with duration over 18 hours represented penalization by 1000 CZK
- supply interruption in MV network with duration over 12 hours represented penalization by 5000 CZK

2. ANALYSIS OF PENALIZATION COSTS ACCORDING TO SYSTEM OF STANDARDS APPLIED IN CZECH REPUBLIC

The distribution network consisting of 368 feeders was analyzed. Only feeders where the interruptions of which duration broke the limit determined by standards in [1] was selected

for the penalization costs calculation. The total of penalization for each selected feeder was calculated according to a number of large and small consumers supplied via the feeder.

Figure 1 shows only feeders with requirement on penalization (100 feeders). Feeders are arranged according to the extent of penalization from the feeders with highest penalization costs to the feeders with lowest penalization costs. Average costs of penalization are drawn at the vertical axis. Symbol C_{ppr} represents total average penalization per year with respect to standard used in Czech Republic. Total time of feeder monitoring in this distribution network was 12 years. The cumulative year costs of penalization of feeder are drawn at the secondary axis. This is represented by percentage values. Symbol C_{pkr} represents total penalizations cumulated in one year.

$$C_{pkr1} = \frac{\sum_{r=1}^{r} C_{ppr}}{C_{pps}} 100[\%] \quad (1)$$

$$C_{pprs} = \sum_{r} C_{ppr} \quad (2)$$

Where: C_{pps} is sum of total average penalizations per one year

C_{prk1} is total penalizations cumulated per one year

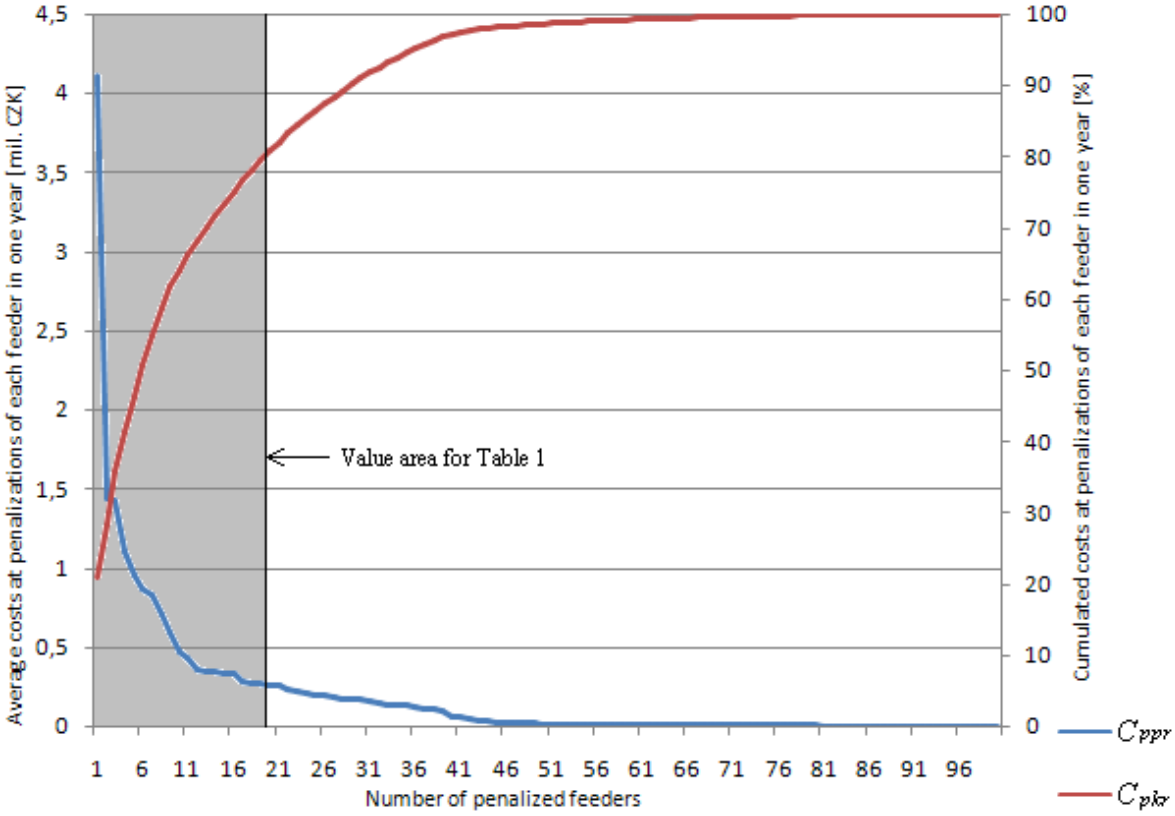

Figure 1: Penalizations costs at every penalized feeder according to Czech Republic standards [2]

It could be seen in the figure 1, that the values of penalization costs are significant for approximately first forty feeders. One of these feeders shows abnormally high value of penalization, in the comparison with another one. The penalization costs of this feeder reaching more than 4 million CZK.

3. ANALYSIS OF FAILURE CAUSES AT WORST FEEDERS FOR STANDARDS APPLIED IN CZECH REPUBLIC

This chapter describes the analysis of failure causes, which led to the supply interruption with the significant value of penalization costs. Twenty feeders in which the highest penalization costs in last twelve years were recorded have been arranged in Table 1. Feeders are arranged according to penalization costs. Failure causes at each feeder are recorded at this table. Table shows how many times the specific cause led to the supply interruption on given feeder. Number of failures is grouped according to it's cause:

- Failure caused by weather – external influences (storm, atmospheric impact; ice accretion; fall of the branch (tree), wind; rain, snow)
- Failure caused by the other influences (corrosion, fatigue wear, production fault, dielectric breakdown)

There is the percentage of the supply interruption caused by external influence in last column of table 1.

Number of feeder	Cause of failure											Number of failure		Meteorological influences [%]
	Storm, atmospheric impact	Corrosion	Ice formation	Unknown cause	Fatigue wear	Fall of the branch	Wind	Production fault	Rain	Snow	Dielectric breakdown	External influences	Other influences	
11	2					5	3		2			12	0	100,00
2						8	2	1				10	1	90,91
18	2				1	7						9	1	90,00
9						4	2					6	0	100,00
14	3					1	2			2		8	0	100,00
15						2	2				4	4	4	50,00
1	1					6					2	7	2	77,78
3			2	1		4						6,5	0,5	92,86
17	1			2		3						5	1	83,33
12				2		6						7	1	75,00
4				2								1	1	50,00
6	1					2						3	0	100,00
19						3	1			2		6	0	100,00
5		1				5						5	1	83,33
10	1			2		3						5	1	83,33
8	3					1	1					5	0	100,00
16	1					1	2					4	0	100,00
13					2		2					2	2	50,00
7	3					1						4	0	100,00
20						2						2	0	100,00
Suma	18	1	2	9	3	64	17	1	2	4	6			87,80

Table 1: Causes of failures on feeders with the highest penalization costs

Table 1 shows which the failure causes more frequently lead to supply interruption in the most penalized feeders. The most frequent failure cause is fall of the branch or tree on the electric line. There are the summary table values in the last row of table 1. The average percentage of failures caused by external influences is 87,8 percent. Although this value include half a number of failures caused by unknown reasons.

Figure 2 depicts values from Table 1 in the columnar graph. In graph, the twenty feeders of the highest penalization costs are arranged by serial number. Causes of failures are sorted into three groups. Failures that are caused by external influences are drawn by red colour. Failures, with unknown causes are drawn by green colour. The rest of failures are drawn by blue colour.

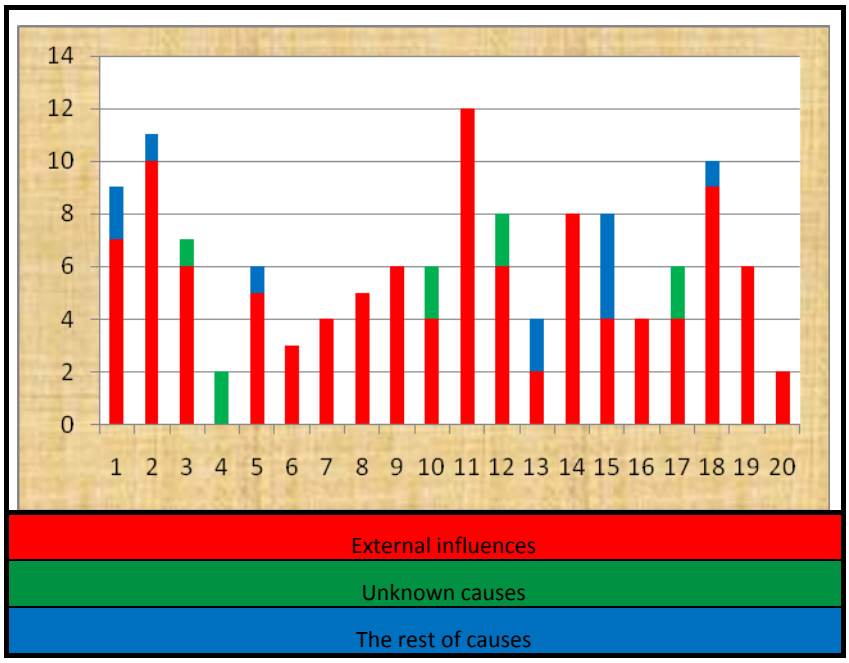

Figure 2: Cause of faults at biggest penalization feeders

Those twenty worst feeders cause whole 80.72 % from total costs sum of penalization feeders in this network of 235 million CZK. This is approximately 189 million CZK.

4. CONCLUSION

External influences cause 87.8% of failures in twenty feeders with signification value penalization cost. The total penalization amount which should be paid by distributor in consequence with the supply interruption in these twenty worst feeders is 189 mil. CZK. This amount shows financial resources which could be saved if the good prevention of failures have been provided.

This fact opens the question of other investments for restriction of supply interruption in distribution networks. Failures could be restricted by wide upgrades in distribution network equipment. For example: usage of insulated lines or change the lines to the cable lines. Above mentioned innovations should be applied on analyzed bad feeders. The study could continue by determination of investment efficient in comparison with the decreasing of supply interruption frequency.

REFERENCES

[1] ERO Implementary Public Notices to Act No. 540/2005 Coll.

[2] Těžký, J.: *Evaluation of penalization costs charged in a specific power distribution network.* Master‘s Thesis, Brno 2008.