Jerzy Szkutnik

Software STRATY'2007 PLUS in Analysis of Efficiency in the Distribution Networks

The report presents the software package, which is very useful for evaluation of the functioning of the networks of distribution companies taking into account the efficiency of energy distribution. The efficiency is determined by the level of energy losses in particular elements of the network in each voltage types. The software enables the detailed diagnosis of situation and through simulations shows the most appropriate actions aimed at increasing efficiency of networks of a distribution company. It is one of the key elements inevitable for taking strategic decisions by company's management.

Keywords: distribution network, electric energy, efficiency of distribution, energy losses

I. INTRODUCTION

For the last couple of years, the team of the Częstochowa University of Technology has designed a broad range of software used for evaluation of functioning of the network in distribution companies. They all have been grouped in one package called STRATY'2007 PLUS [LOSSES'2007 PLUS], which consists of the following elements:

- Software STRATY'2007
- Software ANALIZA [ANALYSIS]
- Software TREND

The first one has been implemented practically in all distribution companies in Poland. It is used in 28 energy boards (in Poland, there are 33 distribution companies). The software is used for calculation of energy losses in the networks of distribution companies – in the 110k, medium and low voltage. Calculations are conducted in two variants:

- Split into technical and trade losses
- Split into real and justified losses

The software ANALIZA is used for analysis of losses in particular elements of the network, which occurred in the longer period of time. It enables evaluation or verification of the company's policy aiming at increasing efficiency of the network.

The third software – TREND – constitutes an inevitable tool for estimation of energy losses in the future – forecasts for the next years. Results achieved thanks to the software enable the creation of the final, complex balance of energy in the distribution company for the next year of operation, which in the market economy (characterised by fierce competition) is of crucial importance.

The above mentioned software may be used also for analysis aimed at choosing the best investments from the efficiency and profitability point of view.

II. SOFTWARE STRATY`2007

The problem of efficiency of distribution of electric energy is a basic task of suitable departments of energy boards. The helpful software in this range is software STRATY` 96 and its modernised version STRATY`99 and STRATY`2002 [1,2]. This software is designed to analyse of network losses in scale of energy regions and energy boards. Calculations are conducted in the following breakdowns: 1- according to sources their origin, 2- in partition on technical and trade losses, 3- in partition on real and justified losses. At present, the software operates in different versions in 28 energy boards.

Moreover, there is a split into real and technical losses. The real are losses which would occur if the existing network devices were used properly and the flow in the network was correct.. The difference between real losses and justified losses are the technical unjustified losses.

The presented report refers to the real and justified losses. The analyses of this issue show that among distribution companies there are large differences in amounts of technical real and justified losses. So, the justified losses constitute certain level, which can be reached through an efficient strategy of decreasing of losses.

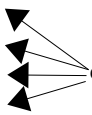
The software STRATY`2007 conducts calculations on the basis of the following input data, which are characteristic for a distribution company:

A Data related to energy (MWh)

A1. Data of distribution company

1. total energy supplies to medium voltage network
2. total energy supplies to 110 kV voltage network
3. energy supplies by export from medium voltage network
4. energy supplies to 110 kV from low voltage network (high voltage - 220 kV and 400 kV)
5. energy supplies to low voltage from 110 kV network
6. energy losses in the 110 kV network
7. energy supplies by export from 110 kV

7.1 thereof to ZE1
7.2 thereof to ZE2
7.3 thereof to ZE3
7.4 thereof to ZE4



export to other companies

A2 .Data of region of distribution company

1. energy supplies to consumers from low voltage network
2. energy supplies to consumers in the city network
3. energy supplies for public lighting
4. total energy supplies to medium voltage network
5. total energy supplies to medium voltage network from 110 kV
6. energy supplies to 110 kV from medium voltage network
7. energy supplies by export from medium voltage network
8. energy supplies to consumers from medium-voltage network (industrial power consumer)
9. supplies to traction undertakings
10. general auxiliaries
11. illegal consumption of energy
12. energy losses in low- and medium voltage networks

B. Data related to electrical equipment

B1. .Data of distribution company

1. length of 110 kV lines [km]
2. number of substations of high voltage/110 kV
3. number of transformers of 110k/medium voltage
4. capacity of transformers of 110k/medium voltage [MVA]
5. capacity of transformers of high voltage/110 kV [MVA]
6. capacity of capacitor unit of 110 kV [MVAr]

B2. . Data of region of distribution company

1. area [km2]
2. number of customers
3. number of industrial power consumer
4. number of single phase meters
5. number of multiphase meters
6. length of low voltage lines [km]
7. length of low voltage cables [km]
8. length of medium voltage lines [km]
9. length of medium voltage cables [km]
10. number of substations of medium voltage/low voltage
11. number of substations of 110kV/medium voltage
12. number of transformers of medium voltage/low voltage
13. capacity of transformers of medium voltage/low voltage [MVA]
14. number of substations of medium voltage/medium voltage
15. capacity of transformers of medium voltage/ medium voltage [MVA]
16. capacity of capacitor unit of low voltage [MVAr]
17. capacity of capacitor unit of medium voltage [MVAr]
18. capacity of transformers of medium voltage/low voltage
19. capacity of transformers of medium voltage/low voltage [MVA]
20. capacity of transformers of medium voltage/low voltage [MVA]
21. capacity of transformers medium of voltage/low voltage [MVA]
22. capacity of transformers medium of voltage/low voltage [MVA]

Figure 1 depicts the structure of energy losses at different voltage levels in a distribution company. Figure 2 depicts the distribution of energy losses in particular regions (basic units of a distribution company).

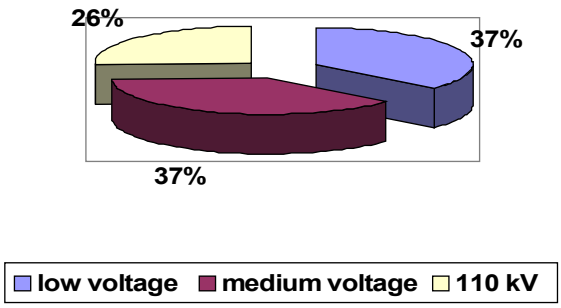


Figure 1. The structure of energy losses in a distribution company.

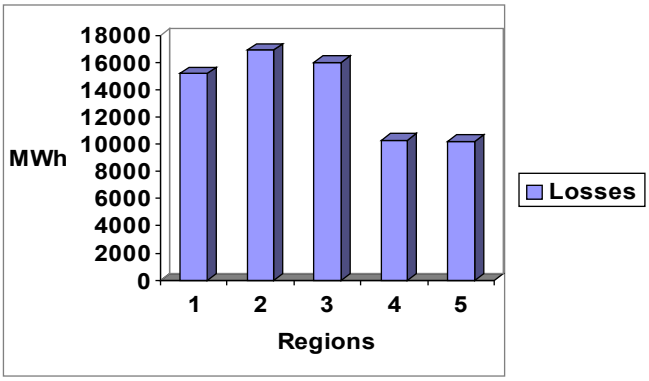


Figure 2. Distribution of energy losses in a distribution company.

The software STRATY`2007 may be used also as a basis for selection of strategy of distribution network development in energy board [3,4,5]. The starting point for analysis constitutes the following ratios:

- investment effectiveness for lines

$$e_L = \frac{\delta \Delta E}{\Delta L \cdot k_{Lj}}$$

- investment effectiveness for stations

$$e_F = \frac{\delta \Delta E}{\Delta F \cdot k_{Fj}}$$

where:

$\delta \Delta E$ - difference in energy losses before and after investments [MWh]

e_L - investment effectiveness for lines [MWh/km PLN]

e_F - investment effectiveness for stations [MWh/units PLN]

ΔL - increase of lines within the respective period [km]

ΔF - increase of lines within the respective period [units]

k_{Lj} - construction cost of 1 km of lines [PLN/km]

k_{Fi} - construction cost of 1 distribution station [PLN/unit]

Data source is the same for both of them, however additional data is also required i.e.:

- planned increase of energy p.a. - q
- predicted increase of lines and stations - ΔL , ΔF
- unit cost of construction of lines and stations of different voltage - k_{Li} , k_{Fi}
- proportions of expenses between stations and lines (balance of expenses for medium and low voltage)

It is expected that the software will be able to present balance of expenses in both kinds of network, with the limited funds for investments, for the predicted increase of energy flowing through the network, at the same time ensuring maximum usage of these funds, on the basis of investment effectiveness ratios for lines and stations. In addition, the software will be able to determine necessary investments ensuring stable level of losses or required level for different networks.

III. SOFTWARE ANALIZA [ANALYSIS]

The software is designed for evaluation of losses ratio in a distribution company in a longer period of time. Calculations are possible as data are archived. Figure 3 depicts the level of real losses in the network of a distribution company in the years 2003-2007.

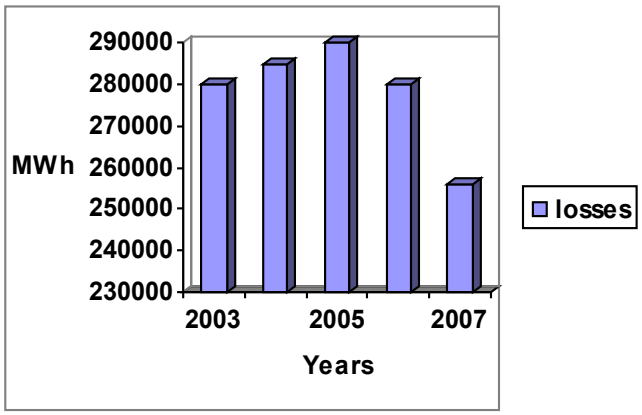


Figure 3. The level of real losses in the network of a distribution company in the years 2003-2007.

The situation presented in the Figure 3 indicates that in the years 2003-2007 the level of losses was growing and after the peak in 2005 started to decline, which resulted from implementation of the appropriate development strategy by company's management.

IV. SOFTWARE TREND

The software, on the basis of data for the last 5 years, enables to forecast losses both as total and split into different voltage levels for the years t+1, t+2. The software is an inevitable tool for preparation of balance of losses in a distribution company, where one of the elements constitutes the value of energy losses. The results are used also for preparations of new tariffs for energy approved by Urząd Regulacji Energetyki [Energy Regulatory Office] for the next year. Figure 4 depicts the level of losses in the years 2003 –2007 and forecast for the year 2008.

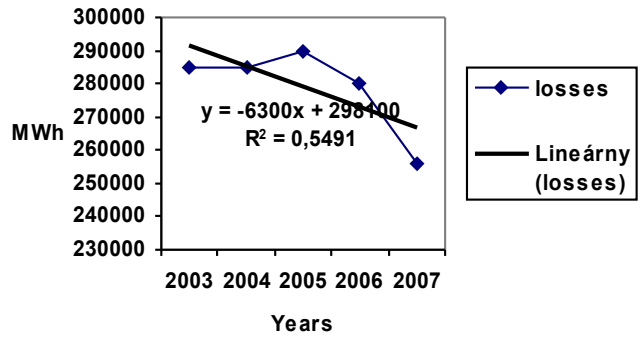


Figure 4. Forecast of energy losses

V. CONCLUSION

The software package presented in the report is a basic tool for evaluation of efficiency of distribution companies in the field of energy losses. Positive results of its usage in the Polish power energy sector, makes it worth recommending for distribution companies in Western, Central and Eastern Europe. However, implementation of the software must be preceded by verification of distribution network models used for calculation.

ACKNOWLEDGMENT

There is place to give thanks to sponsors who has supported your work at the end of the paper

REFERENCES

[1] J. Szkutnik, A. Gawlak Program Straty 96 dla Rejonów i Zakładów Energetycznych, Materiały Konferencji Naukowo–Techniczej ZASTOSOWANIA KOMPUTERÓW w ELEKTROTECHNIC Poznań/Kiekrz April 199

[2] A. Gawlak, J. Szkutnik Strategia identyfikacji strat handlowych przy pomocy programów komputerowych: STRATY`96 oraz STRAHA Materiały III Konferencji Naukowo - Technicznej ZASTOSOWANIA KOMPUTERÓW w ELEKTROTECHNICE Poznań/Kiekrz, April 1998 [the strategy of identification of trade losses with usage of computer software]

[3] J. Szkutnik Selection of distribution network development in energy board on the basis of investment effectiveness ratios from the energy losses point of view; I TH International Scientific Symposium ELECTROENERGETIKA, STARA LESNA SLOVAKIA January 2001, pages 65-68

[4] M. Kolcun, Ľ. Jahnátek, Systémové poruchy v elektrizačných sústavách, IVth International Scientific Symposium ELEKTROENERGETIKA 2007, 19.-21. 9. 2007, Stará Lesná, Slovak Republic, pp. 723 – 728, ISBN 978-80-8073-844-0

[5] Janusz Grabara, Ľubomír Jahnátek: Poprawa pozycji konkurencyjnej przedsiebiorstwa dzieki nowoczesnym rozwiazaniom logistyki odwrotnej, Zarzadzanie w przedsiebiorstwie, XV Medzynarodowa Konefencja Naukowo-Techniczna, cz. 2., 27. - 30. 6. 2007, Zakopane, Poland, pp. 50-53, Wydawnictwo Politechniki Czestochowskej, Czestochowa 2007, ISSN 1234-9895, ISBN 978-83-7193-343-1.

[6] Szkutnik J., Kolcun M., (red) Technical and economic aspect of modern technology transfer in context of integration with European Union, Mercury – Smekal Publishing House, Kosice,2004

[7] Horak J., Gawlak A., Szkutnik J., Masłoń W., Zając J., Doświadczenia z wdrożenia programu komputerowewgo STRATY`2002 w Zakładzie Energetycznym Częstochowa S.A., III Konferencja Naukowo-Techniczna. Straty Energii Elektrycznej., 20-21 październik 2005 r. s.113-117

[8] Szkutnik J. New Solution for Efficient Distribution of Electrical Energy, Proceadings of the IIIrd International Scientific Symposium ELECTROENERGETIKA, Stara Lesna, Slovak Republic 2005, s.12

[9] Szkutnik J. The management of distribution process in the electrical power system, VSB-Technical University of Ostrava, Proceedings of 8th International Scientific Conference, Kouty nad Desnou, Czech Republik, 12-14 June, 2007, ISBN, 978-80- 248-1391-2, pp.8 (Abstract) , + paper (CD)

[10] Szkutnik J. The future European electric power system, Technical University of Kosice, Symposium ELEKTROENERGETIKA 2007, Stara Lesna, 18-20 September 2007, ISBN 978-80-8073-844-0, invited lectures pp. 71-73)

[11] Szkutnik J. Models of electrical energy distribution in decision-making processews. Interdisciplinary approach to sustainable development, Edited by Ralph Lescroart, Piotr Pachura and Tomasz Nitkiewicz, ISI Pierrard HEC Du Luxemburg, Virton, Belgigue 2007, Depot legal: D/2007/9727/4 Edited in Belgium, pp. 161-173

ADDRESSES OF AUTHORS

Prof. Jerzy Szkutnik, Częstochowa University of Technology, Al. Armii Krajowej 17, Poland szkutnik@el.pcz.czest.pl