LOGISTICS IN THE EFFICIENCY OF DISTRIBUTION OF ELECTRICAL ENERGY

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Abstract: The report presents the solution, 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: efficiency, energy losses, smart metering

1. Introduction

For the last couple of years, the team of the Technical University of Częstochowa 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 [1., 2., 3.]:

- Software STRATY'2002,
- 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.
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.
Energy losses in Polish reality have also additional dimension i.e. they are split into technical and trade losses. The first type refers to losses connected with energy distribution, the second one is the difference between the registered energy (energy supplied – energy consumed) and technical losses. Figure 1. depicts the structure of energy losses at different components in a distribution company.

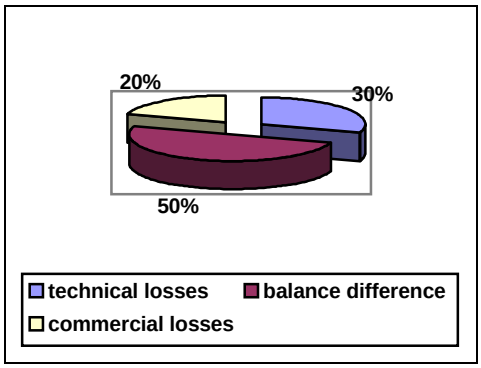

Figure 1. The structure of energy losses in a distribution company.

As you can see on Fig. 1., trade losses in the analysed company constitute 12% of the total energy losses. This is an average level in Poland [3.]. There are companies that have this ratio of a high 30%, but there are also companies with the ratio of 8%.
Trade losses consist of the following three basic elements [2.]

$$\Delta E_h = \Delta E_{hs} + \Delta E_{he} + \Delta E_{hn} \tag{1}$$

where

ΔE_h - trade losses,

ΔE_{hs} - systematic trade losses,

ΔE_{he} - registered trade losses,

ΔE_{hn} - trade losses due to illegal consumption.

Systematic trade losses result from errors of measuring units, too high threshold for measuring start (at least for some receivers e.g. night lighting), bell transformers or more and more often used transformers supplying halogen lamps. Such losses are rather low and amount on average to 0,2 kWh /day for a receiver.
The second type of trade losses constitute registered losses. They result from mistakes in registration of the sold energy, delays in measurements etc. In the long run, these losses are close to zero, so they are not real losses, however they make it difficult to determine the real load of the network.
Losses ΔE_{hn} are the losses resulting from illegal consumption by the receivers. These are real losses for the energy distributor and unfortunately they are quite significant.
The percentage distribution of trade losses in the analysed distribution company is depicted on Fig. 2.

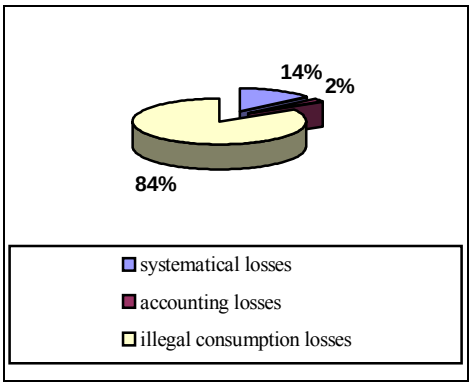

Figure 2. The percentage distribution of trade losses

The majority of trade losses in the analysed company constitute losses due to illegal consumption - 84%. The remaining 16% come from the other two sources.

2. Data of energy and losses

Distribution companies take various steps in order to reduce losses. One of the most efficient methods is installation of modern measuring equipment in the network. This method has been analysed on the basis of solutions offered by the company Kamstrup. It is automated, remote reading of data based on radio-controlled and PLC method designed by Kamstrup A/S. Automated reading of data created by Kamstrup is a modern system of collection and analysis of data from energy meters designed for energy distributors. The main idea of the system is to enable energy distributors to read the energy meters in a timely manner. The system may also be used foe reading other meters like heat, water or gas. It enables collection of data according to the specified time schedule or at any time on request e.g. in the moment of supplier change. The system bases on three pillars: core system, network components and meters with integrated modules.
Software – core system is used for administration and planning of activities of the whole system. Network components are responsible for communication and consist of concentrators, routers and communication modules e.g. GSM modems. The next part of the structure comprises meters with integrated modules that assure appropriate functionality.

Communication between meters/modules and concentrators is done through radio-controlled, low voltage network (PLC) or cable network e.g. M-Bus type. Communication between the core system and concentrators, which are often used in transformer stations, is done through radio-controlled network, GSM, PLC, PSTN (phone line) or other.
In the analysed project, communication is done through radio-controlled and PLC network, depending on the building type. Communication between concentrators and the core system is done through GSM network.
Installation of meters is simple as they do not require any configuration or initialisation before start. By delivery, all registers show "0" and communication between the meter and the module is done through serial cable. This creates a basis for a reliable billing system, because there is no danger of loosing some impulses. If the distance between the meter and the concentrator is too large, GSM module is used as a method of communication.
Meters can be delivered as 1, 2 or 3 phase direct meters or 3 phase semi-direct meters. Each of them will be equipped with radio-controlled or PLC module already during production.
In the radio-controlled meters, registers are stored together with the load profile in the time intervals of 5 to 60 minutes with time indication. The capacity of the load profile in case of 60 minutes time interval amounts to 45 days and at midnight all values from the last 45 days are stored in the memory. In the separate register, all supply shortages lasting over 2 minutes together with time of their occurrences will be registered.
Communication to and from meters/modules is done through radio network, PLC or GSM.
Each individual communication module communicates with other modules storing in memory the path of communication in so called local list. On the basis of these connections the network is build later. The lists in turn are stored in the concentrator and constitute the basis for establishment of the best communication path between particular meters/modules in the network. Since each module installed in the meter has a router function, each one creates next steps in communication between the concentrator and more distant located meters. It can be 10 such steps, which gives superior possibility to cover the area with only one concentrator.
The significant advantage of the Kamstrup system is lack of necessity to configure the meters, modules, or concentrators before the installation.
The configuration is done automatically as each meter has its own identification number and the system automatically finds for it the best communication path to the router or concentrator.
The system has also a feature of double security, which enables a different concentrator to read the meter if the there is no connection with the first concentrator.
The meters with integrated modules enable to register the load profile in the time intervals of 5, 15, 30, 60 minutes. The memory capacity equals 1 080 cells i.e. 45 days with 60 minute intervals or 11 days with 15 minute intervals. Data is stored daily at midnight, but the registers can be read by the central system at any time. These data constitutes for the system the basis for analysis and graphic presentation.
The main objective of Kamstrup is to make the system as easy and user friendly as possible. In order to facilitate installation, they designed a tool, which enables the control and visualisation of the communication network. This tool acts as co-ordinator between the system of data collection made by Kamstrup and the geographic information system (GIS). Co-ordination is done in the GIS application and shows the configuration of the radio-controlled system i.e. location of meters with modules, routers and concentrators as well as lines depicting communication paths between these network elements. As a result of this tool, connection of low quality can be immediately located and corrected. (GIS = Geographic Information Systems). Fig. 3. depicts the co-operation of the Kamstrup system with the GIS

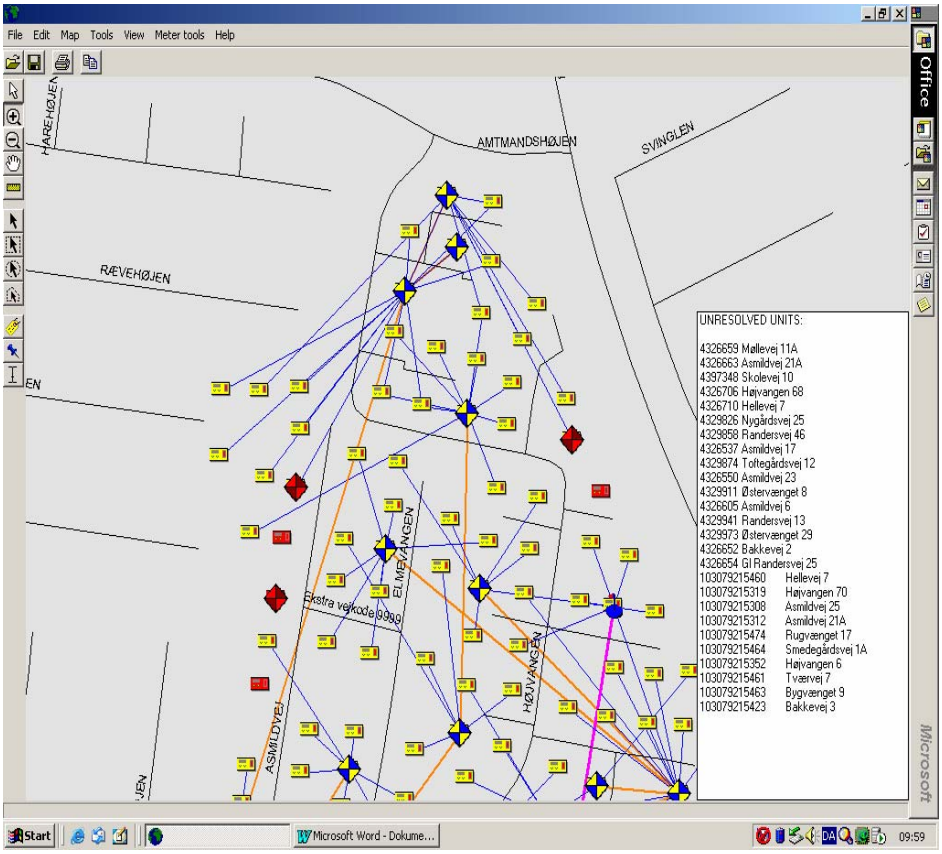

Figure 3. System Kamsrup A/S and GIS

The main system communicates directly with concentrators. Communication can be done though different ways: radio-controlled, GSM or LAN networks. Having the possibility to use different methods of communication, it is possible to chose the most appropriate one from the practical and economic point of view. The potential solutions are depicted on Fig. 4.

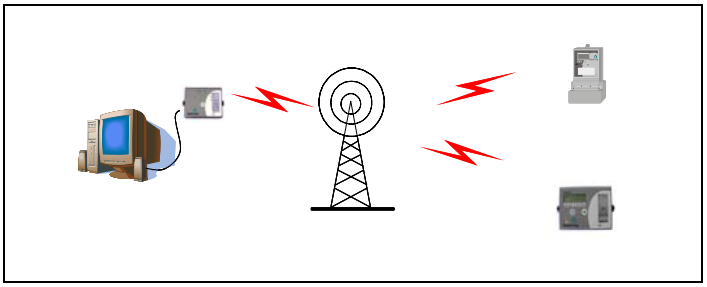

Figure 4. System communication solution – radio-controlled

The presented system is now being prepared for implementation in one of the distribution companies in Poland. For this purpose, two circuits have been created: one in the overhead network, the other in the cable network. Fig. 5. depicts one of these circuits i.e. overhead network.

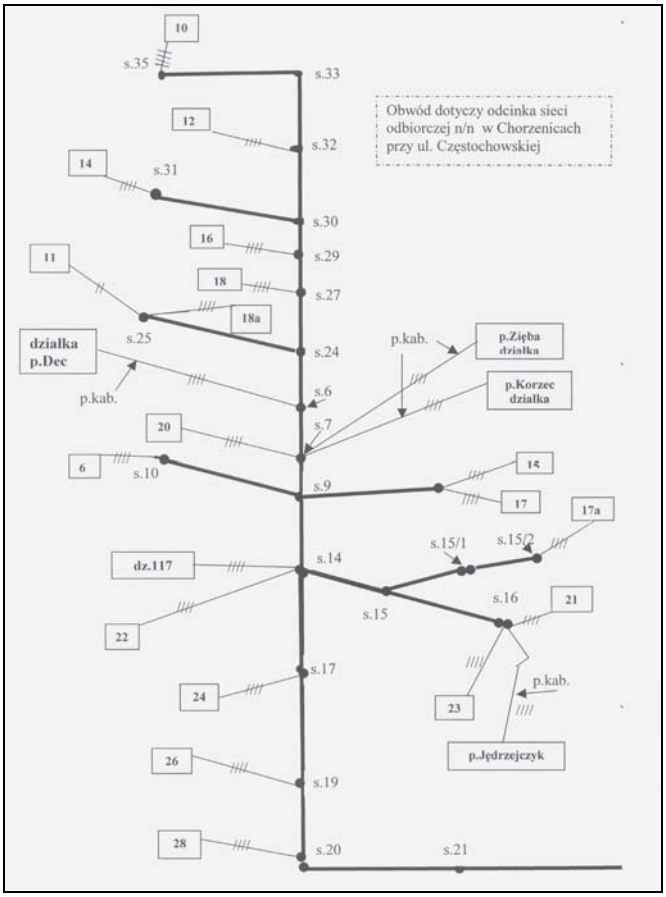

Figure 5. Circuit of the pilot Kamstrup system

It is expected that the implemented pilot installation of the system will enable to gain the necessary experience for the next implementations of the system.
The main objective of a distribution company would be to reduce the difference between the registered losses to the lowest possible level. This level is known as so called 'losses in the norm' and is defined as the sum of technical losses and systematic trade losses [6.]. Each value over that level indicates that there is room for increased efficiency in the energy distribution of a distribution company.

3. 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. The condition precedent for the planned strategy of increasing efficiency of energy distribution is the well functioning measuring system. The presented system made by Kamstrup possesses the required features to be regarded as the system that meets all expectations in this respect. Researches in this frame will be continued.

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