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EXPERT SYSTEM FOR EFFICIENCY COMPARISON OF ELECTRIC NETWORK COMPANIES

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Abstract- In this article the expert system of electric networks efficiency comparison with consideration of electric power losses and the electric power is offered. The problem of companies comparison by the efficiency criterion is rather actual and interesting. The results of such comparison can be used both for current activity and for prospective work (for development and specification of actions programs, for parameters planning, etc.).

Keywords: Electric Power Losses, Transmission Networks, Expert System, Criterions, Objective Factors.

I. INTRODUCTION

One of the major parameters of the electric network companies performance is the electric power losses. But the simple comparison of the networks by this parameter is not always correct because it does not allow to consider a number of the objective factors directly or indirectly influencing the electric power losses in each specific network.

At the same time the problem of companies comparison (or different branches of one company) by the efficiency criterion is actual and interesting. Results of such comparison can be used both for current activity (for example, for making the reasonable solution for staff stimulation), and for prospective work (for development and specification of actions programs, for parameters planning, etc.) [1].

In this article the expert system of electric networks efficiency comparison with consideration of electric power losses and the electric power is offered. In spite of the fact that the system is applicable for networks comparison for all voltage levels, according to authors, the application for comparison of the networks with considerable proportion of 10-0.4 kV voltage levels represents the greatest interest.

The expert system consists of ten criterions each of them appears with the weighted factor into a cumulative rating of the considered network company (see Table 1 and Figure 1). Values of weighted factors are set by experts and can vary. Most of the criterions can be conditionally divided into three groups: criterions of the first group consider the dynamics of electric power losses changes; criterions of the second group consider the structure of losses and their distribution by voltage levels, and the third group of criterions allows to summarily considering the some features of schemes and network operating states.

The criterions of the first group show the dynamics of electric power losses and other criterions allow considering the objective circumstances which have an influence on the losses and on the possibilities for their optimization.

Let's consider the criterions and their weighted factors in details.

II. THE CRITERIONS CONSIDERING THE DYNAMICS OF ELECTRIC POWER LOSSES CHANGES

Two most important criterions in this group are saving in relative losses of the electric power in an electric network 10-0.4 kV and in networks 35 kV and higher. Such division is made for several reasons. All commercial losses (defined by subtraction from actual losses technical losses and losses caused by errors of electric power metering system) are practically concentrated in network 10-0.4 kV [2]. Besides, in this network the most part of actions for electric power losses saving in which realization the essential part of network company staff participates (disconnects of defaulters, control of the validity of consumers metering devices, etc.) is carried out.

The change of losses in networks 35 kV and higher depends practically only on change of network states and the realization of small group of optimizing actions.

The values of the given criterions are defined as a difference of relative (in relation to all electric power) losses of the electric power for current period and the similar period of last year. According to the authors, it is necessary to consider also the fact that electric power losses saving, for example, in network 10-0.4 kV on 5 % (from 30 % to 25 %) it is impossible to compare in the pure form with electric power losses saving on the same 5 % (from 15 % to 10 %). Because at higher initial level of losses it is much easier to carry out such optimization.

To consider the given factor in expert system the value of electric power losses saving is multiplied by correcting the coefficient. The scale of correcting the coefficients for network 10-0.4 kV is accepted in the form of discrete values in a range from 0.5 (at initial level of losses 30% and more) to 1 (at initial level of losses 10% and less) with step 0.025. For networks 35 kV and higher the scale begins with the factor 0.28 (at initial level of losses 10 % and more), and comes to an end with value 1 (at initial level of losses 1% and less) with step 0.08 (see Table 2).

The weighted factor for both considered criterions in expert system is accepted equal to 1 as the electric power losses saving is undoubtedly the major parameter of network efficiency.

If the growth of relative losses of the electric power is observed the corresponding negative value of criterion will reduce the general rating.

III. THE CRITERIONS CONSIDERING THE STRUCTURE OF LOSSES AND THEIR DISTRIBUTION ON VOLTAGE LEVELS

The first criterion is the part of technological losses in network 10-0.4 kV. Obviously, the more this part the less the commercial losses. So the network operation is effective. The weighted factor is 1.

The next criterion is the part of losses in network 10-0.4 kV in total losses. The weighted factor of this criterion is 0.9. If the company does not have networks with high voltage this criterion is 1, otherwise when if network has only 35 kV lines and higher the criterion is 0.

The third criterion is the part of losses depending on loads in the total technical losses. It allows estimating degree of network loading. The weighted factor is 0.7.

IV. THE CRITERIONS CONSIDERING THE FEATURES OF SCHEMES AND NETWORK OPERATING STATES

These criterions are necessary for the estimation of the objective factors influencing on electric power losses. For example, it is known that the more the proportion of cables in network the less the technical losses. Therefore in expert system the part of overhead transmission lines in network 10-0.4 kV is considered with weighted factor 0.6.

The part of electric power transit to other networks is used for the estimation of so-called losses from electric power transit. As influence of the given index on electric power losses in network 10-0.4 kV is not so considerable the weighted factor is accepted equal to 0.2.

The important criterion characterizing the status of the metering system (and the losses caused by the errors of the system) is the part of electronic metering devices with weighted factor 0.6.

Besides, the population part in power demand is included with weighted factor 0.8. The more this parameter the more difficult situation with the commercial losses in network is.

Last, the tenth, criterion does not concern to one of group. It is the part of the documents confirming electric power theft in total actions for electric power losses saving. The weighted factor is 0.5.

V. THE EXAMPLE OF NETWORK COMPANIES COMPARISON BY PROPOSED EXPERT SYSTEM

For the system analysis let's consider the comparison of four transmission network companies. The company 1 includes only 10-0.4 kV network in the urban territory. The level of actual losses at the moment of comparison is hardly less than 15%. The company 2 includes networks from 0.4 to 110 kV, both in the city and in countryside. Actual losses in network 10-0.4 kV exceed 24%, in network 35-110 kV are about 1.8%. The companies 3 and 4 include rural electric networks. Actual losses in network 10-0.4 kV at the company 3 are 16% (in network 35 kV and higher are about 2%), at the company 4 are 11% (in networks 35 kV and higher are about 3.2%).

The values of criterions for all companies are presented in table 1 and in Figure 2. The cumulative rating for each company is defined. Here the bold font indicates the largest values of each criterion.

As it is shown (see Figure 3) the company 4 which have achieved considerable electric power losses saving both in network 10-0.4 kV and in networks of higher voltage level has the largest rating (smallest commercial losses). Besides, this company has the most modern base of metering devices.

The company 2 has the best electric power losses saving in network 10-0.4 kV but they remain still very high - more than 23%. The growth of losses in networks 35 kV and higher has not allowed catching up in a rating with the company 4.

The company 1 carries out electric power transmission mainly for the population. As consequence, it has the largest part of the documents confirming electric power theft.

The company 3 has the worst rating because of the increase in actual electric power losses in network 10-0.4 kV.

VI. CONCLUSIONS

One of the advantages of the proposed expert system is the possibility of its application both for small and for large network companies.

As it has already been mentioned above the system is first of all fit to comparison of the network companies with large network 10-0.4 kV. To compare the networks of higher voltages it is necessary to partially revise the criterions and weighted factors.

Certainly, offered system is not final and can be improved both from the point of view of qualitative structure of criterions and from their influence on the general rating of the compared network companies.

According to the authors, the given expert system is especially useful for:

- the comparison of the network companies and their branches on electric power losses saving;
- the staff stimulation (by the losses level);

- the estimation of possible effect of actions for losses decreasing (by comparison of a current rating with extremely possible - according to experts - in the given conditions).

Table 1. The example of network companies comparison by proposed expert system

Criterion	Factor	Network companies			
		1	2	3	4
1. Saving in relative losses of electric power in network 10-0.4 kV*	1	0.1243	**2.4237**	-2.261	2.1867
2. Saving in relative losses of electric power in network 35 kV and higher**	1	0.0000	-0.480	1.2171	**1.3979**
3. The part of technological losses in actual losses in network 10-0.4 kV	1	0.5700	0.3809	0.8774	**0.9258**
4. The part of losses in network 10-0.4 kV in total losses	0.9	**1.0000**	0.8940	0.8303	0.3977
5. The part of losses depending on loads in total technical losses	0.7	0.5407	**0.6117**	0.4162	0.4989
6. The part of overhead transmission lines in network 10-0.4 kV	0.6	0.3091	0.9836	0.9983	**1.0000**
7. The part of electric power transit to other networks	0.2	0.0127	0.1967	0.2907	**0.4610**
8. The part of electronic metering devices	0.6	0.4569	0.4201	0.3726	**0.6912**
9. The population part in power demand	0.8	**0.5026**	0.3138	0.1688	0.3173
10. The part of the documents confirming electric power theft	0.5	**0.9045**	0,5883	0.3432	0.5455
Rating = the sum of productions (criterion* coefficient)	-	**3.2893**	**4.9841**	**2.0594**	**6.8511**

* With correcting factor for network 10-0.4 kV:

- for company 1 the coefficient is 0.875 (electric power losses saving from 15.03% to 14.88%)
- for company 2 the coefficient is 0.56 (electric power losses saving from 27.48% to 23.15%)
- for company 3 the coefficient is 0.9 (electric power losses saving from 13.72% to 16.24%)
- for company 4 the coefficient is 0.91 (electric power losses saving from 13.62% to 11.22%)

** With correcting factor for network 35 kV and higher:

- for company 2 the coefficient is 1 (electric power losses saving from 1.27% to 1.75%)
- for company 3 the coefficient is 0.8 (electric power losses saving from 3.69% to 2.16%)
- for company 4 the coefficient is 0.65 (electric power losses saving from 5.36% to 3.21%)

Table 2. The values of correcting coefficients for criterions 1 and 2

Criterion 1 (network 10-0.4 kV)		Criterion 2 (network 35 kV & higher)	
% of losses for current period	Correcting coefficient	% of losses for current period	Correcting coefficient
30	0.5	10	0.28
29	0.525	9	0.36
28	0.55	8	0.44
27	0.575	7	0.52
26	0.6	6	0.6
…	…	5	0.68
13	0.925	4	0.76
12	0.95	3	0.84
11	0.975	2	0.92
10	1	1	1

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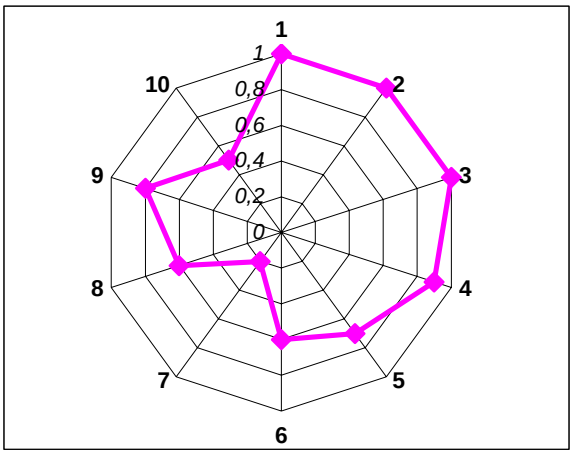

Figure 1. Weighting factors of ten criterions

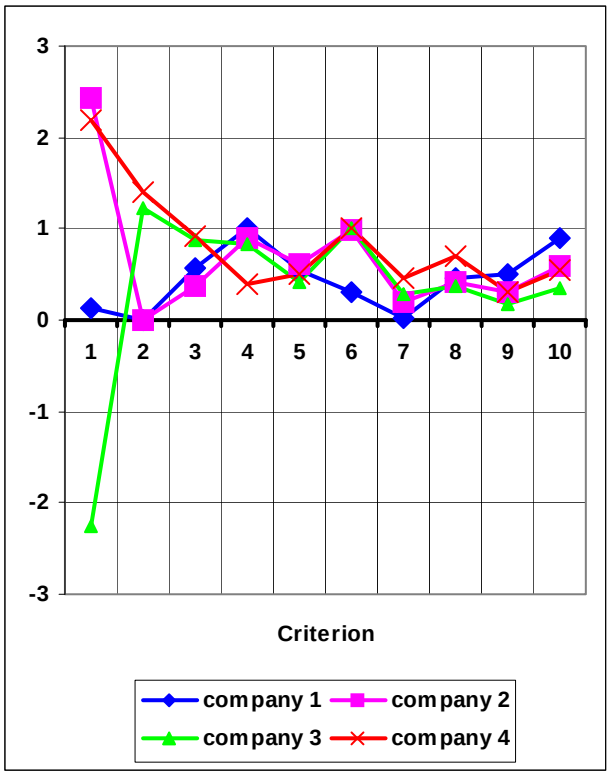

Figure 2. Values of criterions of the network companies

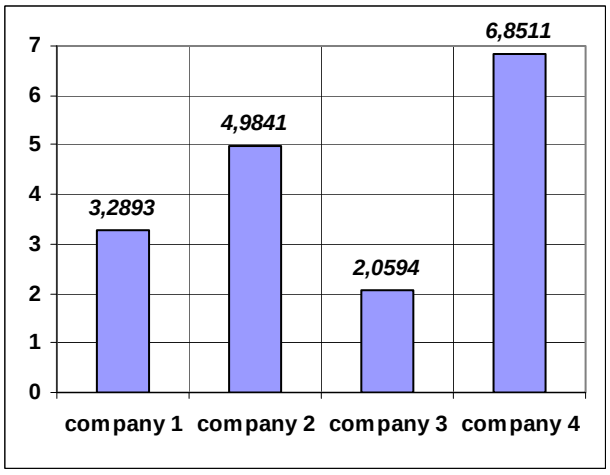

Figure 3. Ratings of the network companies

BIOGRAPHIES

Alexander Valerjevitch Mogilenko was born in Leninsk, Kazakhstan, USSR, 1976. He received his M.Sc. and Ph.D. degrees from Novosibirsk State Technical University in 1999 and 2003, respectively, all in Power Electrical Engineering. His careers were as teacher in Novosibirsk State Technical University, Novosibirsk, Russia (1999-2003), chief of power losses department (2003-2007) and main expert of power engineering department (2008) in open joint stock company Novosibirskenergo, Novosibirsk, Russia. He is the author about 90 publications and participated in 34 conferences. Dr. Mogilenko is the member of Swiss SEV Association for Electrical Engineering, Power and Information Technologies, Austrian Electrotechnical Association and Germany VDE Association for Electrical, Electronic & Information Technologies, Germany.

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