Analysis of the post-merger efficiency of companies in the wholesale electricity market by the example of Russia*

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Abstract. This paper considers electricity market in its smaller and greater concentrations and presents comparison of effective functioning for power generating companies and their parts before and after forming large market corporations. We give description of the analysis technique, including cluster analysis, based on several performance indicators under study. The methods proposed are then used to evaluate Russia's electric energy market.

Keywords. Generating company, Merger of companies, Electricity markets, Cluster analysis model.

M.S.C. classification. 62P20, 03C25, 68P10.
J.E.L. classification. L41, L16, C53, C38.

1 Introduction

Long-term performance assessment of power generating companies implies an analysis of merger and separation of individual companies. Since the mid-80s of the 20th century, the processes of liberalization have acquired a mass character worldwide. The majority of large electric power systems were divided into several separately functioning segments. First of all, the vertical separation was performed. Natural monopoly segments, such as grid companies, were singled

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out, whereas electricity producers joined a separate wholesale market. Since generating capacities present quite large facilities, they face objective barriers when entering the industry. Therefore, competitiveness in the electricity markets is imperfect and oligopolistic. In this regard, power generating companies have some market power. The degree of this power is determined by the share occupied by the company in the market. There exist some oligopolies where this power is small. This is due to a rather large number of operating agents, small market shares belonging to an individual generator, possibilities for small capacities to compete with large power producers, etc. The State can regulate the process of splitting the power generating companies by establishing certain rules. The purpose of interference in the wholesale electricity market is to push competitiveness, and, accordingly, to reduce prices, bringing them closer to perfectly competitive ones.

The question is to what extent it is necessary to split or amalgamate companies for the effective market structure development. By an effective structure we mean the profitable environment with minimal market power of companies (markup is small). Theoretically [5, 10, 3], the oligopoly is most effective when the number of generating capacities is as small as possible.However,it turns out that everything is not so simple. The key role is played by elasticity, and great elasticity always stipulates the negative effect produced by the merger (the case of quadratic costs without the linear part is considered) [4]. Low elasticity is typical for the electricity market, and, as practice shows, can yield either positive or negative merger results. The rules for a quantitative merger of companies in the UK electricity market have been changed several times [8, 9, 2]. Until recently, the parameters of the existing balance have been improving, but this effect did not last. Using the example of the UK market "a day ahead",it was empirically proved in [13] that excessive splitting of firms can be destructive. It was shown that small power generating companies began to use the market power more (inflating the prices of applications) than they did it when operating as a part of larger companies.

In order to analyze the market power in the wholesale market it is necessary to assess effectiveness of the operating power generating companies.

In this work, we carried out a consistent analysis of the financial indicators for individual power generating companies, which initially were separate economic entities in the market and later became a part of large power generating companies. We performed the analysis of profitability, market share, installed capacity utilization factor, as well as the cluster analysis of the efficient functioning of companies. All studies were carried out using the example of the Russian electric power industry, which for the last 10 years has undergone significant changes. The oligopoly with a sufficient number of individual players in the industry transformed into the oligopoly with a small number of participants.

2 Liberalization stages of the Russian electricity market

The electric energy sector in Russia is one of the biggest in the world. It largely determines competitiveness and growth of the Russian economy, a significant share of which is taken by energy-intensive industries. Over the last 15 years, the electric energy market of Russia has undergone a large-scale reconstructing, during which a completely new for Russia system of economic relations in the electricity sector has been created. The oligopolistic market structure model is now being formed in the wholesale generation market. One of the key objectives of the present paper is comparison of the structure of the wholesale electricity market immediately after the liberalization of 2005 and at the end of 2015. Particular attention is paid to the activities of foreign companies in the Russian market, because the foreign investors used the sector reformation to acquire part of the assets.

The power sector reconstruction can be roughly divided into three stages [1]. The first stage from 2001 to 2003 was preliminary and for legal basis for economic relations in the electric power industry. The Resolution "On Restructuring the Electric Power Industry of the Russian Federation" was adopted [11] was adopted in 2001, whereas the Federal Law "On the Electric Power Industry" was adopted in 2003 [12]. The second stage begins in 2004, and by this time the reorganization of RAO UES of Russia had been mainly completed. In 2005, 20 power generating companies of the wholesale market were established on the basis of RAO, and the market liberalization began as early as in 2007. The beginning of the third stage can be considered as the termination of the RAO UES existence and the launch of the capacity market in 2008. The electricity market had been completely liberalized by 2011.

The most effective way of fair pricing is market liberalization through promotion of competitiveness. In the context of the policy of increasing the number of companies in the electricity market, 2004-2005 witnessed emergence of 14 territorial generating companies (hereinafter referred to as TGC) and 7 wholesale generating companies (WGC); afterwards they were merged and swallowed up several times, changing owners and there by participating in the creation of concerns. It should be noted that all hydroelectric power plants were joined into a single company of PJSC *RusHydro*, the majority share holding of which belongs to the Russian Federation represented by the Federal Agency for State Property Management. *Rosenergoatom* Concern is also fully state-owned. Such participation of the State in the market is due to the specific nature of power generation facilities: any malfunction in the normal operating conditions might result in a disaster.

As of today, several groups that own the main generation power have been formed in the generation market: in nuclear energy it is JSC *Rosenergoatom Concern*, in hydropower - JSC *RusHydro*, thermal power - JSC *Gazprom*, CJSC *KES-Holding*, JSC Inter RAO UES, etc. Also a part of the generation facilities have been purchased by such foreign companies as E.on (Germany), Enel (Italy), Fortum (Finland).

Table 1 below shows allocation of the power generating companies between the main shareholders in the authorized capital for 2016. It should be noted that initially it was planned that generating companies would be individual economic entities in the wholesale market (26 power generating companies), but the mergers that occurred in the industry from 2010 to 2015 changed the picture, significantly amalgamating the participants of the market (12 companies).

Table 1. Allotment of the power generating companies based on the main shareholder in the authorized capital.

Shareholder	Power generating company
Concern Rosenergoatom	Concern Rosenergoatom
RusHydro	RusHydro
Inter RAO Group	RAO UES
	OGK-1
	OGK-3
	Nizhnevartovsk station
	TGK-11
Gazprom	Mosenergo
	OGK-6
	TGK-1
	OGK-2
The Group of Companies "T Plus"	TGK-5
	TGK-6
	TGK-7
	TGK-9
	Orenburg TGK
EN+ GROUP	Irkutskenergo
	OJSC Krasnoyarskaya HPP
E.On	OGK-4
Enel	OGK-5
Fortum	TGK-10
GK Sintez	TGK-2
ONEXIM Group	TGK-4
LUKOIL	TGK-8

3 Performance analysis of power generating companies

Assume that n power generating companies operate in the electric power industry. Each generating company $i = 1, \ldots, n$ will be examined on the basis of: revenue R_i, operating profit π_i^o, net profit π_i^c, generated electricity (output) q_i, installed capacity Q_i. The above indicators were taken from the annual and financial statements of companies obligatory for publication.

Table 2. The indicators of financial statements of companies.

2016	R_i, RUB m	π_i^o, RUB m	π_i^c, RUB m	q_i, kWh	Q_i, MW
OGK-2	134397,9	9389,245	3052,589	67 086	18 954
TGK-1	78891,1	8600,927	5324,173	27 655	6 852
TGK-3	190656,1	15636,121	13438,002	59 068	12 963

Based on the revenue figures, the operating and the net profit IFRS, we calculated the return on sales (ROS) for each year.

$$ROS_i = \frac{\pi_i^o}{q_i},\ i = 1, \ldots, n.$$

A similar indicator was calculated based on the net profitπ_i^c. The return of sales ROS_i demonstrates a share of the operating profit in sales.

The next necessary indicator for the analysis is the installed capacity utilization factor (hereinafter referred to as ICUF). Data for its calculation are taken from the production figures of the company's annual statement. ICUF is the most important indicator of the efficiency of electric power industry enterprises and is determined by the participant's electric stations located within price zones of the wholesale market by the formula: $ICUF_{ik} = \frac{VG^{fact}}{NG_{ik} \cdot n_k \cdot 24}$, where ik is the installed capacity utilization factor; VG^{fact} is actual volumes of electricity generation by the electric stations of the participant of the wholesale market i per quarter k; NG_{ik} is volumes of the installed capacity of the power stations of the participant in the wholesale market i in the quarter k; n_k is the number of days in the quarter k [6].

ICUF is important because it characterizes the efficiency of the power plant as a whole, including not only its technological perfection, but also personnel qualifications, work flow management at the power plant and at State level, as well as many other factors.

Taking into account the profitability indicators and the installed capacity utilization factor, for each year we compiled a table. Below are given the examples for JSC *Gazprom Energoholding*, the German concern *E.On*, and the Italian concern *Enel*.

Gazprom Energoholding is one of the largest owners of electricity (generating) assets in Russia and owns the majority stockholding in *Mosenergo*, *TGK-1*, and *OGK-2*. The diagram below (Fig. 1) demonstrates the activities of *OGK-2*. It shows the return of sales (ROS OP), the net income (ROS NI),and the installed capacity utilization factor (ICUF).

On the whole, we can see the dependence of the *Gazprom's* performance indicators on macroeconomic factors, crisis situations, exchange difference (Fig. 2), and the overall decrease in ICUF at OGK-2, TGK-1, and TGK-3 (Fig. 3).

There are private investors in the generation market, with three foreign investors among them. One of the investors is the Italian *Enel*, which also the owner of OGK-5 (now *Enel Russia*). Enel's installed capacity utilization indica-

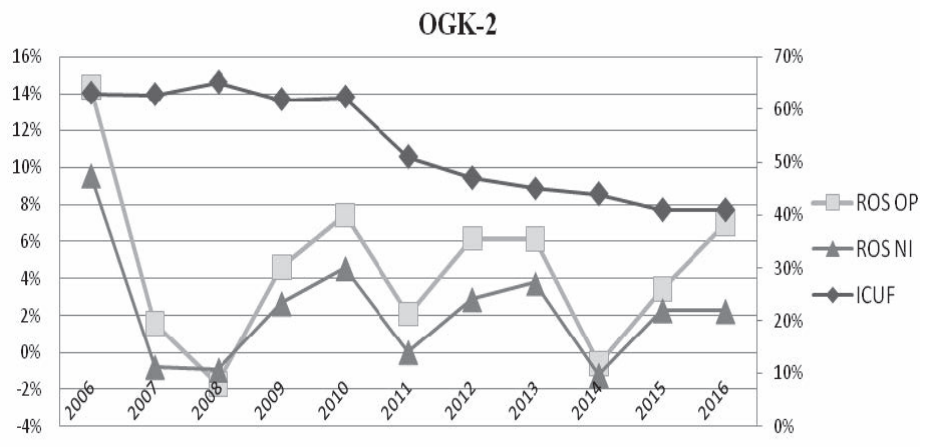

Fig. 1. Indicators of profitability and ICUF of Gazprom Energoholding.

tor is one of the most stable in the industry, which indicates the competent use of the company's capacities and balance load of the equipment. ROS was not affected by the crises of 2008 and 2011, however, 2015 shows a sharp drop (Fig. 4) caused by the complicated macroeconomic situation.

The same diagram (Fig. 5) shows the performance indicators of *Gazprom* and foreign companies for 2012 and 2016 in. We can observe some reduction in electricity generation in all generating capacities, ROS is also decreasing.

The combined diagram below illustrates the annual profitability and ICUF indicators for all companies considered in the study for 2006, 2012, and 2016 (Fig. 6). We can see some decline in ICUF general earnings dilution since 2006-2016. Two factors contribute to this: the first factor is drop in demand. And indeed, at this moment demand is declining: drop in demand for aluminum in the world has led to the reduction of its output in Russia. And the aluminum industry is one of the largest consumers of electricity. By 2016, demand had begun to grow again, and the situation slightly improved. The second factor is a great number of capacities introduced in 2012-2016. If in 2006 our electric power industry had insufficient reserve capacity, now there is some oversupply, which also has a negative impact on the effective functioning,including contribution to price increase.

By evaluating the return of sales and installed capacity of generating equipment, we can assess financial and production aspects of a company's performance in dynamics. To improve the analysis, the share of individual companies in the wholesale electricity market should also be taken into account. The indicator of electric energy generation of the generating equipment was used as the basis for the analysis. The percentage of total output was calculated for each company.

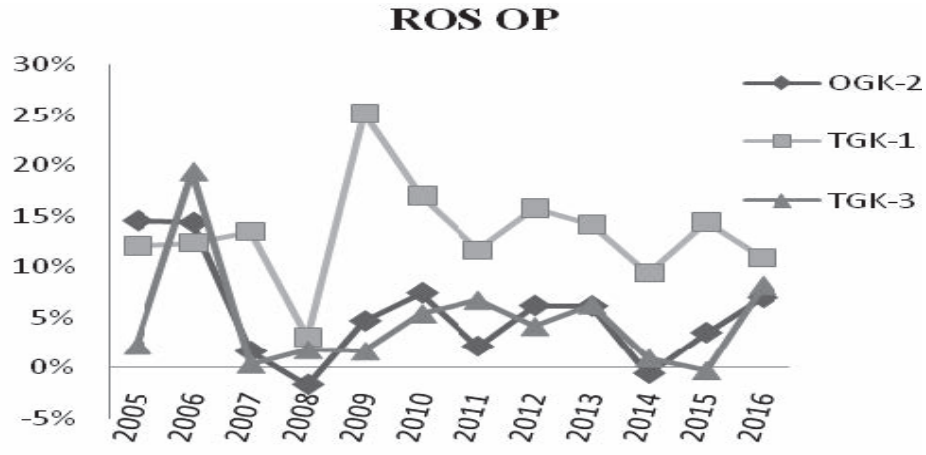

Fig. 2. Indicators of profitability of the companies being a part of *Gazprom*.

The results are shown in Fig. 7. We chose the year 2012, because the main stage of the restructuring was completed in 2011.

In general, after merger large associations increase their share in the total output, which leads to an increase in market power in the market.

4 Clustering of power generating companies

First of all, we identify the most effective companies depending on their position in the market and the return of sales. Then we will use cluster analysis as a classification method to combine the companies into groups to monitor general trends in the structure of the wholesale generation market as well as to split them into homogeneous groups.

Cluster analysis [7] is a way of grouping multidimensional objects based on representation of the results of individual observations as points of a suitable geometric space. Afterwards, the groups are singled out as clusters of those points.

Let $I = \{I_1, \ldots, I_n\}$ be n objects. There exists a set of quantitative characteristics of these objects. The result of measuring the characteristic i of the object I_j will be denoted as x_{ij} (for our problem this may be, for example, profitability, installed capacity utilization factor, market share, etc.), for all objects we have a set of measurement vectors $X_j = [x_{ij}]$.

The task of cluster analysis is to find $m < n$ of group partitions satisfying some optimality criterion on the basis of available measurements $X = \{X_1, \ldots, X_n\}$ of objects I. This criterion can be a certain functional expressing the levels of desirability of various partitions and groupings which is called target function. For example, the intra group sum of deviation squares:

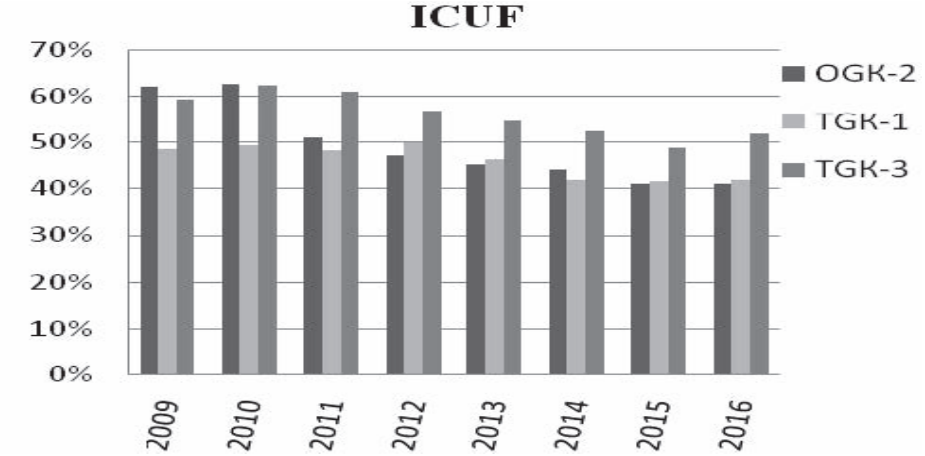

Fig. 3. Indicators of ICUF of the companies being a part of *Gazprom*.

$$W_i = \sum_{j=1}^{n} x_{ij}^2 - \frac{1}{n}\left(\sum_{j=1}^{n} x_{ij}\right)^2$$

where $x_j$are measurements of the *j-th* object, $j = 1,\ldots, n$.

The problem can be solved if we determine the degree of similarity and heterogeneity of the objects under study. The data under study can be represented as proximity matrices or distances between objects $d(X_i, X_j)$ or as points in a multidimensional space. The choice of distance between the objects is the key moment of the research, and the final variant of partitioning into classes by the chosen partitioning algorithm largely depends on it.

Let us take a closer look at some distance functions that determine the remoteness of the objects from each other:
Euclidean distance

$$d_2\left(X_i, X_j\right) = \left[\sum_{k=1}^{p}\left(x_{kl} - x_{kj}\right)^2\right]^{\frac{1}{2}},$$

l_i-norm

$$d_1\left(X_i, X_j\right) = \sum_{k=1}^{p}\left|x_{kl} - x_{kj}\right|,$$

Supremum Norm

$$d_\infty\left(X_i, X_j\right) = \sup\left\{\left|x_{kl} - x_{kj}\right|\right\} \qquad k = 1, 2, ..., p,$$

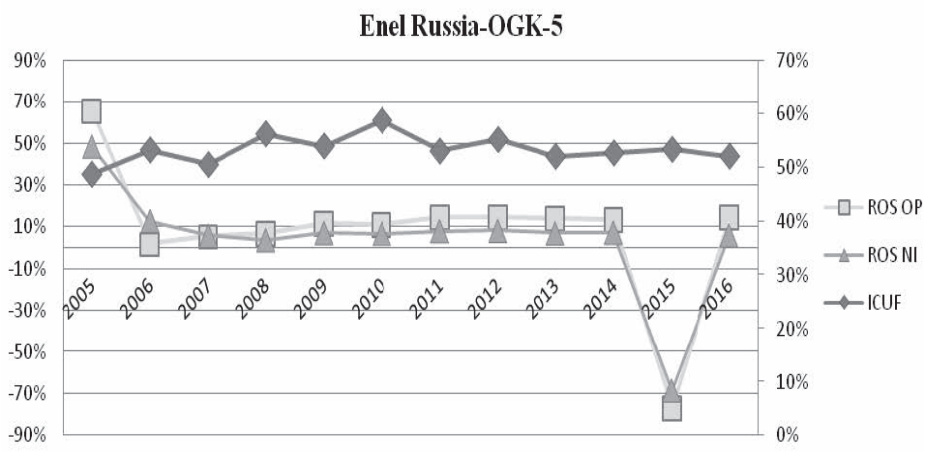

Fig. 4. Enel's indicators of profitability and ICUF.

l_p-norm

$$d_p\left(X_i, X_j\right) = \left[\sum_{k=1}^{p}\left(x_{kl} - x_{kj}\right)^p\right]^{\frac{1}{p}},$$

Mahalanobis distance

$$D^2\left(X_i, X_j\right) = \left(X_i - X_j\right)^T W^{-1}\left(X_i - X_j\right).$$

In this work, we used hierarchical methods of cluster distance (Agglomerative Nesting). This group of methods is characterized by a consecutive combination of initial elements and corresponding decrease in the number of clusters. At the beginning of the algorithm all objects are separate clusters. In the first step, the most similar objects are combined into a cluster. In subsequent steps, the merger continues until all objects form a single cluster. The algorithm of actions is shown in Fig. 8.

To perform cluster analysis,n measurements$X_1, ..., X_n$, can be written in a form of the matrix

$$X = \begin{pmatrix} x_{11} & x_{12} & ... & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & ... & \vdots \\ x_{n1} & x_{n2} & \dots & x_{nn} \end{pmatrix} = (X_1, X_2, \dots, X_n).$$

Our task is to classify sixteen power generating companies, each of which is characterized by two features – return of sales by operating profit and market share. We use the usual Euclidean norm to measure the distance between the objects:

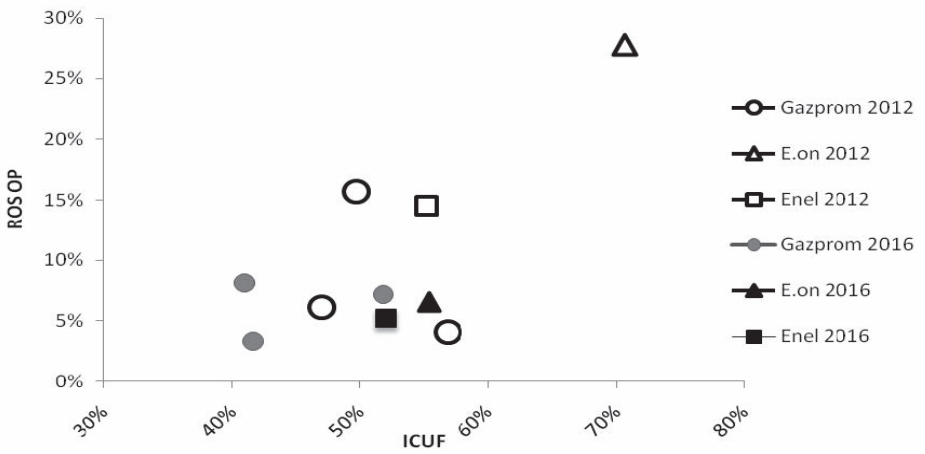

Fig. 5. Comparison of characteristics of the companies being a part of *Gazprom Energoholding* and the companies with foreign investors.

$$d_2\left(X_i, X_j\right) = \left[\sum_{k=1}^{p}\left(x_{kl} - x_{kj}\right)^2\right]^{\frac{1}{2}}.$$

Then we calculate a symmetric matrix of distances between the objects:

$$D = \begin{pmatrix} 0 & d_{12} & \ldots & d_{1n} \\ d_{21} & 0 & \ldots & d_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ d_{n1} & d_{n2} & \ldots & 0 \end{pmatrix}.$$

Note that the diagonal elements $d_i = 0$ for $i = 1, 2, \ldots, n$.

At each step, we look for the minimum value corresponding to the distance between the two closest clusters in the matrix of distances. The clusters found are combined to form a new cluster. This procedure is repeated until all clusters are combined.

In addition to partitioning into clusters, we have made some additional measurements characterizing the distance between the selected groups. Let $I = \{I_1, \ldots, I_{n_1}\}$ and $J = \{J_1, \ldots, J_{n_2}\}$ denote two selected clusters. The set of quantitative characteristics of these objects is, respectively, $X = \{X_1, \ldots, X_{n_1}\}$ and $Y = \{Y_1, \ldots, Y_{n_2}\}$. Denote the set of all distances by

$$D = \{d\left(X_i, Y_j\right),\ i = 1, ..., n_1,\quad j = 1, \ldots, n_2\}$$

and find the minimum local distance, the maximum local distance, the average distance between clusters,the minimum local distance

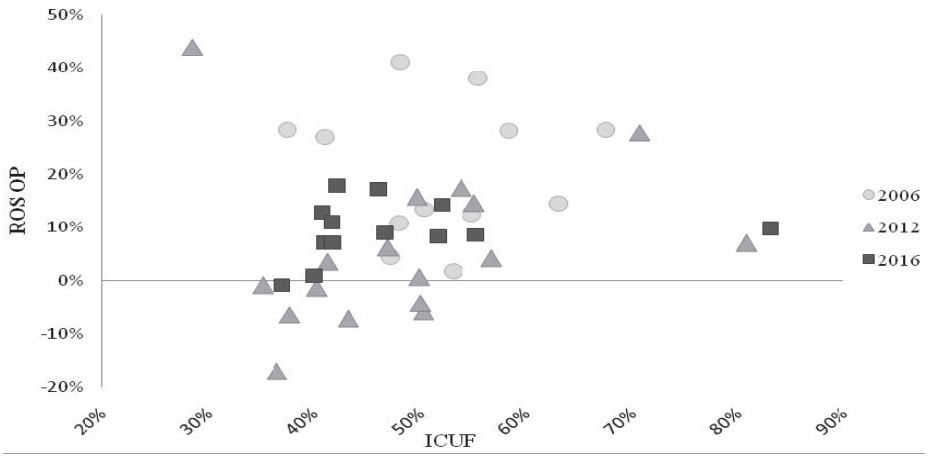

Fig. 6. Dynamics of main characteristics of profitability on an annual basis.

$$D_1(I,J) = \min d(X_i, Y_j), \ i = 1,\dots,n_1, \quad j = 1,\dots,n_2,$$

the maximum local distance

$$D_2(I,J) = \max d(X_i, Y_j), \quad i = 1,\dots,n_1, \ \ j = 1,\dots,n_2$$

and the average distance between the clusters

$$D_3(I,J) = \sum_{j=1}^{n_2}\sum_{i=1}^{n_1} d(X_i, Y_j)/n_1 n_2.$$

Fig. 9 shows the results of clustering for 2006 and 2016. Select some clusters, give them the main characteristics and consider the movement of the companies among the clusters from 2006 to 2015. The first cluster has a high return of sales factor and a relatively large market share. In 2006, *RusHydro, OGK-1, OGK-2, TGK-3, OGK-4,* and *Irkutskenergo* were in the first cluster. The average profitability in this cluster is 20% and the market share of an individual company is on average 8%. Hence, in 2006, profitable companies in respect of the operating profit had 49.66% of the market.

The second cluster includes companies that have a relatively small market share, but a high profitability. In 2006, *OGK-3, TGK-5, TGK-9, TGK-4*, having each a share less than 5%, demonstrated profitability above 30%. The total share of these four power generating companies is 10.76%. *OGK-2, TGK-1, TGK-3, OGK-4, OGK-5, Irkutskenergo* were most effective in 2012 in terms of share-profitability parameters. The total share of the companies is 40%. In relation to 2009, we see the growth in the second cluster. In 2015, the profitability

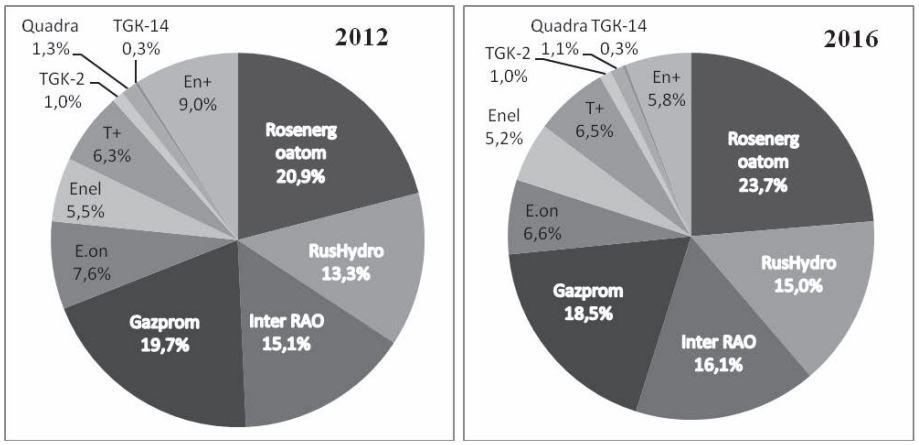

Fig. 7. Change in the share of the main operating companies in the electricity market of Russia.

indicators levelled off, but did not return to the level of 2006. *OGK-2, TGK-1, Irkutskenergo, OGK-4, TGK-7* remain in the second cluster. The total share of the companies for 2015 is 29.26%.

The third cluster is characterized by a low market share and profitability and in 2006 included *InterRAO, TGK-1, OGK-5, TGK-6, TGK-7, TGK-11*. The share of each company did not exceed 5%, their total share was 15.32%. By 2012, the number of companies in the low-efficiency cluster increased and included *TGK-5, TGK-6, TGK-9, TGK-7, TGK-2, TGK-4, TGK-14*. The total share of the companies was 9%. In 2015, only *TGK-4, TGK-2* and *TGK-14* remained in this cluster.

5 Conclusion

The electric power sector of Russia is one of the largest in the world. The major branches of the Russian economy are energy-intensive, and, therefore, the electric power sector determines the competitiveness and potential growth of the Russian economy. Over the past 15 years, the Russian electricity market has been reformed and became an oligopoly. Generating and grid companies perform as individual economic agents, interacting with each other at different levels of electricity trade. The goal of the reform is to create a market close by its characteristics to perfect competition. Generating companies, excluding nuclear and hydropower power plants, were divided into more than twenty companies with equal opportunities for generating electricity and the same cost of electricity unit. The initial structure of the market significantly changed during 2005-2015 due to the change of owners, an increase in the share of some companies in the market, mergers and takeovers in the electricity market. The purpose of this

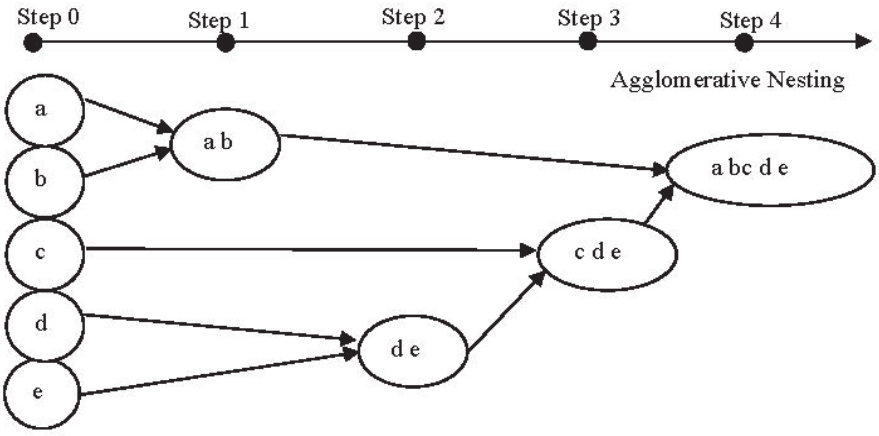

Fig. 8. Dendrogram of the agglomerative method.

study is to assess the effectiveness of market reforms, taking into account the activities of foreign and Russian wholesale market companies. Cluster analysis is based on the market share and return on sales during 2006-2015.

We have analyzed the financial results of the work of some power generating companies in the wholesale market of Russia before their merger and afterwards. They can be formulated as follows:

1. foreign companies have fairly stable performance indicators, but in 2014-2016 their performance deteriorated. This is due to the fall in Russian Ruble exchange rates, introduction of sanctions and other macroeconomic reasons;
2. there are some companies that constantly work almost at the break-even-point. Those companies are *T Plus, Quadra, TGK-4, TGK-14, TGK-2*;
3. companies that have solid performance: *OGK-2, Irkutskenergo, OGK-4, Rosenergoatom, TGK-1.*

All companies suffered some decrease in ICUF, which indicates a fall in demand for the period studied.

Mergers have had a significant impact on the structure of the wholesale market. Several post-merger years show the trend of increasing the share of power generation by large corporations comparing to other small companies. This increases the market power of large holdings and adversely affects competitiveness. On the other hand, it is obvious that large companies are more financially stable than other companies. Thus, the results of amalgamations in the wholesale electricity market of Russia present a mixed picture.

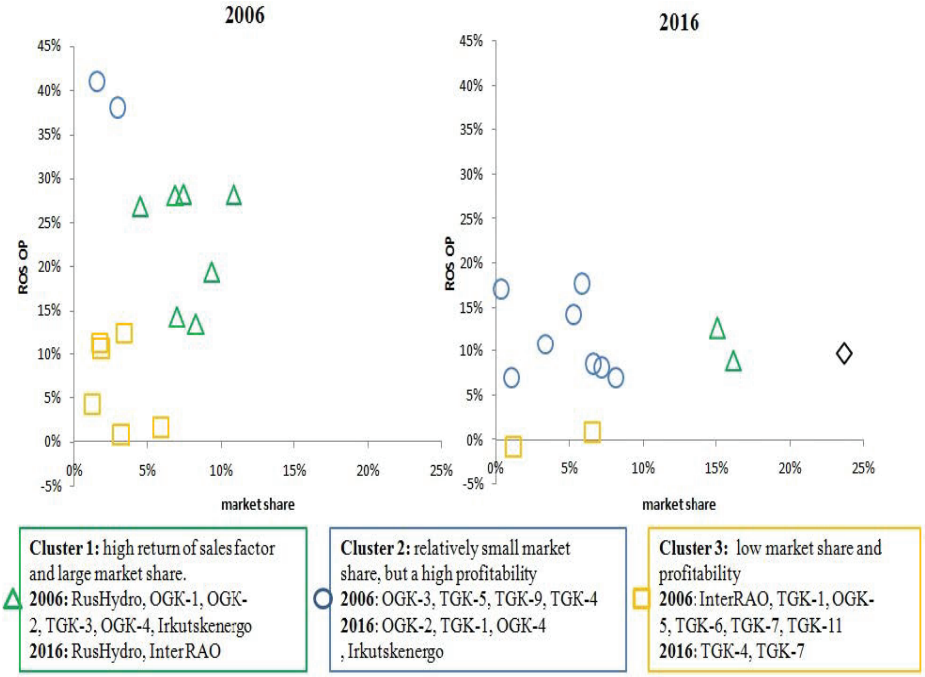

Fig. 9. Main existing clusters based on the assessment of profitability of power generating companies from 2006 to 2016.

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