Methods of Evaluation of the Market Power Level on the Wholesale Electricity Market

A. Trachuk and D. G. Sandler

1 Introduction

Over the last few years, much attention has been paid to theoretical research and practical work toward the implementation of competitive relations in the industries traditionally referred to as natural monopolies [1–3].

In most countries that have experienced restructuring of the electric power industry, it was planned that competition would have a positive impact on pricing and generate signals for industry development, which was originally built on the monopoly principles. The study is an attempt to answer the question: how to assess the level of competition in the reformed electricity market or, in other words, the market power level. For this purpose, we examine the wholesale power market.

The authors believe that, apart from determining approaches to the creation of a competitive environment in naturally monopolistic industries, it is important to propose methods of evaluating the competitive level as well. Books and articles propose different approaches to measuring market powers [4, 5]. At the same time, authors focus their attention primarily on competition among sellers.

For instance, one of widely used approaches is an approach developed within the framework of the economic theory and based on an analysis of concentration and monopolistic power. The nature of such approaches and the interrelation between them should be appropriate to consider in the case study of Lerner and Herfindahl–Hirschman indexes [6].

A. Trachuk (✉)
FSUE Goznak, Financial University Under the Government of the Russian Federation, Moscow, Russia

D. G. Sandler
Ural Federal University, Yekaterinburg, Russia

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2 Research Methodology

The monopolistic power level of a firm on the market could be evaluated by determining a difference between the price and marginal costs. The more the price asked by the firm deviates from marginal costs, the higher market power the firm seizes and hence the higher level of the market monopolization is. The Lerner index is defined as a difference in prices of competitive and noncompetitive markets with respect to a noncompetitive price:

$$L = \frac{P_m - P_c}{P_c}, \tag{1}$$

where L is Lerner index, P_m noncompetitive market price, and P_c competitive market price.

In the long run the price in case of perfect competition is equal to marginal costs, yet it is difficult to determine actual marginal costs, so they can be considered to be approximately equal to average marginal costs. The Lerner index can be defined as a difference between the price and average variable costs with respect to the price, and, given that the price and marginal costs are interrelated through elasticity of demand for the price and that on the competitive market elasticity of demand for the price is endless for an individual firm, the price is equal to marginal costs, and the Lerner index can be presented as follows:

$$L = \frac{P - AVC}{p} = -\frac{1}{E_d}, \tag{2}$$

where P – price of a product of this firm (on this market); AVC – average costs of the firm (this firm); E_d – elasticity of demand.

The Lerner coefficient ranges from zero (on a market with perfect competition) to one. The higher the index is, the higher the monopolistic power and the greater the gap between the market and an ideal condition of perfect competition. The problem of applying the Lerner index in practice is preconditioned by the fact that demand for services of natural monopolies in the short run is practically nonelastic with respect to the price.

In practice, the Herfindahl–Hirschman index (HHI) [7, 8] is mostly used to evaluate market competition, which is determined as a sum of the squares of shares of all the firms operating on the market:

$$HHI = \sum_{i=1}^{n} Y_i^2, \tag{3}$$

where Y – market share of a firm operating on the market.

The *HHI* ranges from 0 (in case of ideal competition when there is an endless number of sellers on the market and each of them controls an insignificant market share) to 1, which corresponds to a monopoly. The main advantage of the index is a

capacity of giving information about the market power of certain companies and assessing the level of concentration in the industry.

It is worth noting that, proposed as a method of market concentration evaluation, this indicator has been transformed into the market power indicator. Theoretically, this is associated with a relation between the Lerner index and market concentration in case of an oligopoly.

Let us assume that such market is described by the Cournot model. The Cournot model is based on an assumption that the firm establishing the scope of sales considers that the scope of sales of other firms is invariable. In this case, for firms interacting according to Cournot, the Lerner indicator for the firm will be directly dependent on the firm's share market (ratio of the scope of sales on the market to the industry-specific scope of sales) and inversely dependent on the demand elasticity indicator:

$$L = -\frac{Y_i}{E_d}. \tag{4}$$

The average Lerner index for the industry (where shares of firms on the market serve as weights) is calculated according to the formula below:

$$L = -\frac{HHI}{E_d}, \tag{5}$$

where *HHI* is Herfindahl–Hirschman concentration index.

Interrelation between the concentration indicator (Herfindahl–Hirschman index) and the monopolistic power indicator (Lerner index) is widely used in empirical research despite obvious theoretical limitations associated with the need to assess the elasticity of demand and a condition that competition according to Cournot is present.

It is sometimes indicated [9] that the *HHI* is not fully suitable for analyzing the electricity market as it fails to take into account practical lack of elasticity of demand, practically total dependence of certain suppliers on actions of other suppliers (competition not according to the Cournot model), existence of long-term liabilities and forward contracts, and difficulties in determining the market boundaries. It should be noted that the first two factors in general increase the market power and, therefore, even an *HHI* below 0.18 may not guarantee lack of the supplier's market power.

However, according to authors, application of the Herfindahl–Hirschman index is completely justified in case of the reformed RF power industry characterized by quite a complicated network structure with multiple network and system limitations.

For this reason, one more aspect, i.e., market boundaries, should be studied to prove a possibility of using this approach.

System limitations divide the uniform price zone market into local segments: the zone of free transmission (ZFT) of electrical energy and hubs. In fact, the single competitive selection is split into several smaller tenders limited primarily to the frameworks of free power transfer zones. Therefore, competition should be

determined not only according to the market in general or price zones, but within the frameworks of free power transfer zones as well.

Furthermore, competition in general on the market or price zones could be evaluated through set-theoretical unions of results for ZFT (volumes within the price zone are aggregate volumes in certain ZFT).

Taking into account the aforesaid circumstances and the fact that the share of direct and forward contracts between suppliers and buyers in the electricity wholesale market is relatively low, it is appropriate to apply the *HHI* to assess the market power of the wholesale market suppliers.

3 Testing of the Proposed Approach

The presented approach could be demonstrated by using the case of the ZFT Tyumen. The following plants are located in specific zone (Table 1).

Given the calculated shares of suppliers, the *HHI* of this free power transfer zone is equal to (15.7%)2 + (15.7%)2 + (25.3%)2 + (43.3%)2 = 0.220. Total transfers from ZFT Tyumen are equal to 1.143 MW, i.e., total output in the zone in the worst case (with highest possible transfers from ZFT) amounts to 11.359 – 1.143 = 10.216 MW. The peak demand across ZFT totals 9.967 MW. Therefore, at the peak time only 249 MW of "unclaimed capacity" are not loaded. Any entity's capacity is much higher than the amount of unclaimed capacity. Therefore, each entity in the zone in the worst case (peak consumption and maximum transfers from the zone) has an exclusive status.

For this zone of free transmission of electrical energy the maximum incoming transfers amount to 1.790 MW. Therefore, in the best case for transfers (all transfers are directed to the zone), unclaimed capacity is equal to 11.359 + 1.790 9.967 = 3.182 MW. Even in the optimal case for transfers E.ON and OGK-2 have an exclusive status.

Table 1 Characteristics of different power plants

Power plant	Company	Major shareholder (owner)	Available capacity, MW	Share in the ZFT
Tyumen CHPP-1	JSC Fortum	Fortum (Finland)	620	4.8%
Tyumen CHPP-2	JSC Fortum	Fortum (Finland)	755	5.8%
Tobolsk CHPP	JSC Fortum	Fortum (Finland)	665	5.1%
Total for TGK-10			**2.040**	**15.7%**
Nizhnevartovskaya GRES	CJSC Nizhnevartovskaya GRES	JSC inter RAO	2.013	15.7%
Surgut GRES-1	OGK-2	JSC Gazprom-energoholding	3.268	25.3%
Surgut GRES -2	E.ON Russia	E-on (Germany)	5.597	43.3%
ZFT total			12.918	100%

It is also interesting to study the extent to which the proposed approach can be used for evaluating the competitive situation for demand. Taking into account the fact that the retail market players are only partly involved in changes that happened on the electricity market, competition between buyers of the wholesale electricity and capacity market (WECM) should be considered.

It should be noted that creation of conditions for competition was one of the most important objectives of reforming the electricity market in most of developed and developing countries. However, a decade after the reform was launched, one could state that the said objective has not been achieved [10]. If the reasons of domination of generators in certain free power transfer zones are mostly determined by the deficit of generating capacities and (or) specifics of the power network topology, competition between consumers is lacking for somewhat different reasons.

In this section of the chapter, we consider the segments of the Russian power market where competition between buyers is possible, i.e., nonregulated trade in electricity (Day-Ahead Market (DAM), balancing market) and conclusion of free bilateral electricity and/or capacity purchase and sale agreements.

However, evaluation of a competitive condition of market sectors should be preceded by a description of the structure of WECM buyers as specifics of participating in the market of buyers of different types form prerequisites for a possible competition pattern.

The subjective structure of the wholesale electricity (power) market of Russia changes quite often, but the shares of categories of buyers change only slightly. Last resort suppliers account for about 50% of the total number of WECM buyers (according to the list of buyers in the WECM entities available on the official website of NP Market Council, www.np-sr.ru) and major end consumers for about 15%, and power-selling companies without a LRS status account for 35%. When evaluating the shares of types of buyers in terms of the volume of consumption, the LRS share drastically declines: for instance, in the second price zone (Siberia), the share of last resort suppliers slightly surpasses 50% in terms of the number and totals about 83% in terms of the volume.

This LRS domination can be explained by the fact that in most cases they are companies split-off upon restructure of regional power JSCs supplying electricity to the entire area, and redistribution of their volumes to other power-selling entities, including the cases of large consumers entering the wholesale market, is slow.

It should be borne in mind that last resort suppliers must submit price-accepting applications to the DAM. However, other groups of consumers authorized to submit price applications almost do not exercise this right (the DAM demand curve in most hours is elastic only in a small section, 1–2% of planned consumption).

Sales organizations (LRSs and those that are not last resort suppliers) buy electricity and capacity in the wholesale market to sell them on the retail market. Major end consumers entering the WECM buy electricity (capacity) for their own consumption needs. This segment of WECM buyers is represented by major industrial plants, normally energy-intensive ones. This structure of end consumers of electricity acquiring it on the WECM can be explained by the fact that the

requirements for operation on the wholesale market are quite complicated and expensive for many consumers.

Economic benefit as a result of entering the wholesale market for the end consumer consists, first and foremost, in declining expenses of buying electricity as a result of saving on intermediaries, i.e., as a result of saving on the sales premium of its retailer. Therefore, participation of a major consumer in the trade on the wholesale market is economically justified in case where sales premium economy is higher than expenses of bringing the record and communication system in line with requirements for them.

In certain cases, before entering the wholesale market, large consumers of electricity possessed their own sales from which electricity was purchased, but an analysis of the financial result of performance of such energy-selling organizations showed that for consumers it is cheaper to buy electricity directly on the WECM, so they decided to enter the wholesale market.

For some large industrial companies, a decision to buy electricity on the wholesale market was purely a political and (or) image-building move.

It should be noted that even companies within the same industry with comparable energy consumption and similar financial standing reach different decisions on entering the wholesale market. This can be explained by a difference in tariffs applicable in different regions of Russia, a difference in relations of management of an industrial company and an electricity-selling company and the like, and in certain cases the above noneconomic causes of entrance in the wholesale market by large consumers.

As in the current DAM model with price applications of buyers, the main parameter determining the competitive condition of the market is its concentration (volume shares of players) assessed, in particular, with the help of Herfindahl–Hirschman indexes [11].

Volumes of consumptions by players change every hour; therefore, the average purchase volumes in statistically important periods can be used to calculate the shares of buyers in electricity markets. However, the peak, not average, consumption of buyers in the wholesale market is used to trade power; therefore, we believe that shares of consumers in all sectors of the WECM should be calculated based on peaks of participants. On average, shares of participants calculated according to peak consumption, slightly differ from shares calculated according to average statistical volumes, which makes it possible to consider calculation of market concentrations based on peaks of consumers to accurately reflect the competitive condition of both capacity markets (characterized for consumers by their peaks) and energy markets (measured by average or total (integral) consumption over a period).

Let us analyze the market shares of buyers for evaluating competition among WECM buyers by free power transfer zones (ZFT) and hubs.

As was mentioned, records of network and system limitations are important for analyzing the market power. These limitations divide the whole market of the target zone into local segments: free power transfer zones (ZFT) and hubs.

Let us consider the results of this calculation of the above ZFT Tyumen (Table 2).

Table 2 Results of calculations

ZFT Tyumen			
Company	Group of companies	Peak of consumption, MW	Share in the ZFT
JSC Tyumen energy-selling company	Gazprom	3,639,465	62.4%
Surgut GRES-1	Gazprom	84,051	1.4%
Total for Gazprom Group		**3,723,516**	**63.8%**
Nizhnevartovsk GRES	Inter RAO	23,209	0.4%
LLC RN-Energo	Rosneft	359,614	6.2%
Total for groups controlled by the state		**4,106,339**	**70.4%**
JSC Omsk energy-selling company	Energostream	1459	0.0%
JSC Tomsk energy-selling company	Energostream	137,812	2.4%
Total for Energostream Group		**139,271**	**2.4%**
Plants of JSC Fortum	Fortum	83,741	1.4%
JSC Tyumenenergosbyt	Energy sales holding	302,740	5.2%
LLC Nizhnevartovsk energy-selling company	NESKO	65,752	1.1%
LLC Noyabrsk steam-gas power plant	Intertechelectro	304	0.0%
CJSC EESnK	TNK-BP	784,683	13.4%
LLC Rusenergoresurs	ESN	260,300	4.5%
Municipal electrical networks of Khanty-Mansiysk	ChMGES	33,906	0.6%
Surgut GRES-2	E-on	59,744	1.0%
ZFT total		**5,836,781**	**100%**
HHI total $= 63.8\%^2 + 0.4\%^2 + 6.2\%^2 + 2.4\%^2 + 1.4\%^2 + 5.2\%^2 + 1.1\%^2 + 0\%^2 + 13.4\%^2 + 4.5\%^2 + 0.6\%^2 + 1\%^2 = 0.435$			

The level of market concentration in this ZFT is quite high as buyers in these zones are normally represented by one or two major sales companies holding large shares of the market and separated from local energy JSCs as a result of their restructure and supplying power to the relevant RF territories and also a number of small consumers in the wholesale market (small sales and power plants consuming electricity for their own economic purposes).

4 Conclusion

In the study, the authors justified the application of the Herfindahl–Hirschman index for the purpose of practical evaluation of the market power level on the wholesale electricity and capacity market. An analysis of actual information about the competition levels both among sellers and buyers in one of the free power transfer zones shows that price offers among sellers on the wholesale electricity and capacity market are currently formed primarily by suppliers that may ensure supplies taking

into account the existing network and system limitations, and a small number of last resort suppliers is predominant among buyers. The oligopoly of suppliers and a similar market condition among WECM buyers form a market structure of oligonomy, which emphasizes again the need for state regulation in this area, however, by taking into account new realities: the oligopoly type market.

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