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Ownership unbundling in electricity distribution: the Russian experience

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Abstract

Russia is the first and thus far only country that has separated ownership of electricity distribution and transmission and then, a few years later, reunified these services under one company. We examine the impact of these changes on the quality of service in electricity networks and the operating costs of electricity distribution companies. We find no evidence that ownership unbundling increased the service quality in electricity networks. Furthermore, our results indicate that ownership unbundling resulted in higher operating costs for electricity distribution companies. This study thus contributes to discussion on the importance of the balance of structural remedies and transparent independent regulation in the development of competitive energy markets in emerging market economies.

Keywords: electricity distribution, ownership unbundling, Russia, vertical disintegration, cost efficiency

1 Introduction

The energy sector is undergoing significant change, both technical change in the form of more decentralized energy production and greater production of renewable energy and structural change resulting from reform of policy and the regulatory setting. The dynamic and uncertain operating environment has created considerable challenges for energy companies, policy makers, regulators and consumers, not only in developed markets but also in emerging markets and developing countries.² As a response to these challenges, many advanced economies reformed, already a couple of decades ago, their previously vertically integrated electricity supply industry and separated electricity supply into a structure consisting of (1) competitive generation and retail and (2) monopoly transmission and distribution. Many emerging market economies, including Russia, have also undertaken reform of their electricity supply industry.

Russia, as is well known, is a significant player in the energy sector: the electrical energy market is the fourth largest in the world; Russia is the world's second largest producer of natural gas; and the country is one of the world's largest oil producers. The energy sector accounts for approximately one fifth of Russia's GDP, half of federal budget revenues, and up to two-thirds of

² Osorio et al. (2017) discuss increasing complexity and security issues in deregulated electricity systems that arise from pricing and investments based on market signals, increased interconnectedness with other countries and a growing share of renewable energy generation. They propose an integral framework to analyze interdependencies and security of electricity supply.

the country's export earnings.³ Thus, Russia's future prospects — economic, social and political — are heavily dependent on developments in the energy sector, nationally and internationally.

The Russian electricity market was reformed between 2003 and 2008. Specifically, the vertical electricity supply monopoly, RAO UES, was liquidated in 2008 and mandatory ownership unbundling⁴ between generation and retail of electricity and network activities of transmission and distribution was put into effect. Wholesale markets for electricity were fully liberalized in 2011. The true extent and impact of these reforms remain unclear. Some studies conclude that Russia has reached its main goals for electricity reform in disintegration of the vertical electricity supply monopoly, indicating that the liberalization has succeeded (International Energy Agency [IEA], 2013). Other studies, however, argue that Russia failed to create a fully competitive market (Institute of Natural Monopolies Research, 2013). Somewhat surprisingly, and despite their importance, the Russian energy market and Russian energy policy, and particularly the electricity sector, remain relatively understudied. In particular, there is a lack of empirical studies that examine and evaluate Russia's electricity reform efforts. One goal of this research is thus to assess the success and effectiveness of Russia's electricity market reforms by empirical analysis of the performance of the electricity distribution sector.

Russia is one of very few countries that have implemented mandatory ownership unbundling of electricity distribution from the rest of the electricity supply industry.⁵ It seems, however, that although the Russian state remained the majority shareholder in the distribution holding company, it was not able to govern the distribution network effectively. Indeed, there is plenty of anecdotal evidence in the Russian press about weak management and coordination problems in electricity distribution. As a result of these difficulties, the Russian government decided to bundle the transmission and distribution networks at the end of 2012⁶ and create one state-owned company, called Joint Stock Company Russian Grids, to manage both transmission and distribution. The company was later renamed Rosseti, Public Joint Stock Company (PJSC ROSSETI).⁷

³ See Russia Economic Report (2014) and Simola and Solanko (2017).

⁴ Ownership unbundling in the electricity industry is when a separate company owns and operates the network assets (distribution and/or transmission) and this company is then not allowed (or only with severe limitations) to also own non-regulated generation and/or retail activities.

⁵ There are several forms of unbundling: functional, legal and ownership. Few countries have adopted a mandatory ownership unbundling of electricity distribution from the rest of the electricity supply industry. New Zealand enforced mandatory ownership unbundling of electricity distribution in 1998, and Russia in 2008.

⁶ November 22, 2012, the President of the Russian Federation signed the Decree No.1567 "About Open Joint Stock Companies "Russian Grids". March 23, 2013, IDGC Holding JSC, was officially renamed Joint Stock Company Russian Grids. (<http://www.rosseti.ru/en>)

⁷ Rosseti, Public Joint Stock Company (PJSC ROSSETI) is one of the largest electricity network companies in the world. The company maintains 2.30 million km of electricity transmission lines and 496,000 substations with a transformer capacity of more than 773 GW. In 2015, the net electricity supply to consumers amounted to 720.5 billion kWh. Companies in the Rosseti Group have 216,000 employees. PJSC ROSSETI has 37 subsidiaries and affiliates, including 14 interregional distribution grid companies and a main network company. The Russian state, owns 87.9% of the share capital. Rosseti networks distribute 75% of Russian electricity. The remaining 25% of electricity is distributed by regional and municipal networks by the Ministry of Defence and Ministry of Transportation. (<http://www.rosseti.ru/en>)

Russia seems to be the first country to have decided to bundle ownership of transmission and distribution networks after having previously mandated their separation, which makes the case particularly interesting. Why did this happen? Is this change of direction specific to Russia alone? Further, do the costs of the coordination problems associated with managing separated power system units outweigh the benefits of potential efficiency gains from a disintegrated system, more generally, in emerging markets? Are there lessons that can be applied to developed economy markets? In this work, we will empirically examine the effects of these structural reforms on the Russian electricity supply industry, focusing specifically on the impacts of ownership unbundling on electricity distribution as measured by operating costs and service quality of the electricity distribution networks..

Previous literature based on data from developed countries indicates that structural reforms such as mandatory separation of ownership of electricity distribution from vertical electricity system can reduce the operating costs of electricity distribution companies and increase the quality of service in electricity networks. However, as discussed in more detail in the literature review, evidence for the positive effects of these structural reforms is mixed even for developed countries. Knowledge concerning emerging market economies is even more limited. We do not know, and here we identify a knowledge gap in current understanding, for example, how structural reforms in electricity distribution, which is a monopolistic function, affect the quality of service and operating costs of electricity distribution companies in emerging markets, where law enforcement in particular and institutional quality in general are weak and there are difficulties reconciling the interests of the individual with the common interest. Anecdotal evidence does seem, however, to indicate a greater incidence of problems because of the more challenging coordination. Existing empirical research has not addressed and explained what happens in emerging markets when electricity distribution is separated mandatorily from the rest of electricity system by ownership unbundling.

Russian electricity sector reform is a particularly important area of research because of the size of the Russian electricity sector, the world's fourth largest, and because the reform was done in a textbook manner, that is, with mandatory ownership unbundling of generation, transmission, distribution and retail. The scope of the Russian electricity reform, its ambitious goals and the speed of its implementation were quite exceptional globally. The reform sought to create a cost-efficient electricity distribution sector by setting up independent stock exchange listed regional electricity distribution companies. Independence and incentives for shareholders and management should, in theory, have encouraged cost-effective behavior by the distribution companies.

To the best of our knowledge, the consequences of mandatory ownership unbundling in electricity distribution in emerging markets have not been analysed to any significant extent. Therefore, our first contribution is address this research gap by analysing ownership unbundling in the Russian context. Our second contribution is related to measurement of service quality. We construct a new relative indicator to measure quality of electricity distribution: electricity requests not connected divided by kilowatt-hour (kWh). Especially in emerging markets, where gaining access to the electricity supply can be a long and bureaucratic process, this indicator

reflects the technical quality of the electricity grid as well as the service quality provided by the companies and the administrative environment.

The structure of this paper is as follows. In section 2, we provide an overview of relevant literature on vertical integration and vertical disintegration in the electricity sector and describe Russian interregional and regional electricity distribution companies. In section 3, we present and discuss the data used in the study. Section 4 reports the results of analysis of the effects of ownership unbundling on service quality and operating costs, and in section 5, we draw conclusions and consider the implications of the Russian experience.

2 Previous literature on vertical integration, vertical separation and the Russian context

2.1 Literature review

Traditionally, the electricity industry was considered to have strong vertical integration economies or economies of scope. The studies of Weiss (1975) and Joskow and Schmalensee (1983) challenged this view: it was claimed that the efficiency benefits of competition (in generation) can outweigh the costs of vertical separation.

Researchers have long recognized that vertical separation of an integrated electricity system has costs that arise from coordination of the parts of the formerly integrated system. Brunekreeft (2015), for example, draws attention to the costs of flawed coordination. In a competitive separated approach, the actions of decentralized actors must be coordinated externally by a market mechanism. However, any system of contracts and prices for market coordination in a vertically disintegrated electricity supply industry is imperfect at best. Brunekreeft concludes that if we assume that signals from network charging will be imperfect, further unbundling will increase coordination issues in the system.

Several empirical studies on vertical separation have been presented in the literature (see Table 1). Michaels (2006) reviews 11 papers on vertical integration in the electricity sector and finds that nine give prominence to the benefits of vertical integration, while one paper describes how vertical integration worsened economic efficiency. One paper does not find statistically significant economic advantages for vertical integration. This contrasts with the view of Weiss (1975) and Joskow and Schmalensee (1983). Eight of the papers consider the separability of generation from either transmission alone or a combination of distribution and transmission. Three of the papers analyse separation of generation from distribution. In another study, Meyer (2012a) reviews theoretical and empirical studies on the effects of unbundling on the cost efficiency of the electricity sector and concludes that ownership unbundling could lead to a significant cost increase for the electricity sector. It is stated that in the case of separation of generation from transmission or distribution, unbundling can lead to a cost increase of up to 5%, and in the case of separation between retail and generation, unbundling can lead to a cost increase of up to 20%.

Among previous empirical studies using data from the United States, Kwoka et al. (2010) find a mixed impact for separation of generation from distribution on distribution and retailing

costs of US utilities. Utilities that were subject to mandatory separation of generation from distribution have experienced increased operating and total costs. Meyer (2012b), too, analyses US electricity data and finds that ownership unbundling seems to lead to increased costs.

Several previous studies focus on New Zealand, which implemented mandatory ownership unbundling of electricity distribution in 1998. Nillesen and Pollitt (2011) find that ownership unbundling of electricity distribution from generation and transmission reduced costs and increased quality of service but did not lead to greater competition and lower prices. In a related study, Filippini and Wetzel (2014) analyse the cost efficiency of 28 electricity distribution companies in New Zealand for the period between 1996 and 2011. They find that ownership separation of electricity generation and retail operations from the distribution network reduced the operating costs of distribution companies in the country. In a recent study, Nepala et al. (2016) analyse the quality of service delivered by electricity distribution utilities in New Zealand using panel data econometrics. They find that ownership unbundling contributed to a fall in the duration and frequency of supply interruptions in electricity distribution, thus improving the quality of electricity distribution. However, their results also indicate that unbundling has not reduced distribution network losses. Nepala et al. (2016) conclude that the impacts of ownership unbundling on the quality of electricity distribution are complex and that improvement of service quality may be achievable using economic regulation rather than by relying only on structural remedies.

Gugler et al. (2013) find in a panel data study of 16 European Union countries⁸ that ownership unbundling of generation from the transmission grid reduces aggregate investment. However, the study does not distinguish between investment in generation assets and network assets. It was noted that regulatory measures that directly affect the market, such as establishment of a wholesale market, increased investment. Gugler et al. (2017) analyse the costs of ownership unbundling between electricity transmission and generation for 28 electricity utilities in 16 European Union countries. They find that there are substantial cost savings from vertical integration and conclude that in order to overcome efficiency losses from unbundling, high quality market institutions, as well as policies fostering competition, are necessary. Growitsch and Stronzik (2014) analyse the effect of ownership unbundling on gas transmission networks using panel data of 18 European Union countries over 19 years. Their results imply that ownership unbundling does not reduce prices. However, legal unbundling seems to reduce prices significantly.

⁸ In the sample period of 1998–2008 of Gugler et al.'s (2013) study, in three countries, namely Finland, Sweden and the UK, ownership of the transmission grid was already unbundled from generation. Five countries, that is Austria, Belgium, France, Germany and Hungary, did not have ownership unbundling but legal unbundling. Eight countries – Czech Republic, Denmark, Italy, Norway, Poland, Portugal, Slovak Republic and Spain – were in the process of switching from legal unbundling to ownership unbundling during the sample period. Gugler et al. (2013, pp. 706–707).

Table 1. Overview of empirical studies on vertical separation in the energy sector

Study	Countries	Sector	Period	Objective	Method	Data	Findings
Filippini and Wetzel (2014)	New Zealand	Electricity	1996–2011	To analyse the cost efficiency of electricity distribution companies	Stochastic frontier panel data model	28 electricity distribution companies	Ownership unbundling reduced costs of electricity distribution companies.
Growitsch and Stronzik (2014)	18 EU countries	Gas	1989–2007	To analyse the effect of ownership unbundling of gas transmission networks on end-user prices	System GMM, LSDVC	Panel data of gas transmission networks	Ownership unbundling did not reduce end-user prices.
Gugler et al. (2013)	16 EU countries	Electricity	1998–2008	To test for interrelations between investments, prices and regulation in the electricity sector	FE GMM	Aggregate investment data in the electricity sector	Ownership unbundling decreased investments. However, regulation that affects the market directly, such as establishment of a wholesale market, increased investments.
Gugler et al. (2017)	16 EU countries	Electricity	2000–2011	To analyse the costs of ownership unbundling between electricity transmission and generation	Quadratic cost function NLSUR	28 electricity utilities	Unbundling between transmission and generation comes with costs. There are substantial cost savings from vertical integration for electricity utilities. In order to overcome efficiency losses from unbundling, high quality market institutions, as well as policies fostering competition, are necessary.
Kwoka et al. (2010)	USA	Electricity	1994–2003	To examine the effects of generation separation on the operating efficiency of the distribution utilities	DEA, FE GLS	73 utilities	There was a mixed impact of generation separation from distribution on distribution and retail costs. The operating and total costs of the utilities with mandatory separation of generation increased.
Meyer (2012a)	USA, EU, New Zealand	Electricity	1991–2011	Review of literature on vertical synergies in electricity supply	Survey of 14 papers		Ownership unbundling could lead to a cost increase for the electricity sector.
Meyer (2012b)	USA	Electricity	2001–2008	To analyse three unbundling scenarios: 1) in generation; 2) in distribution and retail; and 3) in transmission	FGLS, Prais–Winsten estimation	143 utilities from 43 U.S. states	Ownership unbundling seems to increase costs: 1) the highest cost increase in generation unbundling occurs when transmission and distribution are integrated and when distribution includes retail; and 2) the lowest cost in transmission unbundling occurs when generation and distribution (incl. retail) remain vertically integrated.

Michaels (2006)	USA, Japan	Electricity	1970–1997	Review of economics of vertical integration in the electricity industry	Survey of 11 papers		Nine of eleven papers show benefits from vertical integration in the electricity industry.
Nepala et al. (2016)	New Zealand	Electricity	1996–2009	To analyse the quality of service of electricity distribution companies	FE model, RE model	29 electricity distribution companies	Ownership unbundling contributed to a decrease in supply interruptions but did not affect distribution network losses.
Nillesen and Pollitt (2011)	New Zealand	Electricity	1995–2007	To examine the impact of ownership unbundling on electricity prices, quality of service and costs	FE model, RE model	Panel data on 28 distribution companies	Ownership unbundling reduced costs and increased quality. However, competition was reduced, and consumer prices rose.

Notes: GMM = generalized method of moments estimator, LSDVC = corrected least-squares dummy variable estimator, FE GMM = fixed effects estimates with GMM, NLSUR = non-linear GLS estimator, DEA = data envelopment analysis, FE GLS = GLS estimation with fixed effects, FGLS = feasible generalized least squares (FGLS) estimator, FE = fixed effects, RE = random effects

2.2 Russian electricity distribution reforms

At the beginning of the 2000s, Russia had an enormous, vertically integrated monopoly electricity supply industry that had under-invested throughout the 1990s and whose equipment was outdated. Consumer prices for electricity were heavily subsidized, and inflation was still very high. The Russian economy had begun to grow after the dramatic contraction of the immediate post-Soviet era, but significant tax reform had yet to be done. The need to reform the electricity supply industry and the vertical electricity monopoly, RAO UES, established in 1992, was obvious.⁹ Russian electricity market reform is often called a ‘textbook reform’, which refers to how the vertically integrated electricity supply industry was separated into independent transmission, distribution, generation and retail operations. The Russian electricity market and its reform are described in several sources (see, e.g., Chernenko, 2013; 2015; Gore et al., 2012; IEA, 2013; Solanko, 2011;).

Corporatisation of the distribution companies started in 2005 and 2006. The companies remained part of the vertically integrated state-owned RAO UES until July 1, 2008, when RAO UES was liquidated in accordance with the plan of electricity reform. After the electricity reform of 2008, the Russian state remained a majority shareholder (54.5%) in the distribution holding company, JSC Interregional Distribution Grid Companies Holding. The holding consists of 11 interregional distribution companies (IDGCs) and four regional distribution companies, which are all regulated monopolies. The IDGCs are natural monopolies and the companies’ rates of service are set by the Federal Tariff Service and regional regulating boards. The Russian state is the single or majority shareholder in the remaining four regional grid companies, namely, Yantarenergo in Kaliningrad (100%), Kubanenergo in Kuban, (92.2%), Tomsk Distribution Company in Tomsk (85.8%), and Chechenenergo in Chechenia (72.7%).

Interregional electricity distribution companies are public joint stock companies. In the ten distribution companies in our dataset, the Russian state is the majority shareholder and minority shareholders consist of institutional as well as industrial investors. Empirical literature on the relationship between ownership structure and firm performance does not give an unambiguous answer to the question of whether ownership matters.¹⁰ However, it is often

⁹ Xu (2006) explores electricity reforms in China, India and Russia and presents a view of the reform of the electricity supply industry which differs from the mainstream. According to Xu, the World Bank’s electricity reform policy over-emphasized economic performance at the expense of physical and engineering attributes of the electricity supply industry and neglected differences between developed, developing and transition economies.

¹⁰ The results of numerous empirical studies on the relationship between ownership structure and firm performance have been mixed (see, Holderness, 2003). These studies have tested two main lines of research: Demsetz and Lehn (1985) found that there is no statistically significant relationship between ownership and performance, and Morck et al. (1988) found that managers’ ownership affects firm performance.

claimed in the literature that heterogeneous owner identity increases the costs of ownership.¹¹ This also seems to be the case in Russian electricity distribution companies.¹²

The state ownership of distribution companies in the IDGC holding company is described in Table 2. The size of the IDGCs, as measured by electricity distribution, is given in Figure 1. Comparative valuation of the Russian electricity distribution companies with international peers from developed and emerging markets is given in Table 3 and indicates that Russian electricity distribution companies remain clearly undervalued in comparison with their international peers.

Table 2. State ownership in Russian electricity distribution companies in 2015

IDGC:	%
Moesk	50.9
Siberia	55.6
Tyumenenergo	100
Urals	51.5
Centra	50.2
Volga	67.6
Centre i Volgi	50.4
North-West	55.4
Lenenergo	64.5
South	51.7
Northern Caucasus	92
DGC:	
Kubanenergo	92.2
Yantarenergo (Kaliningrad region)	100
TDC (Tomsk Distribution Company)	85.8
Chechenenergo	72.7

Note: IDGC = Interregional Distribution Grid Company; DGC = Regional Grid Company.

Source: Rosseti Annual Report (2015)

¹¹ The costs of collective decision-making result from the heterogeneity of interests among the owners.

Heterogeneous ownership causes negotiation costs between owners, who may have different interests. (Jensen and Meckling, 1976; Demsetz, 1983; Hansmann, 1996).

¹² "The big difficulty is also in the fact that our economy is regulated by the state, which, of course, is not always synchronized with the notion of a public joint stock company. The state acts in two ways: it is both the owner and the regulator, and we have been living in quite severe grip in terms of tariff decisions since 2013. At the same time, we already have minority shareholders and there are subsidiaries in which the minority shareholders have a controlling stake and a decisive word. We do not always have a comfortable relationship with them, but these are working relationships. For example, one of the shareholders says that does not agree with the fact that the state financed the construction of networks for the 2018 FIFA World Cup (due to a contribution to the charter capital. "Kommersant") and will sue on this matter. But we need to understand his position, too, because his share is diluted and loses its attractiveness." The former CEO of Rosseti, Oleg Budargin, in an interview in June 2017. *Kommersant*, 30 June 2017.

Figure 1. Electricity distribution by IDGCs, mln kWh in 2015

Source: Rosseti Annual Report (2015)

Table 3. Comparative valuation of electricity distribution companies in 2015

Company	Country	MCAP, \$mln	P/E
Rosseti	Russia	2170	1.7
FGC	Russia	2936	4.3
Moesk	Russia	676	3.4
IDGC North-West	Russia	67	5.3
IDGC Centre & Volgi	Russia	141	2.6
IDGC Centra	Russia	160	11.2
IDGC South	Russia	31	2.9
IDGC Siberia	Russia	76	n/m
IDGC Volga	Russia	89	4.5
IDGC Urals	Russia	179	7.6
Average			4.8
Discount to DM, %			72
Discount to EM, %			80
DEVELOPED MARKET PEERS			
United Utilities	UK	9532	17.7
Severn Trent	UK	7907	22.3
Snam Rete Gas	Italy	20141	15.2
Terna Spa	Italy	11190	17

Elia	Belgium	3103	16.3
REN	Portugal	1578	12.4
Red Electrica	Spain	12018	17.8
ITC Holdings	US	6807	21.1
Average			17.5

EMERGING MARKET PEERS

CIA de Transmissao	Brazil	2709	39.1
Transelectrica Sa	Romania	546	6.6
Transener	Argentina	206	37.2
Power Grid	India	11568	14.1
Average			24.3

Notes: FGC=Federal Grid Company; IDGC=Interregional Distribution Grid Company; PJSC=Public Joint-Stock Company; MOESK=Moscow United Electric Grid Company. MCAP = Market capitalization; P/E = Price per Earnings; DM = Developed market peers; EM = Emerging market peers.

Source: Gazprombank, Russia, Equity Research, Electric Utilities, July 22, 2016. "Discounts to peers remain substantial. Distribution companies remain heavily undervalued to international peers, trading at average discounts to emerging market peers of 69 percent on 2016 EV/EBITDA and 81 percent on 2016 P/E." p. 8.

Good institutional quality is vital for attaining efficiency gains in disintegrated electricity industries (Pollitt, 2009; Nillesen and Pollitt, 2011). In many emerging economies — like Russia — weak institutions not only allow but also stimulate rent-seeking and non-competitive, non-transparent behaviour. Therefore, this study will also contribute to discussion on the importance of the balance of structural remedies and transparent, independent regulation in building a competitive energy market in a weak institutional environment.

2.3 Hypotheses

Based on earlier empirical research on vertical separation in the electricity industry and research on Russian electricity distribution, two research issues of interest emerge. First, how has the quality of electricity distribution evolved after the ownership unbundling and how has mandatory ownership unbundling affected the quality of electricity distribution in Russia? Second, how does mandatory ownership unbundling affect the operating costs of electricity distribution companies in Russia?

Following previous studies, we formulate two hypotheses:

Hypothesis 1: Ownership unbundling should cause the quality of service of electricity distribution companies to remain the same or improve.

Hypothesis 2: Ownership unbundling should decrease the unit operating costs of electricity distribution companies.

3 Data

Following the example of Nillesen and Pollitt (2011) in their study of unbundling of electricity distribution in New Zealand, we look at the impact of vertical disintegration in regulated networks between the network stages of transmission and distribution of the Russian electricity industry. In our analysis, we focus on the effects of ownership unbundling on (1) the quality of the networks and (2) the costs of the network operator.

As mentioned earlier, ownership unbundling of transmission and distribution of electricity was introduced in Russia in 2008 and ownership of transmission and distribution was again bundled in the beginning of 2013. Our dataset covers the period of 2005 to 2015, from pre (2005–2008) and post (2009–2012) unbundling to after re-bundling (2013–2015). The data were derived from various public sources, including the annual reports of the Russian IDGCs, Public Joint Stock Company Rosseti and the Russian Federal State Statistics Service.

Outages are commonly used to measure the quality of electricity networks. The System Average Interruption Duration Index (SAIDI), which measures the average outage duration for each customer served, is a commonly used measure of outages. However, we were unable to find time series data about interruptions in electricity distribution and the number of customers from Russian public sources. We thus consider the service quality of a distribution company as a proxy for the quality of networks. Here, we assume that customers of those distribution companies whose management is better organized and where the physical quality of the networks is better get better service. Therefore, we use data on how customers' electricity access requests have been realized by distribution companies as a measure of the quality of distribution. This measure of quality is particularly suitable in the case of Russia because getting an electricity connection has previously been a bottleneck in many regions (see *Doing Business in Russia*, 2012). Moreover, electricity connections have previously been used in a number of studies examining business environments in different countries. For example, Geginat and Ramalho (2015) find that the number of additional procedures involved in getting an electricity connection is correlated with a decrease in the perceived quality of the electricity supply.

We collected data on electricity connections, i.e. electricity connection access requests and realized access requests in each year, from the annual reports of ten distribution companies. The percentage of realization of request (getting a connection) was calculated for every distribution company for the years 2008 to 2015. Additionally, we calculated a relative indicator of unrealized connection requests per output of electricity (not-connected/kWh) for the same companies and for the same period. The data on electricity connection access requests and realized access requests in IDGC Holding companies are presented in Table 4.

Table 5 summarizes other key data for the distribution companies. We collected data on operational costs, operational revenue, total investments, distributed electricity, network length, transformer capacity and power losses for 2005 to 2015 from the annual reports of ten IDGC Holding distribution companies (Moesk, Lenenergo, Centra, Centre and Volgi, North-West, Urals, Volga, Siberia, South, and Northern Caucasus). These IDCGs covered over 80% of the electricity

distributed by Rosseti PJSC¹³ in 2015. Due to missing data for 2005 and 2006 for some of the IDGCs, the data reported in Table 5 begins from the year 2007. In the table, distributed electricity refers to the electricity supplied from the system, and power losses are calculated as the difference between the electricity entering the system and the electricity supplied from the system.

¹³ Rosseti PJSC is the majority shareholder of IDGCs in the dataset.

Table 4. Grid connection results, IDGC Holding

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of requests	119347	160420	170962	199643	278429	331570	404300	477271	487664	478693
connected	47367	76369	88159	107636	134471	168499	203901	261364	345758	393271
not connected	71980	84051	82803	92007	143958	163071	200399	215907	141906	85422
Connected %	39.7	47.6	51.6	53.9	48.3	50.8	50.4	54.8	70.9	82.2
Not conn/mln kWh	0.119737	0.135516	0.131109	0.154785	0.243386	0.276452	0.335287	0.367805	0.239419	0.147965

	CAGR 2006-2008	CAGR 2009-2012	CAGR 2013-2015	CAGR 2006-2015
Number of not connected	7.3 %	29.6 %	-37.1 %	1.9 %
Not conn/mln kWh	4.6 %	29.4 %	-36.6 %	2.4 %

Notes: CAGR = Compound Annual Growth Rate; Source = Annual Reports of IDGCs

Table 5. Overview of operational and quality statistics for ten IDGCs

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total operating costs (RUB mln, 2015 prices)	240176.2	462814	535425.8	598164.3	629753.2	580596	654612.5	601782.6	512353.2
Total operating revenue (RUB mln, 2015 prices)	270550.3	512525.1	601055.3	683929.6	718572.3	659941.8	732086.1	664896	557392.6
Electricity distributed (mln kWh)	504184.3	534518	497456.5	492888	493964.1	503806.9	489073.9	478290.9	470834.6
Operating costs per kWh (RUB 2015 prices)	0.96	0.90	1.12	1.23	1.26	1.13	1.34	1.27	1.12
Total investments (RUB mln, 2015 prices)	141631	162933.2	100724.8	115731.4	152711.2	154801.8	162369.1	136026.5	83480.21
Network length (km)	1809325	1860144	1839726	1757596	1848998	1855746	1883796	1878190	1905365
Transformer capacity (MVA)	202918.1	229143.3	218466.3	221866.1	226105.2	323816.4	235858.2	239798.5	243188.6
Power losses (%)	10.1	9.6	10.0	9.9	9.4	9.1	8.9	9.0	9.1

	CAGR 2007-2008	CAGR 2009-2012	CAGR 2013-2015	CAGR 2007-2015
Total operating costs (RUB mln, 2015 prices)	92.6 %	2.7 %	-11.5 %	9.9 %
Total operating revenue (RUB mln, 2015 prices)	89.4 %	3.2 %	-12.7 %	9.5 %
Electricity distributed (mln kWh)	6.0 %	0.4 %	-1.9 %	-0.9 %
Operating costs per kWh (RUB 2015 prices)	-6.6 %	0.2 %	-8.4 %	1.9 %
Total Investments (RUB mln, 2015 prices)	15.0 %	15.4 %	-28.3 %	-6.4 %
Network length (km)	2.8 %	0.3 %	0.6 %	0.6 %
Transformer capacity (MVA)	12.9 %	14.0 %	1.5 %	2.3 %
Power losses (%)	-5.0 %	-3.2 %	1.4 %	-1.7 %

Notes: Distributed electricity = the electricity supplied from the system; power losses = the difference between electricity entering the system and the electricity supplied from the system; CAGR = Compound Annual Growth Rate. Source: the annual reports of the IDGCs

The data on distributed electricity, network length, transformer capacity and power losses for each distribution company from 2005 to 2015 as well as the data on operational costs, operational revenue and investments for each distribution company from 2005 to 2015 are presented in Table A.1. in the appendix. The data have been collected from the annual reports of the respective companies starting from 2005.

4 Results

4.1 The effect of ownership unbundling on the quality of the electricity networks

This section is related to our Hypothesis 1, which states that ownership unbundling should cause the quality of service of electricity distribution companies to remain the same or improve. To determine whether the hypothesis is supported, we examine how the quality of electricity distribution has evolved during the sample period.

In Table 4, we report summary data on electricity connection requests and realized requests in Rosseti's IDGC holding. Between 2006 and 2015, the relative indicator of low quality, i.e. not-connected/kWh, shows modest growth at an annual rate of 2.4%, indicating a slow decrease in quality. During the pre-unbundling period (2006–2008), the compound annual growth of the relative indicator of low quality is 4.6%. However, after the unbundling and before the rebundling of distribution, which is from 2009 to 2012, the same indicator shows high growth at a compound annual rate of 29.4%. Thus, it seems that the quality of electricity distribution measured by service quality did not improve after the unbundling of distribution from transmission and unbundling from the entire integrated electricity supply system in Russia.¹⁴ From 2013 to 2015, after the bundling of distribution and transmission in 2013, the relative indicator of not-connected/kWh decreases sharply at an annual rate of 36.6%, indicating that the quality of service started to improve after the bundling. However, it is important to note that regulatory measures probably had a significant impact on service quality from 2013. According to market participants, the decree of the Russian government, June 30, 2012, on "Increasing the availability of energy infrastructure" imposed strict conditions and monitoring of the implementation of distribution grid connections.¹⁵ There seem to be substantial differences

¹⁴ Russia has improved its position on the World Bank's "Getting Electricity" ratings. In 2010, it took 281 days to get electricity connection with ten procedures. In 2017, it took 83 days with three procedures. However, it seems that major improvements started to happen after 2013. Between 2010 and 2013, 281 days were needed to get electricity connection. Russia still lags behind some developed countries and also behind some emerging markets in terms of the time it takes to get an electricity connection. For comparison, in 2017, it took 28 days in Germany, 79 days in the UK, 89 days in the U.S., 82 days in Italy and 137 days in Canada. Some emerging markets have substantially shortened the time it takes to get electricity. In 2017, it took 46 days in Vietnam and India, 34 days in Indonesia, 64 days in Brazil, 68 days in the Czech Republic, 100 days in Mexico and 143 days in China. *Getting Electricity*. Doing Business. The World Bank. <http://www.doingbusiness.org/data/exploretopics/getting-electricity>

¹⁵ See: PLAN, meropriyatiy ("dorozhnaya karta"), "Povysheniye dostupnosti energeticheskoy infrastruktury". UTVRZHDEN rasporyazheniyem Pravitel'stva Rossiyskoy Federatsii ot 30.06.2012 g. № 1144-r. Those who consume up to 15 kW of electricity have a right to get a grid connection at a subsidized price of 550 rubles. These

between the IDGCs as regards realizing the connection requests of customers. Some distribution companies substantially decreased not-connected requests per electricity output from 2008 to 2015: Centre and Volgi decreased not-connected requests per electricity output at an annual rate of 22%; Urals decreased not-connected requests per electricity output at an annual rate of 15.5%; and Volga decreased not-connected requests per electricity output at an annual rate of 14.8%. Some distribution companies, however, experienced substantial annual growth of not-connected requests per electricity output during this period: Lenenergo experienced a 16.7% annual growth rate of not-connected requests; Siberia experienced a 9.8% annual growth rate of not-connected requests; and Moesk experienced a 6.5% annual growth rate of not-connected requests.

There was a total decrease in power losses at a compound annual rate of 1.7% for all ten distribution companies from 2007 to 2015 (see Table 5). Power losses decreased during the pre-unbundling period (2007–2008) at a compound annual rate of 5.0% and during the post-unbundling period (2009–2012) at a compound annual rate of 3.2%, thus indicating an increase in the quality of the distribution networks. Between 2005 and 2015, all ten distribution companies, with the exception of South, had an annual decrease in power losses (see Table A.1).

As discussed in a Russian expert survey on the Russian electricity industry reform (Knyaginina and Lipeckaya, 2014), the key reform objectives for Russia in the early 2000s were as follows: to attract investment in the power industry, to renew fixed assets, and to keep tariffs on electricity at an acceptable level for the main consumer groups. From 2007 to 2015, investments in the ten IDGCs had negative annual growth of 6.4%. However, after the 2008 reform, between 2009 and 2012, investment in electricity distribution grew annually by 15.4%. From 2013 to 2015, investment in electricity distribution decreased at a compound annual rate of 28.3%. Therefore, ownership unbundling may have had a positive effect on the growth in investment between 2009 and 2012. However, it seems that the regulatory changes likely had the most significant effect on the investment growth of distribution companies during that period: all distribution companies of the IDGC holding switched from cost plus regulation to return on asset (RAB)-based tariff regulation as of January 1, 2010.¹⁶

customers account for 90% of applications for electricity connections. The average cost for a distribution company to provide an electricity connection is approximately one hundred thousand rubles. In the past, the distribution companies had little incentive to accelerate the receipt of these subsidized electricity connections. See Malyy, sredniy biznes i dachniki mogut lishitsya lgot na podklyucheniye k elektrosetyam. *Vedomosti*, 25.06.2015.

¹⁶ The Russian Federal Tariff Service set a new tariff system based on an 11% return on invested capital for five years starting from 1st January 2010. The former CEO of Rosseti, Oleg Budargin, in an interview in June 2017, described the investment boom in the electricity distribution as follows: “When we took management of FGC (Federal Grid Company) and IDGC, we saw that they had become simply constructors of the power grid complex. And we overdid it, we tuned a lot of superfluous things, which, of course, puts pressure on the economy. The average load of the substations is 27%. On the one hand, we can say that the thesis about the outstripping development of electricity networks is fulfilled, but now the Ministry of Economy and the regions need to load these feeding centers - they are now virtually free. We have built 59 GW to supply consumers, and we use only 7 GW. We have a loss of 100 billion rubles per year, taking into account the average load.” (*Kommersant*, 30 June 2017.)

On the one hand, if quality is measured with (not)realized connection requests, we can conclude that the quality of service of the Russian electricity distribution companies did not improve after the ownership unbundling. However, we did not test causality between the quality of service and ownership unbundling and thus cannot determine what causes deterioration in the service quality after unbundling. On the other hand, we observed a decrease in power losses during the pre- and post-unbundling periods and thus improvement in the quality of the distribution networks. Here we should note that these two indicators measure the quality of electricity distribution differently. The quality proxy, (not)realized connection requests, reflects holistically the overall business quality of distribution companies. This quality proxy has more weight in the business operations of companies and in the governance environment than in the physical condition of the distribution network alone. In contrast, the weight of power losses as an indicator of quality is in the physical condition of the electricity distribution network. A substantial increase in investments in electricity distribution, as shown in the pre-and post-unbundling periods in Russia, has reduced the power losses but has not necessarily had a direct impact on service quality.

4.2 The effect of ownership unbundling on the operational costs of the electricity distribution companies

This section focuses on the question of the effect of mandatory ownership unbundling on the operating costs of Russian electricity distribution companies. Following the findings of Nillesen and Pollitt (2010), Filippini and Wetzel (2014) and Nepala et al. (2016) on costs reductions in electricity distribution after ownership unbundling in New Zealand, we hypothesized the following:

Hypothesis 2: Ownership unbundling should decrease the unit operating costs of electricity distribution companies.

We thus expect ownership unbundling to have a positive impact on the underlying cost structure of the electricity distribution companies studied, although there may be one-off restructuring costs related to the structural separation of distribution from the vertically integrated electricity system. However, we found that only Northern Caucasus IDGC seems to have an exceptionally high peak in operational costs in 2008 and 2009 compared to subsequent years (see Table A.1).

Table 5 shows that for the ten distribution companies in the sample, the total operating costs increased at an annual rate of 9.9% between 2007 and 2015. At the same time, the total operating revenue of these companies grew at an annual rate of 9.5%. Electricity distributed by these companies during this period decreased at an annual rate of 0.9%. As a result, the operating costs per unit of distributed electricity increased at an annual rate of 1.9%. The operating costs per unit distributed decreased during the pre-unbundling period, 2007–2008, at an annual rate of 6.6%. These costs grew during the unbundled period from 2009 to 2012, but only at an annual

rate of 0.2%. After re-bundling, from 2013–2015, the operating costs per distributed unit decreased at an annual rate of 8.4%.

It is difficult to identify clearly the impact of re-bundling of distribution and transmission on the operating costs per unit. It should be noted that the Russian economy shrank considerably during 2014 and 2015, which had a significant effect on the output of the electricity industry in the country. For example, electricity distributed by the sample companies decreased at an annual rate of 1.9%, and total revenue of these companies decreased at an annual rate of 11.5% between 2013 and 2015. As a result, operating costs during this period decreased by 12.7% annually.

Altogether, it seems, as shown in Table 5, that ownership unbundling in 2008 did not decrease the costs of the electricity distribution companies. However, some distribution companies managed to decrease costs during the unbundled period from 2009 to 2012, namely Moesk at an annual rate of 0.3%, North-West at an annual rate of 1.0% and Centre and Volgi at an annual rate of 3.3% (see Table A.1).

Again following Nillesen and Pollitt (2011), we also examined the impact of ownership unbundling on unit operating costs while considering scale effects and technological progress. To do this, we used panel data for ten IDGCs between 2005 and 2015 and specify a standard cost function to be estimated.

The standard cost function can be written as follows (Nillesen and Pollitt, 2011; see also Kwoka, 2005):

$$C = C(Q, P, X) \quad (1)$$

where C denotes the operational costs of distribution; Q refers to output (commonly defined as the units (measured in kWh) distributed, U); P denotes the factor prices; and X refers to (exogenous) factors, such as network length and number of customers, that may also affect costs. The impact of network length and the number of customers is captured by the connection density (D), which can be calculated by dividing the number of connections by the network length. In addition, the quality of the network may also affect the operating costs. As mentioned earlier, SAIDI is often used to measure such quality. However, due to data availability problems, in this study we used data on how customers' electricity access requests have been realized by the IDGCs (see Table 4) as a proxy for the quality of distribution.

The variables used in the analysis are presented in Table 6 together with their descriptions and data sources. All prices and costs of distribution companies were deflated using a CPI for Russia from World Bank data.

Table 6. Descriptions of variables and sources of data

Variable	Description	Sources
Operating cost	Operating cost (mln rub, 2015 prices)	AR IDGCs
Distributed electricity	Distributed electricity (mln kWh)	AR IDGCs
Connection density	Connection density (proxy) = Population in the region (extrapolated and interpolated by the authors) / Network length	Rosstat and AR IDGCs
Not-connected per unit	Results on grid connection: not connected/mln kWh	AR IDGCs
Connected	Results on grid connection: % of connected requests	AR IDGCs
Unbundling 2008	Unbundling dummy (=0 before 2008; =1 from 2008 onwards)	AR IDGCs
Bundling 2013	Bundling dummy (=0 before 2013; =1 from 2013 onwards)	AR IDGCs

Note: AR IDGCs = Annual Reports of Interregional Distribution Grid Companies

The cost function to be estimated can now be written as follows:

$$\begin{aligned}
c_{it} = & \beta_0 + \beta_1 u_{it} + \beta_2 d_{it} + \beta_3 ar_{it} + \beta_4 Y2008_t + \beta_5 Y2013_t + \\
& \beta_6 u_{it}^2 + \beta_7 d_{it}^2 + \beta_8 ar_{it}^2 + \beta_9 Y2008_t u_{it} + \beta_{10} Y2008_t d_{it} + \beta_{11} Y2008_t ar_{it} + \\
& \beta_{12} Y2013_t u_{it} + \beta_{13} Y2013_t d_{it} + \beta_{14} Y2013_t ar_{it} + \beta_{15} Trend_t
\end{aligned} \quad (2)$$

where subscript i indicates IDGCs, subscript t indicates time, c stands for operating cost, u stands for distributed electricity, d stands for connection density, and ar stands for access requests (either connected or not connected). $Y2008$ is the unbundling dummy (which gets a value of 1 starting from the year 2008), $Y2013$ is the re-bundling dummy (which gets a value of 1 starting from the year 2013) and $Trend$ is a time trend. All the variables apart from the dummy variables and the time trend are in natural logs.

Following Nillesen and Pollitt (2011), we assumed factor prices to be equal for all the companies in the sample. Factor prices were thus not included in the cost function. In addition, network quality (ar) measured by not-connected and connected access requests was assumed to be exogenous because it takes time to make changes in the quality (see also Nillesen and Pollitt [2011]).

Like Nillesen and Pollitt (2011), we specified a quadratic cost function in equation (2). However, we had to drop the quadratic regressors and regressors multiplied by the unbundling and bundling dummies from the final cost function due to the relatively small sample size, meaning that Table 7 presents the estimation results for the simplified cost function:

$$c_{it} = \beta_0 + \beta_1 u_{it} + \beta_2 d_{it} + \beta_3 ar_{it} + \beta_4 Y2008_t + \beta_5 Y2013_t + \beta_6 Trend_t \quad (3)$$

Here, we expected β_1 to be positive because operating cost is likely to increase with volume of distributed electricity. We also expected β_2 to be positive because a greater number of customers is likely to increase servicing costs. When using not-connected requests per unit as an indicator

of network service quality (Model 1 in Table 7), we expected θ_3 to be positive because a high number of not-connected requests per unit is likely to result in higher operating costs by changing the cost structure of the network business. Similarly, when using connected requests to measure quality (Model 2 in Table 7), we expected θ_3 to be negative. Moreover, in line with our Hypothesis 2, we expected θ_4 to be negative, which would indicate that ownership unbundling decreases operating costs. Conversely, we expected θ_5 to be positive. We also expected θ_6 to be negative, which would indicate a decrease in the operating cost over time because technological change over time should result in lower operating costs.

Due to the calculation of cluster-robust standard errors that allow for intragroup correlation, we could not use the standard version of the Hausman test to check for the consistency of the random effects estimator. We thus used the *xtoverid* command developed by Schaffer and Stillman (2010) for Stata. The command was built to test for overidentifying restrictions and can be used to test the difference between fixed and random effects estimators because the assumption of the latter that the explanatory variables are uncorrelated with the group-specific error can be viewed as an additional orthogonality condition. The *xtoverid* command can deal with heteroskedasticity- and cluster-robust standard errors. The test results given at the bottom of Table 7 indicate quite clearly that the random effects estimator should not be used. Only the fixed effects estimation results are thus presented in the table 7.

Table 7. Cost function estimation results

	(1)	(2)
Distributed electricity	0.167 (0.23)	0.179 (0.19)
Connection density	0.021 (0.04)	0.035 (0.03)
Not-connected per unit	0.054*** (0.01)	
Connected		-0.230*** (0.06)
Unbundling 2008	0.506*** (0.06)	0.682*** (0.08)
Bundling 2013	-0.025 (0.05)	-0.008 (0.05)
Trend	0.031* (0.01)	0.041** (0.01)
Constant	8.452*** (2.33)	8.944*** (1.94)
Observations	80	80
Number of groups	10	10
Sargan-Hansen statistic	106.96	100.99
Hausman-like test (p-value)	0.0000	0.0000

Note: Robust standard errors are shown in parentheses (*significant at 10%, **significant at 5%, ***significant at 1%).

The results presented in Table 7 indicate that network quality is strongly associated with operating costs: both of the variables that measure network quality are statistically significant at the 1% level. As expected, the better the quality (i.e., the lower the Not-connected per unit or the higher the Connected), the lower the operating cost. This result is in line with the results of Nillesen and Pollitt (2011) for New Zealand. In contrast, distributed electricity and connection density remain statistically insignificant in both of the models.

Interestingly, in contrast to our expectations, our results indicate also that the ownership unbundling resulted in higher operating cost. The unbundling dummy is statistically significant at the 1% level. In addition, operating costs seem to have increased over time, as indicated by the positive and statistically significant coefficient of the trend variable.¹⁷

Overall, it thus seems that the mandatory ownership unbundling of Russian electricity distribution of 2008 increased the operating costs of electricity distribution companies. This contrasts with the results of previous studies on ownership unbundling in the New Zealand electricity industry. Our results are, however, in line with Kwoka et al.'s (2010) and Meyer's (2012b) studies of the U.S. electricity industry, which find that ownership unbundling increases costs. Interestingly, in Kwoka et al.'s (2010) study, particularly those utilities that underwent mandatory ownership unbundling experienced increased operating and total costs.

5 Conclusions

The Russian electricity market was reformed between 2003 and 2008. Specifically, the vertical electricity supply monopoly, RAO UES, was liquidated in 2008, and mandatory ownership unbundling between generation and retail and network activities of transmission and distribution was put into effect. Wholesale markets for electricity were fully liberalized in 2011. In 2013, independent distribution was re-bundled with transmission under one ownership. In this paper, we investigated the impact of mandatory ownership unbundling on the quality and operating costs of electricity distribution companies. As in several previous studies of other countries, this study found that the impacts of ownership unbundling on the quality and costs of distribution of distribution companies in Russia seem to be mixed.

Regarding the quality of service, our results provide evidence of a relationship between firm structure and network (service) quality in Russian electricity distribution. There is a total decrease in distribution electricity losses for all ten distribution companies from 2007 to 2015 as

¹⁷ Our results seem to reinforce the following International Energy Agency's remarks regarding Russian electricity networks: "Reform of monopoly network services can also make a substantial contribution to reducing the overall cost-reflective level of end-user prices. Rapidly increasing network charges were a major contributor to the recent excessive rate of growth in end-user prices, and may offer considerable scope for further productivity improvement." IEA (2013, p. 12)

well as during the unbundled period of 2009–2012. After that, from 2013 to 2015, electricity losses increase slightly.

When using not-connected access requests per unit of distributed electricity as a proxy for network quality, we did not find evidence for increased network quality. While it seems that unfulfilled requests per unit increased modestly from 2006 to 2015, a very clear decrease in service quality can be observed in the data from 2009 to 2012 (i.e., after unbundling). However, after re-bundling distribution with transmission, service quality seemed to increase substantially during 2013–2015.

Our results show that network quality is strongly associated with operating costs. The better the quality (i.e., the lower the Not-connected per unit or the higher the Connected %), the lower the operating costs. This result is in line with the results of Nillesen and Pollitt (2011) for New Zealand.

We did not find evidence that ownership unbundling in the Russian electricity supply industry led to lower operating costs for the electricity distribution companies: operating costs per unit of distributed electricity increased from 2007 to 2015. They also grew after the ownership unbundling from 2009 to 2012, but the growth was modest at an annual rate of only 0.2%. Also the estimated cost function indicated that ownership unbundling resulted in a higher operating cost. The operating costs also increased over time.

The results of our study seem to underline the importance of recognizing coordination issues in vertically disintegrated electricity supply. Benefits upstream, whether from prices due to competition in generation or from increased investments in new generation capacity due to extensive capacity payments, as in Russia, can be lost due to increased coordination costs in distribution operations.

The results of this study are, however, somewhat limited, mainly because the period of ownership unbundling is only four years. There is a lot of noise in the volatile environment in Russia: distribution companies were incorporated only a few years before the mandatory ownership unbundling and regulatory institutions were just developing. The quality and availability of data for distribution companies, especially for the years 2005 and 2006, could be better. Nevertheless, the results show how complicated, and costly, structural remedies can be in an environment of weak and emerging institutions.

We did not examine the effect of ownership unbundling in electricity distribution on consumer prices or competition. Thus, we do not make any conclusions regarding general welfare effects. Future research can examine the relationship between heavily regulated and subsidized retail markets and distribution companies in Russia, as well as the development of regulatory regimes to incentivize distribution companies to improve service quality and increase their efficiency.

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Appendix

Table A.1. Overview of operational and quality statistics for electricity distribution companies in Russia

Distributed electricity (mln kWh)												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	59168	62701	69667	72811	71128	74208	75470	78546	80133.3	80980.3	80127.2	3.1 %
Lenenergo	25470	25393	26549	28439	27672	29095	28975	30007	29613	28680	28249	1.0 %
Centra		54042.1	56394.8	56618.4	53129.2	56028.9	56667.4	57900.0	57814.3	57045.1	56706.0	0.5 %
Centre and Volgi	53254.1	53816.8	54302.7	55431.42	50889	54100	54299	54539	53881	49882	48676	-0.9 %
North-West	54247.8	39408	41050	42437	38948	40752	40244	40468	38118	37168	36955	-3.8 %
Urals	76637.8	79850.6	82868.53	79902	69339.2	72048.4	71577	70080.9	68903	67217	64192	-1.8 %
Volga		55635.0	57524.0	58478.8	53355.6	56367.8	58002.4	57462.2	54706.0	51293.2	49364.1	-1.3 %
Siberia	91651.4	99240.2	99818.1	96490.0	91794.7	73813.3	72079.2	74004.8	69488.3	68710.4	70161.4	-2.6 %
South			4555.8	32030.0	29464.9	27441.6	27172	27262	26732	26781	25947	24.3 %
N.Caucasus		10786.7	11454.4	11880.4	11735.8	9033	9478	13537	9685	10534	10457	-0.3 %
Average												1.8 %
Network length (km)												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	16633	16697	137817	140223	133008	148640	138005	139027	139256	142308	148644	24.5 %
Lenenergo		54563	55180	55816	56937	58041	56141	57259	58370	59963	61106	1.3 %
Centra		770067	377542	362329.2	363654.6	365045.9	371691	372970	388500	379144	382540	-7.5 %
Centre and Volgi			263409	262187	261972	262320	263391	265477	267260	268944	270067	0.3 %
North-West	153677.2	135287	161740	169535	167225	166642	167216	167946	167327	167723	166891	0.8 %
Urals	347932.2	371841	140622	122043	113210	114348	115012	115550	116715	117943	119251	-10.2 %
Volga			214000	225973.4	221777.6	223265	223752.9	224380.2	225233.8	224898.8	225104.8	0.6 %
Siberia			248459	251991.6	252000.3	252008.9	251656.5	250389.3	249349.3	250184	250900.9	0.1 %
South			242078	160746	160611	156265.2	155802	156193	159619.6	159380	159125.8	-5.1 %
N.Caucasus			109100	109300	109330.9	11019.5	106331	106554	112165.2	107702	121734.2	1.4 %
Average												0.6 %
Total transformer capacity (MVA)												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk			22755	24002	19335	20542	21209	21557	22093	22957	24963	1.2 %
Lenenergo		6463	6486	6548	6818	7275	7686	7983	8489	9259	9427	4.3 %
Centra		68856.63	30336.3	30592.7	31013.4	31403.9	32781.2	32747	33226.1	33936	34243	-7.5 %
Centre and Volgi			10845	27900	28500	28600	29350	29470	29670	29820	29960	13.5 %

North-West	29546	18039.5	17484.6	17690	17835	17877	18003	18163	18345	19030	19031	-4.3 %
Urals	60468.1	61446.8	22512.8	20140	20453	20813	21116	21459	21560	21612	21639	-9.8 %
Volga			25835.4	34129.7	26572.2	26893.2	27107.2	27294.7	27464.6	27698.7	27769.7	0.9 %
Siberia			30927.0	39733.0	39468.6	39877.6	39992.8	40328.1	40542.3	40961.9	41372.5	3.7 %
South			25516	18177.9	18237.5	18336.48	18532	18484	23716.6	23752.9	23800	-0.9 %
N.Caucasus			10220	10230	10233.6	10247.9	10328	106330.6	10751.6	10771	10983.4	0.9 %
											Average	0.2 %
Power losses (%)												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	9.18	8.24	11.62	11.05	11.29	11.15	10.33	9.63	9.16	8.77	8.55	-0.7 %
Lenenergo	15.8	14.1	12.1	9.97	10.3	10.7	10.6	10.35	10	9.98	9.66	-4.8 %
Centra	10.46	10.35	9.52	9.4	10.11	10.01	9.93	9.53	9.16	9.17	9.35	-1.1 %
Centre and Volgi	10.7	9.67	9.56	9.31	9.41	9.06	8.97	8.62	8.44	9.23	9.08	-1.6 %
North-West	10.2	7.1	6.8	6.7	7.14	6.82	6.39	6.41	6.31	6.41	6.38	-4.6 %
Urals	10.4	8.79	8.24	7.48	8.52	8.08	7.95	7.87	7.62	7.68	7.77	-2.9 %
Volga	10.21	7.17	7.57	6.88	7.38	6.96	6.8	6.36	6.43	6.62	6.7	-4.1 %
Siberia	9.43	7.45	7.24	7.1	7.35	9.24	8.71	8.15	7.64	7.3	7	-2.9 %
South		8.01	7.63	8.21	8.31	9.31	9.47	9.66	9.38	9.3	9.83	2.3 %
N.Caucasus		22.36	20.28	19.43	20.32	17.47	14.36	14.11	14.59	15.57	16.94	-3.0 %
											Average	-2.4 %
Operating cost RUB mln (2015 prices)												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	24940.0	43240.7	61035.1	102302.6	112332.9	129161.0	141272.1	122750.6	128335.2	125598.6	113648.0	16.4 %
Lenenergo		21484.3	26998.6	31958.8	33700.5	41650.0	44376.2	43658.6	45379.4	45355.4	44060.0	8.3 %
Centra		1505.6	1914.9	55746.2	71966.4	79636.8	80631.4	79800.6	101474.8	88623.8	70713.9	53.4 %
Centre and Volgi	55532.5	47777.6	53920.8	51452.3	71254.4	76092.0	79772.3	69077.1	82244.5	71428.0	62803.0	1.2 %
North-West	113.9	362.7	482.3	26401.6	38293.8	39313.5	40005.3	38641.1	49399.3	47796.6	36642.0	78.1 %
Urals	78400.8	60670.8	68070.2	61363.8	59295.4	67948.5	69955.2	65637.7	68430.4	63951.5	56069.4	-3.3 %
Volga			220.2	35975.2	43920.7	56994.8	63724.0	56852.7	59988.5	51583.4	45658.7	94.8 %
Siberia		305.9	509.1	62744.5	60918.3	64691.1	70159.5	64807.0	77046.2	65220.3	43083.0	73.3 %
South			26471.7	19741.1	26824.4	29380.9	28040.1	28001.1	29088.2	28028.7	26099.0	-0.2 %
N.Caucasus			553.2	15128.0	16919.0	13295.6	11817.2	11369.8	13226.0	14196.3	13576.2	42.7 %
											average	36.5 %

Operating revenue RUB mln (2015 prices)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	30217	57220	79787	113908	137996	167640	176826	156931	155377	144718	129288	15.6 %
Lenenergo		23632	31487	37649	42238	51824	51642	48237	49706	51669	43727	7.1 %
Centra		1674	2028	64459	79420	91529	91908	92287	115784	100174	79817	53.6 %
Centre and Volgi	55532	47778	53962	57276	76405	82423	89993	79643	96753	79905	68884	2.2 %
North-West	115	374	533	28839	40386	40411	43105	41450	52381	51138	39623	79.3 %
Urals	25523	56761	71086	65011	66863	75436	76254	68267	71557	68868	60535	9.0 %
Volga			321	40879	47468	59732	66830	60858	61263	53136	47860	87.0 %
Siberia		325	503	66025	63316	65785	73250	66102	78811	66317	42744	72.0 %
South			30153	23728	30806	33300	34034	31203	34164	33380	30365	0.1 %
N.Caucasus			691	14751	16158	15851	14730	14963	16289	15591	14549	46.4 %
											average	37.2 %

Operating costs per kWh (RUB 2015 prices)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	0.422	0.690	0.876	1.405	1.579	1.741	1.872	1.563	1.602	1.551	1.418	12.9 %
Lenenergo		0.846	1.017	1.124	1.218	1.432	1.532	1.455	1.532	1.581	1.560	7.0 %
Centra		0.028	0.034	0.985	1.355	1.421	1.423	1.378	1.755	1.554	1.247	52.6 %
Centre and Volgi	1.043	0.888	0.993	0.928	1.400	1.407	1.469	1.267	1.526	1.432	1.290	2.2 %
North-West	0.002	0.009	0.012	0.622	0.983	0.965	0.994	0.955	1.296	1.286	0.992	85.1 %
Urals	1.023	0.760	0.821	0.768	0.855	0.943	0.977	0.937	0.993	0.951	0.873	-1.6 %
Volga			0.004	0.615	0.823	1.011	1.099	0.989	1.097	1.006	0.925	98.6 %
Siberia		0.003	0.005	0.650	0.664	0.876	0.973	0.876	1.109	0.949	0.614	80.1 %
South			5.811	0.616	0.910	1.071	1.032	1.027	1.088	1.047	1.006	-19.7 %
N.Caucasus			0.048	1.273	1.442	1.472	1.247	0.840	1.366	1.348	1.298	50.9 %
											average	36.8 %

Investments RUB mln (2015 prices)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
Moesk	8040	22876	47409	63927	35127	29595	41259	48000	63795	52561	36715	16.4 %
Lenenergo	5270	6431	18110	20623	16731	23961	21045	19803	23331	27048	6741	2.5 %
Centra	8527	10139	16169	16397	10571	18532	21232	21074	17969	14069	12937	4.3 %
Centre and Volgi			11637	14709	10764	12750	18960	14460	11930	9272	5173	-9.6 %
North-West	8691	4421	6482	7274	4403	4100	7225	9032	7891	5985	4002	-7.5 %
Urals	5066	6086	12640	5755	7205	8466	8960	9358	11310	8279	6274	2.2 %

Volga			10966	12028	3597	6445	10575	12296	10802	6688	2521	-16.8 %
Siberia	5878	4164	8778	8947	5496	5836	9907	6643	7389	8135	6196	0.5 %
South			6734	9655	4610	2733	5739	6818	3938	1377	1665	-16.0 %
N.Caucasus		1406	2707	3617	2221	3314	7810	7319	4017	2613	1256	-1.2 %
											average	-2.5 %

Source: the annual reports of the IDGCs