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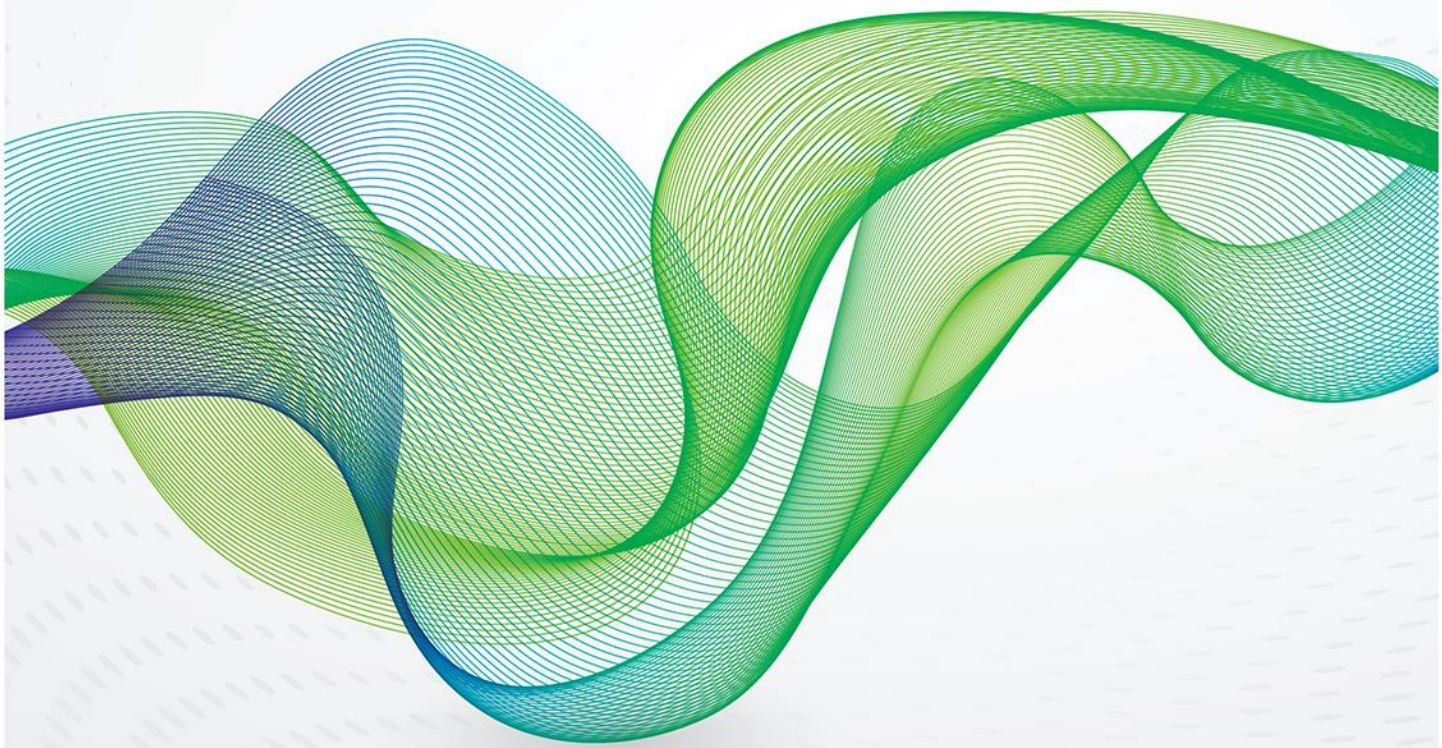
The Development of Natural Gas Demand in the Russian Electricity and Heat Sectors



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Preface

Russian gas exports to Europe have been the topic of much discussion over the last few years, in particular because relations have deteriorated in the wake of the 2014 Ukraine crisis. However as Evgenia Vanadzina notes at the start of this paper, Russian domestic gas demand is around twice the size of Gazprom's record export sales in 2017. Indeed, it is clear to any analyst of the gas market that to fully appreciate Russia's gas export potential it is important to first understand its productive capacity, which has been discussed in numerous OIES papers, and its domestic demand. This latter subject receives much less attention than it perhaps deserves, and this working paper represents an attempt to redress that balance as it analyses two of the most important sectors in the Russian gas market, power generation and heat.

As discussed by Vanadzina, these two are linked due to the frequent production of heat in tandem with electricity, but also have separate development trajectories due to the heating systems that were been developed during the Soviet era to cope with the freezing winters experienced across much of the country. These systems, which comprise centralised and decentralised plants as well as Combined Heat and Power (CHP), are now very inefficient and the whole sector is in need of reform. This working paper provides details both of that process and its potential impact on gas demand.

Gas dominates fuel use in the power sector, although in various regions it is in competition with coal and to an extent nuclear and hydro. Vanadzina outlines some forecasts for future electricity demand and assesses the potential for efficiency improvements across the sector as the asset base is upgraded. She then assesses the outlook for future gas use, relative both to the traditional competition but also in reaction to the gradual emergence of renewable energy in some parts of the country.

Overall, this paper provides an important contribution to understanding the future of gas demand in Russia and the development of two important consumers of primary energy in the country. Although the author's overall conclusion is that the effects in the two sectors actually balance each other out, the detail of the analysis and the light it shines on a vital part of the Russian energy economy make this research a valuable addition to the library of OIES publications on gas in the Former Soviet Union.

James Henderson

Director, Natural Gas Programme

Oxford Institute for Energy Studies

Glossary

Bcm - billion cubic metres

bbl - barrel of oil

toe – tonnes oil equivalent

Gcal - gigacalorie

mln Gcal - million gigacalories

kg/Gcal - kilogram of oil equivalent per gigacalorie

kW - kilowatt

GW - gigawatt

MWh - megawatt hour

TWh - terawatt hour

Tcm - Trillion cubic metres

mln tonnes - million tonnes

bln tonnes - billion tonnes

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Executive Summary

Natural gas supplies to Russia's domestic market are about twice the size of supplies to its export markets. Most of the gas supplied to the domestic market is used for electricity and heat production, which account for about 50 per cent of domestic natural gas consumption – more than 200bcm annually. Natural gas demand in this sector is highly influenced by the economic situation in the country, fuel pricing policy, and energy policy and regulation.

While the economic situation shapes electricity demand (as most of this demand comes from industrial consumers), natural gas demand for electricity production is subject to inter-fuel competition between coal and natural gas, and inter-technology competition between nuclear and gas power plants. The latter is affected by capacity support mechanisms. Natural gas demand for electricity production is on an upwards trend, due to anticipated electricity demand growth. The additional volumes of natural gas required to cover this demand are estimated to be in the range of 24.5–32.5bcm by 2035, compared to total demand of 120bcm in 2016, an estimate which takes into account power production efficiency improvements resulting from the commissioning of new power plants.

New nuclear and large-scale hydro power plants are the major source of competition for gas power plants in the western part of Russia. However, the high capital cost of these technologies and limited resource availability for large-scale hydro power will limit the spread of these plants. In some regions, there are already instances of delays in the introduction of nuclear power plants.

Heat demand is influenced by weather conditions and the efficiency of the heat supply chain. Currently most heat producing assets operate in a sub-optimal mode, with heat supply network losses averaging 30 per cent, but in some cases reaching as much as 60 per cent, according to the Ministry of Energy. The introduction of new and more efficient power production technologies, improvement of the heat supply system, and new policies could decrease natural gas consumption in the long term. Heat demand in Russia is declining due to the implementation of the Law on Energy Efficiency, which obliged owners of both new and old buildings to assess energy efficiency and install heat metering systems. The implementation of the Heat Reform, which came into force in July 2017, included heat tariffs which should incentivize consumers to use heat more efficiently. The reform also aims to increase heat production efficiency and gradually renovate obsolete heat supply systems. The extent to which the Heat Reform will be successful is uncertain, but it should negatively impact natural gas demand for heat. The trend for natural gas use for heating is declining, and the decrease could be in the range of 20–42bcm by 2035, from 114bcm in 2016.

Inter-fuel competition between natural gas and coal will remain at its current level, meaning a prevalence of natural gas in the western and central parts of Russia, and a dominance of coal in Southern Siberia. Although coal prices are low and un-regulated, power and heat produced using coal becomes high-cost due to delivery costs from coal production areas, operational costs related to coal storage, and the capital costs of coal power plant technology.

Altogether, natural gas demand for the power and heat sectors is not likely to change substantially from its current levels. In the most probable scenarios, power demand for gas should increase by 24bcm, while the decrease in gas demand for heating purposes will be a little above 20bcm. Therefore, the increase in gas demand from the electricity sector will be compensated by a decrease in demand from the heat sector, resulting in unchanged natural gas demand for the power sector overall in Russia up to 2035.

1. Introduction

Russia is the largest natural gas exporter to Europe, with proven gas reserves that would last more than 50 years at the current production rate[1]. Annual production was 640bcm in 2016, of which 184bcm was supplied to the export markets[2] (see Figure 1). Natural gas plays a vital role in the country's welfare: together with oil, revenues from fossil fuel exports account for 50 per cent of the federal budget income. The role of natural gas in the domestic market is also significant as about 50 per cent of primary energy resources comprise natural gas.[3] Currently, this vital industry faces cost increases in the areas of exploration and production, in addition to tougher competition over exports to the European market. Natural gas demand in the domestic market therefore becomes a highly relevant topic, which encompasses increases in energy efficiency and inter-fuel competition within the market, and which contributes to a discussion on future gas supplies from Russia.

Supplies of natural gas to the domestic market are usually more than double supplies to export markets, as Figure 1 shows. The majority of gas supplied to the domestic market is used for electricity and central heat production, which accounts for about 50 per cent of domestic natural gas consumption, more than 200bcm per annum[4]. Demand for natural gas for electricity and heat production is highly dependent on the economic situation in the country, on fuel pricing policy, and on energy policy and regulation. The economic situation determines overall electricity demand, as most of this demand comes from industrial consumers; however demand for natural gas for electricity production purposes is subject to inter-fuel competition between coal and natural gas, and inter-technology competition in light of the existence of capacity support mechanisms in the electricity and capacity market in Russia[5]. Heat demand is subject to weather conditions during the winter and energy efficiency in the heat supply chain.

There is an enormous potential for efficiency improvements in the Russian heating sector. The majority of heat producing assets operate in a sub-optimal mode resulting in an inefficient use of fuel. In addition, heat supply network losses can reach up to 60 per cent in some cases, and average 30 per cent, according to an assessment by the Ministry of Energy[6]. Consequently, the introduction of new and more efficient power production technologies, an improvement in the heat supply system, and new policies could decrease natural gas consumption over the long-term, with the implementation of energy efficiency measures and construction of new power generating facilities over the next 10–20 years. Conversely, an increase in electricity and heat demand, driven by industry development, could increase demand for natural gas in the domestic market over the same time period.

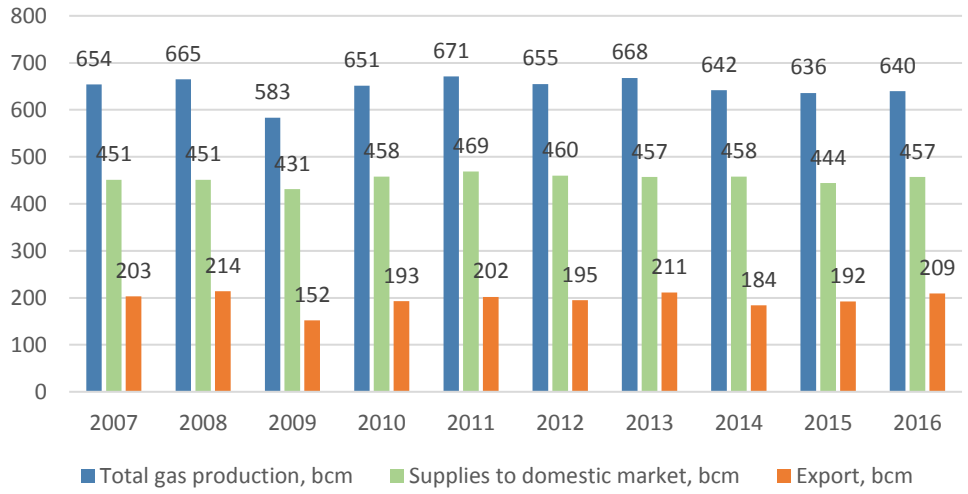
The objective of the paper is to define the most important factors shaping natural gas demand in Russia's electricity and heat sectors, to analyse the extent of their impact, and to reach conclusions on the long-term natural gas demand for electricity and heat production up to 2035, taking different power demand and supply scenarios into consideration.

The next section of this paper considers the link between economic growth and power demand, and provides a background to electricity and heat supply and demand in Russia. The third section analyses the role of natural gas in the electricity and heat sectors, and addresses issues on inter-technology and inter-fuel competition in the power sector. The section explains the background for long-term development analysis. The fourth section looks at future electricity demand in Russia. It proposes scenarios for future changes in demand, and assesses the volumes of natural gas which would be needed to cover that demand. The fifth section discusses the development of the heating sector and

[1] BP (2014), Statistical Review of World Energy.
[2] Ministry of Energy (2017), Gas supplies. Link: http://minenergo.gov.ru/node/1217
[3] LUKoil (2013), Global trends in oil and gas markets to 2025.
[4] Analytical Center for the Government of the Russian Federation (2015), Positions of natural gas in energy balance. Link: http://ac.gov.ru/files/publication/a/6397.pdf
[5] Russia has a dual-commodity market, where electricity and capacity are traded separately.
[6] Ministry of Energy (2017), Ministry of Energy (2016), Presentation on the current state of the heat supply industry.

the Heat Reform, and proposes heat demand development scenarios. Finally, the last section combines the main findings of the paper and draws conclusions from the research.

Figure 1: Natural gas production and domestic consumption in Russia, bcm



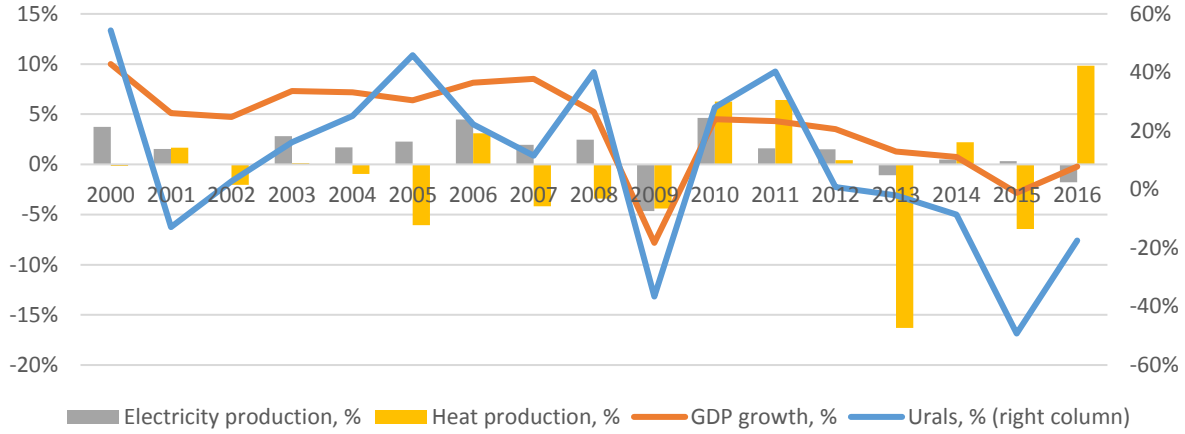
Source: The Ministry of Energy of the Russian Federation (Ministry of Energy).

2. Gas demand for electricity and heat production

The Russian economy is highly dependent on export revenues and, historically, the oil price has played an important role in the country's GDP growth. The main driver for GDP growth between 2001–2008 was not only the increase in export volumes of hydrocarbons, but also the increase in the oil price and the existence of oil-price indexed long-term gas contacts. The Urals crude spot price increased from $17.18/bbl in 1999 to a record $139.52/bbl in 2008[7], contributing to stable economic growth between 2001–2008. Rapid GDP growth resulted in high expectations for future power demand and high growth in fixed capital investments of up to 21 per cent in 2007 until the global financial crisis in 2008. The Russian economy was hit hard by the crisis, which led to an outflow of investments from the country. After the crisis, due to macroeconomic uncertainties, economic growth failed to reach pre-crisis levels, and became almost entirely dependent on oil and gas revenues[8]. By 2015, GDP growth had become negative, tracking oil price falls, as shown in Figure 2.

In turn, the trend for electricity production is correlated with the country's economic development, with more than half of power demand coming from industry[9]. Heat demand, on the other hand, can be highly influenced by other factors such as winter temperatures, consumers switching to decentralised heat supply,[10] or electric heating.

Figure 2: Economic rates, oil price indexes, power, and heat production growth rates in Russia, 2000–2016



Source: World Bank, IEA (2000-2017).

2.1 Electricity demand and supply

Electricity demand in Russia has shown no significant growth over the last ten years. With an average annual growth of 1.1 per cent, electricity demand increased from 941 TWh to 1078 TWh between 2005–2016. Industrial consumers were the main contributors to demand growth, with demand from this area increasing by 68 TWh between 2005–2016, followed by residential consumers (45 TWh), as illustrated in Figure 3. It should be noted that average annual residential demand growth was almost three times higher (3.2 per cent) than average demand growth during the period. This dynamic can be explained

[7] World Bank (2008), Russian economic report N17.
[8] Kudrin A. and Gurvich E. (2015), A new growth model for the Russian economy. *Russian Journal of Economics 1*, pp. 30–54.
[9] Analytical Center for the Government of the Russian Federation (2016), The dynamics of electricity consumption as an indicator of economic activity. Link: http://ac.gov.ru/files/publication/a/7945.pdf
[10] Decentralised heat production is not included in the statistics.

by an expansion of cities due to the urbanisation trend seen in the late 1990s[11] and a considerable increase in the use of electrical appliances by households from the 2000s[12]. The combination of these two factors has resulted in a substantial increase in residential electricity consumption over the last two decades. In addition, relatively low regulated tariffs for residential consumers have provided a disincentive to the consideration of electricity saving measures. Industrial consumers are obliged to buy their electricity from the wholesale electricity and capacity market (WECM) at a price set by the market, which is higher than the regulated tariffs for residential consumers. Economic stagnation initially affects demand from industrial consumers, which accounts for more than 50 per cent of total electricity demand, including energy industry own use[13]. Electricity demand from other sectors such as agriculture, construction, transport, and communication has remained stable for the last ten years, with transmission losses also remaining at the same level, about 10 per cent. At the end of 2008 and in 2009, electricity consumption decreased across all sectors due to the global financial crisis. It recovered slowly until 2012, mirroring the economic recovery and high oil price indexes, but after 2013, industrial demand decreased again due to the fall in the oil price and rouble devaluation. Therefore, there are two major factors shaping electricity demand in Russia: (1) industrial development, which is highly influenced by economic growth rates, and (2) the development of cities and urbanisation that defines residential demand growth.

Anticipated high growth in power demand documented in the 'General Scheme of Electric Power Facilities up to 2020' published by the Ministry of Energy in 2007, resulted in a considerable increase in installed capacity of power plants[14]. The initial growth rate for demand in the document was projected at 4.5-5.7 per cent per annum, and power demand was expected to reach 1400 TWh in 2015. This proved to be an enormous overestimation, as actual demand in 2015 was 1008 TWh[15]. These estimations, together with the general obsolescence of generating equipment, were the basis for the introduction of capacity support mechanisms for the construction of new power plants. Capacity mechanisms were introduced to attract investment in new power plants and guaranteed capacity payments to investors for 10-20 years via a type of contract using a weighted average cost of capital (WACC) of 14 per cent. It should be noted that there are two different types of contracts: Long-Term Agreements (LTAs) for hydro and nuclear power plants, which are the most capital intensive, and Capacity Delivery Agreement (CDAs) for thermal power plants. As a result of the over-optimistic demand forecast, installed capacity of power plants in Russia reached 236.3 GW by the end of 2016, while maximum capacity demand during that year was 153.1 GW[16]. Excess capacity creates tough competition between power producers within the wholesale electricity and capacity market, although in isolated regions, where electricity tariffs are regulated, competition between power producers is limited.

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[11] Kolosov V.A. and Nefedova T.G. (2014) Cities, rural areas and urbanization: Russia and the World. *Regional Research of Russia*, vol.4, No 2, pp. 68–75.

[12] According to Rosstat's Russian Statistical Yearbook 2017, the number of personal computers by household increased 21-fold between 2000 and 2016. The quantity of other electric appliances, such as TV sets, dishwashers, air conditioners etc., has also followed an upwards trend.

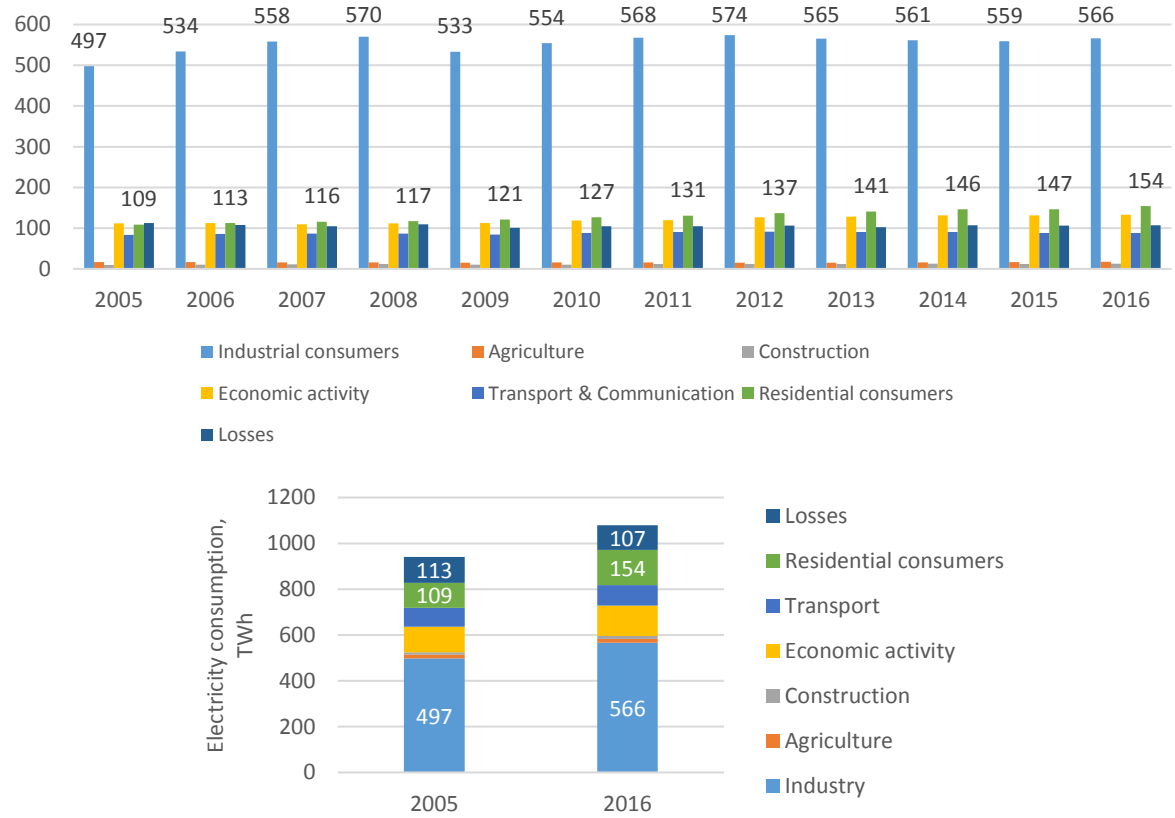
[13] According to the IEA's electricity information (2017), 7 per cent of total electricity production was accounted for by energy industry own use, while 13.5 per cent of total production was electricity consumed by energy industries for heating, traction, and lighting purposes in 2015. This consumption is included as industrial electricity consumption in Rosstat data.

[14] Government of the Russian Federation (2008), Decree N 215-r of 22.02.2008 On the General Scheme for Placing Electricity Facilities by 2020.

[15] System Operator (2016), Report on the functioning of Russia's UES in 2015. Link: http://so-ups.ru/fileadmin/files/company/reports/disclosure/2016/ups_rep2015_01.pdf

[16] System Operator (2017), Report on the functioning of Russia's UES in 2016. Link: http://so-ups.ru/fileadmin/files/company/reports/disclosure/2017/ups_rep2016.pdf

Figure 3: Electricity consumption by sector in Russia, TWh

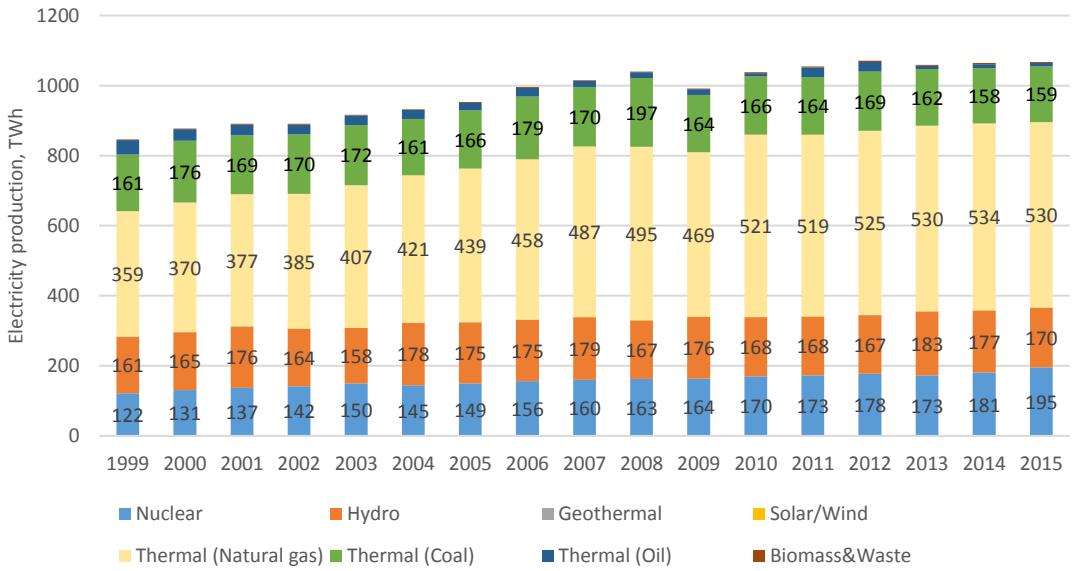


Source: Rosstat.

Electricity production was dominated by thermal power plants (65 per cent) in 2015, followed by nuclear power plants (18 per cent) and hydro power (16 per cent), as shown in Figure 4. There is a relatively small amount of production from biomass and renewable power plants whose share is less than 1 per cent of total electricity production. The share held by fossil fuel power plants decreased slightly from 68 per cent in 2008 to 65 per cent in 2015, while nuclear power production increased from 15 per cent in 2008 to 18 per cent in 2015. This trend occurred because power producers holding CDAs or LTAs were able to cover their investment costs through receiving capacity payments, while their electricity production costs were lower than competitors' costs. In the case of nuclear and hydro power plants, their marginal cost is lower than the marginal cost of power plants running on fossil fuel; consequently, due to the merit order effect, they run as baseload plants. By 2015, 4 GW of new nuclear power capacity was built under LTAs[17], mostly situated in the western part of Russia and taking a considerable market share from natural gas-based thermal power production.

[17] Analytical Center for the Government of the Russian Federation (2016), The dynamics of electricity consumption as an indicator of economic activity. Link: http://ac.gov.ru/files/publication/a/7945.pdf

Figure 4: Electricity production mix in Russia



Source: IEA (2002–2017).

2.2 Heat demand and supply

Heat is an essential product given Russian climatic conditions, where average January temperatures vary from -3º C in southern parts of the country to -26º C in the Far East region[18]. The length of the heating season also varies from five months to ten months depending on the region. Heat supply plays an important socio-economic role, as about 40 per cent of centralized heating is consumed by domestic consumers and budget organisations (such as schools and hospitals), while the rest is accounted for by industrial companies (46.6 per cent) and other economic spheres. Due to the lack of heat metering systems at a consumer level, exact numbers on consumption by sector are difficult to retrieve, and the percentages given are estimates. Demand for heat is usually highly correlated with the temperature during the winter[19], and consequently with the length of the heating season. Therefore, it has a very seasonal dependency: for instance, heat demand in July is 4.5 times lower than in January, because heating is used only for hot water supplies during summer.

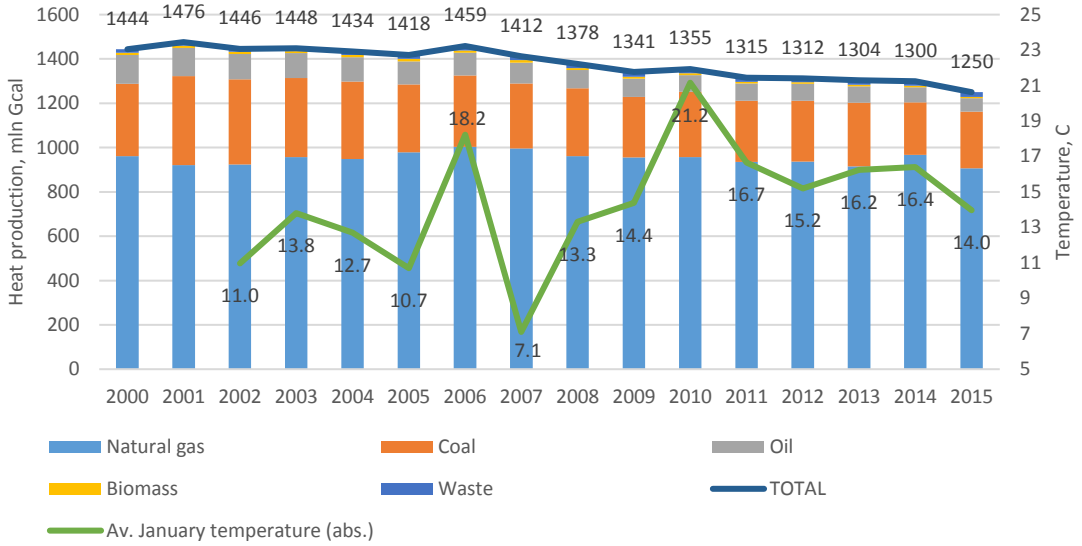
Heat production systems can be divided into centralised and decentralised heating systems, located in residential areas and used mainly by households. Centralised heating systems comprise district heating boilers which produced 47.6 per cent of total heat in 2015, combined heat and power (CHP) plants which had a heat production share of 45.3 per cent, and industrial utilisation plants, which produced the remainder[20]. Statistics on decentralised heating systems are unavailable, but they had a strong tendency to increase and already constituted 23 per cent of total heat production[21] in 2007, according to Nekrasov et al.[22].

Natural gas is a primary fuel for centralised heat production, and its share has increased from 66 per cent in 1999 to 73 per cent in 2015. However, actual heat production from natural gas has declined

[18] Rosstat (2003–2017), Russian Statistical Yearbook.
[19] Analytical Center for the Government of the Russian Federation (2015), Position of natural gas in the energy balance. Link: http://ac.gov.ru/files/publication/a/6397.pdf
[20] TASS (2016). Rosstat: Electricity production in Russia in 2015 grew by 0.3%. Link: http://tass.ru/ekonomika/2611898
[21] Total heat produced for final consumption.
[22] Nekrasov A.S.,Sinyak Y.V., Voronina S.A., Semikashev V.V. (2011) Current state of heat supply in Russia. The authors classify output of small boilers with capacity lower than 20 Gcal/h as decentralised heating systems.

from 962 mln Gcal in 2000 to 907 mln Gcal in 2015. Coal's share of heat production has been slowly decreasing from 22 per cent in 1999 to 20 per cent in 2015, as shown in Figure 5. It is mainly used for heat production in CHP plants situated in Siberia and the Far East of Russia, in regions with limited access to the Unified Gas Supply System (UGSS). Finally, oil's share of heat production has decreased by a factor of two since 1999.

Figure 5: Central heat production by fuel type and average January temperature[23] in Russia, mln Gcal and ºC



Source: IEA (2002–2017), Rosstat (2001–2016).

Centralised heat production has been declining at an average of 0.9 per cent annually between 2000 and 2015. A decrease in average January temperatures was followed by higher heat production in 2006 and 2010, showing the impact that the weather has on heat demand. A winter that was almost twice as cold as the year before in 2006 resulted in an increase in heat production of 3 per cent in 2006 compared to 2005, and similarly in 2010, a colder winter increased heat production. However, a decrease in the average January temperature in 2013–2014 did not impact heat production in the same way, indicating that there was another factor at work driving heat production down.

The decrease in heat production seen in the statistics can be explained by the renovation of housing stock and new construction, combined with the implementation of the Law on Energy Efficiency. Analysis carried out by the Analytical Center in 2013 found that in every tenth residential apartment building in the southern district of Moscow, heat losses could reach up to 66 per cent[24]. The analysis suggested that potential savings from the reduction in heat loss could cover the costs of improving insulation in the buildings. Low tariffs for heating had incentivized the construction of energy inefficient buildings, and a lack of heating meters at the point of use prevented the monitoring of heat consumption. The Federal Law on Energy Efficiency was adopted in 2009[25], and it obliged developers to assess the energy efficiency of new residential housing. The law also introduced a mandatory energy efficiency audit, energy saving programs, and energy passports for older buildings. However, the methodology

[23] Average January temperature is shown as an absolute value and is an average for the five federal districts with the highest heat production values.
[24] Analytical Center for the Government of the Russian Federation (2013): Analysis of energy consumption for the heating of apartment buildings, as a method of increasing energy efficiency in the housing and communal services sector. Link: http://gkhaltay.ru/d/205499/d/06_24_kr_stol_analitika_dor_abotannaya_po_rezultata_m.pdf
[25] Russian Federation (2009), Federal Law N 261-FZ of 23.11.2019 On Saving Energy and Increasing Energy. Efficiency, and on Amendments to Certain Legislative Acts of the Russian Federation.

and targets[26] for energy saving programs for state organizations and institutions were only introduced in 2014[27]. Penalties for not having an energy passport and non-compliance with the energy saving program vary from Rub5,000–200,000 ($88–3,526)[28]. The annual report of the Ministry of Energy shows a slow but stable increase in energy efficiency measures such as an increase in heat meter installations (currently 53 per cent of homes have meters), and a decrease in specific heat consumption in apartment buildings of 8 per cent in 2018 compared to 2014[29].

Russia's heat sector can be characterized as being highly inefficient and lacking sufficient investment to increase its efficiency by renovating heat production and transmission facilities. Despite this, the official statistics on heat losses showed them running at a little above 9 per cent at the end of 2015, and even lower prior to that. This discrepancy comes from the limited number of metering systems at the consumer end: only half of the building stock has heat meters in Russia. Heat production volume is usually measured at the place of production, and statistics on losses mostly rely on calculations rather than on measured data. Therefore, there is no reliable data on actual heat consumption by consumer in most cases, nor is it usually published by the Federal State Statistic Service (Rosstat).

Heat tariffs are regulated by the Federal Antimonopoly Service (FAS), and based on the fuel consumption rates[30] reported by heat producers annually using a cost-plus pricing approach. The tariff formation methodology does not incentivize heat producers to invest in energy efficiency; on the contrary, it incentivizes them to produce more heat to increase their income[31]. Most CHP plants and heat supply systems have poor efficiency and require investment to renovate and modernise them. Currently, 75 per cent of CHP boilers are more than 30 years old, and 23 per cent of them are more than 50 years old. This issue has resulted in a low efficiency of CHP plants in some regions of Russia, and therefore, low competitiveness of CHP plants compared to district heating boilers. Therefore, CHP plants usually subsidise heat production by electricity production and, in some cases, have to curtail their excess heat production[32], which is not sold to the consumers. District heating boilers can also be expensive to maintain, but the administration of a region can be unwilling to close them down due to the configuration of the heat supply network or their proximity to consumers. Therefore, competition between CHP plants and district heating boilers depends on the location. The heat production industry is highly subsidised, with the difference between the payment to heat producers and the tariff that consumers pay being covered by regional budgets. Subsidies from the budget amounted to Rub150 billion in 2015, while the industry needed Rub200 billion [33] in order to invest in renovation and development of the sector.

Unwillingness to pay for heat losses incentivizes consumers to consider other heat supply solutions. New housing complexes prefer autonomous gas boilers closer to the complex rather than paying for connection to a centralised heating system, which would imply paying for distribution network losses and inefficiently regulated tariffs. Large industrial companies invest in their own CHP plants in order to avoid high electricity costs and inefficient heat supply. For instance, large steel producers such as

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[26] Ministry of Energy (2014), Order 399 of 30.06.2014 On approval of the methodology for the calculation of indicators for energy saving and increasing energy efficiency, including comparable conditions.
[27] Ministry of Energy (2014), Order N 398 of 30.06.2014 On approval of requirements to the form of programs in the field of energy saving and increasing energy efficiency of state and municipal organisations, organisations engaged in regulated activities, and on the reporting on the progress of their implementation.
[28] Russian Federation (2009), Article 19.4, N 195-FZ Code of the Russian Federation on Administrative Offenses of 30.12.2001.
[29] Ministry of Energy (2017), State report on the state of energy saving and energy efficiency in the Russian Federation in 2016.
[30] Fuel consumption per Gcal produced.
[31] Boute A (2012), Modernizing the Russian District Heating Sector: Financing Energy Efficiency and Renewable Energy Investments under the New Federal Heat Law.
[32] For instance, Lipetskaya CHP.
[33] Ministry of Energy (2016). Current State of the Heat Supply Industry. Link: https://minenergo.gov.ru/system/download-pdf/4759/60329

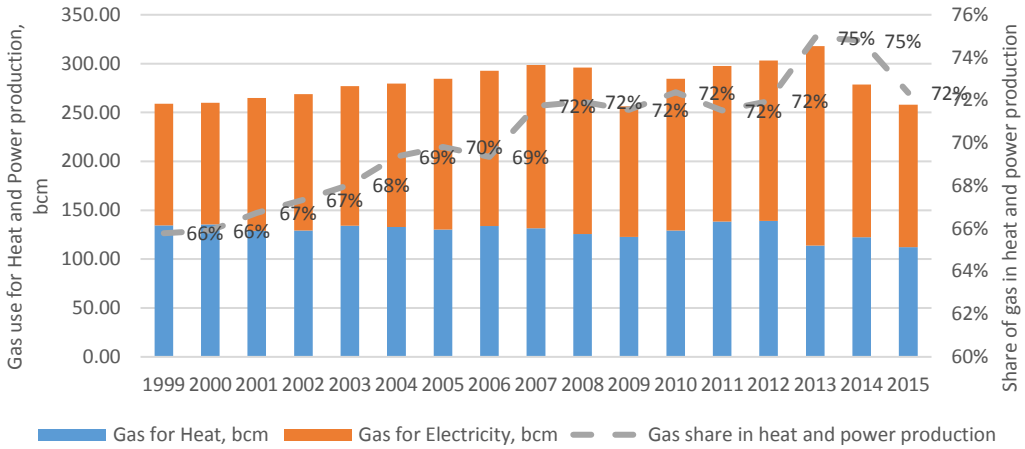
NLMK, Severstal, and Rusal are using their by-products for electricity and heat production[34]. NLMK Lipetsk owns a CHP plant with an installed capacity of 522 MW that uses associated metallurgical gases (a by-product of the industry) as a fuel, and supplies 55 per cent of the company's power needs. The company also supplies heat to the neighbouring town. The implementation of on-site power generation has resulted in a decrease in the energy intensity of metal production by 20 per cent during the last 15 years[35].

[34] Vedomosti (2014). How Russian industry tries to save on electricity. Link: https://www.vedomosti.ru/business/articles/2014/11/25/v-poiskah-deshevoj-energii
[35]Steelland (2017). NLMK increased electricity generation using secondary energy resources. Link: https://www.steelland.ru/news/metallurgy/8422.html

3. The role of natural gas in electricity and heat production

Natural gas is a primary fuel for electricity and heat production. Its share in power and heat production has increased from 66 per cent in 1999 to 72 per cent in 2015, as shown in Figure 6. However, gas consumption by the power industry, after peaking in 2013, has followed a declining trend for the past few years following the economic slowdown in the country. The 3 per cent decrease seen in power production in 2015 can be explained by the higher output of nuclear power, which runs as a base load due to the merit order effect.

Figure 6: Natural gas use for power and heat production in Russia



Source: IEA (2001-2017).

The reduction in natural gas consumption in 2014-2015 can also be explained by a combination of the implementation of the Energy Efficiency Law and an overall improvement in the efficiency of thermal power. The specific fuel consumption rate for electricity production in thermal power plants decreased by 4 per cent in 2012-2016, while the specific fuel consumption for heat production fell by 0.2 per cent. In addition, the trend for large industrial users to switch to their own electricity and heat generation using their own fuel has surely influenced overall gas consumption. However, there are no statistics on this trend. Natural gas consumption could increase if there is higher demand for electricity and heat in the future, provided that natural gas is a winner of inter-fuel competition and inter-technology competition. At the same time, efficiency improvements in the electricity and heat supply chain, from production through to the end consumer, negatively affect levels of fuel consumption. For instance, energy efficiency improvements in the heating sector could have a considerable impact in the long-term. If it could reduce heat losses, the industry could increase its efficiency by 30 per cent[36]. As for the electricity production sector, the renovation of existing gas power plants and the construction of more efficient modern power plants, with a lower fuel consumption rate, could affect demand considerably.

3.1 Inter-technology competition in electricity production

The electricity production industry in Russia was fully liberalised in 2011. The previously state- owned and vertically-integrated monopoly RAO UES, was unbundled and privatized, forming Wholesale Generation Companies (WGKs) and Territorial Generation Companies (TGKs) which were then sold to domestic and foreign investors. Nuclear and hydro power plants remained state owned and operated by Rosatom and RusHydro respectively. Russia's wholesale electricity and capacity market (WECM) operates under the Federal Law N 35-FZ[37] and the market regulations are defined by Government

[36] ACRA (2017). Gas consumption in Russia: will there be growth? Link: https://www.acra-ratings.com/research/155
[37] Russian Federation (2003) Federal Law N 35-FZ of 26.03.2003: On Electric Power.

Resolution N 1172[38]. The WECM is divided into 21 zones of free power flow[39] (ZFPF), where the electricity price is formed, and into two price zones, European Russia and Siberian Russia. The separation into two price zones occurs due to the considerable difference in the generation mix within the zones and the limited transmission capacity between them. The majority of power plants (197 GW in total) produce and sell their electricity within the WECM that covers all the western part of Russia and Southern Siberia. The rest (about 39 GW) are situated in isolated, non-competitive zones, where competition is limited and power demand is comparably low. ES Center, North-West, Volga, South, and Ural constitute the first price zone of the WECM, which is dominated by natural gas-fuelled technologies, because of access to the UGSS. Conversely, the southern part of ES Siberia, which constitutes the second price zone, is dominated by coal and hydro power plants, as shown in Figure 7.

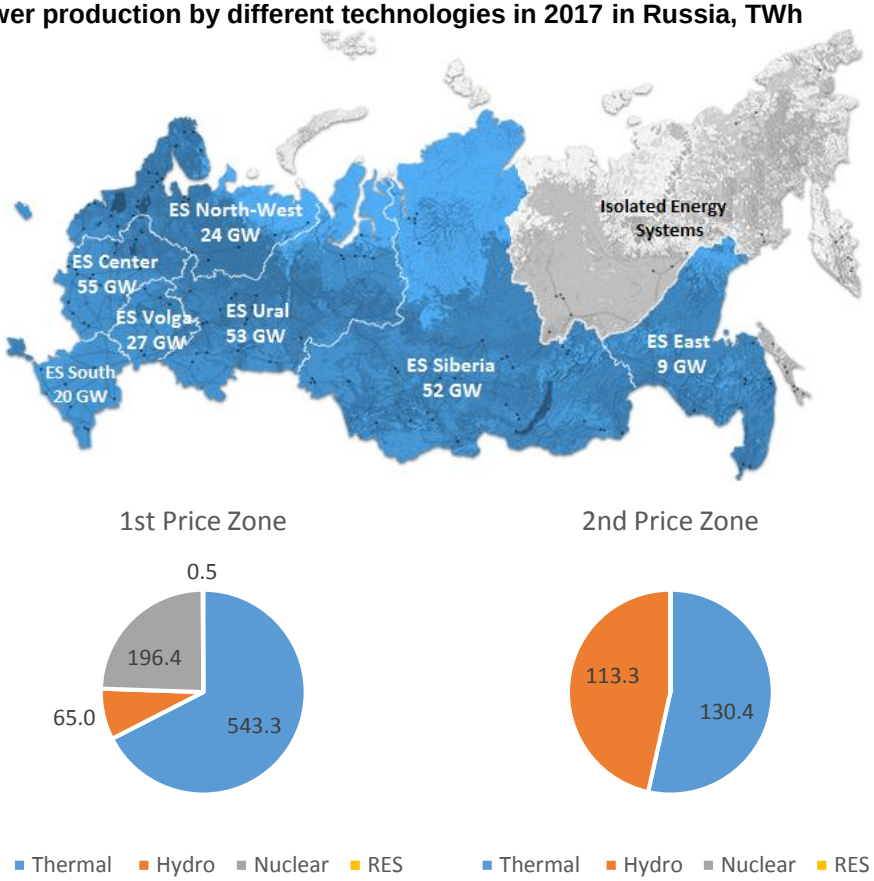
The electricity price is defined competitively in the day ahead market as the least expensive bid from power producers in the zone of free power flow that meets the demand in this zone, defined by the system operator. Therefore, the procedure employs the least cost dispatch model. Historically, average electricity market prices in the first price zone were higher than in the second, because of the dominance of relatively expensive gas power plants determining the equilibrium prices in the zone. Conversely, in the second zone, the electricity price is mostly defined by coal power plants.

In addition to electricity, power plant capacity is sold through the capacity auction in the capacity market. The capacity market was introduced during the reform of the electricity industry, when capacity availability could have been an issue and the risk of outages was high due to insufficient profits from the evolving electricity market. The capacity auction is held once a year for the period four year ahead, meaning that the set of power plants which would run in 2020 would have been selected in 2016. This adjustment to the WECM rules was added in 2016 in order to give price signals for the modernisation of power plants and to provide the right investment signals; prior to this change, the capacity auction was held once a year, for the year ahead. Selected power plants get capacity payments that should cover their fixed costs and investments costs in renovation and efficiency improvements, and in return power producers are obliged to guarantee their capacity availability at any time requested by the system operator.

[38] Government of Russia (2010) Government Resolution No. 1172 of 27 December: On Approval of the Rules for the Wholesale Market of Electric Power and Capacity and on Amending Certain Acts of the Government.

[39] Zones of the wholesale electricity and capacity market where there are no system constraints for 30 per cent of the time during a month, meaning power flow can be considered as unconstrained and an equilibrium price can be defined for the whole zone.

Figure 7: Power production by different technologies in 2017 in Russia, TWh



Source: System Operator of the Unified Energy System of Russia (System Operator) (2018).

Russia has a surplus of installed generating capacity: total installed capacity of power plants in Russia was 236 GW at the end of 2016, while peak capacity needed during the year was 153 GW[40]. This has happened due to a combination of two factors:

1) The massive introduction of new generating capacities though capacity support mechanisms, and

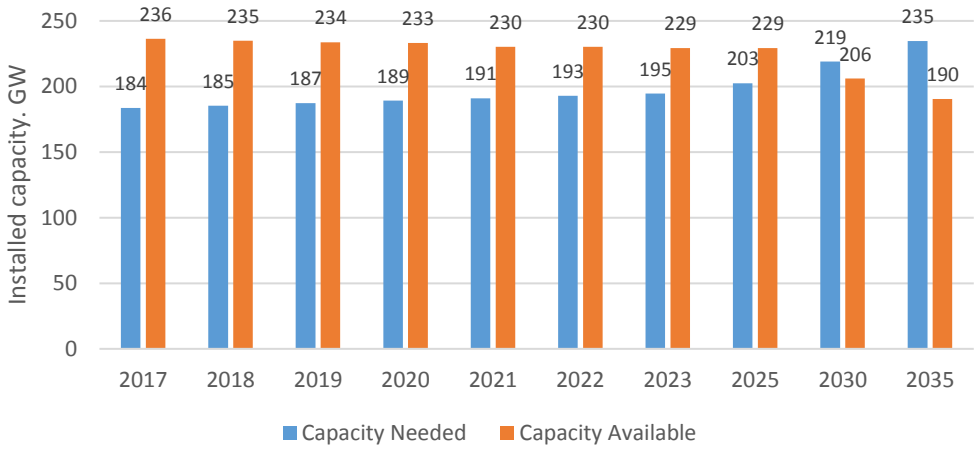
2) The capacity market failing to provide the right signals for old and inefficient generation to leave the market.

More than 20 GW of new capacity was built between 2011 and 2016, and about 5 GW of thermal power is contracted to be built by 2020[41]. At the same time, older power plants are continuing to operate under the current market conditions. However, about half of this capacity should be renovated or replaced in coming years. According to the Ministry of Energy, 17.5 GW of generating capacity was commissioned before 1961, while 47.2 GW of existing capacity was built in 1961-1970, 61.1 GW in 1971-1980, and 51.2 GW in 1981–1990[42]. Therefore, substantial demand for additional capacity and renovation is expected after 2025, according to the projections of the Ministry of Energy, as shown in Figure 8. The need for new generating capacity could be 13 GW in 2025, and reach 45 GW by 2035. Capacity

[40] System Operator (2017), Report on the functioning of UES in Russia in 2016.
[41] Market Council (2016), Realization of obligations of generating companies under CDA: results of 2011-2015 and plans for 2016.
[42]The government of the Russian Federation (2017), Decree N – 1209-r of 9.06.2017: On the approval of the general plan for electric energy facilities for the period up to 2035. Pp.6.

requirements shown in Figure 8 include projected export and reserve capacity, and capacity available includes planned and recommended generating capacity decommissioning from 2017–2035[43].

Figure 8: Capacity needed vs. capacity available in Russia, GW



Source: System Operator, Ministry of Energy.

Mechanisms for investment in new power plants and the renovation of existing ones are different and depend on the location of a power plant. Investments in new power plants are supposed to be attracted through the capacity market only. However, competitive capacity market prices are considerably lower than capacity payments received by the investors through CDAs and LTAs, which makes the investment environment weak. This means new investments in power plants are unlikely under the current design of the WECM. (The construction of new hydro and nuclear power plants is a subject of energy policy rather than a market-based decision, because they are more expensive to build than power plants running on natural gas or coal.)

Due to the merit order effect in the day-ahead market, hydro and nuclear power plants can noticeably decrease the share of production for gas-based power plants. The capacity factor[44] of nuclear power plants was 81 per cent and that of hydro power plants was 42 per cent in 2016, compared to 47 per cent for thermal power plants[45]. Nuclear power plants represent the main competition to gas power technology in the first price zone, and gas power plants have already lost some share in production. The introduction of a new unit at the Beloyarsk Nuclear Power Plant resulted in an 8 per cent increase in nuclear electricity production in 2015, which represented 1.5 per cent of the total electricity production in Russia. In the second price zone, where hydro power production represents almost half of electricity production, coal power plants compete with hydro power plants. Therefore, the introduction of new nuclear and large hydro power plants can considerably decrease the capacity factor of gas power plants, leading to less natural gas consumption.

There has been an increase in the construction of renewable energy sources (RES) capacity, following the introduction of a system similar to the CDA mechanism for renewable power plants in 2013. Installed capacity of RES power plants was 86 MW in 2016. Power production from these plants is currently negligible compared to conventional power plants, amounting to just 0.007 per cent[46] at the end of 2016.

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[43] The Ministry of Energy (2017), Order N – 143 of 1.03.2017: On the approval of the scheme and program for the development of the unified energy system of Russia for 2017-2023, and Ministry of Economic Development of Russian Federation (2013): Forecast of the long-term socio-economic development of the Russian Federation for the period up to 2030.

[44] Percentage of actual electrical energy output over a year compared to the maximum possible electrical energy output over that year.

[45] System Operator (2017), Report on the functioning of UES of Russia in 2016.

[46] See System Operator (2017).

In addition, a retail market level renewable support was introduced in 2015[47], and another RES microgeneration support mechanism was proposed in 2017 for installations of less than 15kW[48]. However, these last two mechanisms have not yet been used for the development of RES projects.

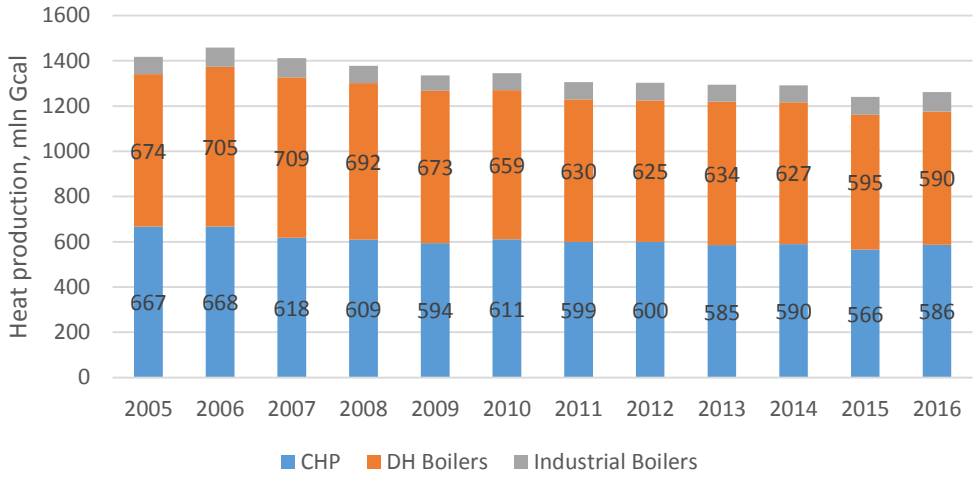
3.2 Inter-technology competition in heat production

For the heat sector, the main inter-technology competition remains between district heating (DH) boilers and CHPs. Historically, in the Soviet Union, CHPs were designed to supply central heating to the cities and large industrial and commercial consumers. Combined generation of power and heat is considered the most economical solution for heat production, as in combined mode, heat used for electricity production can be extracted and then used for heat production, increasing the efficiency of power plants by up to 80 per cent. CHP can also operate only in power generation mode, when the heat produced is condensed in a cooling tower or in a reservoir, or heat production only mode. However, in these cases the electricity or heat produced becomes more expensive and not competitive. The efficiency of heat production in CHP is therefore highly dependent on its operation mode. In the optimal mode of combined power and heat generation, specific fuel consumption by CHPs for heat production can achieve 100 kg/Gcal, which is considerably lower than the average of 151.7 kg/Gcal in 2016[49], and electricity production will also be economical and competitive in the market. In other words, there is the potential to increase the efficiency of heat production by 50 per cent by operating it in the mode for which it was designed. However, in sub-optimal cases, specific fuel consumption can increase to 145 kg/Gcal, and with additional losses during transmission, consumption can reach up to 188 kg/Gcal.

Another trend in the heating sector known as 'boilerisation', has been fast developing during the 1990–2000s in response to the low reliability of heat supplies and tariff issues[50] connected to the challenging economic context during this period. Increasing heat supply tariffs for industrial consumers made autonomous heat production more profitable and reliable. In addition, by investing in decentralised CHP, consumers can hedge themselves from uncertainties in heat and electricity prices. This becomes more relevant for the industry with a free by-product that can be used as fuel for autonomous electricity and heat production[51]. DH boilers accounted for half of heat production in Russia in 2016, as shown in Figure 9.

[47] Vygon Consulting (2017), RES support on the retail markets: time to intervene.
[48] Analytical Center for the Government of the Russian Federation (2017), Microgeneration on the basis of RES. Link: http://ac.gov.ru/files/publication/a/14640.pdf
[49] Semenov V.G. (2013), On the specific fuel consumption for the generation of thermal power stations. Link: http://www.ntsn.ru/5_2013.html
[50] Boute, A. (2012), Modernizing the Russian District Heating Sector: Financing Energy Efficiency and Renewable Energy Investments under the New Federal Heat Law.
[51] Tsay N. (2015) Million stoves instead of CHP. Power and Industry of Russia N 3(18). Link: https://www.eprussia.ru/teploenergetika/18/7997730.htm

Figure 9: Heat production by type of technology in Russia



Source: Rosstat (2004–2017).

Statistics on heat production show that production from DH boilers has typically been slightly higher than heat production from CHPs over the past decade, despite the higher cost of heat production from boilers. Overall heat production has been decreasing as a result of the drive towards energy efficiency. Heat production from industrial boilers, which usually use by-products as a fuel, remained at the same level, except for a small increase in 2016.

Fuel use in DH boilers is higher than in CHPs. In most cases, DH boilers have higher production costs compared to CHPs, and prices for heat produced by boilers were at least 1.8 higher than prices for heat produced by CHPs in 2012–2014[52]. Nevertheless, the complexity of the heat distribution network and the divisions of heat supply territories prevents inefficient boilers from being shut down, despite the fact that - according to the Ministry of Energy - Russia has an overcapacity of heat producing facilities. At the end of 2011 the capacity factor of CHPs for heat production was a little over 30 per cent and that of DH boilers was only 16 per cent. At the same time, demand for heat has been declining at an average rate of 1 per cent per annum over the last ten years, as shown in Figure 9.

As a result, incentives are needed to optimise the heat production sector. From the perspective of the economical use of resources, the production of heat from CHPs is more efficient than DH boilers. However, due to high losses in the heat supply network and the relevance of proximity of the heat production point to the consumer, the overall efficiency of heat production can vary. Therefore, competition between boilers and CHP is dependent on the topology and efficiency of the heat supply network, access to the gas supply network, and distance from the heat production site to consumers.

3.3 Inter-fuel competition: coal vs. natural gas

Russia has coal reserves of 157 bln tonnes[53], the second highest reserves worldwide after the US. The country produces more than 350 mln tonnes of coal annually, mainly by the open-pit mining method[54] which considerably reduces the cost of coal production. In 2015, 197.5 mln tonness of coal (including imports) were supplied to the domestic market, and 151.4 mln tonnes were exported[55]. As a result of

[52] High School of Economics (HSE) (2015), Electric Power Industry in Russia: key figures and analysis of performance indicators.
[53]Analytical Center for the Government of the Russian Federation (2017), Russian Energy – 2016. Link: http://ac.gov.ru/files/publication/a/13691.pdf
[54] According to Analytical Center, 73 per cent of coal was produced using open-pit mining method in 2016.
[55] Ministry of Energy (2017), Coal supplies. Link: https://minenergo.gov.ru/node/437

coal industry restructuring and privatization, the whole industry is dominated by eleven coal mining and five steel smelter companies, with Siberian Coal Energy Company (SUEK) being the major coal producer in the country, responsible for about 30 per cent of coal production. Coal prices are not regulated and producers set their own prices, depending on the type of coal and its calorific value, and coal is mainly traded through bilateral agreements. The main disadvantages of using coal in the power sector are that coal results in additional expenses associated with its transportation to the power production site, storage, and the fact that technology which uses coal is less efficient compared to gas technologies. Furthermore, the technology is designed to use a certain type of coal, when it comes to electricity and heat production[56]. Therefore, in Russia, coal is used for electricity and heat production in places situated close to coal mining areas, primarily in Siberia close to coal mining regions such as the Kuznetsk and Kansko-Achinsky coal basins situated in Southern Siberia.

As for natural gas, in 2016, Russia had the second largest proved reserves of natural gas in the world after Iran, accounting for 32.3 Tcm[57]. Gas is supplied to consumers through the UGSS, which covers the European part of the country and Western Siberia. There is also a gas transmission pipeline in the Far East of Russia, which supplies natural gas to the main cities in the region. Due to the dominant position of Gazprom in the domestic market, the price for natural gas produced by Gazprom is regulated, and the FAS sets a cap-price annually for both industrial and residential consumers. Independent gas producers can set their own prices, but they typically sell their gas at a comparable price level to Gazprom regulated cap-prices in order to be competitive in the domestic market.

At current average natural gas and coal prices for the domestic market in Russia, the cost of electricity production has comparable dynamics, as shown in Table 1. Despite the higher price of natural gas, the power production technology for gas power plants is higher, therefore, it compensates for the higher fuel costs, resulting in a lower electricity production cost overall.

Table 1: Natural gas vs. coal prices in the Russian domestic market

Fuel type	Price[58]			Price, Rub/toe			η	Electricity production cost, Rub/MWh		
	2014	2015	2016	2014	2015	2016		2014	2015	2016
Natural gas[59]	3910	4051	4193	3412	3507	3631	0.46	912.3	937.8	970.9
Coal[60]	1212	1312	1328	2001	2151	2210	0.26	946.6	1017.6	1045.5

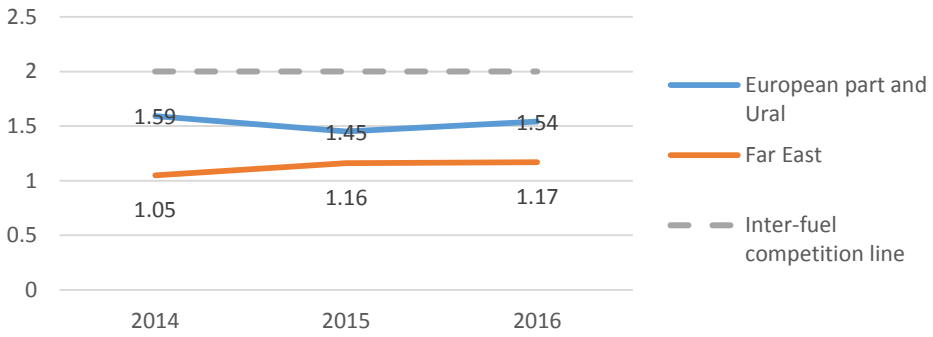
Source: Ministry of Energy, Gordeev.

In order for coal to be competitive with natural gas for electricity production, the natural gas/coal price ratio should be more than 2:1[61]. This ratio is calculated on the basis that operational costs (delivery and storage), fuel use rates for electricity and heat production, and emission costs are higher for coal power plants. For the European part of Russia, Ural, and the Far East, this ratio is below two, therefore coal is not competitive in these regions, as shown in Figure 10. Moreover, according to the analysis in Gordeev (2016), the investment cost of new power plants can add up to 50 per cent to the levelised cost of electricity production, making coal even less competitive, as the capital investment costs for coal power plants are twice as high as for gas power plants[62]. Therefore, in order to reach inter-fuel parity in the domestic market, natural gas prices would have to be increased considerably. Another way to improve the competitiveness of coal use in the power and heat production sector would be a decrease

[56] Gordeev D. (2016), Inter-fuel competition in power generation: coal and gas.
[57] BP (2017), Statistical review of world energy.
[58] Rub/Tcm for natural gas, Rub/t for coal.
[59] Average gas price for industry in the domestic market including transmission cost.
[60] Average coal price in the domestic market including transport cost.
[61] Ministry of Energy (2017), Report on the functioning of the electric power industry.
[62] Gordeev D. (2016), Inter-fuel competition in power generation: coal and gas.

in the capital costs of coal power plant construction and a considerable improvement in coal power plant efficiency.

Figure 10: Natural gas/coal price ratio in different parts of Russia



Source: Ministry of Energy.

Nevertheless, about 8 per cent of installed capacity in the first price zone is coal based. Despite its low production cost, coal competitiveness in the domestic market is very limited due to the logistics. Coal is usually transported by rail, and when it reaches the consumer in the Western part of Russia, the cost can have increased by up to 75 per cent[63]. Gazprom Energoholding, which owns a majority of coal power plants in the first price zone, pushed for an increase in capacity payments for coal power plants, stating that the company's coal-firing assets would otherwise not be profitable and would have to be closed down. It should be noted that some coal power plants were built to run on a specific type of coal and it is not economically viable for them to switch to another type as that would require additional investments for the reconstruction of power plant equipment. For instance, Reftinskaya GRES, with installed capacity of 3.6 GW owned by Enel and situated in the first price zone, uses Ekibastuz stone coal from Kazakhstan as its main fuel[64]. All the boilers of the power plants are customized to use this specific type of coal which has a high level of impurities. In contrast to the power plants of Gazprom Energoholding, coal for Reftinskaya GRES is delivered by direct train connection from Kazakhstan, which is relatively cheaper than delivering coal from the Southern Siberia basins. Coal use therefore remains viable for power production where there are existing coal-fired plants in territories with mature fuel logistics schemes. However, when it comes to the replacement of old coal power plants in the European part of Russia, investment decisions are made in favour of gas power plants because of their lower capital and operational costs. More than 3 GW of coal power capacity was decommissioned in 2012–2016 in the first price zone, while only 0.78 GW has been introduced in 2010–2016[65]. Therefore, taking an average capacity factor for thermal power plants of 47 per cent and an average efficiency of gas power plants of 45 per cent would mean the addition of approximately 2bcm of natural gas consumption per year in 2010–2016.

[63] Kommersant (2017), The coal-fired power plants of Gazprom cannot stand competition with gas. Link: https://www.vedomosti.ru/business/articles/2017/10/12/737529-ugolnie-elektrostantsii-gazproma
[64] Enel (2017), Reftinskaya GRES. Link: https://www.enelrussia.ru/en/about-us/reftinskaya-gres.html
[65] EEnergy (2017), Coal generation in the European part of Russia and Ural does not withstand inter-fuel competition. Link: http://eenergy.media/2017/11/23/ugolnaya-generatsiya-evropejskoj-chasti-rossii-i-urala-ne-vyderzhivaet-mezhtoplivnoj-konkurentsii/.

4. The role of natural gas in covering future electricity demand

4.1 Electricity demand projections

There are several official forecasts for electricity demand in Russia, published by the Ministry of Energy and the government of Russia, which are based on forecasts from the Ministry of Economic Development up to 2030[66]. The first document, the 'scheme and program' for the development of the Unified Energy System (UES) of Russia[67], is a medium-term detailed forecast of electricity demand in different energy systems (ESs) and contains a plan of generation capacity to be installed to cover the projected demand in 2017–2023. The forecast is based on information from signed contracts for technological connection to the grid (new power plants and new consumers), a forecast on the socio-economic development of Russia for the period 2017–2019[68], and a long-term forecast of the socio-economic development of the Russian Federation. The document consists of detailed analyses of demand development in each region of Russia, plus supply-side information on the power plants; specifically which should be decommissioned or commissioned during the forecast period based on signed contracts. In addition, the document provides electricity and capacity balances for each type of generating capacity on a yearly basis for each ES. Electricity demand growth is based on the presumption of an average GDP growth of 2.07 per cent until 2023 (starting from 0.6 per cent in 2017), and $40/bbl oil prices, which contribute to an average 1 per cent annual electricity demand growth. The macroeconomic basis in the scheme and program was updated in 2016 and demand development is considered in detail for each region, ensuring that the electricity demand forecast closely corresponds to the existing situation.

Another official document, which defines the long-term strategy for power industry development, is the 'General Scheme of Electric Energy Facilities until 2035'[69], which was published in 2017. The General Scheme aims to envisage future electricity demand and determine the generation capacity mixture required to cover that expected demand. It also constitutes a list of technologies which are most likely to be introduced or decommissioned through to 2035. In addition, the plan also provides projections on the construction of new power transmission equipment to better balance supply and demand within the UES. The demand forecast in the General Scheme is based on an econometric model which takes into account large existing industry projects approved by the government in April 2015, and a long-term electricity demand forecast until 2035, which projects annual electricity demand growth of 0.9–1.7 per cent.

Both documents are recommendations rather than a binding regulatory document. It should be mentioned that previous long-term forecasts from the Ministry of Energy projected electricity demand growth of 2.2–3.1 per cent until 2030, almost twice as high as the current projection[70]. Overestimation of demand growth led to energy policy mistakes and resulted in the current capacity oversupply. These mistakes were associated with expected high economic growth in light of high oil price expectations, which were around $100/bbl, and projections of annual GDP growth of 4–5 per cent[71]. They also considered Russia's electricity demand at a country, rather than regional, level.

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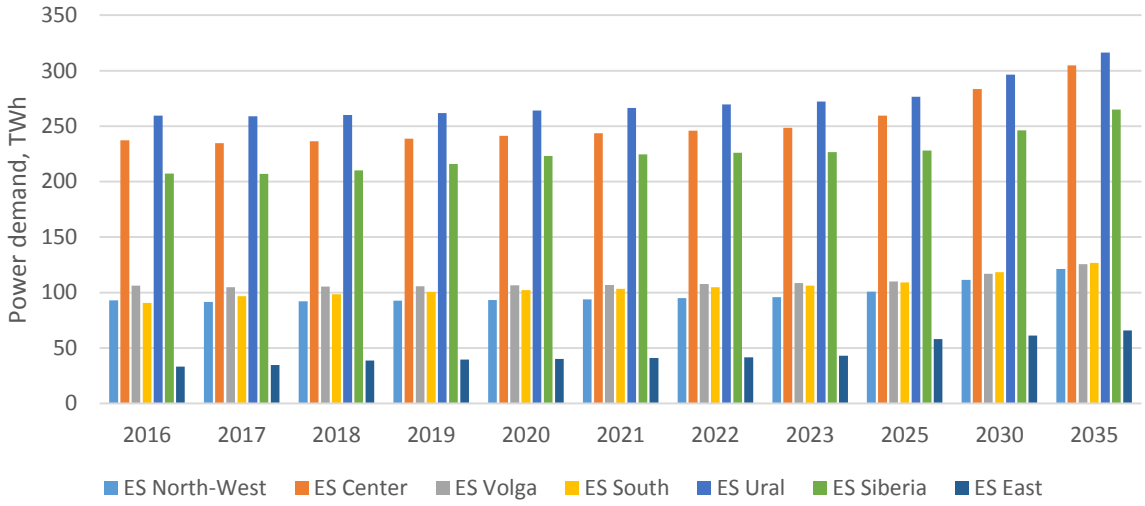
[66] The Ministry of Economic Development of the Russian Federation (2013), Forecast of the long-term socio-economic development of the Russian Federation for the period up to 2030.
[67] The Ministry of Energy (2017), Order N – 143 of 1.03.2017 On the approval of the scheme and program for development of the unified energy system of Russia for 2017-2023.
[68] The Ministry of Economic Development of the Russian Federation (2016), Forecast of socio-economic development of the Russian Federation for 2017 and the plan period 2018 and 2019.
[69] The government of the Russian Federation (2017), Decree N – 1209-r of 9.06.2017 On the approval of the general layout of plan of electric energy facilities for the period up to 2035.
[70] BigpowerNews (2015), Ministry of Energy has updated the energy consumption growth forecast up to 2035, reducing the estimate of average annual demand growth by half - to 0.9–1.7%. Link: http://www.bigpowernews.ru/news/document63344.phtml
[71] Ministry of Energy, ABPE (2011), Scenarios of electric power development for the period up to 2030.

4.2 A regional view of electricity demand development

This sub-section discusses electricity demand development and its constituents for each energy system, as shown in Figure 11. Electricity demand development is highly dependent on the mix of consumer types in the system, and varies significantly depending on the economic and industrial development of the regions within the ES.

Figure 11: Power demand in Energy Systems of Russia, TWh



Source: Ministry of Energy

Power demand growth in ES North-West is powered by industrial companies which are involved in oil production and refining, pulp and paper, forestry, mechanical engineering, and construction. Oil production growth is expected in the Republic of Komi in the Timan-Pechora basin, which would lead to higher volumes of oil transmission though the Baltiyskaya pipeline and the construction of additional oil refineries. An increase in capacity of the gas pipeline Bovanenkovo-Uhta-Torzhok is also expected in order to supply gas to the Nord Stream 2. Nevertheless, according to forecasts, 70 per cent of the increase in power demand in the North-West system will occur due to increased demand in the St Petersburg and Leningrad oblasts. Power demand in these regions would increase due to the construction of new housing complexes, leisure and business centres, technology parks, hotel complexes, and sport facilities (mainly connected to the 2018 FIFA World Cup). Additional demand would be associated with the enlargement of St Petersburg's subway. Average demand growth is expected to be 0.45 per cent up to 2023, which translates into a 400 MW peak capacity demand increase by 2023. Long-term forecasts are more optimistic, suggesting a 1.9 per cent annual increase after 2025 according to the base scenario, and 1.4 per cent in the minimum scenario.

The largest consuming regions in ES Center are Moscow and the Moscow region, which account for 44 per cent of total power consumption in the ES. Increased demand in this region is mainly associated with the construction of new housing complexes and urban infrastructure, and an expansion of transport routes (including the Moscow metro). This is in comparison to other regions where demand growth would be caused by increases in industrial demand. The average demand increase in the ES would be 0.7 per cent per annum and peak capacity demand would be 2500 MW higher by 2023 compared to 2016. In the general scheme, annual demand in the ES will be 1.3 per cent in the minimum scenario and 1.7 per cent in a base scenario.

The forecast increase in demand in ES Mid-Volga is the lowest in the scheme, and accounts for a 0.3 per cent annual increase. This small increase would be due to expansion of capacity at the current industries situated in the ES, such as oil refineries in the Republic of Tatarstan, metallurgical plants in the Saratov oblast, and the automotive industry complex in the Volga region. In 2018, four regions of

the energy system are hosting events related to the FIFA World Cup, thus new sport and hospitality facilities have been constructed in these regions creating additional demand. In the long-term, demand increase is forecast to be 1 per cent per annum in the minimum scenario and 1.4 per cent in a base scenario.

ES South's demand increase is the highest in the country and is expected to average 2.3 per cent annually, partially due to the connection of the Republic of Crimea and Sevastopol in 2017, and the development of industry in some regions of the ES. The Republic of Crimea will account for 7.6 per cent of total demand in the ES by 2023. The forecast increase in electricity demand occurs primarily due to the implementation of a number of major investment projects for new high-tech industries in the iron and steel industry (CJSC DonElektrostal, Krasnosulinsky Metallurgical Plant, TAGMET), in the engineering industry (aircraft building), and the implementation of the project of OJSC Rostvertol. There are also plans for the reconstruction and development of the oil refineries Afipka, Il'sky, and Tuapsinskiy. Demand growth slows down in the general scheme to 1.3 per cent and 1.6 per cent after 2025, in the minimum and base scenarios respectively.

ES Ural has the highest energy intensity system in Russia due to the concentration of major oil production industries and metallurgical industries in the area. However, demand increases are forecast to be 0.7 per cent on average within the ES, mainly accounted for by an increase in oil production capacities. Commercial production of oil should start at the Russkoye oil field in 2018, one of Rosneft's biggest oil fields, and a new West Siberian oil refinery is planned for construction in the same region. Conversely, production in the metallurgical industry is declining in the region, partially due to low demand from export markets and partially as a result of the implementation of energy efficiency programs by metallurgical companies. The long-term scheme projects 0.9 per cent and 1.4 per cent annual demand increases after 2025.

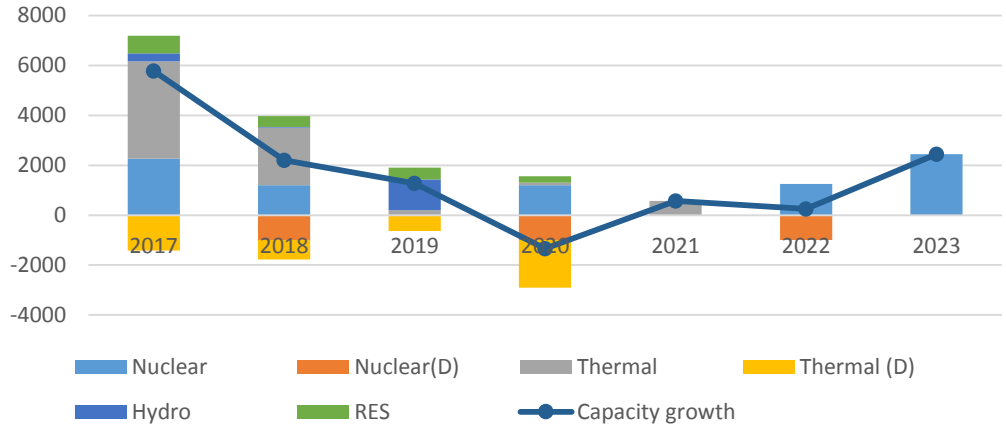
ES Siberia also does not show any significant increases in power demand during 2017–2023, with growth in the ES expected to be 1.3 per cent on average until 2023. This increase in demand occurs mainly because of the planned commissioning of a number of aluminium plants[72] by Rusal, the largest industrial power consumer in the region which has an annual consumption of 63 GWh, or 27 per cent of total consumption in ES Siberia. Additional demand increases are associated with oil production in the Vankor field: Vankorneft should start production in Suzunskoye, Tagulskoye, and Lodochnoye, and there is expected to be some development of new gold deposits in the Krasnoyarsk region. Average demand growth is expected to be 1.3 per cent and 1.5 per cent after 2025 according to the general scheme.

4.3 Role of gas in covering future electricity demand

The medium term plan for the introduction of new power capacity and the decommissioning of old plants can be found in the scheme and program for 2017–2023. The volume of the capacity decommissions through to 2023 in Russia will be 7726.6 MW, according to the orders of the Ministry of Energy. The first block of capacity of 1000 MW should be decommissioned in the Leningradskaya Nuclear Power Plant (NPP) in 2018, followed by another 1000 MW of capacity in 2020. Kurskaya NPP should decommission 1000 MW in 2022. Decommissioning of thermal power plants should total 4726 MW, of which 3165 MW will be gas power plants[73]. The number of total decommissions is twice as low as the commissioning of new power plants. It is expected that commissioning of new power plants over the period will be 18895.8 MW, which will include 8361.8 MW of nuclear power plants, 7075 MW of thermal power plants (of which 6933 MW will be gas-fired power plants[74]) , 1583.7 MW of large hydro power plants, and 1875 MW of power plants based on RES (see Figure 12).

[72] The launch of Taishetsky aluminium plant in 2018, launch of the second stage of Khakas aluminium plant in 2019, and production increases at the Boguchansky aluminium plant. All belong to Rusal.
[73] Appendix N2 to the scheme and program for development of the unified energy system of Russia for 2017–2023.
[74] Appendix N4 to the scheme and program for development of the unified energy system of Russia for 2017–2023.

Figure 12: Capacity decommission and commissioning in 2017–2023 in Russia, MW



Source: Ministry of Energy

These numbers are based on the investment plans of generating companies and their obligations according to signed capacity agreements. These capacities are therefore most likely to be constructed on time due to high fines imposed in case of delay. With such a generation mix, the output of thermal power plants in 2023 would be 711–727 TWh, or 64 per cent of total power generation. If the structure of fuel consumption remains unchanged, that would mean a slight increase in natural gas consumption. It is estimated that natural gas demand for electricity production would be 184bcm versus 178bcm estimated in 2017, which implies a 0.6 per cent average annual increase in gas consumption by the power production sector until 2023[75].

Over the long-term, anticipated natural gas demand growth is higher, and corresponds to 1.4–1.9 per cent growth per annum in a minimum scenario and 1.5–2.3 per cent in a base scenario, as shown in Table 2. For a more detailed projection and analysis of natural gas consumption, it is very important to consider the future generation mix of the power system in Russia at a regional level, as this will define the volume of power output from thermal power plants required to cover the projected demand. Secondly, the inter-fuel competition between natural gas and coal will define the share of each fuel in power production from thermal power plants. And, lastly, the efficiency of gas power plants will give estimates on the volumes of natural gas consumed by the power plants.

[75] P. 73 of the scheme and program for development of the unified energy system of Russia for 2017–2023.

Table 2: Natural gas consumption for power production in Russia

		2020	2025	2030	2035
Base Scenario	Power production by thermal power plants, TWh	676.5	745.7	834.6	900.7
	Natural gas consumption, bcm	202.7	216.4	233.7	240.3
	Annual growth of gas consumption		1.3 %	1.5 %	0.6 %
Minimum Scenario	Power production by thermal power plants, TWh	656.7	723.2	793.9	852.7
	Natural gas consumption, bcm	170.0	187.2	205.5	220.7
	Average growth of gas consumption		1.3 %	1.1 %	0.7 %

Source: The general scheme of electric energy facilities until 2035[76].

4.4 Inter-technology competition

Nuclear and hydro power plants represent the main competition to thermal power plants, because they have a lower marginal cost of power production and operate as a base load. At the same time, their capital cost can be several times higher than the cost of gas power plants, as shown in Table 3. Investments in new nuclear and hydro power plants, as previously mentioned, were generated through LTAs for the capital intensive nuclear and hydro power technologies, and though CDAs for thermal power plants. The last capacity agreement was signed in 2010[77], and payments for contracted new capacity are included in the capacity cost paid by consumers during the agreement period (10–20 years). After peaking in 2020[78], the capacity support constituent of the capacity cost should decrease substantially. From the perspective of the regulators and power producers, this would allow new investments in the electricity production sector due to expiration of the capacity agreements. If consumers continue to pay the same price for capacity, it would make Rub1500 mln available for new investments within capacity market in 2020-2030[79]. The Ministry of Energy is however considering the introduction of a similar support mechanism but this time aimed at the renovation of existing power production assets. Consequently, a capacity support mechanism will continue to exist but will mainly target the renovation of existing capacities. However, it is uncertain exactly how the new scheme would work, and how it would deal with the construction of new power plants within the scheme, including RES capacity. A detailed version of new support scheme is expected by the end of 2018[80].

[76] Appendices 11–14 and 16–17 of the general scheme of electric energy facilities until 2035.
[77] Market Council (2018), Wholesale electricity and capacity market. Link: https://www.np-sr.ru/ru/market/wholesale/index.htm
[78] Vygon Consulting (2017), Modernisation of CHP: manoeuvre to avoid market? Link: https://vygon.consulting/upload/iblock/7f1/vygon_consulting_power_plants_modernization.pdf
[79] Belkina (2017), On the verge of modernization. *Energy without borders*. Link: https://www.interrao.ru/upload/iblock/a8a/EBG_06_2017.pdf
[80] TASS (2017), Ministry of Energy expects to complete work on a new model of the energy market by 2018. Link: http://tass.ru/ekonomika/4438728

Table 3: Approximations of the capital cost of different technologies

	Thermal (natural gas)	Thermal (coal)	Nuclear	Hydro	Hydro (small scale)	Solar	Wind
Cost, Rub/kW	34655-39850	56270-71520	85000-182100	64000 - 112000	146000	99072	109232
Cost, $/kW[81]	575 - 661	934 – 1187	1416-3033	1066 - 1866	2433	1651	1821

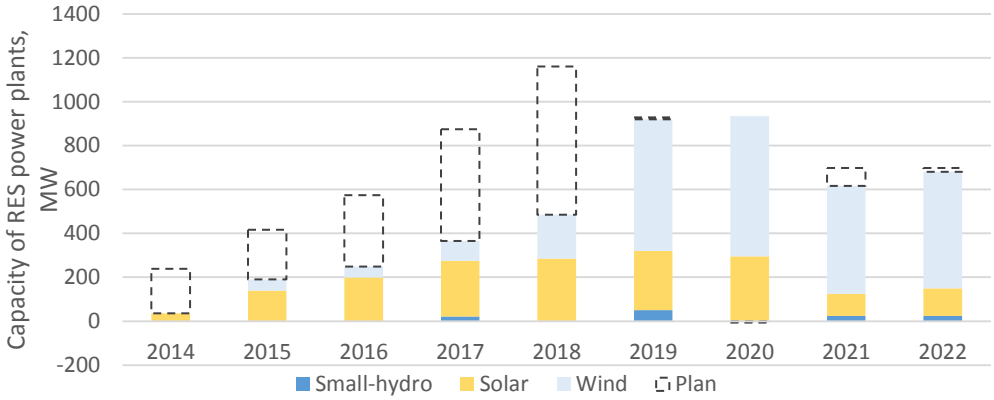
Source: Ministry of Energy, ATS[82].

Support for renewables is provided through the capacity support mechanism in Russia. CDA for RES was introduced in 2013 with the goal of developing local renewable power production technologies rather than the power output from renewable power plants. It was a targeted support for solar and power installations over 5 MW and small hydro power plants with capacity of less than 25 MW. Similarly to the CDA for conventional power plants, investors would be guaranteed a capacity payment over ten years to cover their investment costs in exchange for an obligation to implement the RES project on time. Since then, more than 4 GW of renewable capacity has been selected competitively. The support mechanism limits capital costs for RES power plant projects and has local content requirements[83], which have been gradually increased from 35 per cent in 2014 to 65 per cent in 2022 for wind power, from 20 per cent in 2014 to 65 per cent in 2022 for small hydro power, and from 50 per cent to 70 per cent in 2022 for solar power[84]. It was believed that a lower local content requirement would be easier to meet at the beginning; however, initial results showed that the market was not ready to introduce RES at such a short notice. Nevertheless, the results of recent RES project selection have been more successful in meeting the planned RES capacity due to involvement of large power market players such as Fortum and Rosatom[85] in the wind generation business, and T plus and Rosnano[86] in the solar power business, as shown in Figure 13.

There is also a support for solar power installations at the retail electricity market level, which was introduced in 2015. However, not a single project had been implemented by 2017 due to a lack of regulatory legal acts at the regional level. Even with the successful implementation of all projected RES power plants by 2023, expected power production by renewables would only reach 4.1 TWh, which is 0.4 per cent of total forecast power production. Therefore, renewables production will not represent a major competition to conventional energy sources over the medium-term. Nevertheless, the involvement of large generation companies in the field and a consideration of the vast renewable potential of Russia could potentially lead to higher penetration of renewable energy in the country, and it is unclear what RES capacities could amount to under support after 2023.

[81] At the official rate in November 2017, $1= RUB60.27.
[82] Based on the costs of power plants constructed recently in Russia, presentation of the Ministry of Energy (2017), and information on requirements for competitive RES project selection.
[83] A policy imposed by the government that require firms to use domestically manufactured goods or domestically supplied services for renewable energy projects under support mechanisms.
[84] ATS (2017), Competitive selection of RES projects. Link: https://www.atsenergo.ru/vie
[85] Represented by its subsidiary company Vetro OGK.
[86] Represented by its subsidiary company Hevel Group.

Figure 13: Results of competitive RES project selection until 2022 in Russia, MW



Source: ATS.

Planned nuclear, hydro, and RES power plants through to 2023 leave production from thermal power plants with about a 64 per cent share of forecast demand growth, or 711 TWh, which is 6 per cent higher than their share in 2016. The General Scheme projects that, through to 2035, power demand from thermal power plants should reach 901 TWh, 33 per cent higher than in 2016. It should be noted that this forecast is based on a rather optimistic trend of economic development in the country, corresponding to 3 per cent annual GDP growth up to 2030 in a base scenario and 5 per cent in a target scenario[87].

4.5 Impact of efficiency improvements on natural gas demand

Around half of the existing power generating capacity in Russia should be replaced or renovated by 2035, as 126 GW of currently operating power plants were built prior to 1980[88] and will reach their technical limit by then. New generating capacities and replacements will be more efficient and therefore consume less natural gas which could decrease demand for natural gas in the long-term. Currently, the average efficiency of thermal power plants[89] is around 39.3 per cent, while a modern combined cycle gas turbine can reach efficiencies of up to 60 per cent. By assuming that the least efficient power plants are replaced in the ESs, and taking the forecast generation and fuel mixture, plus knowing the capacity factors according to the scheme and program for the development of the Unified Energy System up to 2023 and the General Scheme until 2035, it is possible to estimate gas consumption for each ES up to 2035.

Methodology

Gas demand projections are based on the forecast output from gas power plants for the corresponding years. The General Schemes forecast demand for future years in Russia for each ES and define the required capacity in order to cover this demand and a capacity factor for each type of power plant. Knowing the output of gas power plants and their weighted average efficiency, it is possible to estimate natural gas consumption in the energy system (1) as follows:

$$NG_{it} = \frac{E_{it}}{\eta_{it}^{av} \cdot K} \qquad (1)$$

[87] Ministry of Economic Development of the Russian Federation (2013), Forecast of the long-term socio-economic development of the Russian Federation for the period up to 2030. Pp. 49.
[88] The government of the Russian Federation (2017), Decree N – 1209-r of 9.06.2017 On the approval of the general layout of the plan for electric energy facilities for the period up to 2035, Pp. 6.
[89] Both coal and natural gas power plants.

Where i – index of energy system, t – year index, NG_{it} – natural gas consumption in the energy system (bcm), E_{it} – output of the gas power plants (TWh), η_{it}^{av} – weighted average efficiency of the gas power plants in the energy system, and K is a conversion coefficient from GWh to bcm (K =9239)[90].

The weighted average efficiency is calculated for each year (2), where P_{nit} is the capacity of the power plant, and η_{nit} is the efficiency[91], taking into account decommissioning and commissioning of new power plants assuming that power plants with the lowest efficiency are replaced by new ones, where P_{nit} is the capacity of the power plant, and η_{nit} is the efficiency of power plant n, in the ES i at time t.

$$\eta_{it}^{av} = \frac{\sum_n P_{nit} \cdot \eta_{nit}}{\sum_n P_{nit}} \quad (2)$$

It is assumed that all new power plants in the first price zone (European part) are natural gas-based with an efficiency of 50 per cent, because they have lower capital costs[92] and natural gas is more competitive in the territories covered by the UGSS[93]. The regions of ES Siberia and ES East are different because of limited access to gas pipelines, so in these areas the type of technology commissioned in these regions is taken from the general schemes.

To provide an analysis of supply and demand deviations from the base scenario in the official projection, the following scenarios were developed:

- ***Base Scenario*** which corresponds to the electricity demand and supply provided in the scheme and program for 2017–2023 and the general scheme for the period up to 2035;
- ***Low Nuclear/Low Hydro Scenario*** is introduced in order to assess the impact on natural gas demand of delays in the construction of nuclear power plants. Such delays require thermal power plants to increase their electricity production in order to cover the missing base load, which leads to higher natural gas demand. Similarly, lower production from hydro power plants results in higher natural gas use for electricity production, especially in the ESs with high hydro power presence (ES Siberia and ES East);
- ***Low Demand Scenario*** considers a combination of Low Nuclear/ Low Hydro and the case when electricity demand after 2023 is even lower than projected in the general scheme for the period up to 2035. Electricity demand growth follows the trend in the scheme and program for 2017–2023 for most ESs, which corresponds to a lower annual GDP growth than expected, of about 0 –0.5 per cent;
- ***Low Demand & Base Nuclear/Base Hydro Scenario*** is a combination of lower electricity demand growth that follows the trend in the scheme and program for 2017–2023, and the case where all nuclear power plants are constructed according to the plan of the generating companies. This scenario is not likely to happen, because high capital investment decisions on building new nuclear power plants or units where there is low demand forecast are unlikely. However, this scenario illustrates the extent of the impact of inter-technology competition on natural gas demand for electricity production. For the ES Siberia and ES East, this scenario shows the lowest demand for natural gas, which would happen in the case of slow demand development and high electricity production from hydro power plants.

[90] Conversion coefficient is taken from: http://www.cogeneration.ru/ratio/
[91] Based on data on power plants in Russia collected by the author.
[92] See Table 3. Approximations of capital cost of different technologies.
[93] See Table 1. Natural gas vs. coal prices.

Table 4: Main assumptions for the scenarios

Energy System	Scenario	Electricity demand growth, %		New gas power plants introduced, MW		New nuclear and hydro capacity introduced, MW	
		2017-2023	2025-2035	2017-2023	2025-2035	2017-2023	2025-2035
Center	Base	0.66	1.62	838	10693	4533	6275
	Low Nuclear/Low Hydro	0.66	1.62	838	13603	3646	5015
	Low Demand	0.66	0.66	838	10693	3646	5015
	Low Demand & Base Nuclear/Hydro	0.66	0.66	838	10693	4533	6275
North-West	Base	0.45	1.78	1038	5348	3596	1799
	Low Nuclear/Low Hydro	0.45	1.78	1038	5348	2447	2398
	Low Demand	0.45	0.45	1038	5348	2447	2398
	Low Demand & Base Nuclear/Hydro	0.45	0.45	1038	5348	3596	1799
Mid-Volga	Base	0.29	1.34	694	4425	0	2510
	Low Nuclear/Low Hydro	0.29	1.34	694	4425	0	0
	Low Demand	0.29	0.29	694	4425	0	0
	Low Demand & Base Nuclear/Hydro	0.29	0.29	694	4425	0	2510
Ural	Base	0.69	1.36	2084	11258	0	1220
	Low Nuclear/Low Hydro	0.69	1.36	2084	11258	0	0
	Low Demand	0.69	0.69	2084	11258	0	0
	Low Demand & Base Nuclear/Hydro	0.69	0.69	2084	11258	0	1220
South	Base	2.3[94]	1.51	1323	6193	1444	0
	Low Nuclear/Low Hydro[95]	2.3	1.51	1323	6193	1444	0
	Low Demand	2.3	1	1323	6193	1444	0
	Low Demand & Base Nuclear/Hydro	2.3	1	1323	6193	1444	0
Siberia	Base	1.29	1.49	225	949	0	1084
	Low Nuclear/Low Hydro[96]	1.29	1.49	225	949	0	1084
	Low Demand	1.29	1	225	949	0	1084
	Low Demand & Base Nuclear/Hydro	1.29	1	225	949	0	1084
East	Base	3.8[97]	1.2	861	1440	320	400
	Low Nuclear/Low Hydro[98]	3.8	1.2	861	1440	320	400
	Low Demand	3.8	1	861	1440	320	400
	Low Demand & Base Nuclear/Hydro	3.8	1	861	1440	320	400

Source: Ministry of Energy, author's elaboration based on proposed scenarios.

[94] The average growth rate is considerably higher than the average rate in Russia due to the connection of Crimea and Sevastopol to ES South in 2017, which added 6.74 per cent to demand in 2017.
[95] Construction of nuclear power plant is delayed.
[96] Hydro power production is in accordance with low water conditions.
[97] The average growth rate is considerably higher than average rate in Russia due to connection of previously isolated territories of Republic of Sakha (Yakutia) to ES East, which added 12.14 per cent to demand in 2018.
[98] Hydro power production is in accordance with low water conditions.

ES Center

Installed capacity of power plants in ES Center was more than 52 GW at the end of 2016. The current capacity mix consists of 2.2 GW of hydro power plants, 12.8 GW of nuclear power, and 37.8 GW of thermal power plants, of which 6.3 GW are coal based. Gas consumption for electricity production was 24.1bcm in 2016. In the ***Base Scenario***, in order to cover the expected demand growth, an additional 1.8 GW of capacity should be added by 2035, taking into account decommissioning of old production capacities. It should be noted that most of this new capacity would be nuclear (2.5 GW) taking into account the decommissioning of old units. Thermal capacity overall would be 1.5 GW less in 2035 than the current amount, the result of decommissioning inefficient and old power generating capacities, and most coal power plants would be replaced by gas power plants. The average efficiency of gas power plants is forecast to increase from 41 per cent in 2016 to 45.1 per cent in 2035, as shown in Table 5. On the other hand, the capacity factor of thermal power plants is expected to reach 57 per cent by 2035 (compared to 40 per cent in 2016), which would lead to higher electricity production, and consequently higher demand for natural gas. The annual gas consumption growth in ES Center for power production until 2035 would be 3.6 per cent in the base case scenario, see Figure 14 (***Base Scenario***).

Table 5: Gas power plant capacity development and efficiency improvement in ES Center (Base Scenario)

	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW	523.8		600	1235				4265	2984	3465
Commissioning, MW	492.5	830						2060	4939.8	3693.2
Installed capacity, MW	28394.4	29224.4	28790.2	28495.2	28495.2	28495.2	28495.2	29865.2	32150.2	29756.2
Average efficiency	40.9 %	41.0 %	41.4 %	41.8 %	42.2 %	42.6 %	42.6 %	42.6 %	43.4 %	45.1 %

Source: Author's calculations.

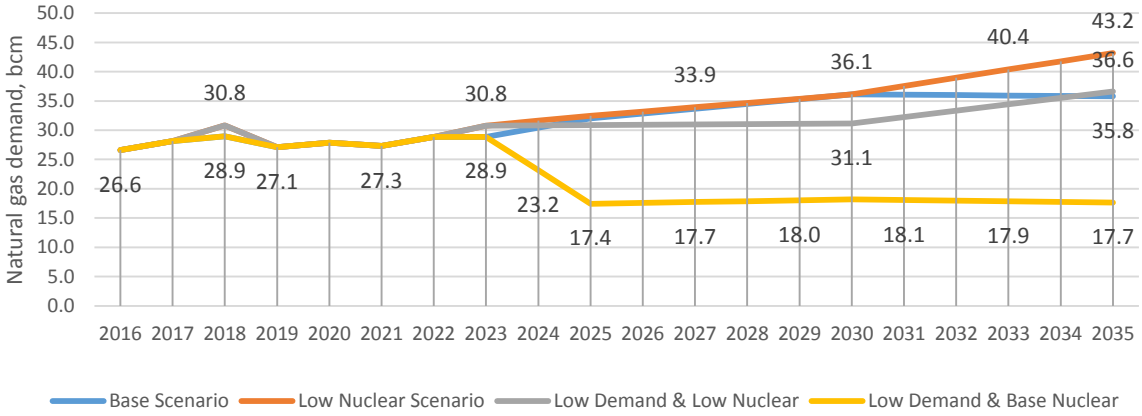
According to the forecasts, 9.9 GW of nuclear power capacity will be introduced by 2035. Given the history of delays and cancellations associated with the construction of nuclear power plants[99], some of the planned commissioning could be postponed. Novovoronezh Nuclear Power Plant II (NNPP-II) with installed capacity of 1195.4 MW should start operations in 2018, and construction has been already completed. However, Rosatom is considering postponing the start-up until 2019 due to concerns about consumer capacity cost increases[100]. The Kursk Nuclear Power Plant II (KNPP-II) project received a license for the construction of its first unit in June 2016, and capital costs are estimated at Rub225 billion[101] ($3.8 billion). The first power block should start producing power in 2022, replacing 1000 MW which should be decommissioned, and another unit should be introduced in 2023. KNPP-II is a strategic project for Rosatom, because it will be the first power plant to be built using a new type of nuclear technology, VVER-TOI. This technology is considered to be a main export product for the company in the future[102], and therefore the introduction of KNPP-II is not likely to be postponed; at the very least, the first unit should be in operation by 2022. However, due to the high capital cost of the power plant, commissioning of the second unit could be delayed by a few years. After 2025, KNPP-II should double its installed capacity, reaching 5 GW in 2035, and the new Smolensk Nuclear Power Plant II (SNPP-II) which will have a capacity of 2.5 GW, should be built to replace the old units at the Smolensk Nuclear Power Plant (SNPP), which are based on old technology, RBMK, designed in Soviet times. The ***Low Nuclear Scenario*** considers the case whereby nuclear power plants are introduced only to replace

[99] Regnum (2012), The decision not to build the fifth power unit of the Kursk NPP is logical: an expert. Link: https://regnum.ru/news/economy/1507185.html
[100] Kommersant (2017), The peaceful atom is put on hold. Link: https://www.kommersant.ru/doc/3448572
[101] RIA (2017), The project of Kursk NPP-2 in 2017 may cost approximately 16.5 billion rubles. Link: https://ria.ru/atomtec/20170111/1485495519.html
[102] NG (2017), The battle for power. Link http://www.ng.ru/economics/2017-10-30/100_7106_atomst.html

outdated RBMK technology, resulting in no nuclear surplus in the ES. In addition, in this scenario the commissioning of NNPP-II and the second unit of KNPP-II is postponed by one year. This case would result in higher demand for thermal power capacity to cover the demand growth and a higher capacity factor to replace nuclear power production. Until 2023, with the current plan for the decommissioning and commissioning of power plants and considering delays in the introduction of nuclear power plants, the required capacity demand is met. After 2023, 3 GW of gas capacity should be built in order to meet expected capacity demand in 2030. A delay in the NNPP-II decommissioning would result in 7.3bcm of additional gas consumption in 2018, and a delay of the second block of KNPP-II would result in the need for an additional 7.6bcm of natural gas supply in 2023, as shown in Figure 14 (***Low Nuclear Scenario***).

The third scenario considers the case where power demand growth continues at 0.7 per cent annually after 2023, as in the scheme 2017–2023. Combined with the Low Nuclear Scenario, this case could be the most probable scenario for ES Center, as shown in Figure 14 (***Low Demand Scenario***). In the Low Demand Scenario, natural gas consumption in 2030 is still higher than in the base scenario, due to lower nuclear production. By comparison, in the ***Low Demand & Base Nuclear Scenario***, natural gas demand could be dramatically low, as most of the electricity demand would be covered by the nuclear power plants. The scenario under consideration assumes that all the planned nuclear power plants would be introduced on time (NNPP-II in 2018, KNPP-II in 2024, SNPP-II in 2035) and demand growth will be at a rate of 0.7 per cent per annum.

Figure 14: Natural gas demand for electricity production in ES Center, bcm



Source: Author's calculations.

ES North-West

Installed capacity of ES North-West was 23.5 GW in 2016. The current mix of capacity consists of 2.9 GW of hydro power, 5.7 GW of nuclear power, and 14.9 GW of thermal power plants, of which only 0.7 GW are coal based. Annual natural gas consumption for electricity production in the ES amounts to 9.3bcm without taking into account gas consumption by power plants operated by industrial companies. The increase in installed capacity would be 3.5 GW by 2035 at the expected rate of demand growth, considering the decommissioning plans, as described in Table 6. The average efficiency of the gas power plants would gradually increase to 52.8 per cent from 49.4 per cent in 2016, which, in combination with new nuclear power production, would keep average natural gas consumption growth at 0.3 per cent until 2023 against a forecast 0.45 per cent power demand growth in the ***Base Scenario.***

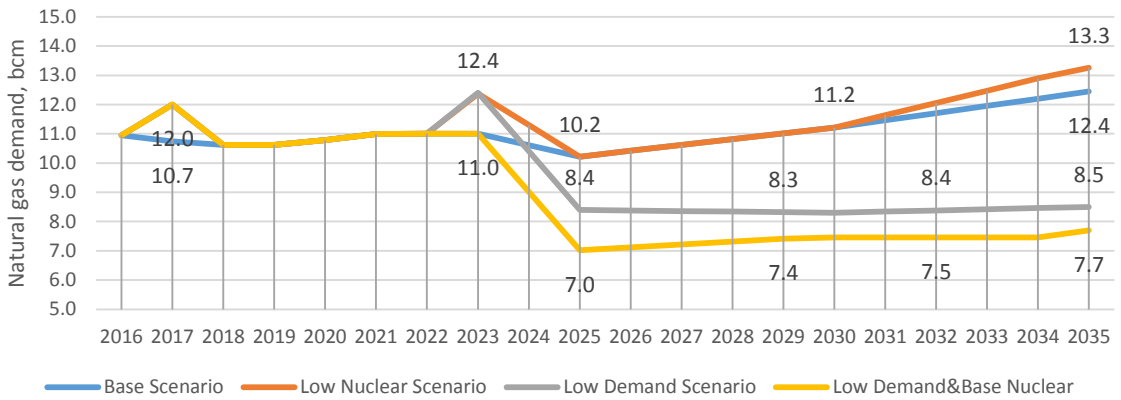
Table 6: Gas power plant capacity development and efficiency improvement in ES North-West (Base Scenario)

	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW	147.5	0	0	18	0	0	0	2056.9	935	1544
Commissioning, MW	75	768	195	0	0	0	0	1254	1882	2212
Installed capacity, MW	11364	12132	12327	12327	12327	12327	12327	11876.1	12823.1	13491.1
Average efficiency	41.8 %	42.4 %	42.5 %	42.5 %	42.5 %	42.5 %	42.5 %	44.0 %	45.9 %	47.9 %

Source: Author's calculations.

The commissioning plan of the ES includes replacement of all units of the Leningrad Nuclear Power Plant (LNPP), a total of 4 GW, via the construction of the Leningrad Nuclear Power Plant-II (LNPP-II) with new VVER reactors. In addition, the commissioning of the new Kolsks Nuclear Power Plant (KNPP) is planned between 2030 and 2035. The first unit of LNPP-II should have begun operations in 2017, but is now expected to start during 2018[103]. The ***Low Nuclear Scenario*** tests the case whereby the nuclear units of LNPP-II are constructed with a delay. The units start operation only when the old RBMK reactors are decommissioned between 2025 and 2030 instead of the planned introduction during the 2020s. The scenario also includes a delay in KNPP's construction, anticipating that it will not be operating before 2030. Each nuclear power unit construction delay would result in higher demand for natural gas in those years, as shown in Figure 15. The average growth of natural gas consumption in this scenario would be 2 per cent until 2023, decreasing to 0.5 per cent after the replacement of all the units of LNPP in 2025–2030.

Figure 15: Natural gas demand for electricity production in ES North-West, bcm



Source: Author's calculations.

In the ***Low Demand Scenario***, electricity demand after 2025 follows the trend of 2017–2023 (0.45 per cent growth), which significantly lowers natural gas consumption by up to 8bcm. The decrease in gas consumption happens due to the commissioning of the new nuclear units of LNPP-II after 2025, which would cover more than half of the power demand. The ***Low Demand & Base Nuclear Scenario*** considers the case of no delays in the introduction of nuclear power capacity, which results in further decreases in electricity production from thermal power plants, resulting in even lower natural gas demand of 7bcm in 2025, which then increases slightly to 7.7bcm in 2035.

[103] TASS (2017) Rosatom launched the first power unit of Leningrad Nuclear Power Plant-2. Link:http://tass.ru/ekonomika/4796474

ES Mid-Volga

Installed capacity in ES Mid-Volga is dominated by gas power plants, which account for more than 16 GW, followed by 6.3 GW of hydro power and 4 GW of nuclear power plant. Natural gas consumption for electricity production was 14.8bcm in 2016, without taking into account gas consumption by the power plants of industrial companies. The medium and long-term schemes consider the replacement of the gas power plants' output by nuclear power by 2030–2035. Nizhegorodsk Nuclear Power Plant (NNPP) with an installed capacity of 2.5 GW should be built in the ES, while the total installed capacity of thermal power plants will decrease by 1.6 GW by 2035. The ES already has 8 GW of surplus capacity: expected peak capacity demand in 2017 was 19 GW, whereas the system had 27 GW of installed capacity at the end of 2016.

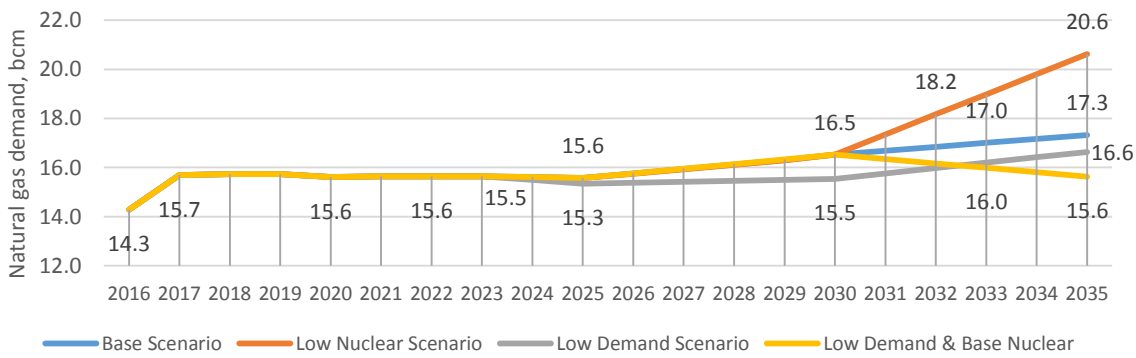
Table 7: Gas power plant capacity development and efficiency improvement in ES Mid-Volga (Base Scenario)

	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW	41	36		305.7				2487	2478.7	1405
Commissioning, MW	413.6	230		50				679	2017.5	1728.5
Installed capacity, MW	17152	17346	17346	17091	17091	17091	17091	15283	14821	15144
Average efficiency	39.8 %	40.0 %	40.0 %	40.4 %	40.4 %	40.4 %	40.4 %	41.2 %	43.2 %	45.5 %

Source: Author's calculations.

The ***Low Nuclear Scenario*** considers the case whereby NNPP has not been constructed by 2025–2035. The installed capacity required to cover the demand growth according to the general scheme in 2035 is 22.6 GW. Without the introduction of NNPP and taking into account all decommissioning of thermal power plants, the installed capacity of power plants in the ES would be more than 25 GW. Therefore, the introduction of additional nuclear power could be postponed. This scenario will result in higher power production by thermal power plants, and consequently higher demand for natural gas by 2035, reaching 21bcm. The capacity factor of thermal power plants will increase from 35 per cent in 2016 to 65 per cent in 2035.

Figure 16: Natural gas demand for electricity production in ES Mid-Volga, bcm



Source: Author's calculations.

The ***Low Demand Scenario*** continues the trend of 2017–2023: demand growth is assumed to be 0.3 per cent, rather than the 1.3 per cent per annum forecast in the general scheme. After 2025, due to the replacement of old generating capacities with new and more efficient ones, gas demand decreases to 15.5bcm. Then it starts to increase slowly, reaching 17.1bcm in 2035. Average electrical efficiency of gas power plants increases from 38.6 per cent in 2017 up to 44.2 per cent in 2035. In the ***Low Demand & Base Nuclear Scenario***, NNPP starts its operation after 2025 and provides the base load, lowering gas demand to 15.6bcm.

ES Ural

ES Ural has the highest natural gas consumption volumes due to the proximity of the region to the gas fields, access to the UGSS, and the high energy intensity of the power consumers situated in the system. Installed capacity of the ES is more than 51 GW, of which more than 36 GW are gas power plants, about 7 GW coal power plants, 1.8 GW hydro power, and 1.48 GW nuclear capacity. There is also a high concentration of capacity at industrial power plants, with an estimated aggregated capacity of 4 GW. Calculated gas consumption for power production was 51.2bcm in 2016, excluding consumption by industrial companies. An additional 3.47 GW of capacity will be introduced by 2035, of which 1.8 GW will be thermal power plants. Additionally, the second unit should be added to Beloyarsk Nuclear Power Plant (BNPP) giving it a capacity of 1.22 GW by 2030-2035 according to the general scheme (***Base Scenario***). Commissioning of new efficient thermal power plants would increase the average electrical efficiency of gas power plants from 39.8 per cent in 2016 to 43.7 per cent in 2035, as shown in Table 8.

Table 8: Gas power plant capacity development and efficiency improvement in ES Ural (Base Scenario)

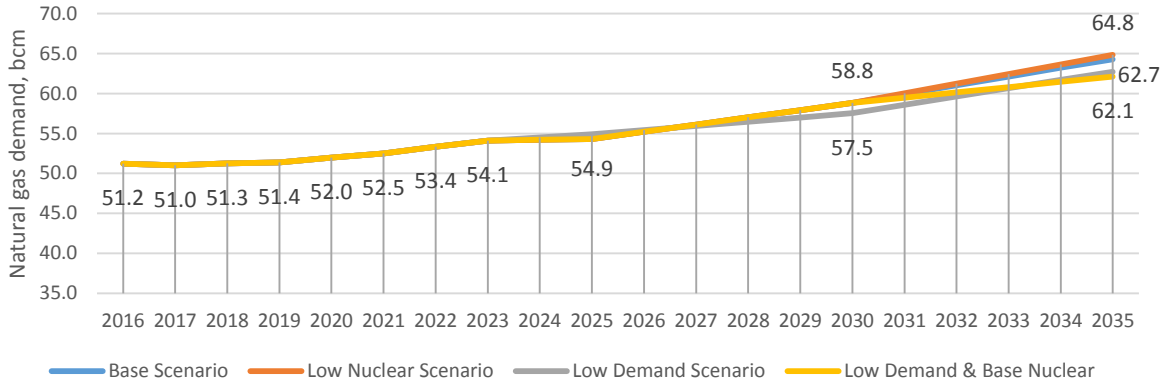
	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW	391.1	643		181.5				3856.1	2691.5	3726.2
Commissioning, MW	2072.5	11.2						1388.77	4346.1	5524
Installed capacity, MW	38782.3	38793.5	38793.5	38612.0	38612.0	38612.0	38612.0	37031.0	39800.5	44483.4
Average efficiency	40.3%	40.3%	40.3%	40.3%	40.3%	40.3%	40.3%	41.5%	42.7%	43.7%

Source: Author's calculations.

The ***Low Nuclear Scenario*** considers the case whereby the second unit of BNPP is not built during the period 2030–2035. Even without the commissioning of the nuclear power plant, installed capacity of power plants in the ES would reach more than 53 GW by 2035, while required capacity by 2035 is 51.6 GW. Therefore there is no need for the construction of additional nuclear capacity. Nuclear power production would be covered by thermal power plants, increasing their capacity factor by 0.8 per cent in 2035. The overall capacity factor of gas power plants would increase from 58 per cent in 2016 to 67 per cent under the Low Nuclear Scenario.

In the ***Low Demand Scenario***, average demand growth continues the trend of the scheme and program for 2017–2023 beyond 2025, with annual demand growth at 0.7 per cent, as shown in Figure 14. Gas consumption in ES Ural is increasing because most of the capacity introduction planned in the system is thermal, except for 399 MW of renewable capacity that should be commissioned by 2035. Therefore, gas consumption is projected to reach 62.7bcm following the growth in power demand. In the scenario where BNPP is introduced, its electricity production would replace production from thermal power plants lowering natural gas demand to 62.1bcm by 2030. The impact of the ***Low Demand & Base Nuclear Scenario*** would not be as significant as in other energy systems because the system would be still dominated by thermal power production.

Figure 17: Natural gas demand for electricity production in ES Ural, bcm



Source: Author's calculations.

ES South

Installed capacity in ES South was 21.5 GW at the end of 2016. The mix of generating capacity in the system is diverse, consisting of 8.8 GW of gas power plants, 2.3 GW of coal power plants, 3 GW of nuclear power, 5.6 GW of hydro power, and the remainder consisting of capacity at industrial companies. Natural gas consumption was 11.5bcm in 2016, and has been decreasing due to the commissioning of the fourth unit of the Rostov Nuclear Power Plant (RNPP) with a capacity of 1.07 GW. In addition, 0.373 GW of hydro power and 1 GW of renewable power capacity will be added in 2017–2023, according to the Base Scenario. As all these technologies have lower marginal costs, due to the merit order effect, they would be selected first in the wholesale market, lowering the competitiveness of thermal power plants. Nevertheless, the capacity of thermal power plants will increase by 1.66 GW between 2017 and 2035, which would allow an increase of average electrical efficiency for gas power plants from 38.4 per cent to 45.3 per cent, as shown in Table 9.

Table 9: Gas power plant capacity development and efficiency improvement in ES South (Base Scenario)

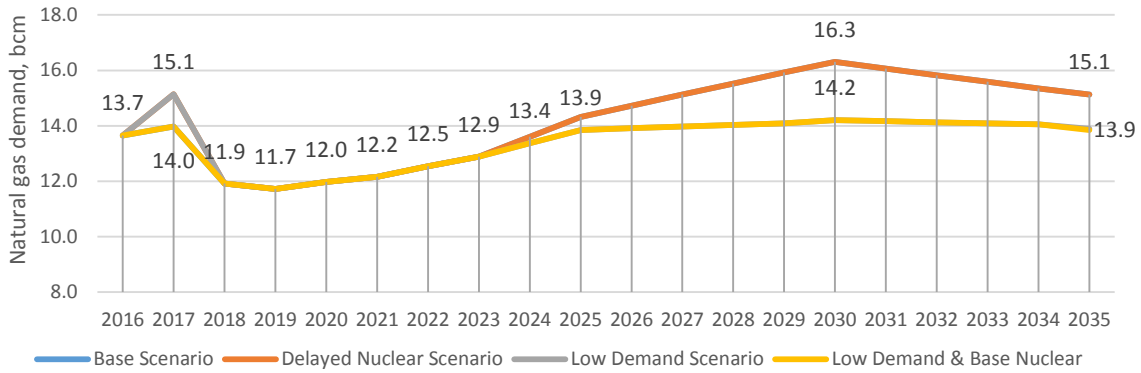
	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW	81	50		25				2078	1215	2402
Commissioning, MW	492.5	830						1545	1515	3133
Installed capacity, MW	9275.4	10055.4	10055.4	10030.4	10030.4	10030.4	10030.4	11257.4	11806.4	11022.8
Average efficiency	38.4%	39.4%	39.4%	39.5%	39.5%	39.5%	39.5%	41.1%	42.9%	45.3%

Source: Author's calculations.

The fourth unit of the RNPP should have begun operating in 2017, but it only received a licence for the operation of nuclear installations in December 2017[104]. It will therefore start producing power from 2018 onwards. The ***Delayed Nuclear Scenario*** therefore becomes the real scenario, and gas consumption should increase by 0.7bcm to substitute for nuclear power production and cover demand growth in 2017, as shown in Figure 15.

[104] TASS (2017) Launch of Rostov NPP and Leningrad NPP will happen in December. Link: http://tass.ru/ekonomika/4784016

Figure 18: Natural gas demand for electricity production in ES South, bcm



Source: Author's calculations.

The ***Low Demand Scenario*** assumes a 1 per cent per annum increase in electricity demand after 2025, which results in a lower capacity factor for gas power plants, and consequently lower demand for natural gas for electricity production after 2024. The high average electricity demand growth in 2017–2023 in ES South was due to the addition of Crimea to the statistics, and the demand growth rate after 2023 will not be likely to exceed the average rate in Russia. In the ***Low Demand & Base Nuclear Scenario***, electricity production from thermal power plants repeats the base scenario up to 2023, and then follows the Low Demand Scenario. The introduction of new nuclear power capacity and new, more efficient thermal power capacity lowers natural gas demand in 2017–2023 and could absorb future demand increases in the case of low demand growth. Therefore, natural gas demand in the low demand scenarios would be at 2016 levels at the end of 2030.

ES Siberia

ES Siberia is characterized by a dominance of coal and hydro power generation. Of total installed capacity of 52 GW, only 886 MW are gas power plants, the rest being hydro (25 GW) and coal (23 GW) power plants[105]. Natural gas consumption for electricity production is about 1bcm, as illustrated by Figure 16. Access to the UGSS is limited in the system, with most of the gas power plants running on associated petroleum gas (APG). Total commissioning until 2023 is expected to be 465 MW, of which 275 MW would be gas power plants, including 150 MW based on APG[106]. APG power plants in the oil fields are not included in the scenarios as they use a by-product of oil production. Nevertheless, gas power capacity is expected to double in 2017–2035, thereby increasing natural gas demand. In addition, the commissioning of new gas power plants would result in the improvement of average electrical efficiency from 33.9 per cent in 2017 to 43.1 per cent in 2035, as shown in Table 10.

[105] There is 2.8 GW of capacity which belongs to industrial companies, and there is limited data on the fuel mixture at those power plants.
[106] Power plants of Vankorneft to be built in 2018.

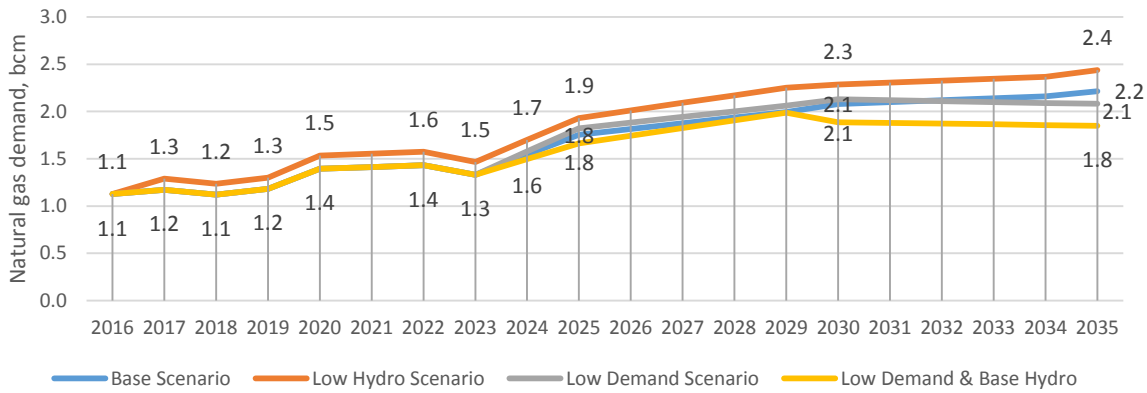
Table 10: Gas power plant capacity development and efficiency improvement in ES Siberia (Base Scenario)

	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW							60	60		
Commissioning, MW		75		170				419	180	
Installed capacity, MW	886.1	961.1	961.1	1131.1	1131.1	1131.1	1071.1	1430.1	1610.1	1610.1
Average efficiency	33.9%	35.1%	35.1%	37.4%	37.4%	37.4%	38.3%	42.2%	43.1%	43.1%

Source: Author's calculations.

The ***Low Hydro Scenario*** shows the case when hydro power output is lower than in the base scenario as a result of weather or climatic conditions. Therefore, power that should have been produced by hydro power plants is partially covered by thermal power plants. The ***Low Demand Scenario*** assumes 1 per cent annual demand growth after 2023. However, in combination with low electricity production from hydro power plants, natural gas demand would be close to levels in the Base Scenario, 2.1bcm in 2035. In the ***Low Demand & Base Hydro Scenario***, natural gas demand could be lower by 14 per cent compared to the base scenario. Overall, natural gas demand in ES Siberia is following an increasing trend and demand could double by 2030.

Figure 19: Natural gas demand for electricity production in ES Siberia, bcm



Source: Author's calculations.

ES East

Total installed capacity in ES East is 9.1 GW, of which 3.3 GW is hydro power, 3.2 GW coal power plants, and 2.5 GW gas power plants. Calculated natural gas consumption for 2016 is 3.1bcm and natural gas is supplied from the gas producing fields in the region. According to the general scheme, the surplus of gas power plants will be 1.9 GW by 2035, while coal power plants' installed capacity will increase by 458 MW. Therefore, consumption of natural gas would double in the ES, as indicated in Figure 17. These dynamics are associated with the development of the Eastern Gas Program, allowing access to natural gas supply for new power plants.

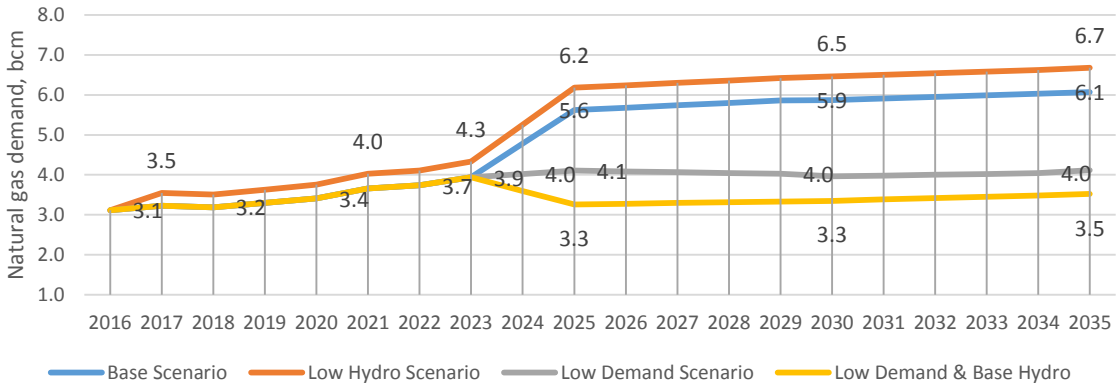
Table 11: Gas power plant capacity development and efficiency improvement in ES East (Base Scenario)

	2017	2018	2019	2020	2021	2022	2023	2025	2030	2035
Decommissioning, MW		41	30	67				283		
Commissioning, MW	295.5				565			1440		
Installed capacity, MW	2848	2848	2848	2848	3413	3413	3413	4570	4570	4570
Average efficiency	36.4%	36.4%	36.4%	36.4%	38.7%	38.7%	38.7%	42.8%	42.8%	42.8%

Source: Author's calculations.

The ***Low Hydro Scenario*** shows the case when hydro power output is lower than in the base scenario as a result of weather or climatic conditions. Therefore, power that should have been produced by hydro power plants is partially covered by thermal power plants. The ***Low Demand Scenario*** assumes 1 per cent annual demand growth after 2023, instead of 1.2 per cent projected in the general scheme. In the ***Low Demand & Base Hydro Scenario***, natural gas demand decreases to 3.5bcm in 2035, comparable to 2016 demand. Therefore, for ES East, natural gas demand is highly correlated with the increase in electricity demand, because this increase will be covered mostly by new gas power plants.

Figure 20: Natural gas demand for electricity production in ES East, bcm



Source: Author's calculations.

Summary for all Energy Systems

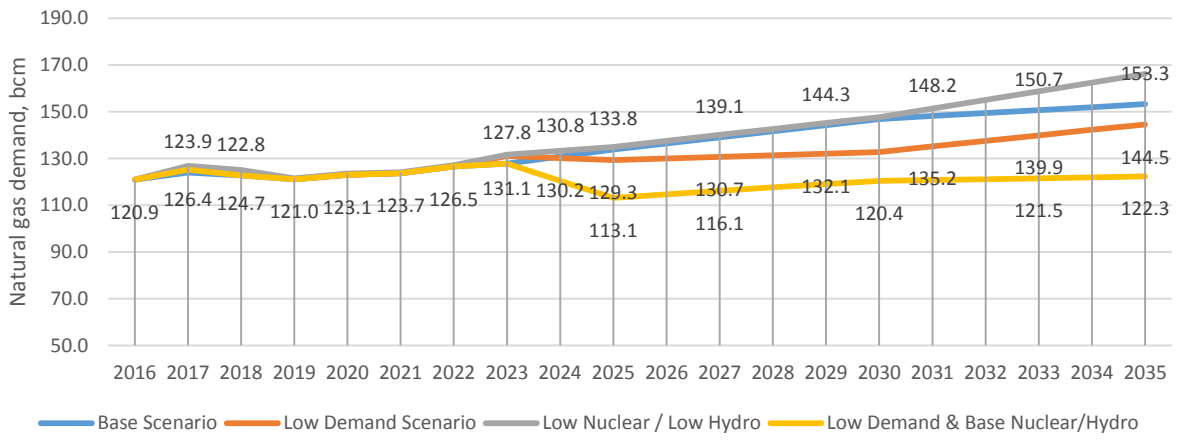
The projections are made for all UES of Russia, excluding consumption by power plants owned by industrial companies, due to limited information on their technological specifications. The combined natural gas consumption projections for all the energy systems of Russia under all scenarios show an increasing trend, even under the Low Demand & Base Nuclear/Low Hydro Scenario, which considers the lowest gas demand scenario. Overall gas demand from energy systems for power production is likely to increase by 20–27 per cent by 2035, even taking into consideration efficiency improvements due to the introduction of more efficient power plants in the thermal power generation mix. High demand for natural gas in the Low Demand Scenario occurs due to delays in the commissioning of nuclear power plants or low levels of hydro power construction, whereby their power production is substituted by thermal power production in a number of cases. Therefore, natural gas demand for electricity production should increase by 20 per cent by 2035 under the Low Demand Scenario, which is most likely scenario of all of those under consideration.

These results are derived by analysing the most likely development of electricity demand and production. However, they can be altered in the case of such extreme events as a very low or even negative electricity demand growth rate, associated with economic slowdown. However, in this situation, the renovation of existing power production assets could be also delayed, resulting in greater

inefficiency in power production, which increases natural gas consumption. Another case which could impact the results is high penetration of RES after 2024 due to the introduction of a new (or the continuation of) RES support scheme. Nevertheless, this event seems unrealistic due to the high cost of RES technologies, and an abundance of cheap fossil fuel.

Natural gas is most likely to be the main fuel in the European and central part of Russia (the first price zone), because gas prices and gas power production technology are economically favourable there. Coal will continue to be a main fuel in the Siberian part of Russia where it is produced and is highly competitive due to low transportation costs. Furthermore, limited coverage by gas transmission systems in the region makes coal the only fuel available for electricity production. However, in ES East, natural gas could increase its share in electricity production because of the construction of a gas transmission network in the region.

Figure 21: Total natural gas demand by power plants for electricity production in Russia, bcm



Source: Author's calculations.

5. The role of natural gas in covering future heat demand

5.1 Heat demand development

Analysis of demand development is limited due to an absence of detailed demand data on final consumption, with the only available data on heat being measured at the producers' end, specifically centrally produced heat before it is supplied to the distribution network. The Law on Energy Efficiency (2009) obliged owners of new and old buildings to install energy consumption metering systems, including heat meters, which would allow consumers to monitor and manage their heat consumption, and give better data on heat losses in the supply system. Obligation for developers to consider energy efficiency and to have energy passports, according to the Law, should prevent the construction of low energy efficiency buildings in the future. The Law obliges each building to have its own energy passport and energy efficiency audit. Therefore, demand for heat should be declining rather than increasing because of more efficient use of heat supply by consumers. After the introduction of the Law on Energy Efficiency, heat production followed a decreasing trend (1.2 per cent between 2010–2015). Heat demand growth is unlikely, because population growth in Russia is low, averaging 0.25 per cent over the last 10 years, and was even negative prior to then. With the existing energy efficiency policy, new housing to accommodate this growth will meet the energy saving requirements, replacing older, more inefficient houses. Nonetheless, the extent of the impact of efficient use of heat on overall heat demand is hard to assess

Another factor which could influence the demand for heat is the implementation of the Heat Reform, which came into force in January 2018. Currently, heat production efficiency is low and heat losses in supply network are about 30 per cent, according to the Ministry of Energy. The Heat Reform should create a favourable market environment to attract investment into the sector in order to renovate obsolete supply systems and to create competition among heat suppliers for more efficient heat production. However, there remains a question mark over the speed of implementation of the Heat Reform, whether it is actually going to be implemented, and if implemented, when it would start to have an effect. The basis for the Heat Reform was established in 2010 with the introduction of the Law on Heat Supply, and a plan of measures to be taken in order to achieve a competitive heat market was also introduced in 2014. Heat sector regulation is a sensitive matter for policy makers due to affordability issues, because half of the heat produced is supplied to residential consumers, who are vulnerable to price increases.

5.2 The Heat Reform

Investments in the heating sector have been delayed for over ten years now, and as discussed earlier, the industry is characterized by capacity oversupply accompanied by low efficiency of heat production and heat supply networks. Heating sector reform was approved in 2017[107], based on the Law on Heat Supply[108] which was adopted earlier in 2010 but which has not been implemented due to concerns about heat price increases. The aim of the reform is to gradually optimise the sector and attract investment through a competitive price formation. There are three main steps in the transition from the old model of the heat supply market to a new, competitive market:

- **Creation of price zones.** The introduction of a new target model of the heat supply market will be carried out in stages in the territories of individual regions and city districts classified as heat supply price zones (excluding cities of federal significance). The list of heat supply pricing zones will be approved by the Government of the Russian Federation based on proposals from the Ministry of Energy. These price zones will become heat supply markets, where price is defined competitively and the maximum price will be limited by the price of alternative boilers.

[107] Russian Federation (2017), Federal Law N 279-FZ of 29.07.2017 On Amendments to the Federal Law "On Heat Supply" and certain legislative acts of the Russian Federation on the improvement of the system in heat supply.
[108] Russian Federation (2010), Federal Law N 190-FZ of 27.07.2010 On Heat Supply.

- **Alternative boiler price** is the price of a new boiler that could be built in order to supply heat to the consumer in the price zone. If the heat price in the price zone is higher than the price of alternative boiler, it would give a clear indication that the heat producers in the zone are not efficient enough, and a new boiler should be built.
- **Introduction of Unified Heat Supply Organization (UHSO).** The UHSO will be responsible for the operation and organization of the heat supply market. It will organize competitive selection of heat producers for heat supplies and volumes, and it will be responsible for the renovation and expansion of heat supply systems. In order to receive the status of UHSO, a heat producer should own the majority of heat production capacities in the heat supply market. The Federal Antimonopoly Service should monitor the actions of the UHSO to avoid market manipulation.

The alternative boiler approach works in two directions: (1) it should prevent more consumers from choosing decentralised or autonomous heat production solutions over centralised heat supply; (2) it should solve the problem of overcapacity in the heat production sector which occurred during the 2000s, leaving only more efficient producers (most probably CHPs). More consumers within a centralised heating system means more consumers in the payment pool, which should guarantee payback of investments in the heating sector. Theoretically, the alternative boiler approach could be a fair solution, which could bring transparency and competitive heat pricing to the heat market and guarantees to investors.

There are many uncertainties regarding the implementation of the Heat Reform. The main question is exactly how the price of the alternative boiler would be calculated and would it be enough to include investments not only in new boilers, but also in the heat distribution network. From the perspective of fuel use, successful implementation of the Heat Reform would result in lower demand for natural gas and coal due to efficiency improvements in heat production sites and distribution, and the impact should be quite perceptible. The Heat Reform would probably be deemed successful if it resulted in competitive and transparent pricing for heat, which would in turn solve the problem of heat capacity oversupply, and attract investments in the renovation of obsolete heat production and supply assets. This will depend upon the speed of uptake of the new rules for the heat sector by regional authorities and district heat producers. An increase in heat tariffs for consumers remains a major concern for the regional authorities, and this will most probably delay the implementation of the new model.

5.3 Scenarios for gas consumption

Natural gas is most likely to continue being the main fuel for heating in the areas with access to the UGSS. Thus, European and Central parts of Russia would still use gas as a main fuel for heating, including the use of natural gas for decentralized heating (residential, small-scale boilers). However, it is difficult to assess demand from decentralized heating due to lack of data on small heating installations, therefore the scenarios consider only centralized heat production. Conversely, in Siberia, heat production as well as electricity production will be dominated by coal burning technologies with the exception of oil production sites and villages, where APG is used for power and heat production purposes. Therefore, for a simplified analysis of gas consumption trends for centralized heat production, the share of natural gas in heat production is pegged at 2016 levels.

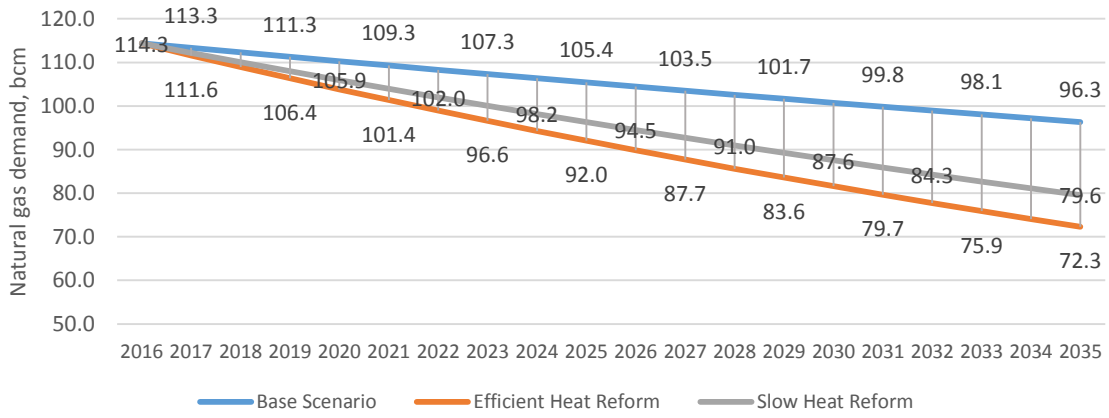
The ***Base Scenario*** for natural gas demand for heating follows the trend of the past ten years, which assumes that demand for heating decreases due to efficiency improvements in heat use by consumers as part of energy efficiency programs. Therefore, annual heat consumption decreases by 0.9 per cent annually. Natural gas's share of heat production stays at the same level as it was at the end of 2015, because it will continue to be used by the same heat production facilities as before. This scenario can be considered as the most conservative scenario as it does not take into account inter-technology competition change or inter-fuel competition. It also does not take into account the possible effects of the Heat Reform. Most probably, in this case it is a question of the proximity of the boiler to the consumer and the efficiency of the heat supply network. The fuel mix for heat production is likely to stay similar

(with the share of natural gas at about 70 per cent), due to the low competitiveness of coal in the western part of Russia and in the Far East.

The ***Efficient Heat Reform*** scenario considers the case where the Heat Reform is implemented in an efficient way, with heat losses reaching a more normal level of 10 per cent by 2035. This indicator of efficient implementation would require efficiency improvements of the heat supply system of 1 per cent annually. Competitive pricing should eventually leave only efficient heat producers in the market, which is most likely to increase the share of CHPs within the heat supply market. The decrease in specific fuel consumption is taken as 0.5 per cent per year for the whole heating sector of Russia. This assumes specific fuel consumption is moderate, although there were higher fluctuations in 2012–2016[109] in both directions, and it is also highly dependent on the mode of CHP or boiler operation. However, for the Efficient Heat Reform scenario the trend is taken as decreasing, whereby average specific fuel consumption in Russia starts from an average of 151.7 kg/Gcal in 2016 and reaches 137.9 kg/Gcal by 2035.

However, there are some uncertainties over the timely implementation of the Heat Reform, which is most likely to face delays, due to reasons discussed earlier. The Heat Reform requires not only regulatory change but also reconstruction of the heat supply system, which could take a considerable amount of time to be built or renovated. The complexity of the actions needed to transform the sector means that its implementation could be delayed, depending on different assessments, by several years. The ***Slow Heat Reform*** scenario considers the case where the heat supply efficiency improvement indicator is twice as low as in the Efficient Heat Reform scenario. The Base scenario and Efficient Heat Reform scenarios would define the range for natural gas demand in the future from the heating sector.

Figure 22: Natural gas demand for centralised heat production in Russia, bcm



Source: Authors' estimates based on proposed scenarios.

It should be noted that Figure 22 considers only centralized heating, but there is a possibility that more consumers, especially large ones, could switch to autonomous heat production if heat tariffs increased. The investment required for heat supply system renovation and expansion makes an increase in heat tariffs an inevitable part of the Heat Reform. In such a situation, the volume of natural gas consumption for heating would still be similar because autonomous boilers would still be using natural gas as a fuel. It is a cheaper and more convenient source of heat, can be delivered through the gas network, and, unlike coal, does not require storage. However, at this stage it is hard to estimate the possible increase in heat tariffs, and consequently to form any conclusions on the potential extent of consumer switching.

[109] Ministry of Energy (2017), State report on the state of energy saving and energy efficiency in the Russian Federation in 2016.

The enormous potential for efficiency improvement at the consumers' end alone would most likely decrease heat consumption, and consequently, natural gas consumption by 20bcm by 2035 with the continuation of the Energy Efficiency policy. The successful implementation of the Heat Reform has the potential to reduce natural gas consumption by another 24bcm by 2035. But there are many uncertainties regarding the timing and extent of its implementation and its impact on the efficiency of fuel use. In any case, the overall trend for natural gas demand from the heating sector is decreasing, with the range of decrease varying from 20bcm to 42bcm by 2035, according to the results of this simplified analysis.

5.4 Summary of the heat sector

There is no official projection for heat demand in the future, however the trend will most likely be decreasing due to the implementation of the Energy Efficiency Law. Considering the high potential for efficiency improvements in Russia, this trend is likely to continue especially when consumers are incentivized by penalties imposed for not taking energy efficiency measures. Reduction of heat losses and heat production efficiency increases could reduce fuel consumption due to the implementation of the Heat Reform. The extent of the reform's impact on fuel consumption is uncertain, however, and depends on the uptake of the new rules for the heat market by the regions and municipalities in Russia. Natural gas will remain the main fuel for heat production because it is cheaper than coal and other oil-based alternatives. Three scenarios of demand development were proposed, and gas demand estimates suggest that, in the case of a continuation of the energy efficiency policy, natural gas demand for heating would decrease by 18bcm by 2035, without taking into account the impact of the Heat Reform. The reform could reduce gas consumption by up to 42bcm in the case of fast and successful implementation, which would see the achievement of normative targets on heat losses and the optimization of heat production in CHP power plants.

6. Conclusions

Natural gas is the main fuel for electricity production in Russia: 120bcm of natural gas was used to produce electricity in 2016, and consumption is increasing due to anticipated electricity demand growth. The additional volumes of natural gas that are needed to cover this demand are estimated to be in a range of 24.5–32.5bcm by 2035 in the Low Demand and Base Scenarios. The introduction of nuclear and large-scale hydro power plants represents a major challenge to gas power plants in the western part of Russia. However, the high capital cost of these technologies and limited resource availability for large-scale hydro power prevent their prevalence in the system. In some regions, there are already cases of delays in the introduction of nuclear power plants. In addition there are plans for the construction of more hydro and nuclear power plants, which are not likely to be realized due to sluggish power demand growth and the existing oversupply of power production capacity.

Heat demand in Russia is declining following the implementation of the Law on Energy Efficiency, which obliged new and old buildings to consider energy efficiency measures and to install heat metering systems. With the implementation of the Heat Reform, which came into force in 2017, heat tariffs should increase, therefore incentivizing consumers to use heat more efficiently. The Reform also aims to increase the efficiency of heat production and to gradually renovate the obsolete heat supply system. However, whether the implementation of the Heat Reform will be successful is uncertain. Nevertheless, the reform should negatively impact natural gas demand for heating as the production of heat should become more efficient, and the renovation of the heat supply system should reduce heat losses. Natural gas used for heating is declining, and according to simplified analysis, gas demand could decrease by 18–42bcm by 2035 from the current 114bcm as a result of a combination of both policies.

Inter-fuel competition between natural gas and coal will remain at its current level, meaning a prevalence of natural gas in the western and central part of Russia, and coal domination in Southern Siberia. Although coal prices are not regulated and considerably lower, power and heat produced using coal becomes high cost due to coal delivery costs from the coal production zones, operational costs related to coal storage, and the capital costs of coal power plant technology.

The analysis in the paper does not consider innovative scenarios such as the larger integration of RES power plants after 2024, when the current renewables support expires. Due to the considerable cost of RES capital compared to combustion technologies, combined with low natural gas prices in Russia, such a scenario looks unlikely.

Taking the analysis of the two elements of the sector together suggests that natural gas demand for the power and heat sectors is not likely to change considerably from its current level. Under the most probable scenarios, power demand for gas should increase by 24bcm, while the decrease in gas demand for heat production in the conservative scenario is also a little above 20bcm. The increase in gas demand from the power sector is therefore compensated by a decrease in demand from the heating sector.

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Appendices

Appendix 1: Natural gas demand for power production[110], bcm

Year	Base Scenario	Low Nuclear/Low Hydro	Low Demand	Low Demand & Base Nuclear/Base Hydro
2016	120.9	120.9	120.9	120.9
2017	123.9	126.8	126.4	125.2
2018	122.8	125.1	124.7	122.8
2019	121.0	121.5	121.0	121.0
2020	123.1	123.5	123.1	123.1
2021	123.7	124.2	123.7	123.7
2022	126.5	127.1	126.5	126.5
2023	127.8	131.6	131.1	127.8
2024	130.8	133.3	130.2	120.4
2025	133.8	135.0	129.3	113.1
2026	136.5	137.5	130.0	114.6
2027	139.1	140.1	130.7	116.1
2028	141.7	142.7	131.4	117.6
2029	144.3	145.2	132.1	119.1
2030	146.9	147.7	132.8	120.4
2031	148.2	151.4	135.2	120.8
2032	149.5	155.1	137.5	121.2
2033	150.7	158.8	139.9	121.5
2034	152.0	162.4	142.3	121.9
2035	153.3	166.2	144.5	122.3

[110] Sum of gas demand projections for all Energy Systems in Russia for different scenarios, described in the section 'Impact of efficiency improvements on natural gas demand', and represented in Figure 21.

Appendix 2: Natural gas demand for centralised heat production[111], bcm

Year	Base Scenario	Efficient Heat Reform	Slow Heat Reform
2016	114.3	114.3	114.3
2017	113.3	111.6	112.2
2018	112.3	109.0	110.1
2019	111.3	106.4	108.0
2020	110.3	103.8	105.9
2021	109.3	101.4	103.9
2022	108.3	98.9	102.0
2023	107.3	96.6	100.1
2024	106.4	94.3	98.2
2025	105.4	92.0	96.3
2026	104.5	89.9	94.5
2027	103.5	87.7	92.7
2028	102.6	85.6	91.0
2029	101.7	83.6	89.2
2030	100.8	81.6	87.6
2031	99.8	79.7	85.9
2032	98.9	77.8	84.3
2033	98.1	75.9	82.7
2034	97.2	74.1	81.1
2035	96.3	72.3	79.6

[111] Gas demand volumes are based on scenarios for heat sector development, described in the section 'Scenarios for gas consumption', and represented in Figure 22.