Energy sector of Russia and Siberia: problems and prospects

N I Suslov, V A Kryukov, V M Markova and V N Churashev
Institute of Economics and Industrial Engineering SB RAS, Novosibirsk, Russia
Novosibirsk State University
E-mail: nsus@academ.org

Abstract. The energy sector of Russia is one of the most potent in the world – it is the second in extraction of oil and gas, the third for total output of fuel and energy resources. While exporting nearly 45% of its total production of energy resources, Russia produces more energy per capita than most other countries – 5 times higher the global average and 3 times higher than the average level for OECD countries. The energy sector of Siberia represents the crucial part of the country’s energy sector. Over decades, the energy resources of the region massively contributed to the Russian federal budget and brought in a major part of hard currency from export trade. In the current conditions of existing geopolitical challenges and expected global demand for energy resources, it is much more of a priority for Russia not to raise the output of fuel and energy resources but to improve the overall quality and reliability of the whole energy supply system, increase the depth of mineral fuel, including solid fuel and waste recycling.

1. Russian energy sector: overall state and trends

The energy sector of Russia is one of the most potent in the world – it is the second in extraction of oil and gas, the third for total output of fuel and energy resources (about 10% of the global output). It has a high scale of nuclear energy use and volumes of oil processing along with leadership in other parameters of energy industry development. However, the Russian economy is still lagging behind the frontrunners of deep processing of raw resources and efficient energy consumption (Tab. 1). While exporting nearly 45% of its total production of energy resources, Russia produces more energy per capita than most other countries – 5 times higher the global average and 3 times higher than the average level for OECD countries. At the same time, the energy-output ratio of the Russian GDP is considerably higher than the global average or that for OECD countries, - by ¾ and twice as much, respectively. It is also higher than in such countries as Canada, Norway, Finland and USA that have higher energy consumption among the OECD countries. Among the contributing factors are severe climate, continental position and vast distances for goods transportation. However, according to our analysis, the more serious aspect of the problem is low efficiency of energy consumption caused by poor production technologies lagging far behind advanced practices, outdated equipment and low quality of general institutions and specialized ones that oversee energy saving measures [1].

The energy sector of Siberia represents the crucial part of the country’s energy sector. It is located on the territory of the Siberian Federal District and Tyumen oblast, which is administratively part of the Urals Federal District. The sector produces over 88% of the total natural gas, 86% of coal and about 2/3 of coal in the country (Tab. 2). Hydroelectric power stations of Siberia represent over half of the total hydropower produced in Russia. Over decades, the energy resources of the region massively contributed to the Russian federal budget and brought in a major part of hard currency from export trade. Currently, up to 40% of gas and coal and all of the oil extracted in Siberia is exported.
Table 1. Energy output and consumption in Russia and globally (% of those in USA)

|                | Per capita GDP PPP, 2010 | Per capita energy output | Energy output to GDP ratio | Per capita energy use | Energy use to GDP ratio |
|----------------|-------------------------|--------------------------|---------------------------|-----------------------|------------------------|
| Canada         | 81.8                    | 209.2                    | 255.7                     | 110.6                 | 135.2                  |
| Finland        | 73.3                    | 51.6                     | 70.3                      | 86.9                  | 118.5                  |
| Norway         | 114.7                   | 637.8                    | 556.1                     | 83.7                  | 73.0                   |
| Russia         | 41.7                    | 147.6                    | 353.5                     | 72.4                  | 173.5                  |
| Sweden         | 85.5                    | 55.3                     | 64.6                      | 68.3                  | 79.8                   |
| OECD           | 72.4                    | 52.0                     | 71.7                      | 60.5                  | 83.6                   |
| World          | 27.8                    | 30.0                     | 108.0                     | 27.4                  | 98.5                   |

Sources: Energy data: International Energy Agency, Population: OECD/World Bank GDP(PPP) (in 2010 USD); OECD/World Bank/CEPII (Paris).

Table 2. Output of Fuel and energy resources by Federal Districts in Russia in 2017

|                | Coal, mill. tons | Oil, mill. tons | Gas, bln m³ | Electricity, bill. kWh | Hydro-power, bill. kWh |
|----------------|------------------|-----------------|-------------|------------------------|------------------------|
| Russia total   | 410.1            | 546.5           | 690.5       | 1090.1                 | 187.3                  |
| Central federal District | 0.2             | 32.0            | 4.9         | 227.6                  | 3.9                    |
| North-West federal District | 8.9             | 12.7            | 19.3        | 119.5                  | 14.6                   |
| Southern federal District    | 5.8             | 1.2             | 0.6         | 72.6                   | 14.9                   |
| North-Caucuses federal District | 0.0             | 0.0             | 0.0         | 26.8                   | 6.8                    |
| Volga federal District      | 0.2             | 117.6           | 22.9        | 183.2                  | 32.4                   |
| Urals federal District      | 1.1             | 302.4           | 589.3       | 195.6                  | 0.0                    |
| Siberian federal District   | 351.4           | 52.5            | 19.7        | 212.6                  | 97.4                   |
| Far-East federal District   | 42.4            | 28.1            | 33.9        | 52.2                   | 17.1                   |

Source: Rosstat data - Unified Interdepartmental Statistical Information System

The prospects of energy development of Russia and Siberia are mostly connected to the opportunities of growth and structural shifts in the country’s economy. In the current conditions of existing geopolitical challenges and expected global demand for energy resources, it is much more of a priority for Russia not to raise the output of fuel and energy resources but to improve the overall quality and reliability of the whole energy supply system, increase the depth of mineral fuel, including solid fuel and waste recycling.

According to the draft of Energy strategy of Russia for the period until 2035 [2], internal consumption of energy resources in the country might grow by 12-27%, that of solid fuel – no more than 7%, gas - by 17%, at most by a quarter. Primary processing of oil may fall by 20-25%, which will be replaced by its deeper processing. Modern trends of business development, greater significance of innovations, and faster growth of human capital economy are bringing about a rise in electric energy consumption – by 24-36%. Additional opportunities for electric energy production appear in view of its export to the countries of North-East Asia. The same may be true for coal: the growth of coal output is possible in the eastern part of Russia being linked to the implementation of eastern ‘corridor’ to Asian-Pacific markets. Development and implementation of technologies for complex and deep utilization of solid fuels represents one of the priorities of technological evolution. The sector of oil and gas complex requires institutional change and technological renovation that may enable
higher resource extraction and allow maintaining the level of extraction, partly due to exploitation of arctic regions and sea shelves.

2. Power industry

In the last years, there were significant changes in conditions that determine development of power industry. High economic growth rates in the first decade of the 21-st century and concurrent acceleration of power (energy) consumption required a General scheme of investment projects for express development of power industry in Russia and Siberia. Subsequent to the crisis of 2009, investors that have privatized power stations practically abandoned their investment programs. As compared to 2000, the power growth in 2017 was only 24 MW.

Table 3. Power generating capacity structure by type of generation, MW

| Type of Generation          | 2000  | 2005  | 2010  | 2017  |
|----------------------------|-------|-------|-------|-------|
| The Russian Federation     | 213.4 | 219.2 | 215   | 237.2 |
| Hydro-power stations       | 44.1  | 46.5  | 44.9  | 50.6  |
| Nuclear power stations     | 21.2  | 23.2  | 24.1  | 28.7  |
| Heat and power stations    | 148.1 | 149.7 | 146   | 157.9 |
| The Siberian FO            | 50.1  | 51    | 49.9  | 51.9  |
| Hydro-power stations       | 23.2  | 22.2  | 22.3  | 25.2  |
| Nuclear power stations     | 0     | 0.2   | 0.2   | 0     |
| Heat and power stations    | 26.9  | 28.6  | 27.4  | 26.7  |

Source: Rosstat data, Unified Interdepartmental Statistical Information System database, reports of RAO UES of Russia, Interregional Dispatching Office

Along with current surplus capacity of United Energy Systems, some subjects of the Russian Federation are facing shortages. At the same time, the capacity utilization factor for heat and power stations is 53.8 for Russia and 56.8 for Siberia.

The Siberian Federal District (SFD), having surplus capacity, experiences a shortage of electric power. The total output in the District in 2017 was 210.4 million kWh. In 2000, the SFD started importing power from Kazakhstan and the Urals FD. A specific feature of SFD power industry is a prevalent part of Hydro-power stations in the overall generating capacity (50% versus 21% on average in the country) and a dominant part of coal as fuel consumed by heat and power stations (84% versus 22-24% of average coal share).

Table 4. The structure of electric power output by type of generation in Russia, million kWh

| Type of Generation          | 2000   | 2005   | 2010   | 2017   |
|----------------------------|--------|--------|--------|--------|
| The Russian Federation     | 877.8  | 953.1  | 1038   | 1090.1 |
| Hydro-power stations       | 165    | 173.4  | 168.3  | 187    |
| Nuclear power stations     | 131    | 149.6  | 170.5  | 203    |
| Heat and power stations    | 580    | 628.5  | 687.1  | 639.8  |
| other                      | 1.8    | 1.6    | 12.1   | 60.3   |
| The Siberian FD            | 195.2  | 199.9  | 210.2  | 212.6  |
| Hydro-power stations       | 92.8   | 96.8   | 91.4   | 93.9   |
| Nuclear power stations     | 0.2    | 1.3    | 0      | 0      |
| Heat and power stations    | 102.2  | 101.8  | 118.9  | 118.7  |

Source: Rosstat data, Unified Interdepartmental Statistical Information System database, reports of RAO UES of Russia, Interregional Dispatching Office

There is an opportunity to launch an additional market for surplus regional energy systems through formation of inter-regional and inter-country ‘power circles’.
However, the current state of Russian power industry demonstrated that the last reform of the industry, which strove to counter a presumed power shortage with simultaneous renovation of productive capacity, failed to resolve the problem and making up additional ones instead. The projected higher demand for power did not materialize. With stagnating levels of demand for electric power, it would have made more sense to modernize existing heat and electricity stations on a wide scale, and at the same time, to build new generating facilities through replacing the outdated equipment. What we see in the industry now is surplus capacity with a higher share of morally and physically outdated equipment.

3. Coal industry
The total volume of extracted coal in 2017 reached 408.9 million tons, having risen from 2000 by 139.9 million tons. Underground extraction in 2017 accounted for 105.4 million tons (26%), aboveground – 303.5 (74%). The share of open mining has been growing steadily (from 62% in 2000), which brought about increased labor productivity (monthly from 102.0 thousand tons/man in 2000 to 192.2 in 2010), relative cost reduction and higher volume of energy coals. The dynamics of energy coal extraction is more intensive, with higher growth, whereas volumes of metallurgical coal show slower growth. Despite the fact that coal processing has grown considerably in the last decades (up to 48%), the share of processed energy coal remains low (below 30%), with 100% processing of metallurgical coal. Unfortunately, there is no demand to boost processing and raise the quality of produced coal from internal customers. Coal enrichment depends solely on export trade. The Siberian FO has been the unchallenged leader of coal production with 85.3% share in the total Russian output.

| Table 5. Coal mining processing in Russia, million tons |
|-----------------|--------|--------|--------|--------|--------|
|                  | 2000   | 2005   | 2010   | 2015   | 2017   |
| The output of the Russian Federation | | | | | |
| Underground      | 90.9   | 104.7  | 102.1  | 103.6  | 105.4  |
| Aboveground      | 167.5  | 195.1  | 221.3  | 270.4  | 303.5  |
| Coal for energy  | 196.9  | 229.9  | 257.9  | 286.3  | 320.3  |
| Coal for metallurgy | 61.0  | 69.9   | 65.1   | 87.7   | 88.6   |
| Coal processing  | 84.8   | 91.8   | 126.0  | 178.3  | 196.5  |
| Export           | 37.5   | 82.5   | 116.4  | 151.4  | 186.3  |
| Extraction in the SFD | 232.7 | 250.6  | 270.9  | 230.1  | 348.8  |
| Source: Rosstat data, Unified Interdepartmental Statistical Information System database |

Almost the entire gain of coal extraction in the XXI century went to export. Thanks to global demand the volume reached 213 million tons in 2017 against 37.8 in 2000. At the same time development of the internal demand came to a halt – the total consumption of energy coal by Russian buyers including import in 2017 was 184.3 million tons (100.5% of 2000).

Under favorable market conditions, coal miners drastically reduced volumes of coal extraction. It should be clear that the strategy of simple extraction growth might no longer be a priority. Competition on the Atlantic market will be intensify, partly due to the shale gas factor that suppressed coal consumption in the USA and pushed the latter towards Europe. According to estimates of the Ministry of Energy, Russian companies may count on having a 50-60 million ton market share for coal in the East.

A major obstacle for coal industry development remains the antiquated transport infrastructure and a high cost of transportation (over 50% for energy and over 30% for metallurgical coal). The combined throughput capability of railway stretches and seaports of Siberia and the Far East is not sufficient to handle the growing demand [3].

Development of the internal market for energy coal is hindered by severe problems caused by shrunken demand from the industry and a fall in demand from utility companies. Significant increment
of energy coal consumption may only be possible within the power industry, but growth prospects of coal-generation have long been a stumbling block between regularly adopted program documents and real life indicator dynamics. Every next forecast brings down the level of projected coal consumption on the internal market.

The prospects of coal consumption growth for the purpose of heat generation within the decentralized system of home heating are limited: on one hand – by the program of the county’s gasification and on the other – by the use of outdated technology of coal burning by layer. That is why coal power generation prospects need to rely on complex strategic optimization of the national fuel and energy balance, combined with resolution of social and economic objectives of coal mining regions as well as streamlining mutual interests of coal mines and power industry at regional and local levels with careful consideration of efficient alternative schemes of municipal power supply [4].

The global experience points to the need for integrated power industry structure with more diversity and shift towards small- and medium-size power enterprises that require state support. It will be necessary to reconsider the logic of power generation development, which is now oriented towards large forms, and the technology of power network building.

The global trends are exerting their influence on our country as well. There is a ‘roadmap’ prepared by the National technological initiative “Energynet” [5] that envisages implementation of a number of pilot projects while setting some ground rules for personnel development. The markets of traditional big power industry are growing by several percentage point a year, while the markets of “Energynet” are growing much faster (such as the segment of reliable and flexible electrical networks).

The technologies of direct coal burning are gradually squeezed out of the power market. The future market of power based on solid fuel will rely on technological power enterprises with complex fuel processing that produce a range of products with high consumer characteristics. Transition from simple burning towards high added value technologies (also known as polygeneration) will raise profitability of municipal and regional power industry and create a new market for the coal industry. This approach stimulates mutual interest of power enterprises and coal mines towards joint

4. Oil-and-gas sector
As indicated in the BP-2018 Outlook [5], Russia will remain the world’s largest energy exporter for the next 20 years. By 2040, Russia will export 9 million barrels of oil per day and 36 bcm of gas. According to BP analyses, by that time Russia will hold the third place in terms of oil production, following the United States and Saudi Arabia, and the second place in terms of gas extraction (after the USA).

Among dominant characteristics of the Russian oil are following:
- a commitment to switching from one oil and gas province (as it becomes more mature) to another new one. The path of development from the 1930s to now has followed this pattern. First it was the Volga-Ural petroleum province, then Western Siberia and the Far East, together with the shelf area of the Arctic and far eastern seas. The main driving idea is to find and put into production new fresh reserves of better quality (bigger, lighter, easier to extract) as fast as possible; but among many other negative effects was the transportation distance from the fields to the main industrial centres (the same problem applies to exports);
- a main emphasis on locating and rapidly developing major and giant fields taking advantage of economies of scale. Economies of scale not only allow cheap extraction of oil from the subsoil but also compensate the high transport costs arising from growing distances. Moreover, they allow huge economic rents to be extracted;
- creation of the capacity to produce hydrocarbons aimed not only at domestic consumption but also for export to other countries.
- because of the former planned economy, a single tightly-integrated infrastructure to deliver, process and transport oil, petroleum products and natural gas was built from the oil and gas provinces to existing refineries (and quite often to refineries which could process oil of a certain quality from a certain area). Russian oil market is dominated by major companies (Rosneft, LUKOIL, Gazprom Neft,
Surgutneftegaz, Tatneft), together producing around 80% of oil, with a small share of local independent companies.

Today in Russia oil and gas condensate production is carried out by 295 organisations, 107 of which are structural parts of 11 vertically integrated companies (VIOCs), mostly oil producers, and 2 mainly gas and condensate producers (as at January 1, 2017). There are also 185 independent producing companies in the industry and 3 production sharing agreement operators. In other terms, around 81% of the total amount in Russia is produced by VIOCs [6].

Country’s gas industry is dominated by state company Gazprom (over 60% of total gas production) with a small number of independent companies. Rosneft, LUKOIL, Gazprom Neft, Surgutneftegaz and other companies, concentrating on oil production, are also involved in gas production, but their share is small (Table 2). Nevertheless, the number of independent companies is expected to grow, stimulating concurrence and subsequent cost reduction and technological progress.

Even though in the upstream and downstream Gazprom is not a monopolist, the Unified Supply System (the world’s largest gas transmission system) belongs to the company. Moreover, Gazprom has exclusive rights to export pipeline gas.

In 2017 Gazprom exported 194.4 bcm of gas (over 90%) to European countries. Since 2009 Russia is an active player on a global LNG market when the first cargo was loaded from Sakhalin II project. The project is realised by Sakhalin Energy, consortium, formed by Gazprom Sakhalin Holdings B.V. (50% plus one share), Shell Sakhalin Holdings B.V. (27.5% minus one share), Mitsui Sakhalin Holdings B.V. (12.5%) and Diamond Gas Sakhalin Holdings B.V. (10%). Another LNG project, which is expected to become the largest LNG production site in Russia, Yamal is managed by Novatek and includes foreign investors (Total, CNPC, Chinese Silk Road Fund). The final construction phase will be completed in 2019, however, supply for long-term contracts has begun since April 2018.

Among main problems of the oil-and-gas development in years to come are following:

a) difficulties arising from specific features of the technological infrastructure developed in Russia. Geography and climate conditions must be mentioned above all. Oil and gas fields are located far from each other and from the consumers, coal basins are situated at a great distance from seaports, electricity transmission covers long distances.

b) declining effects of widely used (and still in use) technologies (like intensive liquid injection, traditional pipeline transportation and so on). Urgent importance of developing new own technologies for exploration, development and transportation of energy resources. This is required as of investments as of service sector development.

Role of science and new technologies are extremely high. Among main indicators of new technologies, first of all, has to be cost reductions at all stages of energy production and transportation. Economic sanctions for Russian companies and banks played an ambiguous role for the country’s economy. From one side, they affected energy sphere, cut the investments and deprived many companies of the possibility to take loans in foreign banks. From the other side, they have reminded of the necessity not to rely only on imported solutions and technologies.

References
[1] Suslov N I 2014 Bulletin of Novosibirsk State University: socio-economic sciences 14 (3) 46-55
[2] Energy strategy of Russia for the period until 2035, Draft (2015) (Moscow) (in Russian)
[3] Long-term development program of Russian coal industry up to 2030 (2014) (Moscow) (in Russian)
[4] Markova V M, Churashev V N 2018 Small-scale Distributed Power Generation Development in the Siberian Regions: Evaluation of Efficiency Modern Management Forum 2(2) (doi: 10.18686/mmf.v2i1.1095)
[5] BP Statistical Review of World Energy (2018 June) 67
[6] Kryukov V A (2016) European Energy and Climate Security. Public Policies, Energy Sources, and Eastern Partners (Berlin: Springer International Publishing) 81-109