Trends and Prospects for Coal Deliveries from Russia's Eastern Regions

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***Abstract* — The coal industry in the eastern regions of Russia is of great economic and social importance. An analysis of the dynamics of coal deliveries from the eastern regions of Russia in 2010–2020 attested to a significant increase in exports while indicating reduced supplies to the domestic market. The eastern direction contributed most to the growth in coal exports. The eastern regions account for about 45% of Russia's coal balance reserves and have a significant potential for the expansion of mining the coal suitable for different uses: export, power generation, coke manufacturing and coke by-product recovery, and coal chemical industry. Based on the existing production capacity and coal mining development projects, the production of coal in the eastern regions is expected to reach up to 195–275 million tons by 2035 and its export volumes are estimated at 75–130 million tons. The expansion of coal supplies is influenced by a variety of factors, including the demand for coal; the condition and capabilities of transport infrastructure; the availability of coal balance reserves and production capacities; the decarbonization of the world's economies; geographical, climatic, geopolitical, and other conditions. The minimum levels of coal supplies correspond to their insignificant growth in the domestic market with moderate growth in exports, and the maximum levels correspond to the maximum possible growth of exports and the commissioning of coal-fired thermal power plants. The potential of the region to supply coal far exceeds the demand for it.**

***Index Terms*: coal, coal balance reserves, eastern regions of Russia, supplies, mining, development of coal mining, projects, reserves-to-production ratio, trends.**

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I. Introduction

The eastern regions of Russia include the federal entities of the Russian Far East and Eastern Siberia. For the economy of Russia as a whole and its eastern regions, coal delivery to the domestic and international coal markets is important. In the domestic market, coal consumers are power facilities (power plants and boilers), coke manufacturing and coke by-product recovery plants, households, and others. The policy prioritizing the conversion of Russia's regions to gas can lead to a significant reduction in coal consumption.

Coal exports from the eastern regions increase significantly every year, thanks to the growth of coal shipments to countries of the Asia-Pacific region (APAC).

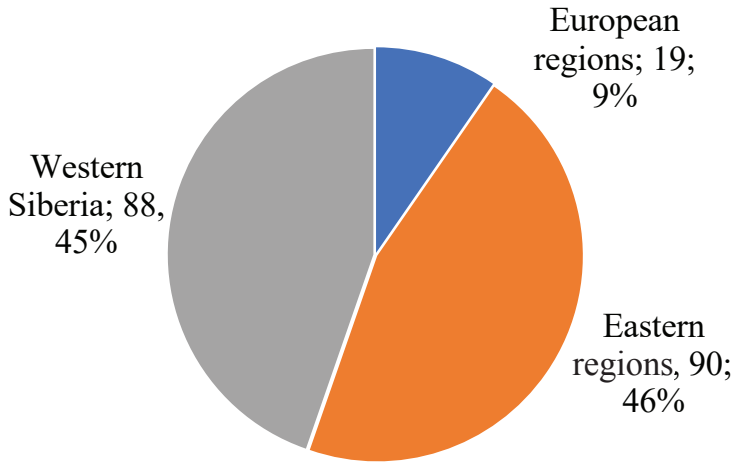
The Energy Strategy of the Russian Federation to 2035 and the Program for Development of the Coal Industry of Russia to 2035 consider the growth of coal production mostly in the eastern regions of Russia and mainly for the development of coal export. Coal mining companies and some power plants using coal as fuel are mainstay companies for monotowns in some regions. Most monotowns are situated in the eastern regions of Russia and Western Siberia. The coal industry is of considerable social importance, primarily because of the high demand for labor and the concomitant need for social services and infrastructure in the coal mining region.

The study of trends and prospects for coal movements from the eastern regions of Russia and the factors influencing the coal supplies is relevant because of the great social and economic significance of coal mining enterprises in the region.

II. Coal Industry of the Eastern Regions of Russia

The eastern regions of Russia have significant coal reserves suitable for various uses, including coal export.

The balance reserves of coal of categories A+B+C1 in the eastern regions are 88 billion tons [1] and account for 45% of those registered in the State Balance Sheet of Mineral Reserves of the Russian Federation (Fig. 1). The assets of the enterprises currently operating in the eastern regions amount to 8.35 billion tons or only 9.5% of the balance reserves of the region, which indicates a considerable potential for their involvement in the economic turnover.



Source: Calculated according to the data presented in the «State Balance Sheet of Mineral Reserves of the Russian Federation as of January 1, 2019» [1].

Fig. 1. Distribution of coal balance reserves of categories A + B + C1 (billion tons; percentage) by region of Russia.

Table 1. Indicators of the coal industry development in Russia and its eastern regions, million tons.

Indicator	Year							2020–2010
	2010	2015	2016	2017	2018	2019	2020	
Production total, incl.	323.4	374	386.9	414.1	441.6	442.7	401.6	78.2
- Eastern regions	111.3	131.2	136.9	142.8	155.2	162	153.6	42.3
Processing, total, incl.	117.6	178.3	186.6	190.3	199.0	210.9	207.2	89.7
- Eastern regions	20.4	39.7	41.6	47.4	47.4	49.0	50.1	29.7
Deliveries to the domestic market, total, incl.	199.8	174.6	167.0	169.9	180.5	180.2	164.0	-35.8
- Eastern regions	92.75	89.07	87.08	90.41	95.88	94.41	85.13	-7.62
Exports, total, incl.	96.3	151.4	162.3	186.3	193.2	193.4	195.5	99.2
- Eastern regions	16.3	30.8	34.2	38.4	42	47.2	53.4	37.1
Share of eastern regions								
- Production	34%	35%	35%	34%	35%	37%	38%	4%
- Processing,	17%	22%	22%	25%	24%	23%	24%	7%
- Domestic market	46%	51%	52%	53%	53%	52%	52%	6%
- Export	17%	20%	21%	21%	22%	24%	27%	10%

Source: The figures for the eastern regions were estimated based on official statistics [3].

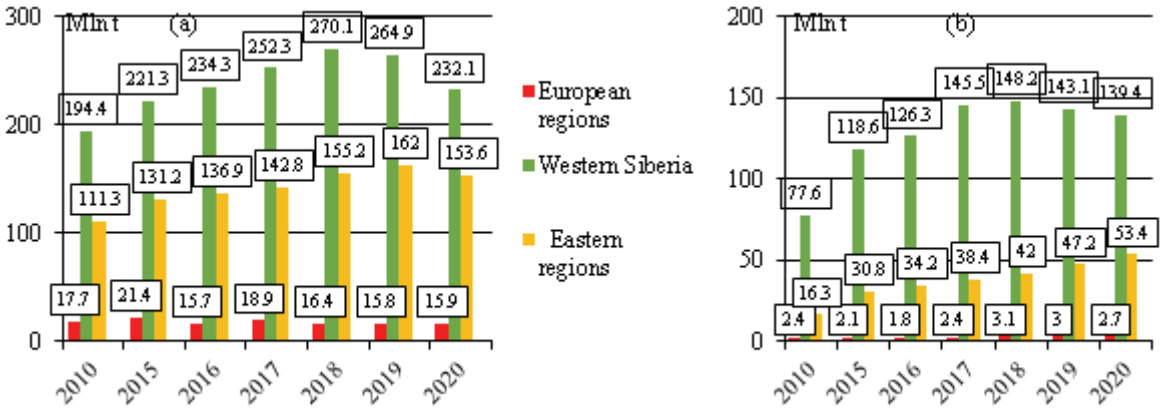
A retrospective analysis of the coal industry development in Russia from 2010 to 2020 shows an increase in the volume of mining, processing, and supply of coal in Russia, and especially that of the eastern regions (Table 1). During the period under review, the proportion of coal originating from the eastern regions in Russia's overall production increased from 34% to 38%. The shares of other regions, including Western Siberia, where the main coal mining facilities are located, decreased. Coal is mined mainly by the open-pit method, which is deemed most economically feasible [2].

The volume of coal production in the eastern regions increased by 42.3 million tons over the period in question (Fig. 2(a)), and in Western Siberia by 37.7 million tons, while in European Russia, it decreased by 1.8 million tons.

The growth in coal production in Russia's eastern regions is mainly due to an increase in exports (Fig. 2(b)) to eastern destinations. The exports of Russian coal in recent years have tended to grow and have exceeded deliveries to the domestic market since 2016 [3]. The main source of growth in exports was the eastern direction [3] due to the strengthening of positions in the markets of countries of the Asia-Pacific region (APAC).

The share of eastern regions in the mix of exports increased from 17% in 2010 to 21% in 2020, although the main growth in supplies was provided by the regions of Western Siberia. Coal export shipments from Western and Eastern Siberia increased approximately twofold, and from the Russian Far East almost fourfold. The growth in coal exports from the eastern regions was also facilitated by the increase in coal processing (Table 1). Exports are mainly high-quality products of coal processing.

Analysis of trends in the production, processing and supply of Russian coal shows the ever-increasing role of the eastern regions.



Source: Calculated based on official statistics [3].

Fig. 2. Dynamics of coal mining and export by region of Russia: (a) – mining; (b) – export.

Table 2. Coal supplies to the domestic market to major consumers, million tons.

Indicator	Year							2020-2010
	2010	2015	2016	2017	2018	2019	2020	
Russia, total, incl.	199.8	174.6	167.0	169.9	180.5	181.3	164.0	-35.8
- Coking needs	38.5	35.2	34.2	31.8	31.6	31.5	34.7	-3.8
- Power plants	95.9	92.1	85.2	87.5	85.8	84.1	73.6	-22.3
- Others	65.4	47.3	47.6	50.6	63.1	65.7	55.7	-9.7
Eastern regions, total, incl.	92.8	89.1	87.1	90.4	95.9	94.4	85.1	-7.6
- Coking needs	0.1	2.1	2.2	2.6	2.7	2.1	1.0	0.9
- Power plants	64.3	64.3	60.5	63.1	67.5	68.3	59.4	-5.0
- Others	28.3	22.7	24.4	24.7	25.7	24.5	24.7	-3.6
Share of eastern regions								
Coking	0%	6%	6%	8%	9%	7%	3%	
Power plants	67%	70%	71%	72%	79%	81%	81%	
Others	43%	48%	51%	49%	41%	37%	44%	

Source: The figures for eastern regions were estimated based on official statistics [3].

III. Coal Supply Trends

A. Domestic coal market.

Analysis of the dynamics of supplies to the domestic market shows a steady downward trend in the coal deliveries in the country as a whole (Table 2). The decrease in coal deliveries across the country as a whole was 35.8 million tons, including 7.62 million tons from the eastern regions, due to the conversion of some consumers, mainly power plants, to gas. Coal deliveries decreased in all areas of its use.

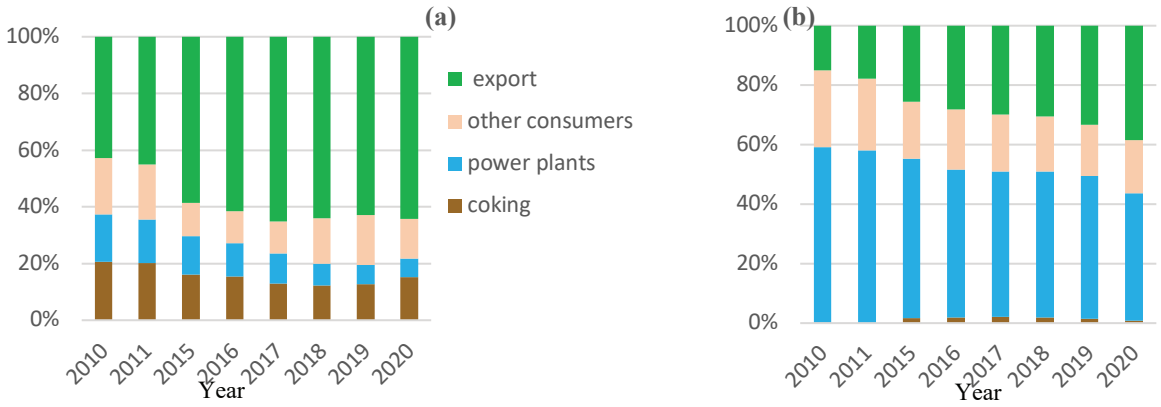
While coal deliveries to the domestic market in Russia as a whole decreased, the share of domestic supplies from the eastern regions increased, almost in all areas of coal use. The main coal consumers in Russia's domestic market are power plants and boilers. In the statistical data [3], boilers are classified as other consumers. Coal supplies to power plants decreased by 22.3 million tons (23% compared to 2010), including nearly 5 million tons or 8% from the eastern regions. At the same time, the coal from the eastern regions supplied to power plants still prevails in the country's supplies, unlike that from the European regions and Western Siberia (Fig. 3). Coal supplies to coke manufacturing and coke by-product recovery plants fell by 7 million tons nationwide, while supplies from the eastern regions increased by almost 2 million tons by 2019. The share of coal from the eastern regions in supplies serving the needs of coke manufacturing and coke by-product recovery in recent years has amounted to 7–9% of total supplies.

The 2020 supply volumes are not representative because of the downturn in the economy associated with the pandemic.

Most consumers of coal from the eastern regions are located in the regions of coal mining and those closest to them. Only coal from Krasnoyarsk Territory (Kansk–Achinsk) and Khakassia are supplied to the European regions and the Ural.

B. Export.

Internationally, Russia is one of the leading countries in terms of available reserves of coal, its production, consumption, and exports. The eastern regions of Russia play an important role in this. Data from Russian [3] and international [4] statistics on coal production in Russia and other indicators differ, but this has no effect on Russia's position in the international coal market. Only the United States is ahead of Russia in terms of coal reserves. Russia



Source: Calculated according to international statistics [4, 8].

Fig. 3. Deliveries of Russian coal: (a) from European regions and Western Siberia; (b) from the eastern regions.

Table 3. Export destinations of Russian coal, million tons.

Indicator	Year							2020 - 2010
	2010	2015	2016	2017	2018	2019	2020	
Exports, including	96.3	151.4	162.3	186.3	193.2	192.3	195.4	99.1
Eastern direction	7.1	45.4	51.2	60.4	60.4	63.1	73.5	66.4
incl. export from the eastern regions	0.9	29.2	32.4	36.2	36.3	44.6	48.7	47.8
Western and southern directions	89.2	106.0	111.0	125.9	132.8	129.2	122.0	8.7
Share of exports to the eastern directions	7.4%	30.0%	31.6%	32.4%	31.3%	32.8%	37.6%	
Share of eastern regions in export volumes to the eastern destinations	13%	64%	63%	60%	60%	71%	66%	

Source: Calculated according to official statistics [3].

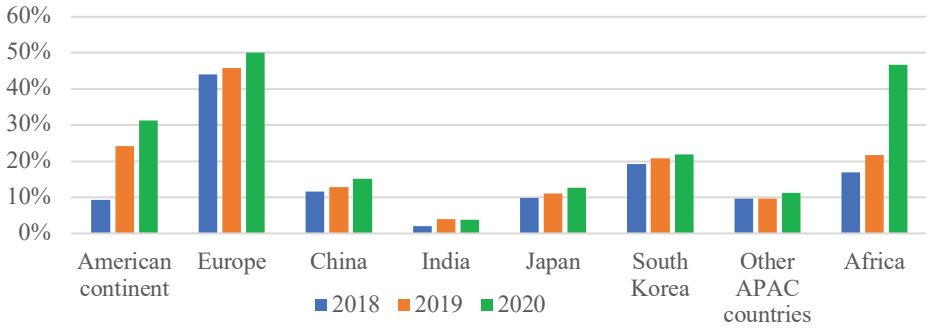


Fig. 4. The share of Russian coal in total imports of the importing countries.

is second in exports only to Australia and Indonesia, and ranks 6th after China, India, Indonesia, the United States, and Australia in terms of production volumes. Russia's share in global coal exports grew from 9.9% in 2010 to 17.8% in 2020 [4].

In the period from 2010 to 2020, exports from Russia more than doubled (Table 3) [3]. Deliveries to eastern destinations increased more than tenfold from 7.1 million tons to 73.47 million tons, including those of coking coal from 2.3 million tons to 10.97 million tons. Russian coal exports to western and southern destinations increased by about 40% from 89.2 million tons to 122 million tons. Growth in exports to eastern destinations was provided by coal mining enterprises in Western Siberia and the eastern regions. Enterprises based in the eastern regions accounted for more than 70% of the increase in exports eastward. Russia delivers coal to the world's largest coal importers, including China and Japan, South Korea, Taiwan, India, Malaysia, and Vietnam [5].

According to international statistics [4-8], the share of the eastern direction in export deliveries increased from 46% in 2018 to 56% in 2020. There is an upward trend in the share of coal imports from Russia in the imports of the world's main coal importers, including China, Japan and South Korea (Fig. 4).

The competitors of Russian coal in the APAC coal market are Indonesia, Australia, USA, South Africa, and Mongolia. If one takes into account the coal reserves-to-production ratio in these countries [4], then there may be fewer competitors in the future (Table 4). Coal reserves-to-production ratio is calculated by dividing proven reserves by annual production [4] and stands for the number of

Table 4. The share of the main coal exporters in the coal import by the main importers of Russian coal at the Asia-Pacific market in 2020.

Country, indicator	Russia	Australia	Indonesia	Mongolia	South Africa	Others
China	12.8%	32.3%	34.2%	16.0%		4.8%
India	3.9%	14.6%	45.8%		21.1%	14.6%
Japan	11.0%	58.7%	14.4%			15.9%
South Korea	20.9%	36.3%	21.3%			21.5%
Other Asia-Pacific countries	9.7%	28.8%	46.7%			14.8%
Country's share in world imports	16.6%	27.5%	26.0%			29.9%
Coal reserves-to-production ratio, years	407	315	62	58	40	

Source: Calculated according to international statistics [4].

years that natural resources will last if consumption rates remain the same.

Most regions export products of hard coal processing, i.e., steam and coking coal concentrates. Low-grade coal processing products are supplied to the domestic market. Run-of-mine coal is exported in insignificant quantities.

Growth in coal production in the eastern regions is associated with the growth of exports [3]. The clear leader is the Sakhalin region, where with an increase in production by 10 million tons in the period under review, exports rose by 12.36 million tons, which is partly due the proximity to target APAC markets. Export shipments from the Republic of Khakassia, Transbaikal Territory, and the Republic of Sakha (Yakutia) increased significantly. Khabarovsk Territory, the Tyva Republic, and Chukotka Autonomous District, which had not exported coal before 2010, became coal exporters as well.

An analysis of coal supply trends shows that the coal industry in Russia and especially in its eastern regions is becoming more and more export-oriented.

IV. Prospects for Coal Supplies from the Eastern Regions

A. Domestic coal market.

Supply of coal from the eastern regions to the domestic market depends on its use mainly for the needs of the energy sector (mostly at power plants). Other uses (coke manufacturing and coke by-product recovery, coal chemical industry) and other consumers (boilers, households, industrial sector, and transport) have a less significant impact on supply volumes. The tendency to reduce supplies to consumers will continue due to the activities aimed at converting certain categories of consumers to gas.

Projects to build coal-fired power plants in Eastern Siberia and the Russian Far East have been considered in various state federal and regional strategies and programs (Program for the Development of the Russian Coal Industry to 2035; Energy Strategy of the Russian Federation to 2035; Scenarios for the Development of the Russian Electric Power Industry to 2030; Federal Target Program «Economic and Social Development of the Russian Far East and the Baikal Region to 2025»). The above documents envisioned the construction of coal-fired thermal power plants using low-grade products of coking and steam coal processing, and run-of-mine coal. Projects to build coal-fired thermal power plants from time to time appeared in and disappeared from policy documents over the years. The revision of the Coal Industry Development Program approved in 2014 considered the construction of several coal-fired power plants at different coal deposits of large (2 400–4 800 MW) and smaller (900–1 500 MW) capacity. The construction of coal-fired power plants was considered for the Irkutsk and Amur Regions, Transbaikal and Khabarovsk Territories, and some other eastern regions.

Most of them were focused on electricity export. In the latest revision of the program, the number of coal-fired power plant projects has been reduced and the construction of power plants for electricity export is not currently being considered. The coal deliveries from the eastern regions to the domestic market can be increased mainly by constructing power plants, However, their decrease is possible due to the conversion of coal consumers to gas. In the short term, the conversion of some power plants in some Russia's eastern regions to gas cannot have a significant impact on the volume of coal supplied to power plants. The conversion of power plants in the Russian Far East (Vladivostok CHPP-2, Khabarovsk CHPP-2, and Anadyr CHPP) to gas, leads to a reduction in coal supplies by about 0.5 million tons, which is much less than the annual fluctuations of coal deliveries to the region's power plants due to climatic conditions.

The program documents do not provide for significant expansion of coke manufacturing and coke by-product recovery and it is most likely that the volumes of supplies targeting this area of coal use will stabilize.

According to the Strategy for Long-Term Development of the Russian Federation with Low Greenhouse Gas Emissions to 2050 and the conversion of consumers to gas, it is projected that the coal consumption by boilers, the industrial sector, transport, and households will go down.

Almost all brown coal and low-grade hard coal are suitable for the needs of the coal chemical industry. Their greatest resources for the development of coal chemical industry are the coal of the Kansk-Achinsk coal basin, the Amur Region's lignite deposits Svobodnoe, Sergievskoe,

Table 5. Possible range of increase in coal production and export, million tons/year.

Indicator	Year		
	2020	2030	2035
	Actual	Possible range	
Production	153.6	182–227	195–275
Export	53.38	64–94	75–130

and Tygdinskoe. Existing projects for the development of coal chemical manufacturing, differ in their degrees of completion, from a preliminary assessment to the specific implementation steps. The most mature project is presented in the Program for Development of Innovative Territorial Cluster «Integrated processing of coal and man-made waste» in the Kemerovo region. In the short term, the supplies of coal for the needs of the coal chemical industry cannot have a significant impact on the volume of supplies for other purposes.

Integrated use of coal is possible when creating a deposit-based cluster comprising the facilities of coal production, power generation, coal chemical industry, and others for processing waste from major enterprises, including recovery of valuable elements and production of construction materials. The mix of enterprises of such clusters is deposit-specific because each deposit has unique mining, geological, and hydrological conditions of development; chemical composition of coal and its quality characteristics; and the state of transport and energy infrastructure. [9–11].

B. Export.

The decarbonization policy in most countries leads to adjustments in projections of demand for coal. At the same time, according to experts, the demand for coal in APAC countries continues to grow. According to the projection by the British oil and gas company BP, by 2040 global coal consumption will increase slightly (0.8%) compared to 2016, with reduced consumption in most countries of the world and increased consumption in APAC countries [12]. China (25% of global coal consumption, despite the decline in overall consumption) and India (14% of global coal consumption) will remain the leaders. According to the projection made by the International Energy Agency [6, 12], demand for coal is also expected to grow in Asian countries, with relatively stable volumes of consumption in other regions of the world. East Asian countries are importers of Russian coal, and coal mining enterprises in the Russian Far East are geographically advantageous for selling coal to Asian markets. The main competitors of Russian coal in this market are the largest coal exporters: Australia and Indonesia.

If the state of the coal market is favorable, the prospects for the development of Russian exports, especially those of coal from the eastern regions, are quite bright.

Analysis of existing investment projects, disregarding the demand for coal in the future, indicated the possible ranges of increasing the coal production and exports (Table 5). Growth in coal production is possible in almost all eastern regions of Russia, which is to be achieved through the utilization of production capacities to a fuller extent and the reconstruction of existing facilities and construction of new ones. First of all, this will affect regions with sufficient reserves of high-quality coal, which is in demand in the world market. Coal exports from the Republics of Khakassia and Sakha (Yakutia); Sakhalin Region; Krasnoyarsk, Khabarovsk, and Primorsky Territories could grow by one and a half times or more as compared to 2020. There may be a significant increase in coal exports from regions that previously exported coal in small volumes (the Tyva Republic, Magadan Region, and Chukotka Autonomous District), as well as from the Kamchatka Territory and Amur Region, which previously did not export coal.

V. Factors Influencing the Development of Coal Supplies

The main factors influencing the development of coal supplies are the demand for coal, the balance coal reserves, and the condition and capabilities of the transport infrastructure. With the growing demand for coal, mainly in the international coal market, there are also factors both favorable for coal supplies and limiting them. The most important of these are geopolitical conditions, the policy of the Ministry of Transport of the Russian Federation on prioritizing freight carried by rail transport, the availability of balance reserves and production capacity of facilities, and the decarbonization policy of the world's economies. Other factors such as coal prices, geographic, climatic, geopolitical, and other conditions can both facilitate and constrain coal supplies.

A. Demand for coal in the world market.

Projections of coal consumption in the world made by international organizations in different years are characterized by great uncertainty and ambiguity [6, 12–14]. The growth in demand for imported coal is predicted for APAC countries. Developing APAC countries are building coal-fired power plants and are planning to build new facilities using coal as fuel [15].

Volumes of coal imports are influenced by changes in the economic growth rates in the importing countries and unpredictable conditions of economic development caused by political decisions, such as sanctions, and others. The greatest growth in demand is possible in India, with a drop in demand in China and its stabilization in South Korea, Japan, and Taiwan. The decline in demand for imported

Table 6. Balance reserves of coal in the eastern regions, billion tons.

Coal type, mining method	Balance reserves by category			Off-balance reserves
	A+B+C1	C2	A+B+C1+C2	
Total, incl	88.0	39.9	127.8	29.2
- Brown	61.2	25.4	86.6	12.0
- Hard	26.7	14.4	41.2	17.1
Including coking, of which	8.9	4.5	13.4	1.4
- High-value coals	4.3	2.7	7.1	0.1
- Anthracite	0.03	0.03	0.07	0.07
Open-pit mining, total, incl.	71.7	28.5	100.1	16.0
- Brown	57.8	22.5	80.3	10.4
- Hard	13.9	6.0	19.8	5.6

Source: Calculated based on the data presented in the «State Balance Sheet of Mineral Reserves of the Russian Federation as of January 1, 2019» [1].

coal in China is also due to plans to increase domestic coal production [16].

In May 2021, the independent international pricing agency Argus held the conference «Russian Coal 2021 – CIS and Global Markets» [17]. The global market review at the conference noted the prospects for coal demand recovery after the Covid-19 pandemic, changes in trade flows and the strengthening of Russian coal's position in premium and growing markets such as China, Japan, South Korea, and Taiwan. It was also noted that there were prospects for an increase in the share of Russian coal in imports of APAC countries.

The reduction in demand for coal in coal-importing countries is due to the following: domestic policies regarding energy sources, the achievements in energy conservation, the shift from energy-intensive industries, and the development of new, more efficient energy sources.

B. Geopolitical conditions.

Currently, geopolitical conditions have become one of the most important factors influencing the volume and destinations of coal exports [18]. In the eastern regions, restrictions due to sanctions related to Russia's special operation in the Ukraine affected only Khakassia, which supplied coal to Poland and Great Britain. According to 2020 data, 1.9 million tons of 12.7 million tons were supplied from Khakassia to the above countries [3].

The largest importers of coal from APAC countries (China, Japan, and the Republic of Korea) have not joined the direct sanctions, which is why there is a theoretical possibility of redirecting exports to APAC countries. The main obstacle to coal exports to eastern destinations is the low throughput capacity of the railroads.

Changing geopolitical conditions can not only fundamentally alter the volume of supplies but also redraw the map of coal transport destinations.

C. Policy of the Ministry of Transport of the Russian Federation on prioritization of freight carried by rail transport.

In the current geopolitical context, the policy of the Russian Ministry of Transport has become the most important factor affecting the volume of coal supplies. The greatest damage from the sanctions for coal shipments from the eastern regions is related to restrictions on the transport of coal eastward since the policy of the Ministry of Transport of the Russian Federation on prioritizing freight carried by rail transport has changed.

Freight carried by Russian Railways is divided according to tariff classes. There are three tariff classes [19]. The first class, which includes coal, was a top priority, and freight of this class was transported at lower rates. Freight of the second class is transported at cost price. Relegation of coal from the first to the second tariff class is being discussed [20], which can render coal exports uneconomical.

Due to the insufficient throughput and carrying capacity of the railroads of the Eastern Polygon, the Government of the Russian Federation adopted Resolution No. 304 of March 6, 2022 «On Suspension of the Decree of the Government of the Russian Federation No. 710 of November 25, 2003 [21].

According to the rules of non-discriminatory access to the railway infrastructure, «transport of export coal from Kuzbass, Buryatia, and Khakassia in an eastward direction falls into the category of transport formed by the decision of Vladimir Putin,» subject to quotas. The total volume of quotas is 76 million tons, of which 18 million tons are for the eastern regions of Russia, which is less than 40% of the coal exported in 2020. Export-quality coal from other regions is not considered. Such a situation could lead to «the breakdown of contracts, failure to fulfill obligations, shutdown of enterprises, job cuts in the regions, a reduction in tax revenues and foreign exchange earnings [21], and a significant increase in social tension. This is especially true of monotowns, where the existing conditions will increase unemployment.

D. Balance coal reserves.

The availability of significant balance coal reserves is a favorable factor for the development of production and increase in coal supplies. A wide range of qualitative characteristics of coal from the eastern regions of Russia determines their suitability for different uses: exports, power generation, coke manufacturing and coke by-product

recovery, coal chemical industry.

The balance reserves of coal of categories A+B+C1 in the eastern regions amount to 88 billion tons (Table 6). These reserves are promising in terms of their development with the state-of-the-art technology. Significant volumes of C2 reserves (39.9 billion tons of balance reserves and 29.2 billion tons of off-balance ones) create prospects for their further commercial development.

The ratio of balance reserves of categories A+B+C1 to inferred resources or the degree of exploration is low and averages only 10%. The degree of exploration differs greatly for different entities of the Federation and different areas of the region - from 0% to 50% or more. The appropriate exploration work will make it possible to book the inferred coal resources in the State Balance Sheet of reserves, which will increase the balance coal reserves.

The share of coal suitable for export in the balance reserves of categories A+B+C1 (hard coal: steaming and coking) is 30%. Steaming coal is represented by hard coal (including that suitable for export) and brown coal, their share in the balance reserves is 79%, with the predominance of brown coal. The main possible use of low-rank brown coal is for power generation. Hard coal from most of the deposits in the eastern regions can also serve as fuel for power plants. Other resources for the energy sector include low-grade products of coking and steaming coal processing. The coal reserves-to-production ratio for export from the eastern regions (at the 2020 level of volumes supplied) is about 500 years. Excluding resources for export, the lignite reserves-to-production ratio of the eastern regions alone exceeds 700 years for the needs of domestic consumption. Such a calculation is approximate; nevertheless, it allows estimating the possible horizons of coal deliveries, irrespective of the addition of promising deposits to the balance sheet of reserves.

Coal is a powerful sorbent. Coal from deposits located in the eastern regions contains rare-earth and other components such as germanium, vanadium, chromium, gold, platinum, silver, titanium, and others, and in the case of some deposits the above are available in commercially significant concentrations [22–24]. Development of new technologies for the recovery of rare and rare-earth elements from coal and coal combustion products are subjects of numerous studies in many countries [25–29].

The significant balance coal reserves available in the eastern regions and favorable mining conditions for most of the deposits create opportunities for the expansion of coal production.

E. Current state of the transport infrastructure.

Most of the coal supplies (88% of the production volume in 2020) are transported by rail to the domestic coal market and to shipping ports and border crossings for export [30]. About 90% of Russian coal is exported by sea, in particular, through the ports in the Russian Far East. A serious issue is the remoteness of coal mines from export ports and the limited capacity of port facilities.

Growth in coal exports to eastern destinations caused an increase in rail traffic along the key routes of the Eastern Polygon, which includes the Far Eastern, Trans-Baikal, Krasnoyarsk, and East Siberian rail lines. The carrying and throughput capacity of the railroads, as well as that of coal terminals impose constraints on the transport of demanded coal volumes. Although the Russian Railways has been implementing the program to modernize the Eastern Polygon since 2013, the measures taken to date fail to meet the growing need to increase the volume of transported cargo, including coal.

Infrastructure constraints are the main obstacle to the increase in coal supplies from the eastern regions to APAC countries. According to analysts from the journal Mining Industry [31], about 6% of exports to APAC countries has to be transported via a «bypass» route running through the ports of the Baltic, Arctic, Black, and Azov Seas. Because of the poor throughput capacity of the Eastern Polygon, Elgaugol LLC (owned by A-Property) decided to put on hold mining at the Ogodzhinskoye deposit in the Amur Region in 2021 to ensure the shipment of the produced output from the top-priority Elga open pit [32]. The growth of coal supplies to eastern destinations has greatly exacerbated the problem of high utilization of the Eastern Polygon. Technologies are also developed and used to increase the weight of freight in railcars. SUEK–Kuzbass Joint-Stock Company's Transport Department together with JSC Russian Railways have developed and implemented a technology to increase the weight of freight to be carried by standard railcars up to 65–71 tons, and in the latest generation of railcars – up to 77 tons. The use of advanced technology allows a more intensive use of the eastern railway route, which has infrastructure limitations in terms of throughput and carrying capacity.

Coal deposits deemed promising for development are often located in regions with underdeveloped or non-existent transport infrastructure, which significantly increases the time of development of such deposits, for example, coal deposits in the Republics of Tyva and Sakha (Yakutia).

F. Coal prices.

Two types of coal (steaming and coking) are sold in the world market. Their prices differ significantly. The average monthly price of coking coal can be higher than that of steaming coal by 1.5 to 2.8 times [32]. Coking coal accounted for only 12% of total coal exports from Russia's eastern regions in 2020 [3].

The price of steaming coal is also influenced by the prices of other energy carriers largely by gas and to a lesser extent by oil. As gas prices rise, coal, being a cheaper resource, becomes more economically feasible, which can push coal suppliers to raise coal prices.

Coal prices depend on the type of contract. It is customary to distinguish between long-term contract

prices and short-term (spot) ones. Spot prices are more sensitive to market conditions and are subject to greater fluctuations than long-term prices. For example, over the past five years, the average monthly price fluctuations for Russian steaming coal in contracts ranged from $51 to $92/t, and spot prices over the same period ranged from $47 to $170/t [33, 34]. Amid rising gas prices and declining coal exports from Australia, international coal prices continued to fluctuate with a pronounced upward trend in 2021, reaching record highs in April 2022 for coking coal at $444.8/ton and steaming coal at $325.3–333.8/ton in the Asian market [35].

The most significant price fluctuations are associated with a slowdown and then an increase in the rate of economic development related to the pandemic and geopolitical conditions. Analysis of the dynamics of coal prices in the APAC market [4] and the volume of coal exports from the eastern regions [2, 3] shows an increase in exports regardless of price fluctuations [3, 7]. This indicates the presence of sufficiently favorable price conditions for coal export from the eastern regions in the medium term.

Final coal prices depend on the relationship between supply and demand in the coal market. In the domestic market, the main consumers of coal are power plants. Each power plant is designed to burn coal from a specific deposit and supply volumes, accordingly, depend little on the price of the coal supplied. Analysis of the dynamics of average coal prices in the international market compared to the volume of Russian coal supplies shows that supply volumes depend less on price and more on demand and geopolitical conditions.

G. Geographical and climatic conditions.

Climate of most of the eastern regions of Russia is strongly continental. Temperatures can drop to –40° C to –50° C during certain periods at some deposits of the Far North regions and equivalent areas. This imposes restrictions on certain types of work as compared to other regions where earthworks can be carried out all year round.

Climatic conditions have a significant effect on the demand for coal for electricity and heat generation by cogeneration power plants. The eastern regions are home to Russia's most powerful hydroelectric power plants, whose share in power generation dominates the region and whose power generation depends on the water content of the rivers. The power shortage is covered by coal-fired power plants. The fluctuation of coal supplies from the eastern regions to power plants ranges from –8% to +11% compared to the previous year. The fluctuations are mainly due to climatic conditions (cold and warm winters, the water content of rivers) and the available coal reserves in the warehouses of companies, which were unused in the previous year.

H. Decarbonization of the world economies.

The decarbonization trend followed by many economies of the world has become highly relevant in recent years [36]. Among the countries planning to reduce coal-fired power generation are the APAC countries importing Russian coal. In the long term (2040–2050), coal consumption may reach a plateau with a further decline in demand for coal. The decline in demand for coal due to the decarbonization policy pursued in the countries of the world had a greater impact on coal export to European countries. Russian coal export to APAC countries will remain lucrative for quite a long time, primarily because of the inertia of the energy sector development and the large investment outlays needed to replace equipment and energy carriers for power and heat generation. Unpredictable weather conditions (cold winters) and fluctuations in the cost of gas do not foster the desired reduction in coal consumption in European countries either, given that coal is still the cheapest source of energy. This is especially true for the countries with scarce energy resources, which include most of the APAC countries. The share of renewable energy sources (with the exception of hydropower), which is the focus of the transition to green energy is quite small [33], the rate of increase in this share is still limited by the high cost of energy from renewable sources.

The Strategy for Long-Term Development of the Russian Federation with Low Greenhouse Gas Emissions to 2050 suggests measures to improve the energy efficiency of the Russian economy. However, the process of switching the production processes to the best available technology takes much time and requires significant investment. In addition, there are no legal and methodological framework for the system of carbon regulation in the Russian Federation. The economy is currently being decarbonized through the conversion of energy facilities to gas. In European Russia, most power plants have been converted to gas. The eastern regions are dominated by coal power. According to the Federal Target Program «Economic and Social Development of the Russian Far East and the Baikal Region to 2025,» both individual boilers and the entire cogeneration plants are gradually being converted to natural gas.

According to the Ministry of Energy of Russia, the share of renewable energy sources (wind and solar) in the mix of installed capacity of power plants in Russia in 2020 was 1.1%. By 2027, it can reach 2.2% [35]. The main obstacle to increasing the capacity of renewable energy sources is their poor economic competitiveness compared to other power generation technologies.

I. Other factors.

Other factors affecting coal production and supply include:

- State support for the development of coal mining and supply;
- High dependence on imported mining equipment and spare parts;
- A lack of highly qualified personnel, not only at coal mining companies, but also for carrying out exploration

and other work;
- The high capital expenditures required over a long time;
- The need for infrastructure investment and a long payback period of investment;
- Unpredictable world events, such as the fires in Australia, the coronavirus pandemic, the sanctions imposed by individual states, and similar phenomena on a global scale.

Large-scale forest fires in Australia, which is the world's main producer of coking coal, may, to some extent, affect the global market conditions. The coronavirus pandemic has caused the introduction of temporary transportation restrictions, which affects the volume and speed of shipments.

State support to the development of coal mining and increase in coal deliveries, planned by the Program for the Development of the Coal Industry and other documents, has faded into the background against the backdrop of geopolitical events.

Foreign companies are interested in developing some of the coal deposits in the eastern regions. The development of coal mining at these deposits depends not only on the degree of participation of these companies in the implementation of projects, but also on the persistence of the interest manifested.

VI. Conclusion

The eastern regions of Russia have coal reserves suitable for different uses. The most likely increase in coal supplies is related to export, but it can be limited due to the current geopolitical conditions. The coal of some deposits has valuable elements: rare-earth metals and other substances that are in demand in the industrial sector and knowledge-intensive industries. Integrated use of coal from such deposits with the output of high value-added products is very promising.

Projections of demand for coal made by international organizations for the countries that are potential coal importers are favorable for the intensive development of coal export from the eastern regions of Russia. The main competitor of Russian coal is the coal from Australia, Indonesia, and Mongolia.

The prospects for export of coal depend on the potential for development of domestic and international coal markets; the tariff policy and freight priorities set by Russian Railways; restrictions on coal consumption, depending on the success of the decarbonization of the economies worldwide; domestic and foreign policies of coal-importing countries, and the prevailing geopolitical conditions.

The state of the global market with respect to energy prices has little effect on the volume of Russian coal exports.

Coal reserves in the eastern regions of Russia are poorly studied. Additional exploration work will not only increase the existing balance reserves but may also identify new deposits or areas promising for development.

The main limitations of an increase in coal export supplies are related to the capabilities of transport infrastructure, geopolitical conditions, the lack of demand for low-grade coal products in the domestic coal market, and the need for large investment outlays.

The significant coal resources available in the eastern regions, including high-rank coal, which is much in demand in the world market; the existing mining capacities, and high coal reserves-to-production ratio allow considering the coal of the eastern regions as a reliable resource to be supplied for export and domestically consumed for the long term.

The key risk for the coal industry in Russia's eastern regions is a potential decline in export volumes due to the geopolitical situation and the resulting changes in regulations of freight transport by rail. This can lead to increased economic instability and social tension in coal-mining regions.

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