

# Problems and prospects for development of the coal chemical industry in Russia

**Irina V. Gavrilenko** (0000-0002-6530-473X)<sup>1(1)</sup>, **Elena A. Fedulova** (0000-0002-1820-3848)<sup>2</sup>, **Artem O. Rada** (0000-0001-7678-8402)<sup>3</sup>, **Alexandr D. Kuznetsov** (0000-0002-1986-3039)<sup>4</sup>

<sup>1</sup> Kemerovo State University, Institute of Economics and Management, Department of Accounting, Taxation and Finance Kemerovo, Russia

<sup>2</sup> Kemerovo State University, Institute of Economics and Management, Department of Economic Theory and Public Administration Kemerovo, Russia

<sup>3</sup> Kemerovo State University, Institute of Digitalization, Kemerovo, Russia

<sup>4</sup> Kemerovo State University, Institute of Digitalization, Computer Engineering Center, Kemerovo, Russia

**Abstract.** In the context of climate change and the mass refusal of countries to use coal as the main type of fuel, it is necessary to consider further prospects for the development of the coal industry. The purpose of the research was the development of the coal-chemical industry as one of such areas. This trend can be considered not only as a variant of using mined coal as a raw material for new products, but also as a trajectory for the economic development of the Russian Federation. The objectives of the research are to identify the problems of development of the coal chemical industry in Russia and consider further prospects for the development of the industry as their solution. The object of research is coal chemistry. The subject is a set of possible vectors for the development of coal processing. The study involved the descriptive, analytical and comparative methods. As a result of the research, the factors influencing the reduction of coal production and its use in the traditional way were examined, processes and products were identified that can become a driver for the development of the coal chemical industry and, as a result, the entire economy of the state. As a result, it was determined that the use of an integrated approach to coal processing will make it possible to effectively use its energy capacity and extract all valuable substances from it, and processed products will increase the added value of newly created products.

**Keywords:** Coal chemical industry · Pyrolysis · Gasification · Hydrogenation · Sorbents · Carbon fibre.

## 1. Introduction

In recent years, the global economy and power engineering have been showing a tendency towards shifting to low-carbon development strategy, which in turn reduces the world community's demand for Russian coal, previously steady and consistent. It is therefore logical to shift from just exporting coal

---

<sup>1</sup> Corresponding author: [irinakalacheva@mail.ru](mailto:irinakalacheva@mail.ru)

to generation of new types of products on its basis with increased added value. Basically, this means the development of a new industry segment – coal chemistry – which was known as early as in the 19th century.

Today, the Russian Federation is one of the richest countries in terms of natural resource stocks: oil, natural gas and coal. At the same time, Russia ranks third in the world in coal reserves that make 157.01 billion tonnes, i.e. about 18% of the world's total stocks, trailing only the USA and Australia (Composites Market Size & Growth, 2020; Statistical Review of World Energy, 2020).

The global trends on the climate agenda have been shaped by the established goals of the developed countries towards transition to low-carbon economy: strategies to reduce greenhouse gas emission are developed and implemented, green energy institutions are founded and other environmental initiatives are realised. Such measures resulted in reduction of coal consumption by almost 7% in 2020 compared to 2018 (World coal market outlook, 2021). However, coal remains a traditional and most affordable energy source, especially for countries with developing economy.

According to the current projections for the global energy sector, the downward trend in coal consumption will continue and, consequently, global coal exports will decline. In this regard, the search for new ways of developing the coal industry in Russia is required already today. One of such promising areas is the development of coal chemistry production. Advanced processing of coal gives rise to new types of chemical products which, in turn, can serve as a raw material for further treatment and generation of new goods. Coal chemistry products exceed the coal price by ten and thousand times. The development of the coal chemical industry will help to bring the Russian coal mining market to a new level (State of the Industry Report, 2020).

Today, the development of this sector of industry can hardly be called successful: whereas the RSFSR produced over 20 thousand items of chemical products from coal, oil and gas, today the domestic enterprises produce a total of about 600 items (Ismagilov, 2021).

At the same time, the chemical industry has been intensively developed in a number of advanced economies over the past 25 years, with the production volume of about 200,000. Meanwhile Russia, with its huge coal reserves, is becoming an importer of coal chemistry products, yielding its leading position in this sector only to China, the USA, India and other countries.

## **2. Materials and Methods**

The purpose of the study is to assess the possibility of reorienting coal from its status of energy resource into a raw material for generating new products and materials based on it. The objectives for achieving this goal include identifying bottlenecks in the modern coal industry and their consideration as promising growth drivers for the development of the coal chemical industry. The paper used the descriptive, analytical and comparative methods. In connection with the high level of coal production in the Russian Federation and consistent decline in coal consumption in other countries, the reorientation of the industry towards new types of production has become an urgent issue. The study required a scrutiny of analytical statistics from the Statistical Review of World Energy, the Industry Report, the official statistics of the Russian Ministry of Energy, the Russian Federal State Statistics Service and the Institute for Investment Policy Analysis.

The issues involving production of a broad range of unique coal chemistry products that are also extremely important for the country's national security are practically not paid due attention to. The Decree of June 13, 2020 adopted a Programme for the development of the Russian coal industry until 2035 (Programme for the development of the Russian coal industry until 2035, 2020) which considers the issues of diversification of the coal industry in its entirety through the manufacture of advanced coal processing products, as part of topical R&D directions; however, the issues of setting up production facilities in coal companies in order to realise these directions remain open.

## **3. Results**

The main research results are represented by the identified problems of the coal chemical industry and the prospects for its further development (Table 1).

**Table 1.** Problems and prospects for the development of the coal chemical industry in the Russian Federation.  
*Source:* compiled by the authors.

Problems	Development outlook
<p>1) Absence of economic incentives for production of new coal chemistry products in terms of the ability to sell mineral deposits (oil, gas, hydrocarbons) in their pure form, since the subsoil assets are rich in them.</p> <p>2) The entire coal industry in the Russian Federation is privatised and aimed exclusively at extraction and marketing of coal within the country as well as exporting it at a higher cost.</p>	<p>1) Coke chemistry (or pyrolysis of coal);</p> <p>2) Gasification of coal;</p> <p>3) Indirect hydrogenation of coal;</p> <p>4) Direct hydrogenation of coal;</p> <p>5) Production of new carbon materials.</p>

#### 4. Discussion

Currently, four vectors of coal processing have industrial application worldwide: pyrolysis, gasification, indirect hydrogenation, hydrogenation; in addition, production of new carbon materials (sorbents, carbon fibre and others) has become a subject of powerful development.

(1) Chemical-recovery carbonisation (or pyrolysis of coal) is one of the areas of coal chemistry production; it involves processing of hard coal by coking. There are currently 12 major manufacturers of coke-chemical products in Russia. The main product is the metallurgical (blast-furnace) coke. The by-products are represented by coke gas and coal tar that are processed into such chemical products as benzene, toluene, ammonium sulphate and carbon oils. The production of coke and semi-coke from hard coal has shown a stable position for four years (Table 2).

**Table 2.** Volumes of coke and semi-coke production from hard coal in the Russian Federation, mln tonnes.  
*Source:* (Unified Interdepartmental Statistical Information System: state statistics, 2022).

	2017	2018	2019	2020
Coke and semi-coke	27.9	26.9	26.8	27.6

Almost all of the coke in Russia is produced by coke-chemical plants for steel mills of their holding companies within the “coal – coke – steel” technological chain. Only about 10% of the total production is exported. Over 15% of coal tar is exported.

According to the Unified Interdepartmental Statistical Information System, exports of coke and semi-coke are increasing annually, except for 2018 (-6% to the level of 2017) and 2020 (3.6% reduction compared to 2019) (Unified Interdepartmental Statistical Information System: state statistics, 2022). The main markets are Kazakhstan (30.8%), Ukraine (18.8%) and India (15.17%). The amount and value of exported coke and semi-coke are indicative of the prospects of this development area for the coal chemical industry (Table 3).

**Table 3.** Export of coke and semi-coke from coal (Product Classifier for Foreign Economic Activities code 2704001900). *Source:* (Unified Interdepartmental Statistical Information System: state statistics, 2022).

Year	Export, mln. tonnes	Cost, mln. USD	Import, mln. tonnes	Cost, mln. USD
2015	2.44	357.71	0.0906	29.91

Year	Export, mln. tonnes	Cost, mln. USD	Import, mln. tonnes	Cost, mln. USD
2016	2.26	262.09	0.06766	21.27
2017	2.92	529.3	0.1046	42.31
2018	2.74	678.87	0.1168	48.22
2019	2.99	706.37	0.0633	24.96
2020	2.68	487.92	0.0735	22.92

(2) Coal gasification. Coal gasification is a more efficient and pure method for converting coal into energy. The coal gasification process is more expensive in terms of generating electricity than construction of a conventional coal-fired power plant. However, in this case the environmental aspect is of paramount importance: synthesis gas can be cleaned of sulphur and most of toxic nitrogen oxides, heavy metals and particulates. At the same time, sulphur can be used in further industrial processes, while the molten gyp deposited to the bottom of the gasifier in the form of slag can be used in road construction.

In order to develop this segment of the coal chemical industry, several investment projects are being developed and implemented in Krasnoyarsk Region (investments equal to 9 billion rubles, implementation timeline – 2020-2023), in Rostov Region (search for investors in the PRC is in progress), in Tomsk Region (investments equalling 4.3 billion rubles) (Programme for the development of the Russian coal industry until 2035, 2020). Thus, it can be noted that the presented area of coal chemical industry development is competitive and can be implemented in practice.

(3) Indirect hydrogenation of coal. The Russian government draws attention to the prospects of producing synthetic liquid fuel from coal. It is known that this fuel has somewhat different properties, being more stable than fuel from petroleum raw materials; however, most studies show that obtaining liquid fuel at present is an expensive process, and it is hardly cost-effective in terms of current oil and gas prices. In order to realise this development area, it is necessary to strengthen the link between the industry and the fundamental science and to attract investment resources for implementation of a number of projects.

(4) Direct hydrogenation of coal represents destructive hydrogenation under pressure (with or without a catalyst), yielding motor fuel and feedstock for organic synthesis.

(5) The production of new carbon materials is an important and promising area for the development of carbon-chemistry industry in Russia.

Carbon sorbents, in particular activated carbons, owing to their developed specific surface and adjustable porosity are widely used for air and gas purification, decolourisation of liquids, filtration of water, aqueous and water-organic media (Gao et al., 2018; Ye et al., 2021). Sorbents are widely used in metallurgical plants, in port purification facilities, sewage treatment units at carwashes, distilleries, at pharmaceutical plants (hemisorbents and enterosorbents), etc.

Russia produces less than 40% of the total consumption of active carbon for water treatment and does not produce carbon sorbents for separation and fine purification of gases, extraction of gold from solutions. The RF demand is about 25 thousand tons/year (Table 4) (Expansion of production of carbon sorbents ..., 2021).

**Table 4.** Activated carbon production in the Russian Federation, tonnes. *Source:* (Expansion of production of carbon sorbents ..., 2021).

	2017	2018	2019	2020
Activated carbon. total	10 468	13 472	10 948	12059.3

Naturally, the pandemic has introduced significant adjustments to activated coal production; however, the output has declined insignificantly (Sergeeva, 2020). Today Russia has 12 enterprises producing activated coal from hard coal, lignite, charcoal, peat, coconut shell, walnut shell and stonefruit raw materials. The production thereof is mainly aimed at satisfying the domestic demand. It is evident from Table 4 that the existing demand is not met in the country; therefore, some products are purchased from other countries. The imports of activated carbon so far have been exceeding the exports four or more times (for 10 years already) (Table 5).

**Table 5.** Data on activated carbon export and import in Russia. *Source:* (Unified Interdepartmental Statistical Information System: state statistics, 2022).

Year	Exports, tonnes	Cost, thousand USD	Imports, tonnes	Cost, thousand USD
2015	1,175.2	2,549.8	12,176.3	29,749.6
2016	932.7	2213	15,749.6	29,800.9
2017	843.3	2,258.3	12,605.84	26,645.4
2018	1,182.4	3,105.6	17,641.1	42,251.7
2019	1,499.01	3,622.2	16,545.6	40,545.2
2020	1,627.3	3,870.4	15,374.424	38,543

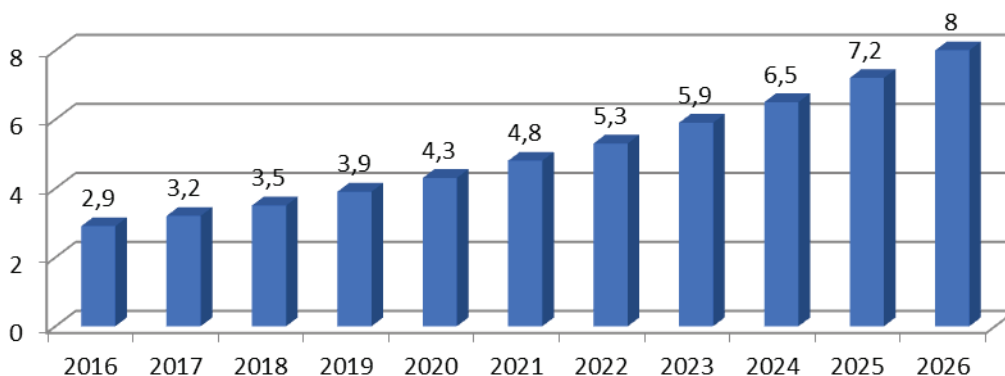
The global market of activated carbon is expected to exceed \$9,466.5 million by the end of 2026, which is 9.5% above the average, increasing from the level of \$4,573.1 million in 2018. The presented data once again confirm the prospective viability of this sector in the coal chemical industry of Russia.

Production of carbon fibre can also be regarded as a promising area of the carbon chemistry today.

The largest share of carbon fibre consumption globally and in Russia accrues to aerospace and aircraft industry (25-29%); it is also used in the technical sector, sports and tourism (Where carbon materials are used: Dipchel, 2017; Global carbon fibre market, 2019; The use of carbon fibre in modern human livelihood, 2015).

The technology, production and sale of carbon fibre is mainly handled by the companies within the Composite Holding Company – 7 companies, such as Argon LLC, Alabuga-Fibre LLC and others (Official website of Argon LLC, 2022; Official website of Balakovo Carbon Production LLC, 2022; Programme for the development of the Russian coal industry until 2035, 2020).

According to the marketing forecasts of Markets&Markets, the global market of carbon fibre will grow and reach 8 billion USD by 2026. The digital, high-tech industries will be the key growth drivers (Figure 1) (Global carbon fibre market, 2019).



**Fig. 1.** Global carbon fibre market forecast, USD billion. *Source:* (Global carbon fibre market, 2019).

According to the numerous marketing forecasts, the near future will show a growing demand for carbon fibre. For instance, the global demand for carbon fibre is expected to grow by 65% in 2022, as

compared to 2018. Currently, polyacrylonitrile (PAN) fibre (Composite production market, 2021; Composites Market Size & Growth, 2020) is the most demanded raw material for the production of carbon fibre. However, carbon fibre based on PAN precursor is characterised by high production costs, with about half of the cost used for manufacture of the precursor – polyacrylonitrile fibre. In Russia, the production of PAN precursor is implemented by Composite Fibre enterprise; moreover, there are plans to commission a PAN precursor plant on the territory of Alabuga Special Economic Zone. That is, the relevant market niche remains practically free for the development of this area of carbon chemistry (Gao et al., 2018).

To summarise, it should be noted that complex coal processing provides for efficient use of its energy by way of preliminary extraction of valuable substances from it. This, in turn, will bring an end to a well-known disadvantage of the coal industry – environmental pollution. The added value increase in coal processing products is a significant positive effect. Relieving the transport infrastructure, creation of new production sites and jobs is another positive economic effect. The development and introduction of new modern coal processing technologies at the mine site will increase the competitiveness of coal and mitigate the energy reliance of the coal mining regions.

## 5. Conclusion

Certain changes in the development trends on the global and domestic market can be viewed already now:

- the advanced processing of coal tar can produce compounds with a high market value. The total content of these products in the coal tar produced per year is about 380,000 tonnes;
- the domestic demand for electrode coal tar is projected to increase to 600,000 tonnes by 2025, subject to commissioning of additional production facilities;
- Russia does not have own production of mineral wax and wax compounds, as well as large-scale production of humate fertilisers; the needs are covered by imports;
- the consumption of activated carbon in Russia is projected to increase by 10,000 tonnes per year (up to 80,000 tonnes by 2025);
- the carbon black production in Russia is tentatively expected to increase by 350,000 tonnes by 2025 (Ismagilov, 2021).

According to the industry experts, one can observe a global understanding of the fact that coal will remain a major fuel and raw material for decades to come; therefore, efficient coal mining, processing and utilisation technologies represent a critical issue requiring maximum possible concentration of resources. In this regard, the coal chemical industry is in for great opportunities.

## Acknowledgments

The research was carried out with the use of the equipment provided by Kemerovo State University Centre for Collective Use of Scientific Equipment under Agreement No. 075-15-2021-694 as of 05.08.2021 concluded between the Ministry of Science and Higher Education of the Russian Federation and Kemerovo State University (federal state budget-funded institution of higher education) (unique contract identifier – RF---2296.61321X0032).

## References

1. Gde primenyayut uglerodnye materialy: Dipchel [Where carbon materials are used: Dipchel]. Accessed on: October 26, 2022. [Online]. Available: <https://www.interfax.ru/pressreleases/566729>
2. Edinaya mezhvedomstvennaya statisticheskaya informatsionnaya sistema: gosudarstvennaya statistika [Unified Interdepartmental Statistical Information System: state statistics]. Accessed on: October 26, 2022. [Online]. Available: <https://www.fedstat.ru/>



3. Rasshirenie proizvodstva uglerodnykh sorbentov dlya razdeleniya gazov, ochistki vozdukha i vody [Expansion of production of carbon sorbents for gas separation, air and water purification] (Kuzbass Sorbents, 2020). Accessed on: October 26, 2022. [Online]. Available: <https://www.investinregions.ru/upload/iblock/b9c/sorbenty.pdf>
4. Z.R. Ismagilov, Uglekhimiya ne vostrebovana rossiiskim biznesom [Carbon chemistry is not in demand by Russian business] (2021). Accessed on: October 26, 2022. [Online]. Available: [https://gudok.ru/content/science\\_education/1551150/](https://gudok.ru/content/science_education/1551150/)
5. Mirovoi rynek uglerodnogo volokna [Global carbon fibre market] (2019). Accessed on: October 26, 2022. [Online]. Available: <https://xn--80aplem.xn--p1ai/analytics/Mirovoj-rynek-uglerodnogo-volokna/>
6. Mirovoi rynek proizvodstva kompozitov [Composite production market] (2021). Accessed on: October 26, 2022. [Online]. Available: <https://arm-plast.ru/o-zavode/novosti/mirovoj-rynok-proizvodstva-kompozitov.html>
7. Ofitsialnyi sait OOO "Argon" [Official website of Argon LLC] (2022). Accessed on: October 26, 2022. [Online]. Available: <https://umatex.com/company/argon/>
8. Ofitsialnyi sait OOO "Balakovo Karbon Prodakshn" [Official website of Balakovo Carbon Production LLC] (2022). Accessed on: October 26, 2022. [Online]. Available: <http://carbon-bcp.ru/>
9. Perspektivy mirovogo ugolnogo rynka [World coal market outlook] Energy Bul. **96** (2021). Accessed on: October 26, 2022. [Online]. Available: [https://nangs.org/analytics/download/7203\\_0fc978db8f3c91bd460acec3e0ae9c1b](https://nangs.org/analytics/download/7203_0fc978db8f3c91bd460acec3e0ae9c1b)
10. Primenenie uglevolokna v sovremennoi zhiznedeyatel'nosti cheloveka [The use of carbon fibre in modern human livelihood] (2015). Accessed on: October 26, 2022. [Online]. Available: <https://igis.ru/blog/item-721>
11. Programma razvitiya ugolnoi promyshlennosti Rossii do 2035 goda [Programme for the development of the Russian coal industry until 2035] (2020). Accessed on: October 26, 2022. [Online]. Available: <https://docs.cntd.ru/document/565123539>
12. A. Sergeeva, Pandemiya zametno sderzhivaet rost mirovogo rynka aktivirovannogo uglya [The pandemic noticeably constrains the global growth of the activated carbon market] (2020). Accessed on: October 26, 2022. [Online]. Available: <https://www.indexbox.ru/news/Pandemiya-zametno-sderzhivaet-rost-mirovogo-rynka-aktivirovannogo-uglya/>
13. Composites Market Size & Growth. Global Report [2020-2027] (2020). Accessed on: October 26, 2022. [Online]. Available: <https://www.fortunebusinessinsights.com>
14. Statistical Review of World Energy, 69th edition (2020). Accessed on: October 26, 2022. [Online]. Available: <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf>
15. State of the Industry Report (2020). Retrieved from <https://compositesmanufacturingmagazine.com/2020/01/2020-state-of-the-industry-report/2/>
16. Sh. Gao, B.S. Villacorta, L. Ge, K. Steel, T.E. Rufford, Zh. Zhu, Fuel Proces. Techn. **177**, 219-227 (2018). <https://doi.org/10.1016/j.fuproc.2018.04.032>
17. Ch. Ye, H. Wu, Sh.-Pe. Zhu, Zh. Fan, D. Huang, F. Han, J.-Sh. Liu, J.-X. Yang, H.-B. Liu, New Carbon Mater. **36**(5), 980-985 (2021). [https://doi.org/10.1016/S1872-5805\(21\)60050-1](https://doi.org/10.1016/S1872-5805(21)60050-1)
18. Statistical Review of World Energy, 68th edition (2019). Accessed on: October 26, 2022. [Online]. Available: [www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf](http://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf)