

Russian Experience of Ferrous Metallurgy Decarbonization in the Context of Global Trends

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Abstract. Decarbonization of production in recent years has become a global trend, one of the necessary steps to ensure sustainable development. Against the backdrop of the desire of most industrialized countries to sequester CO₂ up to complete carbon neutrality in the face of sanctions pressure, the issue of decarbonization of production in the iron and steel industry, an industry in which production processes are inevitably associated with the generation of carbon dioxide, is especially acute. The Russian iron and steel sector has significant potential for decarbonisation. Despite the problems that have accumulated in the industry and new global challenges, metallurgical enterprises do not solve the problem of reducing their carbon footprint. In the article, based on the materials of the mining and metallurgical corporation “Metalloinvest”, a positive example of the decarbonization of industrial production is considered; it is substantiated that the company is a leader in reducing the carbon intensity of products in the industry. The problems of introducing low-carbon technologies in the mining and metallurgical corporations of Russia, which were aggravated by the sanctions pressure of unfriendly countries, were identified.

1 Introduction

The value of sustainable development, the importance of which scientists of various scientific fields do not cease to remind, is not only in the increment of theoretical knowledge, but, above all, in practical implementation in production. The policy document “Sustainable Development in the 21st Century (SD21)” of the UN Department of Economic and Social Affairs clearly states: “Knowledge must serve as the basis for action” [1]. Decarbonization of production in recent years has become a global trend, one of the necessary steps to ensure sustainable development. Moreover, the requirements for limiting CO₂ emissions are constantly being tightened.

Although decarbonization of production is associated with significant financial costs, low-carbon products have additional benefits. First of all, the sequestration of greenhouse gases will lead to a reduction in the transboundary carbon tax, which will increase the financial strength of companies in the real sectors of the economy [2-4]. It is especially important that their products are not only produced using low-carbon technologies, but also

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in the future, with subsequent processing and explication, CO₂ emissions are minimal. This is especially significant for mining and metallurgical production, since the competitiveness of such products increases sharply in the context of global decarbonization trends [5–7].

The synergistic effect of the transition to industrial technologies with low CO₂ emissions should also be taken into account. This is directly indicated, for example, by Australian specialists K. Sumit and N.M. Lodhia [8], Chinese researchers B. Lin and M. Xu [9], an international team of researchers from Norway, Italy, Israel and other countries [10]. More and more mining companies, including transnational ones, are developing a system of corporate criteria for sustainable development, which necessarily include indicators of decarbonization of production [11–13].

The article addresses the following research questions:

- the importance of the decarbonization of ferrous metallurgy for the global processes of greenhouse gas sequestration;
- prerequisites for the leadership of the mining and metallurgical corporation “Metalloinvest” in the decarbonization of industrial production;
- problems of introduction of low-carbon technologies in mining and metallurgical corporations of Russia.

2 Research Methodology

The presented study is based on a critical analysis and generalization of existing theoretical and practical developments in the field of decarbonization of industrial production, with the main focus on ferrous metallurgy.

The information base of the study was the information data of the Intergovernmental Panel for Climate Change, the International Energy Agency (IEA), the World Steel Association WorldSteel, materials of domestic and foreign research developments, annual reports, including reports on the sustainable development of a Russian mining and metallurgical company “Metalloinvest”, presented on its official website. The use of verified data from official sources determines the credibility of the study results.

3 Results and Discussions

3.1 Significance of iron and steel decarbonization for global greenhouse gas sequestration processes

Scientists warn that we are moving toward fundamental changes in Earth systems as a result of changes in the biosphere. The nature and pace of biodiversity loss, and the fact that, despite current efforts, biodiversity loss continues, means that we now need to focus on implementing more transformative solutions. • Concerns about biodiversity loss are becoming increasingly relevant and important to the global debate, including in relation to other key agendas –2– such as the Sustainable Development Goals (SDGs) and efforts to address climate change and its impacts. Biodiversity on land and in the ocean, and the benefits it brings to people, are seen as fundamental to achieving the SDGs, as is the need to meet these targets synergistically through transformative change.

• The cost of inaction makes biodiversity loss an important issue for all sectors and stakeholders. As a result, efforts are intensifying to understand the importance of biodiversity and ecosystem services and to respond accordingly. However, this requires the development of a larger and more ambitious “program of action” that addresses the main drivers of biodiversity loss.

- Actions require a better understanding of the direct and indirect drivers of change and how to respond to them in order to “reverse” biodiversity loss in a way that simultaneously takes into account the entire set of SDGs, and especially climate change, food security, nutrition and health by recognizing and responding to the interconnections.
- There is increasing recognition of the importance of “environmental solutions” to meet cross-sectoral needs, especially in relation to the goal of the Paris Agreement on climate change. Related to this is an increased focus on the need to create an “enabling environment” that defines the necessary understanding, commitment and resources to develop and scale solutions, and to track and report on progress or other issues.

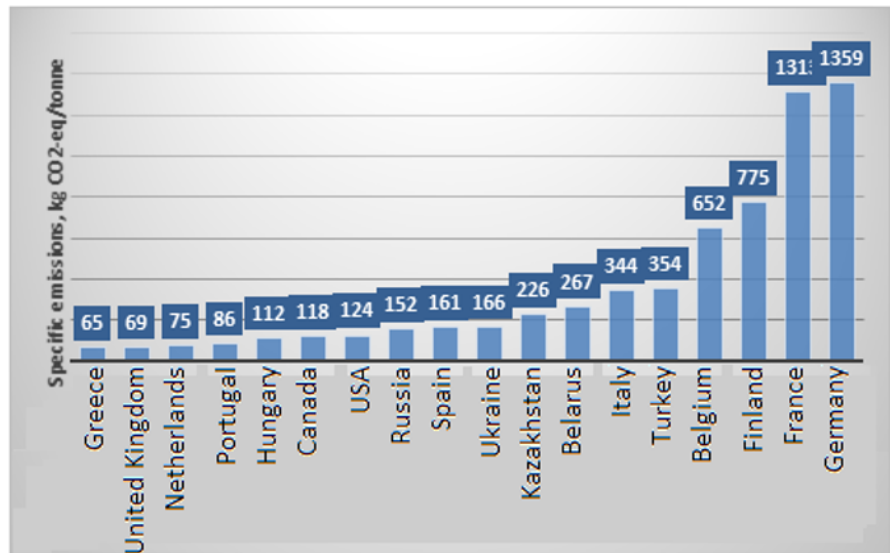


Fig. 1 Carbon intensity of steel production (compiled by the authors based on the materials of the 27th Conference of the Parties to the UN Framework Convention on Climate Change [16])

As can be seen from the graph, against the general world background, the situation with CO₂ emissions in the Russian Federation is not bad. Specific greenhouse gas emissions from steel production in Germany are 8.9 times higher than in Russia; in France - 8.6 times; in Finland - 5.1 times; in Belgium - 4.3 times. At the same time, in Greece, Great Britain, Canada, and the USA, each ton of steel accounts for less CO₂ emissions than in Russia. This means that our country has more opportunities to reduce specific carbon dioxide emissions. Significant potential for decarbonization is contained in the decommissioning of extremely energy- and carbon-intensive open-hearth furnaces, the modernization of blast furnace production, the introduction of an oxygen-converter process and electric steelmaking, projects based on the use of hydrogen [17-19].

A similar situation develops in the production of other types of energy-intensive products, production is accompanied by high CO₂ emissions. Researchers note promising technologies in the production of cement [2, 20, 21], non-ferrous metals [22–24], and mining [5, 8, 25].

The Russian Federation, despite the severe crisis in the ferrous metallurgy, associated primarily with the loss of the European market, the destruction of logistics links and the cessation of equipment supplies by countries that have joined the sanctions, has not abandoned the idea of decarbonizing production. In August 2022, the Ministry of Economic Development of the Russian Federation developed targets for reducing greenhouse emissions by 2030. For the iron and steel industry, the maximum mass of net greenhouse gas emissions for 2030 should be 148 million tons eq. CO₂.

3.2 Prerequisites for the leadership of the mining and metallurgical corporation Metalloinvest in the decarbonization of industrial production

Metalloinvest Mining and Metallurgical Corporation is a leading manufacturer of iron ore, metallized products, and high-quality steel, which are widely known and in stable demand on the Russian and international markets. The Corporation includes the largest Russian mining and processing plants in Russia - Lebedinsky and Mikhailovsky GOKs, a high-quality steel production enterprise - the Oskol Electrometallurgical Plant, as well as assets that perform logistics, repairs and other functions necessary for the operation of mining and steelmaking enterprises. The Metalloinvest Corporation owns 40% of the explored reserves of iron ore (about 13.8 billion tons), concentrated in the Kursk magnetic anomaly at the Lebedinsky and Mikhailovsky deposits of ferruginous quartzites. With the production volumes existing in recent years, this guarantees about 136 years of the operational period [26]. The volumes of production and sales of products are shown in Figure 2.

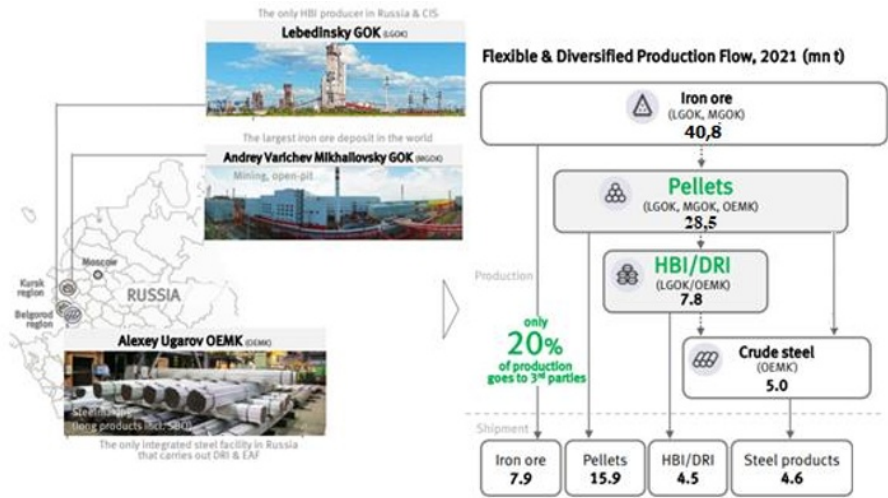


Fig. 2 Structure, production volumes and sales of products of the Metalloinvest Corporation compiled by the authors based on the official website of the Metalloinvest Corporation [26])

The enterprises of the Metalloinvest corporation have a significant impact on the socio-economic development of the regions of presence, determining the branches of specialization and being city-forming enterprises [23, 25, 27]. All enterprises of the corporation are unique in their own way. In addition to having undeniable competitive advantages in the ferrous metals market, they provide the basis for the production of low-carbon products (Fig. 3).



Fig. 3 Low-carbon products of the mining and metallurgical corporation “Metalloinvest” (compiled by the authors based on the materials of the report on sustainable development “Metalloinvest” [28])

The deposits of ferruginous quartzites of the Kursk Magnetic Anomaly, on the basis of which the GOKs of the Metalloinvest Corporation operate, provide high-quality iron ore with a high iron content (an average of 39.2% at the Mikhailovskoye deposit and 34.6% at the Mikhailovskoye deposit). The latest technologies make it possible to obtain high-quality iron ore pellets, the use of which can reduce CO₂ emissions by 46% compared to traditional technologies. An even greater effect is the use of hot briquetted iron, the only producer of which in Russia is Lebedinsky GOK. The use of HBI makes it possible to reduce the specific emission of pollutants by 2.7 times and the specific emission of CO₂ by 2.1 times. The Oskol Electrometallurgical Plant operates with the use of carbon-nickel technologies for the production of direct reduced iron (DRI) and steel smelting in electric furnaces. As a result, the indicator of direct and indirect greenhouse gas emissions at the enterprise is 1.3 tons eq. CO₂ per ton of steel. This is the lowest figure among major metallurgical companies in Russia. The management of the Metalloinvest corporation sets itself the task of not only achieving carbon neutrality of its own production by 2050, but also, due to the quality of its products, to achieve the maximum reduction in emissions from consumers in the near future - by 2025 they should be reduced by 44% [28] .

3.3 Problems of implementation of low-carbon technologies in mining and metallurgical corporations of Russia

The practical problems of introducing low-carbon technologies in the mining and metallurgical corporations of Russia lie in the fact that fairly “soft” framework documents are adopted at the state level, which, nevertheless, fix the goals of decarbonization of the industry and the timing of their achievement. At the same time, industrial enterprises are implementing real measures to minimize CO₂ emissions.

In the context of the crisis caused by sanctions against Russia, the incomes of enterprises are declining, some of which were planned to be directed to the modernization and re-equipment of production facilities, taking into account the requirements of decarbonization. One should take into account the strong dependence of Russian corporations on imported equipment and technologies for low-carbon production, most of which were supplied by countries now unfriendly to Russia.

If the government of the Russian Federation does plan, as stated, to achieve carbon neutrality of industry by 2060, in the face of existing and new challenges, it will be necessary to develop additional mechanisms of state support, primarily of an economic nature. It is especially necessary to support Russian enterprises that produce equipment necessary for decarbonization as part of import substitution. Even those mining and metallurgical corporations that successfully implement low-carbon production projects are already facing a shortage of such equipment. Of course, measures are needed to ensure that all technical modernization projects contribute to increasing the energy efficiency of production and reducing the carbon intensity of products.

4 Conclusions

The study allows us to draw the following conclusions:

1. In the coming decades, developed countries will have an economy with a new innovative and technological basis, the most important characteristic of which will be minimal impact on the environment. Despite the crisis that has gripped the metal industry around the world in the past few years, mining and smelting enterprises do not remove the problem of reducing their carbon footprint. The decarbonization of production, the main criterion of which is the reduction of greenhouse gas emissions, is no longer an accompanying task, but one of the main development goals.

2. Despite the decline in steel output due to the coronavirus pandemic, sanctions against the Russian Federation and other reasons, greenhouse gas emissions from the ferrous metallurgy in 2019-2020 amounted to 3.3 giga tons of CO₂ eq. During this period, the share of ferrous metallurgy in world industrial CO₂ emissions was 28.4%; in the future, a significant decrease in the indicator is not expected. In total anthropogenic greenhouse gas emissions, the share of ferrous metallurgy was 15.9%; in the future, this figure will only grow. The expected rate of reduction of CO₂ emissions in the iron and steel industry is more than twice the average in other industrial sectors of the economy. Thus, the decarbonization of mining and smelting enterprises is in many ways a key factor in ensuring the carbon neutrality of the global industry. The Russian iron and steel sector has significant potential for decarbonisation.

3. The Russian mining and metallurgical corporation Metalloinvest can rightfully be considered the leader in the production of low-carbon products in the iron and steel industry. The company uses technologies that significantly reduce the carbon footprint. As a result, the indicator of direct and indirect greenhouse gas emissions at the enterprise is 1.3 tons eq. CO₂ per ton of steel. This is the lowest figure among major metallurgical companies in Russia.

4. The problems of introducing low-carbon technologies in the mining and metallurgical corporations of Russia have been aggravated due to the sanctions pressure of unfriendly countries. In the face of new challenges, the incomes of enterprises are declining, some of which were planned to be directed to the modernization and re-equipment of production facilities, taking into account the requirements of decarbonization. The rupture of import contracts for the supply of the necessary equipment and technologies significantly limits the possibilities of decarbonization of metallurgical production. In order to achieve carbon neutrality in the industry by 2060, iron and steel companies need significant government support.

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