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# Influence of Hydrogen Energy on the Development of the Coal Industry of the World and Russia

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**Abstract.** Issues related to the influence of hydrogen energy on the development of the coal industry in the world and in Russia are considered and analyzed. It is shown that decarbonization of the economy in recent years has become an urgent direction for many countries of the world intending to limit CO<sub>2</sub> emissions. The ratification of the Paris Climate Agreement, as well as the development of hydrogen energy in many countries of the world, lead to a decrease in coal consumption, as well as their production, export and import. Almost all EU countries have declared their refusal to use coal as a fuel, as well as coal-fired thermal power plants, thereby bringing their policies in line with the objectives of the Paris climate agreement [1]. This is a serious threat to Russian coal producers and exporters. The current "Program for the development of the coal industry in Russia for the period up to 2035" [2] does not consider, and could not consider the "post-like" conditions for the development of the world economy. The options for the development of the Russian coal industry for the period up to 2035, given in the Program, imply a significant increase in the volume of mined coal and its export, which seems impossible in modern realities. In this regard, the Program for the 2nd restructuring of the Russian coal industry is required, within the framework of which a new Strategy for the development of the Russian coal industry for the period up to 2050 should be prepared. account of decarbonization of the world economy by 2050 (60) and the implementation by many countries of the world by this period of programs for the development of hydrogen energy.

**Keywords:** Paris Climate Agreement, decarbonization of the economy, reduction of greenhouse gas emissions, cross-border carbon tax, Hydrogen Energy program, carbon neutrality, coal consumption, coal export and import, Program of the 2nd restructuring of the Russian coal industry, preparation of "stress scenario" of a possible decrease in coal consumption.

## 1. INTRODUCTION

The Paris Agreement on Climate, the goal of which is to prevent the global average annual temperature on the planet from exceeding by more than 2 degrees by 2100. From the pre-industrial level [3], provides for the reduction of CO<sub>2</sub> emissions by 2030 by 25–40% from the 2005 level, and by 2050 - by 70%.

Currently, almost all EU countries have come out with a confirmation of their commitments under the Paris Agreement and are planning to reduce carbon emissions by 55% by 2030, and by 2050 reach the level of carbon neutrality [see. fourteen]. At the same time, they announced their refusal to use coal as a fuel, thereby bringing their policies in line with the objectives of the Paris Agreement on climate.

In May 2021, at a meeting of the ministers of ecology, climate and the environment of the G7 countries, it was decided that the G7 countries will undertake obligations to significantly reduce harmful emissions into the atmosphere. At the same time, UN Secretary General A. Guterres called for abandoning investment in coal and said that countries should transfer their investments from the coal industry to renewable energy sources [5]. This means the termination of financing of coal mining in the country and abroad and the gradual abandonment of its use.

## **2. DECARBONIZATION OF THE ECONOMY AND CROSS-BORDER CARBON REGULATION**

In recent years, decarbonization of the economy has become a topical direction for many countries of the world intending to limit CO<sub>2</sub> emissions. Hydrogen as a means of decarbonization has a significant potential for improving the climatic situation, since when it is used as an energy carrier, carbon dioxide is not emitted into the atmosphere [6–8].

Therefore, at present, the coal industry of the world and Russia is facing serious challenges. Most of the developed countries of the world believe that the negative environmental consequences of coal combustion are much higher than from the use of alternative energy sources. In this regard, many European countries are actively introducing carbon payments and declare a complete rejection of fossil energy resources, including coal.

Already in 2021, the European Commission plans to submit a draft trans-boundary carbon regulation (TUR), which implies the introduction of duties (establishment of a carbon tax) on goods imported into Europe, in the production of which there is a significant emission of carbon dioxide and other carbon compounds. Payments can be \$ 30. US per tonne of CO<sub>2</sub> emissions.

According to the President of the Russian Union of Industrialists and Entrepreneurs A. Shokhin, the cost of a TOUR for Russia can be up to 6 billion euros annually [9].

Russia, which ranks fourth in the world in terms of emissions (after China, the United States and India), plans to develop a regulatory framework for carbon regulation, although carbon pricing has not yet been applied. In accordance with the Decree of the President of the Russian Federation of 04.11.2020 No. 666 "On the reduction of greenhouse gas emissions", the national contribution of Russia to the implementation of the Paris Agreement is determined [10]: the Russian Federation must ensure by 2030 the reduction of greenhouse gas emissions by 70% (relative to the 1990 level), considering the maximum possible absorptive capacity of forests and other ecosystems.

It should be noted that in January 2021, a roadmap was approved for the implementation of the first regional system of international carbon trading in Russia in the Sakhalin Region, and the region may achieve carbon neutrality by 2025.

In world practice, the introduction of a carbon tax is expected no later than 2023, but for certain sectors of the world economy, its entry into force is possible as early as 2021. The TUR may most affect the sectors producing oil refined products and coke, as well as mining products.

The tax rate has not yet been determined. If the duties are introduced in 2022, then their probable size could range from 40 to 80 EUR / t CO<sub>2</sub>-eq. It is expected that by 2050 the size of the transboundary fee may increase to approximately 400 EUR / t CO<sub>2</sub>-eq. At the same time, achieving carbon neutrality is possible with an increase in the price of CO<sub>2</sub> up to 56 EUR by 2030 and up to 444 EUR in 2050.

The application of a cross-border carbon tax can negatively affect a country's budget. However, as the carbon burden rises in the exporting country's economy, it is possible to reduce carbon duties. The form of tax collection is likely to become complex: it will not be based on carbon footprint calculations alone.

With the help of the TUR, the European Union expects to protect the interests of European countries, which, according to the European Commission, are forced to compete with suppliers of products from countries with softer carbon regulations than the EU. It should be noted that in the EU countries carbon regulation already brings to the budget from 6 to 10% of the total collected taxes.

In general, the risks for enterprises of the Russian industry, including the coal industry, are assessed as significant. At the same time, many Russian experts say that they see in the planned EU regulation a violation of the WTO provisions and are ready to challenge the TUR within the framework of this organization.

## **3. RUSSIA IN THE GLOBAL STEAM COAL MARKET**

The ongoing general gasification of the country has led to the fact that the domestic consumption of coal, since the 2000s, began to decline. The rise in coal prices on the world market contributed to an increase in the share of coal exports in the supplies of domestic coal enterprises. So, if in 2000 the share of Russian exports of thermal coal in the total volume of world supplies of thermal coal was 6.7%, then in 2008 it increased to 12.7%, and in 2019 - to 16.3% [11].

The volume of exports of Russian thermal coal in 2019, according to the Central Dispatch Office of the Fuel and Energy Complex, amounted to 176 million tons, and in 2020 increased to 177.9 million tons [12]. In addition to exporting coal to the APR countries, Russia also exported its coal to the EU countries, filling the latter's needs in

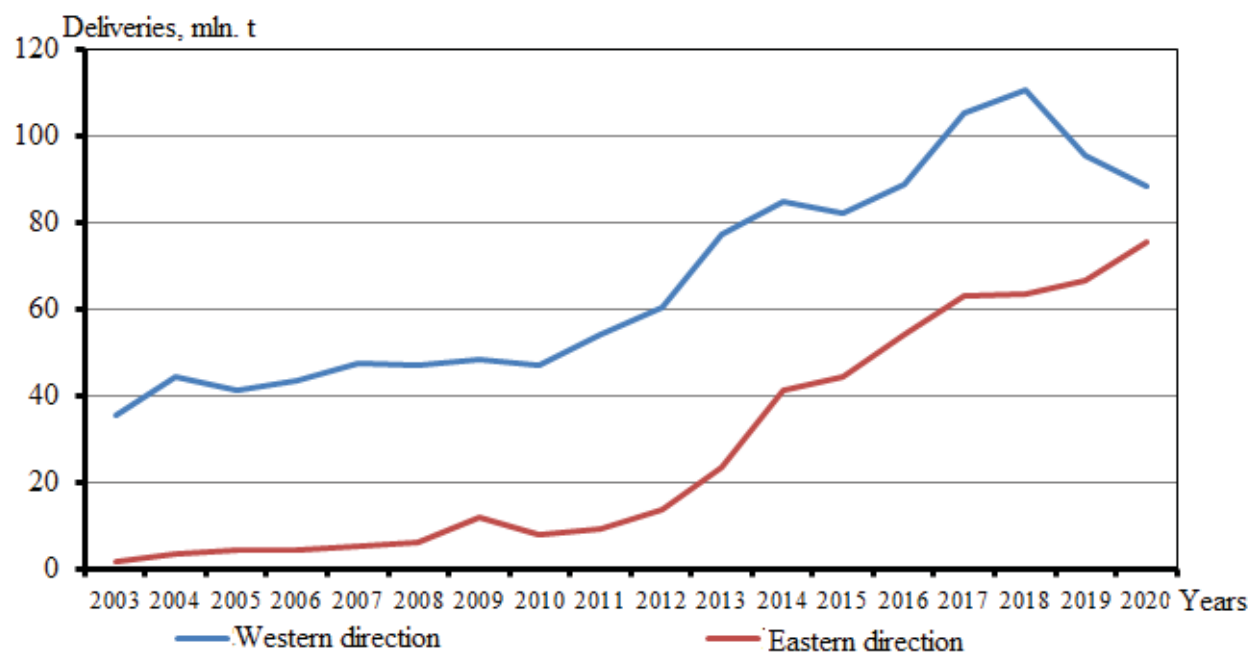
thermal coal. In general, in 2020, thermal coal was exported from Russia to more than 60 countries of the world. The predominant direction of steam coal supplies remains the Western (EU countries, Ukraine and Belarus). However, starting in 2018, supplies of thermal coal in the West direction began to decline, mainly due to the reorientation of the EU countries to gas and renewable energy sources.

At the same time, the export of Russian coal to the East (China, Japan, South Korea, etc.) also increased significantly (Figure 1).

The growth in the export component led to an increase in the income of coal companies and, accordingly, to an increase in investment in fixed assets.

However, increasing the export component, Russian coal mining companies face risks associated with:

- instability of world prices for primary energy resources, their dependence not only on economic, but also on political factors;
- aggravation of competition between various energy sources in the world market;
- the transition to a carbon-free economy and the introduction of a "carbon" tax, leading to a drop in the share of electricity generated from coal;
- execution of the obligations stipulated by the Paris Climate Agreement;
- the transition of the world economy to energy-saving technologies and the gradual displacement of coal from the energy balance, with its replacement by non-traditional energy sources, which is typical for most developed countries of the world;
- development of hydrogen energy, especially in countries that are consumers of Russian coal.



Sources: CDU TEK, ERI RAS

FIGURE 1. Deliveries of Russian thermal coal in the period 2003-2020.

#### 4. HYDROGEN ENERGY AS A COMPETITOR TO STEAM COAL USED AS FUEL IN COAL-FIRED POWER PLANTS

The ratification of the Paris Climate Agreement, the global pandemic of 2020 caused by COVID-19, as well as the development of hydrogen energy in many countries of the world lead to a decrease in coal consumption in many developed countries of the world, as well as in their production, export and import of coal.

Coal-fired generation still accounts for about 38% of global electricity generation today. At the same time, there is an increase in the production of hydrogen, which is produced in the world about 80 million tons per year, and it is expected that by 2030 this figure may reach 100 million tons, and in 2050 - about 500 million tons [13].

The EU countries, China, the USA, Japan and others are betting on hydrogen. The total cost of all projects currently being implemented in the field of hydrogen energy has already reached \$ 90 billion. The EU countries alone plan to invest up to 470 billion euros in the development of hydrogen in the next 30 years.

In order to execution its obligations to reduce CO<sub>2</sub> emissions, the EU provides for the closure of both coal enterprises and coal thermal power plants, primarily those that run on imported coal, including Russian.

Already in the first half of 2019, an unprecedented reduction in coal generation was noted in the EU countries - by 19%, and in the second half of 2019 its pace accelerated to 23%. The falling share of electricity was compensated for by wind and solar generation, as well as the conversion of power plants from coal to gas.

According to the Institute for Energy Sector Economics and Financial Analysis (IEEFA), there are currently dozens of renewable energy-based electrolysis plants under construction, with a total capacity of 50 GW and a cost of \$ 75 billion.

The main initiators of the abandonment of fossil energy sources and the transition to hydrogen are the G7 countries. In 2019, they adopted The European Green Deal, according to which EU countries must achieve zero greenhouse gas emissions and eliminate fossil energy sources by 2050.

Therefore, there is a great threat that coal will be replaced by renewable energy sources and hydrogen.

## **5. GLOBAL COAL CONSUMPTION AND A BAN ON INVESTING IN PROJECTS RELATED TO THE PRODUCTION AND USE OF SOLID HYDROCARBONS**

In recent years, many countries around the world have begun to reduce their coal consumption. Thus, the consumption of thermal coal in the world in 2019 decreased by 1.5% compared to the level of 2018, to 6.0 billion tons [see. 12].

In the first place in coal consumption is China (3.2 billion tons), in the second place - India (847 million tons), in the third place - the USA (469 million tons), in the IV place - South Africa (172 million tons), on the V place - Japan (139 million tons), in VI place - Indonesia (161 million tons), in VII place - South Korea (94 million tons), in VIII place - Vietnam (88 million tons), in IX place - Russia (76 million tons), Kazakhstan (74 million tons).

The EU countries in 2019 reduced their coal consumption by 9.2% compared to the level of 2012 (due to stricter environmental requirements). For this reason, all unprofitable mines, as well as coal-fired power plants, were closed in the EU countries. So, in 2016, coal plants were closed in Belgium. In 2021. they are planned to be closed in Portugal, in 2023 - in Austria and Ireland, in 2025 - in Italy.

The growing popularity of ESG (E - environmental, S - social and G - governance) criteria in the world can accelerate the phase-out of solid hydrocarbons. Many large investment funds and banks, as part of the ESG policy, prescribe in their investment declarations a ban on investing in projects related to the production and use of solid hydrocarbons. In the future, this will lead to an increase in the cost of funding for existing deposits and, possibly, will mean the termination of the development of new coal deposits.

Therefore, many countries of the world, reducing the consumption of coal, decided to compensate for it with hydrogen. So, in March 2020, the hydrogen strategy of the Netherlands was approved, in June 2020 - the "National Hydrogen Strategy of Germany" and Norway, in July 2020 - Portugal and the EU as a whole, in September 2020 - France. The leader in the sale of hydrogen energy is Germany, which announced complete decarbonization by 2038.

On the Asian market, Japan, South Korea, and China have made significant progress in terms of selling hydrogen energy, which, in turn, are also the main importers of Russian coal. Therefore, the current situation can become extremely dangerous for Russian coal producers, aimed at promoting the growing export of coal over the past decade.

The risks for the Russian coal industry, as one of the most carbon-intensive, are especially great. In particular, the load on Russian thermal coal producers is projected to reach € 205–571 million.

## **6. RUSSIA'S PLANS FOR THE DEVELOPMENT OF HYDROGEN ENERGY**

Russia, despite significant reserves of available hydrocarbon raw materials, also plans to develop hydrogen energy. It was included in the list of promising areas of energy development, which was reflected in the Energy Strategy of the Russian Federation until 2035. In addition, in October 2020, by order of the Government of the Russian Federation, a "roadmap" was approved for the development of hydrogen energy in the Russian Federation until 2024 [14].

In accordance with the approved "road map", it is envisaged:

- improvement of the regulatory framework;
- formation and implementation of measures of state support for projects in the field of hydrogen energy;
- strengthening the positions of Russian companies in the hydrogen sales markets and conducting research and development.

The resource base will be both the production of hydrogen from fossil fuels as the most economically efficient option, and production by electrolysis based on low-carbon generation (nuclear power plants, hydroelectric power plants, renewable energy sources) with confirmation of economic efficiency.

Hydrogen fuel is already being produced in Russia. According to Rosstat, in 2019, Russia produced 1.95 billion cubic meters. m of hydrogen. This is 3 times more than in 2010, but clearly not enough to convert many industries, including thermal power plants, now running on coal, to hydrogen fuel, as well as to ensure significant volumes of hydrogen supplies for export.

In the opinion of the Russian Government, there is a real possibility in the country of switching Russian gas pipelines, including Nord Stream-1 and Nord Stream-2, to transport, in addition to natural gas and hydrogen fuel. This pipe alone can transport about 1 million tons of "green" hydrogen per year [15].

With a production of up to 7 million tons (optimistic option), the Russian Federation may occupy 20% of the global hydrogen trade market, in a pessimistic scenario - produce from 1 million tons to 2 million tons of hydrogen by 2030.

The Ministry of Energy of Russia estimates the volume of the world market for hydrogen fuel by 2040 at 32-164 billion dollars. USA.

By 2050, the volume of the European hydrogen market is projected to range from \$ 23.6 billion to \$ 100 billion. USA per year [16]. The difference in forecasts is associated with different scenarios for the development of the world market for hydrogen as an energy carrier and, accordingly, on the demand for it.

It is expected that the export of Russian hydrogen may increase from 0.2 million tons at present to 2.0-7.0 million tons in 2024 and up to 30 million tons - by 2050. Russia's budget revenues from the supply of hydrogen fuel for export may amount to 1.7-3.1 billion dollars. USA annually.

At the same time, one of the most important is the issue associated with significant volumes of carbon dioxide formed during the conversion of hydrogen from natural gas and other fossil energy resources. In the long term, the export of hydrogen may well displace oil and gas in terms of volumes.

At present, the market for hydrogen energy does not yet exist as such. Russia, as a potentially large supplier of hydrogen, is interested in the formation of a market for hydrogen energy carriers.

In the future, hydrogen can replace not only coal, but also the gas industry. A. Novak at the meeting of the Russian-German Raw Materials Forum on December 3, 2020 noted that he hoped that Russia and Germany would be able to agree on close cooperation in the field of hydrogen energy. With an extensive gas pipeline infrastructure, Russia can become a world leader in the supply of hydrogen for export and in the coming years will be able to occupy by 2035 10-15% of the European hydrogen market and up to 20-25% of the world hydrogen market.

With the participation of PJSC Gazprom and State Corporation Rosatom, it is planned to implement a number of "pilot" projects, incl. creation of installations for low-carbon production of hydrogen on the basis of nuclear power plants.

An alliance between Gazprom and Wintershall Dea, Gasunie, RWE and Shell begins work on a gas pipeline project to transport "green" hydrogen from the North Sea to Germany. This pipeline (called AquaDuctus) will be able to transport up to 1 million tons of hydrogen per year after 2035. In turn, hydrogen will be produced from water using electricity from offshore wind turbines with a capacity of 10 GW. One hydrogen gas pipeline can replace five high-voltage lines that would have to be built to transport the same amount of electricity. It is assumed that it is pumping hydrogen that is the most economical option for transporting large amounts of energy over a distance of over 400 km.

The future model of the world energy industry, which will be based on electrolysis and pumping of "green" hydrogen, in fact, can "nullify" the entire modern Russian energy sector. Therefore, Gazprom and the Government of the Russian Federation are trying to "promote" both "blue" hydrogen (obtained from natural gas, with further capture and storage of CO<sub>2</sub>) and "yellow" (produced using the energy of nuclear power plants).

It should be noted that in Russia there is a possibility of obtaining hydrogen in the Far East (HPP of Magadan) by the method of steam reforming, with the provision of capture and disposal of carbon dioxide. Using the excess capacity of nuclear power plants and hydroelectric power plants in the Leningrad and Murmansk regions, it is planned to export hydrogen fuel to South Korea and Japan, and in the future to the PRC.

## **7. FORECASTS OF PRODUCTION AND EXPORT OF RUSSIAN COAL, ACCORDING TO THE "PROGRAM FOR THE DEVELOPMENT OF THE RUSSIAN COAL INDUSTRY FOR THE PERIOD UP TO 2035"**

The current "Program for the development of the coal industry in Russia for the period up to 2035", approved by the Order of the Government of the Russian Federation dated June 13, 2020 No. 1582-r, (hereinafter - the Program) [see. 2], does not consider, and could not consider the "post-like" conditions of the development of the world economy.

The options for the development of the coal industry in Russia for the period up to 2035, given in the Program, imply a significant increase in the volume of mined coal and its export. So, in 2035 it is planned to produce 485 million tons (according to the conservative option) and 668 million tons (according to the optimistic version), of which 345 million tons and 518 million tons, respectively, of thermal coal. At the same time, the export of Russian coal is envisaged in 2035, respectively, in the volumes of 241 million tons and 349 million tons.

However, the options for the development of the world economy outlined in the Program were formed in 2018–2019. and do not consider the new conditions of global technological development, climatic restrictions, the transition to hydrogen energy and "zero" carbon neutrality.

Therefore, the parameters for the development of the coal industry adopted in the Program give government bodies and businesses "distorted" signals, both in terms of the declared volumes of coal production and prices for coal products. Moreover, the Ministry of Energy of the Russian Federation has taken a very contradictory position: on the one hand, it proclaims the development of hydrogen energy, and on the other, it declares the achievement of very "significant" volumes of coal production and export, which, due to the above mechanisms by the development of hydrogen energy, are "knocked out" from the economic turnover of the economy to minimum levels.

In this regard, it is necessary, while there is still time, to adjust the investment flows aimed at achieving too high levels of coal production. Otherwise, the investment may fail. Most likely, it is necessary to prepare for a deep diversification of the coal industry. In fact, the program for the 2nd restructuring of the coal industry in Russia is needed [17].

## **8. PROPOSALS AND MEASURES FOR THE DEVELOPMENT OF THE PROGRAM FOR THE 2ND RESTRUCTURING OF THE COAL INDUSTRY IN RUSSIA**

Within the framework of the Program of the 2nd restructuring of the coal industry in Russia, on the basis of the Law on State Forecasting and the Law on Coal, it is necessary to prepare normative and legislative acts, namely:

1. to prepare a new Strategy for the development of the coal industry for the period up to 2050, providing for the development of a "stress scenario" of a possible decrease in coal consumption due to decarbonization by 2050 (60). the world economy and the implementation of hydrogen energy development programs by many countries;

2. within the framework of the "stress scenario" to assess the forecast dynamics of the industry average indicators of the efficiency of the coal industry, which will allow classifying the enterprises of the industry into three groups:

- the first group of enterprises capable of achieving indicators exceeding the industry average (this group will be able to withstand the forthcoming competition in the "shrinking" foreign market, it will form the basis for the development of the coal industry);

- the second group of enterprises, in which it is impossible to achieve average industry indicators (this group of candidates for a possible systematic "narrowing" of production);

- the third group of enterprises, for which the implementation of liquidation procedures should be envisaged;

3. for enterprises of the second and third groups, within the framework of the legislation of the Russian Federation on public-private partnership, agreements should be developed between coal companies, on the one hand, and on the other, the Government of the Russian Federation (possibly represented by the Ministry of Energy of the Russian Federation) and the Administrations of the respective coal regions.

These agreements should include:

- development of a long-term restructuring plan, consisting of regional plans and providing for a mobilization economy, incl. indicative planning and a system of "return" plans of companies;

- measures for state assistance (including regulatory, legislative, investment and infrastructural) in the organization of new jobs, according to our calculations, 2.5-3.0 thousand units per year, outside the sphere of industry competence (for this, a bank of large backbone projects for the state);

- necessary liquidation procedures, including social protection of laid off workers and ecological rehabilitation of territories (it is possible to create liquidation funds of enterprises, allowing over time to accumulate funds for their subsequent targeted use).

## 9. CONCLUSION

The ratification of the Paris Climate Agreement and the development of hydrogen energy in many countries of the world lead to a decrease in coal consumption, as well as its production, export and import.

In order to fulfill its obligations to reduce CO<sub>2</sub> emissions, the EU provides for the closure of both coal enterprises and coal thermal power plants, primarily those that run on imported coal, including Russian. This is a serious threat to producers and exporters of Russian coal.

The forecasted volumes of coal production and export, adopted in the current Program for the Development of the Coal Industry of Russia for the Period up to 2035, appear to be quite high. This is due to the fact that during the development of this Program it was impossible to take into account the post-crisis conditions of the development of the world economy. Therefore, it seems necessary to develop a Program for the 2nd restructuring of the coal industry in Russia, and on the basis of the Law on State Forecasting and the Law on Coal, prepare and adopt the necessary normative and legislative acts on the proposed measures on this issue. In particular, they should include the development of a "stress scenario" of a possible decrease in coal consumption due to decarbonization by 2050 (60) the world economy and the implementation of hydrogen energy development programs by many countries.

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