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Global Food Security and Fundamental Role of Fertilizer

Part 1. Global Food Security and Fertilizer Production[1]

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Abstract

It is shown that in order to ensure food security on a global scale, it is necessary to focus on the interaction of genetics × environment × management (G × E × M), where management means, first of all, the use of a sufficient amount of mineral fertilizers in precision agriculture. This opens up the potential to feed 9 billion people. The current state of production and application of mineral fertilizers is described, and it is shown that at the same time it is necessary to invest in methane chemistry. The possible role of RES in fertilizer production is also considered. The article presents data showing that the increase in actual yield depends on mineral fertilizers, in the production of which it is necessary to use methane — a source of carbon dioxide and hydrogen, as well as an energy source.

Keywords: food security; mineral fertilizers; investments; production; methane; RES.

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Глобальная продовольственная безопасность и основополагающая роль удобрений

Часть 1. Глобальная продовольственная безопасность и производство удобрений[2]

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Аннотация

Показано, что для обеспечения продовольственной безопасности в глобальном масштабе необходимо сосредоточиться на взаимодействии генетики × environment × management (G × E × M), где управление означает, прежде всего, использование достаточного количества минеральных удобрений в прецизионном сельском хозяйстве. Это открывает возможности прокормить 9 миллиардов человек. Описано текущее состояние производства и внесения минеральных удобрений и показано, что при этом необходимо инвестировать в химию метана. Рассматривается также возможная роль ВИЭ в производстве удобрений. В статье представлены данные, показывающие, что увеличение фактической урожайности зависит от минеральных удобрений, при производстве которых необходимо использовать метан — источник углекислого газа и водорода, а также источник энергии.

Ключевые слова: продовольственная безопасность; минеральные удобрения; инвестиции; производство; метан; ВИЭ.

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Contents

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Introduction

Ensuring global food security is now of paramount importance. So, in 2020, the number of people suffering from malnutrition continued to grow. In 2020, between 720 and 811 million people in the world faced hunger. Taking into account the middle of this range (768 million), 118 million more people faced hunger in 2020 than in 2019, or as many as 161 million, taking into account the upper limit of the range [1].

At the same time, it is important to consider the factors determining the latest trends in this area. Conflicts, climate variability and extreme events, as well as the economic downturn, which is exacerbated by the COVID-19 pandemic, predetermine the growth of hunger and slow progress even in reducing various forms of malnutrition. Their negative impact is further exacerbated by the high and persistent level of global inequality. In addition, millions of people around the world face threats to food security and various forms of malnutrition because they cannot afford the costs of a healthy diet. These main factors are unique, but not mutually exclusive, because they interact to the detriment of food security and nutrition, creating multiple, aggravating consequences.

For example, conflicts and, above all, a variety of unilateral economic sanctions negatively affect almost all aspects of the food system, from production, harvesting, processing and transportation to the supply of raw materials, financing, marketing and consumption. Direct impacts may include the destruction of agricultural assets and livelihoods, as well as severely disrupt and restrict trade and the movement of goods and services, which will negatively affect the availability and prices of food, including foodstuffs. So, at present, there is already a significant increase in prices for wheat grain due to its short supply to the world market.

Currently, in addition to Russia, Canada, the USA, France, Australia, Ukraine, Argentina, Romania and some other countries supply food grains to the world market. At the same time, it can be expected that this season the production of food raw materials in these countries will decrease due to a shortage and an increase in prices for fertilizers, energy carriers and logistics.

Similarly, climate variability and extreme events have multiple and aggravating impacts on food systems. They negatively affect agricultural productivity and also affect food imports as countries try to compensate for the loss of domestic production. Climate-related natural disasters can lead to significant consequences along the entire food value chain with negative consequences for the growth of the food sector, as well as for the food and non-food agricultural industry.

On the other hand, it is global and regional economic downturns that primarily affect food systems, having a negative impact on people's access to food, including the availability of healthy food, as they lead to increased unemployment and lower wages and incomes. This is the case regardless of whether they are caused by market fluctuations, trade wars, political unrest, unilateral sanctions, or a global pandemic such as COVID-19.

Poverty and inequality are the most important underlying structural factors that reinforce the negative impact of the main driving forces that determine the decline in food security. Their impact is felt in all food systems, which ultimately affects the availability of healthy food, as well as food security and food availability.

In addition to the direct impact of poverty and inequality on food systems, these major global drivers and underlying structural factors weaken food security and nutrition due to interrelated and cyclical impacts on other systems, including environmental and health systems.

In this regard, the question arises: “What needs to be done to transform or simply preserve food systems in order to ensure global food security, improve food and affordable healthy nutrition?”, and also: “What is the role of other industries in ensuring global food security?”

Therefore, the purpose of the 1st part of review is to consider current trends in the global market for the production and use of fertilizers both on a global and regional scale, with an emphasis on force majeure circumstances that have developed in the first months of 2022. The state of the food market and its supplies in various economic regions of the planet will also be considered. The role of mineral fertilizers in food security will be characterized. The role of various energy sources (methane, RES) in fertilizer production are also will be considered.

1. Global food security

There are six ways to eliminate the main factors determining the latest trends in food security and nutrition. These include: 1) integration of humanitarian, development and world order policies in conflict-affected areas; 2) increasing resilience to climate change in all food systems; 3) increasing resilience of various systems most vulnerable to economic adversity; 4) intervening in food supply chains to reduce the cost of nutritious products; 5) combating poverty and structural inequality, ensuring that activities are focused on the interests of the poor and include everyone; and 6) strengthening the food environment and changing consumer behavior to promote a diet with a positive impact on human health and the environment [1].

Since many countries are subject to the simultaneous influence of various factors, it is necessary to consider several ways to achieve the set goals for ensuring food security. In some cases, different solutions must be applied simultaneously, which will require consistency between them to ensure the effectiveness of their implementation. Thus, integrated portfolios of strategies, investments and legislation play a central role in ensuring the transformation of food systems.

In conflict situations, the integrity of food systems is often severely disrupted, making it difficult for people to access food. Deep economic crises can occur where the root causes of conflict situations are related to competition for natural resources, including productive lands, forests, fisheries and water resources. It is essential that policies, investments and actions aimed at immediately reducing food security and malnutrition are implemented simultaneously with measures aimed at reducing the level of conflict, and are consistent with long-term socio-economic development and world order efforts.

How food is produced and natural resources are used can be of great importance for ensuring the sustainability of climate systems both now and in the future. This is important not only because climate phenomena affect food systems, but also because food systems themselves affect the state of the environment and are the driving force behind climate change. Central to these efforts are priorities for the protection of nature, the sustainable management of existing food production and supply systems, as well as the restoration and rehabilitation of the natural environment.

Economic and social policies, legislation and governance structures should be developed well before the economic downturn to counteract the effects of adverse economic cycles when they occur and to support access to food, especially for the most vulnerable groups of the population, including women and children. In the near future, they should include social protection mechanisms and primary health care.

Interventions in food supply chains are needed to increase the availability of safe and high-calorie foods and reduce their cost, primarily as a means of increasing the availability of healthy food. This requires a coherent set of policies, investments and legislation from production to consumption aimed at improving efficiency and reducing food losses and waste to help achieve these goals.

The empowerment of poor and vulnerable groups, often small farmers with limited access to resources or those living in remote areas, as well as the empowerment of women, children and youth, i.e. the most vulnerable groups of the population, represent an important lever for transformation and necessary changes. Empowerment measures include increased access to productive resources, including access to natural resources, agricultural resources and technology, financial resources, as well as knowledge and education. Other empowerment measures involve strengthening organizational skills and, importantly, access to digital technologies and communications.

Effective and efficient implementation of strategy and investment portfolios requires the creation of an enabling environment for governance mechanisms and institutions that facilitate consultations between sectors and key stakeholders. Increasing the availability of technologies, data and innovative solutions is the key to accelerating the transformation of food systems, while minimizing the consequences of possible trade-offs as a result of the transformation process [2—11]. The most important factor in this is the preservation and increase of soil fertility, primarily through the use of mineral fertilizers [12—14].

In this regard, it is necessary to consider the role of mineral fertilizers in solving the problem of food security, as well as to assess the contribution of individual countries to these investment decisions.

2. Global and regional fertilizer production

2.1. Global production and demand for mineral fertilizers

Based on the data [15], both the global needs for mineral fertilizers and the possibilities of the global industry in their supply were assessed.

Forecasts of global capacities for the production of ammonia, phosphoric acid and potash fertilizers until 2022 are presented in Table 1.

Table 1. Global ammonia, phosphoric acid and potassium production potential, 2016—2022 (thousand tons)

Таблица 1. Мировой потенциал производства аммиака, фосфорной кислоты и калия, 2016—2022 гг. (тыс. тонн)

Year	2016	2017	2018	2019	2020	2021	2022
Ammonia, N	180 496	184 558	186 974	189 523	187 354	188 908	190 397
Phosphoric acid, P_2O_5	57 295	60 224	61 464	62 357	62 612	63 552	63 702
Potassium, K_2O	54 638	58 455	61 951	62 055	63 467	63 513	64 553
Total	292 429	303 237	310 389	313 935	313 433	315 973	318 652

Table 2. Global supplies of ammonia, phosphoric acid and potassium, 2016—2022 (thousand tons)

Таблица 2. Мировые поставки аммиака, фосфорной кислоты и калия, 2016—2022 гг. (тыс. тонн)

Year	2016	2017	2018	2019	2020	2021	2022
Ammonia, N	153 646	155 253	157 819	161 504	160 492	161 572	163 219
Phosphoric acid, P_2O_5	46 308	47 564	48 620	49 510	50 520	51 520	52 066
Potassium, K_2O	44 177	46 284	49 422	51 373	52 752	53 664	54 197
Total	244 131	249 101	255 861	262 387	263 764	266 756	269 482

Table 3. Global demand for nitrogen, phosphoric acid and potassium for fertilizer production, 2016—2022 (thousand tons)

Таблица 3. Мировой спрос на азот, фосфорную кислоту и калий для производства удобрений, 2016—2022 гг. (тыс. тонн)

Year	2016	2017	2018	2019	2020	2021	2022
Ammonia, N	105 148	105 050	105 893	107 424	108 744	110 193	111 591
Phosphoric acid, P_2O_5	44 481	45 152	45 902	46 587	47 402	48 264	49 096
Potassium, K_2O	35 434	36 349	37 171	37 971	38 711	39 473	40 232
Total	185 063	186 551	188 966	191 981	194 857	197 930	200 919

Estimates and forecast of global supply are presented in Table 2.

At the same time, to assess the role of mineral fertilizers in solving food security, it is important to know the global demand for fertilizers. Forecasts of global demand for nitrogen, phosphorus and potassium for use in fertilizers until 2022 are presented in Table 3.

At the same time, it should not be forgotten that the chemical compounds in question are used not only for the production of mineral fertilizers, but also for a number of other industries, for example, in the food or construction industry. These other needs are shown in Table 4.

Based on these data, it is possible to consider the balance of supply and demand on a global scale. At the same time, the potential balance of nitrogen, phosphorus and potassium is calculated as the maximum achievable production (supply) minus total demand (including fertilizers and other uses):

Potential balance = supply − (fertilizer use + demand for other uses), where the supply of each nutrient relates to:

- ammonia, for the production of nitrogen fertilizers;
- phosphoric acid for the production of phosphoric fertilizers;
- potassium oxide, for the production of potash fertilizers.

Table 4. Global demand for nitrogen, phosphorus (based on phosphoric acid) and potassium for other purposes, 2016—2022 (thousand tons)

Таблица 4. Глобальный спрос на азот, фосфор (на основе фосфорной кислоты) и калий для других целей, 2016—2022 гг. (тыс. тонн)

Year	2015	2016	2016	2017	2018	2019	2020
Ammonia, N	36 930	37 663	38 320	38 965	39 569	40 127	40 660
Phosphoric acid, P_2O_5	6 444	6 677	7 036	7 170	7 291	7 482	7 734
Potassium, K_2O	5 572	5 752	5 876	5 993	6 112	6 237	6 363
Total	48 946	50 092	51 232	52 128	52 972	53 846	54 757

Table 5. Global nitrogen, phosphorus and potassium balance, including forecast, 2016—2022 (thousand tons)

Таблица 5. Мировой баланс азота, фосфора и калия, с учетом прогноза, 2016—2022 гг. (тыс. тонн)

Year	2016	2017	2018	2019	2020	2021	2022
Ammonia, N	11 568	12 540	13 606	15 115	12 179	11 252	10 968
Phosphoric acid, P_2O_5	728	1 223	1 217	1 191	1 231	1 238	771
Potassium, K_2O	3 171	4 183	6 375	7 409	7 929	7 954	7 602
Total	15 467	17 946	21 197	23 716	21 339	20 445	19 341

Unforeseen factors, such as shortage of raw materials and/or resources, logistics problems, unplanned stoppage for technical reasons, natural disasters (for example, earthquakes, flooding of mines), are not taken into account in the balance sheet. Demand forecasts are based on agronomic considerations (e.g. acreage and fertilizer application rate), market feedback, industry association estimates, growth models, econometric models, and expert judgments.

Estimates, including forecasts, of potential global nitrogen, phosphorus and potassium balances for the period up to 2022 are presented in Table 5. It can be seen that both estimates for 2016—2021 and the forecast for 2022 show positive balance results. This indicates that the global fertilizer industry is able to meet the needs of global agriculture in the most important resource for growing crops and ensuring food security.

At the same time, a natural question arises: “What, then, is the cause of the growing food crisis?” To do this, we will consider technological schemes for the production of mineral fertilizers and, above all, nitrogen and complex fertilizers.

2.2. Production of nitrogen (urea) and complex (NP + meso- and micro) fertilizers: chemical technologies

Nitrogen fertilizers primarily include urea and ammonium nitrate, complex fertilizers include diammonium phosphate (diammophos) and various types of fertilizers with the inclusion of 3 main nutrients (nitrogen, phosphorus and potassium, as well as various mixtures with sulfur, calcium, magnesium, zinc, copper and other trace elements). In all cases, the starting product for the production of nitrogen fertilizers is ammonia.

Urea production

At several stages of transformation, natural gas, essentially methane, is upgraded in combination with nitrogen from the air to form nitrogen fertilizers. 80% of the gas is used as a raw material for fertilizers, and 20% is used for heating the process and generating electricity [16].

Russia produces carbamide of two brands — A and B. Carbamide of the A brand is intended for use in industry in the production of plastics, resins, adhesives. Urea grade B is used in agriculture as a mineral nitrogen fertilizer under the brand urea. Carbamide is a type of fertilizer, which is the most concentrated of nitrogen fertilizers, the nitrogen content in it is 46.3%. The specific weight of carbamide in the production of nitrogen fertilizers in Russia is 29—32%.

Currently, of all the known methods for producing urea, the process of synthesis of urea from ammonia and carbon dioxide has received industrial significance according to the method developed in 1868 by the Russian chemist A.I. Bazarov. For the first time on an industrial scale, direct synthesis of carbamide was carried out only in 1920 by I. G. Farbenindustri (Germany).

The technological scheme of urea production, namely the synthesis and distillation stage of one of the modern productions, assumes that the main apparatus of the synthesis stage of urea production is a synthesis column, into the lower part of which carbon dioxide and a mixture of ammonia with ammonium carbamate are supplied from the injector [16]. Liquid ammonia from high-pressure pumps is supplied to the injector as a working flow. In the synthesis column at a pressure of 14.9—15.4 MPa and a temperature of 180—189°C, the synthesis proceeds in two stages: the stage of formation of ammonium carbamate, described below by the equation

$$2\ NH_3 + CO_2 \rightarrow NH_4COONH_2 + 125{,}6\ KJ$$

and the dehydration stage of ammonium carbamate

$$NH_4COONH_2 \rightarrow CO(NH_2)_2 + H2O - 15{,}5\ KJ.$$

The heat released at the first stage of ammonium carbamate formation is partially used at the second stage of ammonium carbamate dehydration.

In addition, the production of ammonia requires hydrogen H_2 (the Haber process, in the catalytic reaction of nitrogen N_2 and H_2). At the same time, all methods of hydrogen production, including water electrolysis, except for hydrocarbon reforming, are absolutely economically unprofitable on the scale of large-scale production, and therefore the main method of hydrogen production, during which carbon dioxide used in the above reactions is released, is steam reforming of methane: at a temperature of 700—1100 °C and a pressure of 3—25 bar, in the presence of a catalyst, water vapor reacts with methane with the release of synthesis gas (the process is endothermic, it goes with the absorption of heat):

$$CH_4 + H_2O\ (+heat) \rightarrow CO + 3H_2.$$

Therefore, this process is used in the production of mineral fertilizers [17].

2.3. Investments in methane chemistry and production of nitrogen fertilizers

The largest branch of methane chemistry is ammonia and its remediation. In Russia, ammonia ranks first in terms of production among the products of methane chemistry (17.8 million tons), several times ahead of methanol (4.4 million tons). Ammonia production will increase by 15% by 2030 and 30% by 2050 compared to the present [18]. The increase in ammonia production will be mainly due to the planned increase in demand for nitrogen fertilizers in developing countries.

The ammonia industry shows resistance to financial and economic changes. According to Argus data for 2020, the market of mineral fertilizers with the beginning of the pandemic not only did not experience noticeable shocks, but on the contrary, actively developed. Thus, in January — October, Russian producers increased shipments of the main types of mineral fertilizers to the domestic market by 11.5%, to 8.2 million tons, for export — by 2%, to 27.5 million tons [18].

It is important to note that among the key projects of the Government of the Russian Federation in the field of petrochemistry are 35 projects for the production of mineral fertilizers worth 780.2 billion rubles until 2030. Based on the survey data [18], we will consider the planned investments in a number of projects for the production of nitrogen fertilizers.

Due to the high demand for mineral fertilizers, intense competition promotes the construction of new efficient integrated production facilities, as well as the modernization of existing capacities. So several major projects have been announced in Russia. First of all, it is worth noting such projects as: the construction of a plant in the Leningrad region with a capacity of 1.1 million tons of ammonia and 1.4 million tons of urea per year announced by Eurochem, as well as the Nakhodka Mineral Fertilizers Plant project with a capacity of 1.8 million tons of ammonia and 3 million tons of urea per year. Shchekinoazot Company has planned the commissioning of the complex of nitric acid and ammonium nitrate AK-270/AS-340. In addition, the construction of a production complex for the production of ammonia and urea with a capacity of 525 and 700 thousand tons per year, respectively, continues at the site of the enterprise. Metafrax's priority investment project in the short term is the construction of the Ammonia-Carbamide-Melamine (ACM) production complex with a budget of more than 58 billion rubles. The project involves the construction of a production complex capable of producing up to 575 thousand tons of carbamide, 308 thousand tons of ammonia and 41 thousand tons of melamine per year. Work on the creation of the ACM started in 2016. Due to the pandemic, the commissioning of the complex goes beyond the design deadlines. At the same time, it should be noted that currently the company was experiencing logistical problems with the delivery of imported equipment to Gubakha, and the arrival of foreign specialists involved in the project was also difficult.

At the end of 2020, one of the leaders of the fertilizer market, Acron, announced the largest investment project in the history of the Novgorod region — the construction of a new production facility with a capacity of 1.6 million tons of urea and 300 thousand tons of commercial ammonia. The amount of investments under the project will amount to 106 billion rubles. The start of the project was scheduled for 2021, and the production was scheduled for the second half of 2025. It is worth noting that Acron has been implementing a series of projects over the past few years aimed at increasing the capacity of ammonia production and its efficient processing into nitrogen fertilizers. In 2021, the project "Carbamide No. 6+", which started in 2019, was completed. Modernization of the unit will increase the capacity from 600 to 2050 thousand tons per day. Investments in the project are estimated at $ 85 million.

According to the development strategy until 2025, Tolyattiazot invests about 112 billion rubles in expanding production capacities and increasing production volumes. As part of this strategy, in 2021, the company launched a complex for the production of urea, developed in cooperation with Casale, with a capacity of 2.2 thousand tons per day and a cost of over 25 billion rubles. This project will increase the existing capacity for the production of urea by 70%.

Kuibyshevazot continues to implement a joint project with MET Development (the project division of Maire Tecnimont) — the construction of a complex for the production of urea with a capacity of 1.5 thousand tons per day. The total amount of investments is tentatively estimated at about 160 million euros (about 11 billion rubles). The production capacity will be 525 thousand tons per year (1500 tons/day) of urea. Stamicarbon company was chosen as the licensor of the project, NIIK was involved as the design institute. The project is scheduled to be completed in 2022.

Kemerovo Azot continues to implement a program launched in 2018 and designed for 6 years called "Technical re-equipment of the production of mineral fertilizers with an increase in the output of ammonium nitrate by 220 thousand tons per year". Modernization of the enterprise will allow, in particular, to increase the output of ammonium nitrate by 1.6 times due to the construction of three workshops for its production. According to the company's website, the output of ammonium nitrate in 2017 during the operation of one workshop amounted to 1 million 50.8 thousand tons. The total amount of investments under the program is 27 billion rubles.

In the autumn of 2020, the Azot branch of Uralchem launched an investment project that will increase the capacity of ammonium nitrate production. The holding's investments will amount to 1.2 billion rubles.

The launch of a fertilizer plant in the Orel region was planned for 2021. Back in 2017, Orelmetakhim signed an investment agreement with the regional government on the implementation of a project to build a plant with a capacity of 700 thousand tons of granular urea per year. The volume of investments is estimated at 181 million euros. The payback period of the project according to various estimates will be from 7 to 9.5 years. Construction time is 40—48 months. Currently, the project is still in the final stage of completion.

Thus, the investments considered can provide both the need for nitrogen and complex fertilizers within the country, and provide the necessary export supplies [18]. At the same time, as noted above, it is necessary to provide these projects with natural gas supplies.

2.4. Use of renewable energy sources for the production of mineral fertilizers

One example of the use of renewable energy is the production of mineral fertilizers in the Scandinavian company Yara, which was founded in 1905 as part of the company NorskHydro. Currently, it is a multinational company with business in 60 countries and an income of $16 billion in 2020 [19]. The company positions itself as a producer of "green fertilizers", meaning mineral fertilizers based on nitrates with exactly the same chemical and physical composition as fertilizers produced on fossil fuels (natural gas, coal, oil), but with a much smaller carbon footprint, since they are produced using renewable electricity (hydro, wind, solar). This means that "green fertilizers" can be an effective and simple way to decarbonize food production that does not use fossil fuels. At the same time, the production of nitrogen fertilizers using modern technologies is carried out on the basis of ammonia, which is produced using the process described above from methane obtained from natural gas. At the same time, as Yara suggests, for the production of "green fertilizers", the hydrogen needed for the production of ammonia will be supplied by photolysis of water using renewable electricity. After the extraction of hydrogen to produce "green" ammonia, all other processes will remain the same. This includes the use of the best Available Technology catalytic process (BAT), which reduces greenhouse gas (GHG) emissions during the production process. The technology allowed Yara to reduce emissions from the production of fertilizers from nitrous oxide (N_2O), a powerful greenhouse gas, by more than 90 percent (Fig. 1).

Today, Yara has a portfolio of projects for the production of environmentally friendly ammonia, which will be of key importance for the production of environmentally friendly fertilizers in Norway, the Netherlands and Australia. The company is actively working to expand the geographical presence of the "green" ammonia production business. Yara plans to start the first deliveries of "green fertilizers" in 2023 in a pilot project in Porsgrunn, Norway. The construction of this plant has already begun. Subsequent deliveries will be integrated into Yara's portfolio of future projects for the production of environmentally friendly ammonia. The Porsgrunn project is the first Yara industrial electrolyzer project with system integration into an existing ammonia production plant. The commercial launch of this project is scheduled for 2023. It will produce about 20,000 tons of ammonia per year, which will make it possible to produce from 60,000 to 80,000 tons of "green mineral fertilizers". Within the framework of the HEGRA project, Yara intends to convert the entire plant in Porsgrunn to environmentally friendly ammonia in five to seven years, which will allow for large-scale production of environmentally "clean" ammonia. At the same time, it is believed that this will reduce the flow of CO_2 into the atmosphere. Thus, according to the company [19], the transition to environmentally friendly fertilizers will also have a big impact on the carbon footprint of the final product, reducing it by about 20 percent for wheat and about 12 percent for a loaf of bread.

2.5. Technological possibilities of using alternative sources

Currently, the only process alternative to natural fossil energy sources, ideally, can be the production of hydrogen. Its combustion in reaction with atmospheric oxygen will make it possible to obtain environmentally

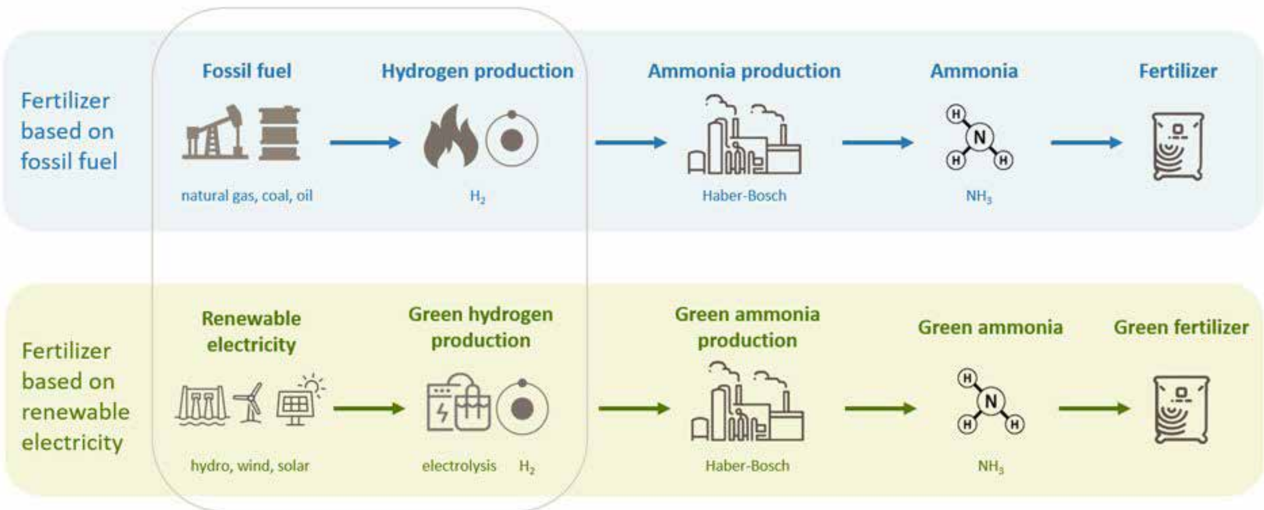

Figure 1. Technological schemes for obtaining traditional (upper line) and "green" (lower line) fertilizers [19]

Рис. 1. Технологические схемы получения традиционных (верхняя линия) и «зеленых» (нижняя линия) удобрений friendly energy. Various hydrogen production methods are discussed within the framework of various programs, and the main focus is on methane pyrolysis. The gas companies are also considering the prospects of pumping hydrogen into existing gas transmission networks. The EU's developments on hydrogen transport in the future are also devoted to this [20,21].

Indeed, from a political and, partly, from an environmental point of view, much is associated with hydrogen, the idealized fuel of the future. But there are no natural reserves of it and it is impossible to "open" a field and extract hydrogen as oil or natural gas. The basic technology for producing hydrogen today is the above-mentioned steam conversion of methane, during which hydrogen is extracted from a hydrocarbon compound in tubular furnaces (chemical steam reformers) in the presence of steam. The technology is extremely energy-intensive, but the main thing is that carbon dioxide is released in the production process, which, from the point of view of renewable energy apologists, is responsible for creating a greenhouse effect.

Another technological process is also known — electrolysis, dissociation of a water molecule into oxygen and hydrogen under the influence of electricity. This technology is used at Russian nuclear power plants, where electrolyzers that produce hydrogen work, and it is used in technological processes for its own needs. It is also possible to consider the possibility of large-scale production of hydrogen in the new generation of high-temperature gas-cooled nuclear reactors (HTGR) being developed. "Gas-cooled" means that an inert gas, helium, is used to remove heat from fuel elements (fuel rods), which is heated to a temperature of 950 °C. This heat is directed to produce water vapor, which spins the turbine of the electric generator. Also, the heat produced by HTGR can be directly used to obtain a methane-hydrogen mixture and pure hydrogen from natural gas by thermochemical methods [21].

But again there is a question of the efficiency of the process. Why not use the received energy directly, but transform it back into an energy source — hydrogen? This is practically a repetition of the same process of methane pyrolysis, because methane itself can be used as an energy source. In addition, these developments on HTGR are still very far from practical application.

And again, the question arises — why is it necessary to abandon methane production and replace it with so-called "green energy" with sufficiently low efficiency indicators?

Therefore, even the production of hydrogen is a very energy-intensive process, in addition, the manufacture, placement and transport for storing and moving hydrogen are also associated with very energy-intensive production. In addition, all these processes are technologically complex and environmentally very harmful. And finally, hydrogen is not methane and this gas can diffuse through metals under certain circumstances, so transporting hydrogen on an industrial scale is quite expensive and dangerous. In case of accidents, hydrogen can combine with oxygen in the air to form the so-called a "rattling mixture" and an explosion.

In addition to electricity production, do not forget about heating, not to mention gas chemistry. Here, the advantages of methane over hydrogen are even more obvious and are unlikely to be challenged by new technologies that have yet to be developed.

Therefore, it can be noted that in reality, in many countries, the development of "green energy" has been turned into an end in itself, forgetting that it is only a means to obtain, at first glance, environmentally friendly and cheap energy and heat. However, green energy does not provide either, being always subsidized. Moreover, they are always forced to switch to it by threats of fines or by legislative decisions and threats. At the same time, the obvious fact is forgotten and ignored that the ecological footprint of any "green energy" is always larger and more dangerous than ICE and even coal plants.

In most cases, the cost of producing "alternative energy" exceeds the amount of energy received. Of all the alternatives, thermonuclear fusion could be now, but it will obviously take more than a decade before its practical implementation. As noted, the production of hydrogen is possible, but it is also not a process in the near future, but only when less energy is spent on its production than it will give. At the present time, everything is the opposite and therefore unrealizable on an industrial scale. The announced decisions are mostly purely political in nature. Therefore, in the next not only 10—30 years, but even 30—50 years, there is and will not be an alternative to fossil energy sources. And among them, it is natural gas that belongs and will probably, like nuclear power plants, play a decisive role in providing humanity with affordable energy.

3. Global and regional fluxes of methane as source of methane chemistry and energy

Russia is the second largest producer of natural gas in the world after the United States and has the world's largest gas reserves. Russia is the world's largest gas exporter. In 2021, the country produced 762 billion cubic meters of natural gas and exported about 210 billion cubic meters through pipelines.

Gazprom and Novatek are the main gas producers in Russia, but many Russian oil companies, including Rosneft, also operate gas production facilities. State-owned Gazprom is the largest gas producer, but its share in production has declined over the past decade as Novatek and Rosneft have expanded their production capacities. However, in 2021 Gazprom still accounted for 68% of Russian gas production. Historically, production has been concentrated in Western Siberia, but in the last decade investments have shifted to Yamal, Eastern Siberia and the Far East, as well as to the Arctic shelf.

Russia also has an extensive network of export gas pipelines, both through transit routes through Belarus and Ukraine, and through pipelines through which gas flows directly to Europe (including the Nord Stream, Blue Stream and Turkish Stream pipelines). Russia completed the construction of the Nord Stream II gas pipeline in 2021, but the German government postponed the certification of the project. Russian natural gas accounted for 45% of imports and almost 40% of gas demand in the European Union in 2021. This share has increased in recent years as domestic natural gas production in Europe has declined. Germany, Turkey and Italy are the largest importers of Russian natural gas.

At the end of 2019, Russia launched a major export gas pipeline to the east — the Power of Siberia pipeline with a length of about 3,000 km, with a capacity of 38 billion cubic meters, in order to be able to send gas from the fields of the Far East directly to China. In 2021, Gazprom exported more than 10 billion cubic meters of natural gas through the Power of Siberia pipeline, and in the coming years it is planned to gradually increase exports to 38 billion cubic meters. Russia is striving to develop the Power of Siberia-2 gas pipeline with a capacity of 50 billion cubic meters. per year, which will supply gas to China from the fields of Western Siberia. Although supply agreements and a final investment decision on the pipeline have not yet been reached, this will further reduce Russia's dependence on European gas consumers.

In addition, Russia is expanding its liquefied natural gas (LNG) production capacity to compete with the growing LNG exports from the United States, Australia and Qatar. In 2021, the government published a long-term LNG development plan aimed at exporting LNG with a volume of 110—190 billion cubic meters. per year by 2025. In 2021, Russia exported 40 billion cubic meters of LNG, making it the 4th largest LNG exporter in the world, accounting for about 8% of global LNG supplies.

In recent years, Russia has been paying more and more attention to the Arctic as a way to increase oil and gas production and compensate for the decline in existing and old production sites. The Arctic accounts for more than 80% of Russia's natural gas production and an estimated 20% of crude oil production. While climate change threatens future investment in the region, it also provides Russia with the opportunity to expand access to Arctic trade routes, which provides additional flexibility in offshore fossil fuel supplies, especially to Asia.

However, the use of methane (natural gas) and its supply for energy supply and fertilizer production while ensuring food security is limited in the context of the sanctions conflict of 2022, which raised commodity prices to new highs with broader consequences for the global economy. [22]

The conflict has put further significant pressure on natural gas markets and increased uncertainty in an already tense market. Europe has been at the epicenter of market tensions since the beginning of the heating season as a result of a combination of lower–than–average reserves in underground storage facilities — mainly at facilities partially owned or controlled by Gazprom — and a sharp annual reduction in supplies via Russian pipelines. The decline in supplies from Russia was largely offset by LNG, which turned Europe into a premium market and diverted cargo from the Asia-Pacific region and other regions. As a result, limited supplies, high prices and increased uncertainty in the market have led to a downward revision of the growth rate of global gas consumption, which as a result is expected to turn negative in 2022 (Fig. 2).

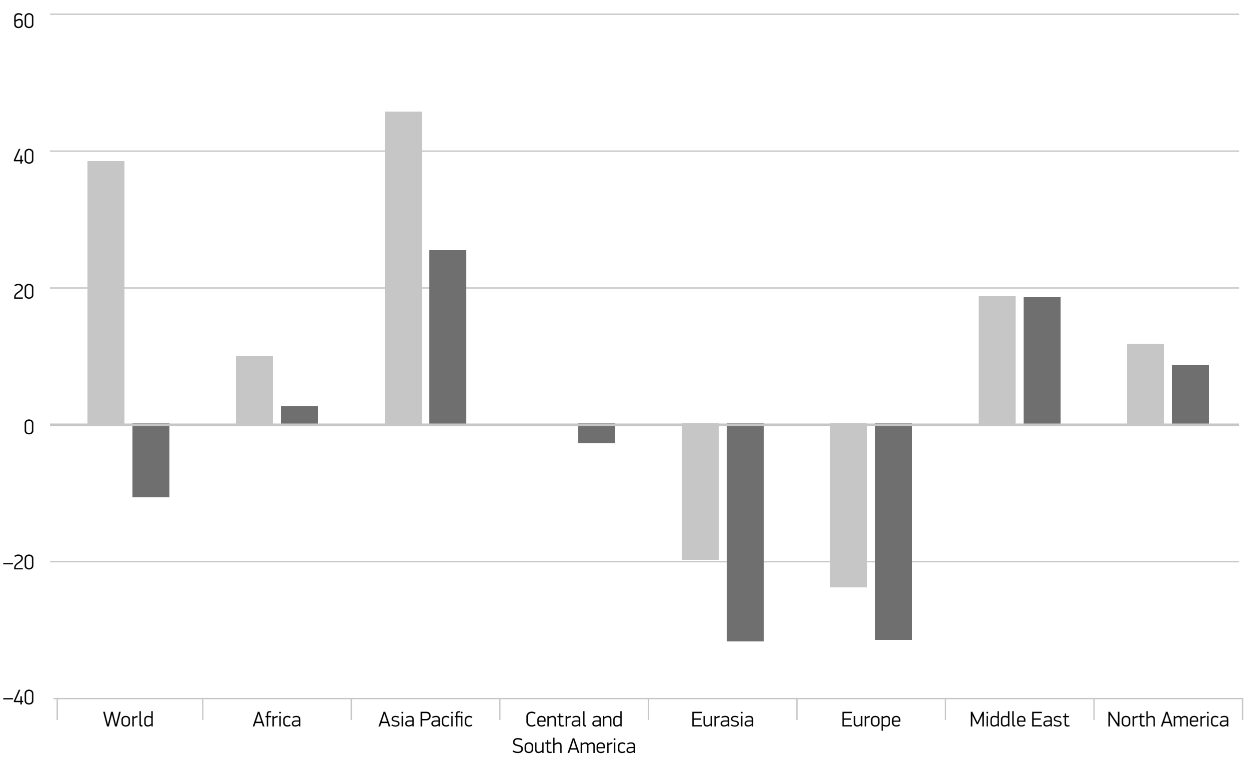

Figure 2. Natural gas consumption growth, Q2 2022 (dark gray bars) compared to Q1 2022 (gray bars) [22]

Рис. 2. Рост потребления природного газа, Q2 2022 (темно-серые столбики) по сравнению с Q1 2022 (серые столбики)

Conclusion

The cost of fertilizers may increase by 70% by the end of the year, according to the analyses summarized by the World Bank [22—26]. It has been stated that the fertilizer price index increased by almost 10% in the first quarter of 2022 in annual terms, following last year's trend, when fertilizers rose by 80% over the year due to supply disruptions and trade restrictions in China. Fertilizer prices are projected to rise by almost 70% in 2022 before falling in 2023.

The main reasons for such dynamics were a sharp increase in production costs, interruptions in supplies from Russia and Belarus and the extension of export restrictions by China.

As noted, the cost of nitrogen fertilizers has increased more than after the 2008 crisis. One may estimate that the surge in prices that began in 2021 also reflecting a reduction in production that occurred in response to a sharp rise in commodity prices and restrictive trade policies. In Europe, production has been sharply reduced due to rising natural gas prices [22].

Prices for phosphorus fertilizers in the first quarter of 2022 increased by 11% due to the rise in the cost of ammonia and sulfur. It is known that the Russia holds the first place in global exports of both resources, and it is currently experiencing logistics problems due to the sanction crisis, which negatively affects the entire global supply chain. China, which accounts for up to 30% of all phosphate trade, has imposed a ban on the export of these products until June 2022. Russia has extended the ban on the export of ammonium nitrate outside the EAEU.

It has been noted also that prices for phosphate fertilizers have almost doubled in 2021. According to the forecast, prices will rise by another 50% in 2022, and then decrease in 2023 if new capacities are launched in developing countries, and restrictive measures are lifted. In addition to reducing production costs, the prospects depend on whether China will resume exports after June 2022 [22].

Potash fertilizers rose in price by almost 80% in the first quarter of 2022. This could have been also linked this with geopolitical events.

The geopolitical risks are also related to the fact that since February 1, 2022, Lithuania has banned the transit of potassium from Belarus on its railways. It is predicted that in 2022, potash prices will be 1.5 times higher on average than in 2021, and will remain high in 2023 if supplies from Russia and Belarus do not return to the world market [22].

Furthermore, currently, in addition to Russia, Canada, the USA, France, Australia, Ukraine, Argentina, Romania and some other countries supply food grains to the world market. At the same time, it can be expected that in 2022 the production of food raw materials in these countries will decrease due to a shortage and an increase in prices for fertilizers, energy carriers and logistics. Accordingly, the food prices will also be up.

Finely, it has been concluded that the sanctions crisis has already turned into economic problems for the United States and Europe, causing a serious increase in fuel and food prices.

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