PUBLISHED BY
VOPROSY
EKONOMIKI
N. P.

Russian Journal of Economics 6 (2020) 424–436
DOI 10.32609/j.ruje.6.55177
Publication date: 14 December 2020

Russian
Journal of
Economics

www.rujec.org

Fossil fuels markets in the "energy transition" era

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Abstract

The global energy sector is undergoing a global transformation under the influence of technological breakthroughs in several sectors of production and consumption, as well as profound socioeconomic changes in approaches to energy use. This process became known as "energy transition." In this paper, the authors investigate the long-term impact of the energy transition and related processes on the markets of key fossil fuels: oil, natural gas, and coal. Research shows that all fossil fuel sectors will face a significant increase in competition, both within traditional markets and from other energy sources, due to the development of inter-fuel competition. At the same time, energy policies and efforts to combat greenhouse gas emissions will mostly determine the energy balances of the largest countries, and will have an even greater impact on the market. Natural gas, as the most environmentally friendly of fossil fuels, with a large potential to supplement the generation of new renewable energy sources (NRES), will be the least impaired by the energy transition. In the next 20 years, its consumption and production are expected to grow significantly. Oil is under serious pressure from environmental legislation and growing inter-fuel competition in the transport sector. It is highly likely that consumption will peak before 2040, yet the depletion of traditional resources is supporting prices. The coal market is set for an almost inevitable reduction in consumption. New technologies for capturing emissions can only partially mitigate the rate of coal use decline.

Keywords: energy sector, fossil fuels markets, energy transition, energy markets forecast, economic modeling.
JEL classification: Q41, Q42, Q43, Q47.

1. Introduction

The global energy sector has entered the stage of another transformation associated with the active development of renewable energy (Smil, 2010), new

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approaches to environmental regulation and a significant increase in competition not only within the fuel markets, but also at the inter-fuel level in the consumption sectors. These changes are widely covered in works by international organizations, such as IEA (2018), World Energy Council (2019), OPEC (2017), IRENA (2020); research centers: OIES (Fattouh et al., 2019), HIS (Yergin, 2015), ERI RAS (Makarov et al., 2019), Bloomberg (McCrone, 2019), McKinsey (Heiligtag et al., 2019), and energy companies: Shell (2020), BP (2019), ExxonMobil (2019). But estimates of the transformation pace and its consequences vary. While some studies suggest that consumption of all fossil energy sources will continue to grow until 2040, others show that peaks in consumption are looming within the next few years. At the same time, it becomes obvious that each type of fossil fuel will face significant changes in their respective markets.

For each of the conventional fuels the key drivers of the energy transition create their own challenges. For the oil market, these challenges are related to the development of inter-fuel competition in all sectors of consumption, and with the most significant role played by the situation in the transport sector (Kapustin and Grushevenko, 2020). For the natural gas and coal markets, the challenges of the energy transition are primarily related to the decarbonization of the electric power industry and the increase in generation volumes from new renewable energy sources (NRES) stations, which is stimulated by tightening climate agenda and an increase in the technological and economic competitiveness of renewable energy sources (RES) generation compared to conventional thermal plants (IRENA, 2018). In addition, changes in the operating modes of power systems, the development of decentralized power supply, energy storage systems and new technologies in the field of more efficient and clean use of fossil fuels will be of great importance.

In addition to energy transition factors, many other elements influence the configuration of global fossil fuel markets. For individual market participants, the impact of these factors may be no less significant than the transformation within the energy transition. Such factors, for example, include the rapid development of unconventional oil and gas production technologies (Grushevenko and Kapustin, 2018) and the long-term artificial restriction of production by conventional oil producers and exporters (Fattouh and Economou, 2018). At the same time, both energy transition processes and other factors are strongly influenced by energy policies and advances in technology development.

Thus, to assess the prospects for market development, a complex approach that takes into account both factors related to long-term trends in the formation of global and national energy balances, as well as energy policies, technology development, and the situation in individual regional and fuel markets, is necessary. In this article, the authors explore the most likely directions for the transformation of the global fossil fuel markets over the next 20 years, analyzing the impact of various factors; they also provide numerical estimates of the prospects for such changes, presenting a possible range of scenarios for the development of oil, natural gas and coal markets.

2. Oil market in the “energy transition” era

For the oil market the key uncertainties regarding the prospects for its development over the next 20 years are related to the process of forming oil demand. During the first two decades of the XXI century, many countries have seen a steady trend towards replacing petroleum products with alternative fuels in several consumption sectors. This has led to a reduction in demand in some countries and a growth slowdown in others. For example, oil fuels have almost ceased to be used in the generation segment, and fuel-oil power plants are being replaced by alternative sources. This is because of both low economic efficiency of oil stations in comparison with their counterparts (according to Lazard's Levelized Cost of Electricity (LCOE) estimates, oil stations are comparable to the costliest small scale renewable energy installations and are almost three times more expensive than coal plants (Lazard, 2015), and the significant emissions of greenhouse gases and other pollutants. Given the low competitiveness of oil as a source of energy for power generation, contemporary practices limit the use of fuel oil and diesel generators to backup sources in the event of accidents or basic fuel supply interruptions. The advantage of oil generating plants is the ease of transport of equipment and fuel, as well as load flexibility.

It is precisely because of these three characteristics: quick start-up, flexible operation, and mobility, that oil-based generators have long been absolutely dominant in the set-up of power systems for remote consumers, naturally disconnected from energy transmission systems (shift camps, remote recreational points, expeditions, etc.). Currently, the decentralized energy supply market is diversifying due to new technological solutions, primarily in the field of renewable energy and small-scale liquefied natural gas (LNG). Already the small RES installations (solar panels, small wind generators) are competitive in terms of LCOE with diesel and gasoline generators and do not require constant fuel supply. But to ensure a stable supply of energy, an energy storage system, or duplicate capacity, for example in the form of small-scale LNG, is still a necessity.

The increase of efficiency of electric household appliances, expanding coverage of power grids, and development of alternative distributed generation have also reduced the demand for petroleum products in the household sector, where until recently diesel generators were widely used for electricity production, and propane-butane mixtures (LPG) for heating and cooking

The petrochemical segment demonstrates stable and even increasing growth rates of demand for oil. However, this is also not without competition. The fact is that ethane, naphtha, propane, butane, and even gas oil, which are used as crudes for chemical synthesis, can only nominally be related to petroleum products. In practice, all these organic compounds can be produced from both crude oil and natural gas, and often production from gas is cheaper. It is important that the basic half-product of petrochemistry — ethylene does not differ in its characteristics, regardless of whether the raw material for its production is obtained from oil or gas, which makes the division of the hydrocarbon chemistry industry into petroleum or gas chemistry an outdated convention. Thus, in many regions of the world, the increase in demand for raw materials for chemical production will not cause an increase in demand for crude oil if there is supply of "wet" natural gas in the region that can be used for the production of ethane and other products.

Nevertheless, despite alarming trends for oil producers in the generation, residential, and petrochemical sectors, the situation in the transport sector (including rail, aviation, water and road transport), which as of 2018 generates 56% of the total global demand for petroleum products, will be of key importance.

Ever since Ford decided to base its mass-produced car on an internal combustion engine (ICE), rather than an electric drive, petroleum products have won the market and have become dominant as a fuel for transport, covering at least 90% of the total energy demand for mobility throughout the 20th—early 21st century.

Numerous attempts to find a cheap, efficient, environmentally friendly and scalable alternative to petroleum products in this sector were unsuccessful for the most of this period:

- in the 1940s, Coal-to-Liquids (CTL) and Gas-to-Liquides (GTL) fuels, produced in large scale through coal gasification during World War II, became such an attempt. In the postwar period, it turned out that the use of such technologies was prohibitively expensive. In addition, although these fuels did not require petroleum for production, they still used other fossil fuels as crude, which means that dependence on oil suppliers changed to dependence on the producers of these fuels. At the same time, the problem of decarbonizing the transport sector was not solved. Currently, the production of such fuels provides less than 1% of the total demand for liquid fuels;
- in the 1970s, the idea of gas as motor fuel was actively circulated. However, despite the existence of support programs in many countries around the world, this initiative has not seen broad development. The main reason for this was problems with more complex infrastructure. In the mid-2010s, the topic of gas fuel fell under the spotlight once again. This was largely due to the development of the small LNG sector, the use of which is of interest primarily in heavy transport. Thus, in addition to the compressed natural gas and liquified petrolium gas, the LNG-based solutions were researched. However, this initiative has not yet been developed to its full potential, not in small part due to the parallel rapid development of alternatives, including electric transport;
- in the 1990s and 2000s, high expectations were put on liquid biofuels to replace petroleum products. However, their consumption over 30 years, despite all the efforts of state support from various countries, has barely reached 3% of the total global demand for liquid fuels. There are two reasons for such a low rate of development of biofuels: first, their production technology is based on expensive and energy-intensive processes of pyrolysis of biomass, and secondly, the main crude for biodiesel and bioethanol comes from agricultural food crops, which can create certain problems in conditions of limited arable land.

In the last decade, there has been significant progress in the field of electric transport, so rapid in fact that it may seem to be the alternative that will end the hegemony of oil in the transport sector. In 2013–2018 alone, the number of electric vehicles (EVs) worldwide grew from 500,000 to more than 5 million units (IEA, 2019), and their annual sales in 2018 accounted for 3.5% of the global auto market (Irle, 2019). The accumulated technological acumen in the field of electric battery production, combined with support measures in the form of significant subsidies, according to the calculations of ERI RAS, provided in 2019 full competitiveness of the average annual cost of ownership of EVs with conventional ICE cars in Europe, the United States and Japan (Kulagin, 2020). In China, EVs became even more competitive in 2018 than ICE vehicles, but the reduction of subsidies in 2019 also led to a simultaneous decrease in their attractiveness.

Almost all key automakers continue to develop electric technologies, promising to reduce the cost electricity storage by another 2.5 times in the coming years (from the 2018 level of $250/kWh), which will ensure the competitiveness of EVs with ICE cars in many countries without government support measures. However, scientific breakthroughs are not always possible, even under the consolidated efforts of many interested participants. At the same time, the development of alternative technologies is still ongoing, including those that are already widely used. All this makes the "business-as-usual" scenario, in which there is no drastic change in the attractiveness of an electric car, appear quite likely.

In the absence of significant technological progress, government policies will play a key role in determining the future competitive positions of petroleum products and electricity in the transport sector. In recent years, this factor has allowed to reduce the cost of ownership of EV by 25–50% from the net values and largely determined the positive dynamics of EV sales. In this context, the case of 2019 in the largest electric transport market in China is significant, as, after the abolition of subsidies for electric vehicles, sales of this type of transport began to decline in comparison with the previous year.

In the context of electric transport spread, it is of great interest to assess the impact of these processes on oil demand. One should understand that the global need for mobility is constantly increasing. Even with a relatively modest growth rate of 2.8% in global GDP, the growth of the global fleet will require about 1.5 billion tons of additional energy by 2040. Part of this increase (about 0.6 billion toe) can be compensated for by 2040 by increasing the energy efficiency of conventional vehicles (reducing fuel consumption in the global fleet as a whole). Another 0.27 billion toe will be cut by the transition to alternative fuels. This roughly corresponds to the development of energy in the framework of "business-as-usual" scenarios while maintaining existing approaches. However, the tightening of policy in terms of emissions, energy efficiency and support for the transition of transport to alternative fuels can lead to a peak in oil consumption already by 2025–2030 and by 2040, the demand for oil can be significantly below 2019 levels.

According to ERI RAS calculations, to ensure such volume of economically and technologically reasonable substitution of petroleum fuels with electric vehicles, including hybrid (HEV), battery (BEV) and hydrogen (HyEV), the ownership cost of EVs for the end user needs to be maintained at a level below the ownership cost of the conventional car throughout the entire 2020 to 2040 period. This is only possible if the goals for reducing the cost of electricity storage are met. It will also be necessary to ensure a high level of government support before reaching economic competitiveness, including a return to the level of subsidizing EVs in China in 2018, and the adoption of similar support measures in other non-OECD Asian countries (Fig. 1).

Taking into account the existing uncertainties regarding the future development of transport sector technologies the total global demand for oil by 2040 may range from 3.7 to 4.6 billion toe compared to 4.3 billion toe in 2019. And this is on the backdrop of excess supply, which creates serious competition in the consumer markets.

By now, the competition between OPEC+ countries and producers of unconventional oil (shale oil, low-permeable reservoir oil, high-viscosity oil, and oil sands), mainly the United States and Canada, is apparent. The expertise in the development of these unconventional resources since the beginning of the 21st century had brought about break-even prices for many projects by 2019

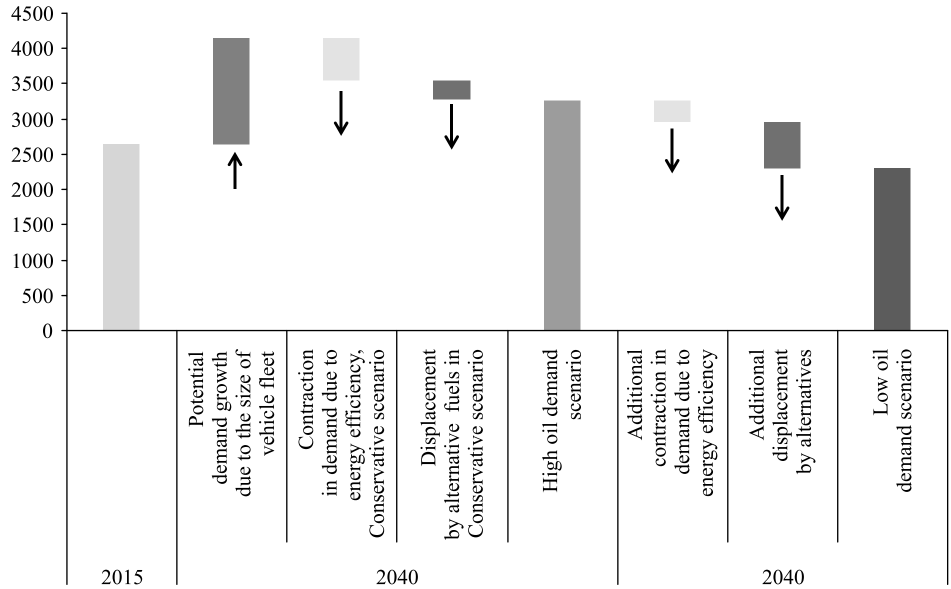

Fig. 1. Breakdown of oil products demand in the transport sector in 2040 (million tonnes of oil equivalent).

Source: ERI RAS estimates.

to the level of $30–$50/bbl, which corresponds to the average range of production costs for new projects from such large producers, as Russia, Iran, and the UAE. Maintaining or progressively increasing the level of costs within their natural escalation for unconventional oils will allow them to preserve their economic competitiveness in the market in the foreseeable future.

At the same time, it should be taken into account that most conventional producers artificially limit their production under the OPEC+ agreement to maintain a stable balance of supply and demand on the global market, while the US and Canada, unbound by political agreements, were free to use the favorable price environment till the spring of 2020. This is facilitated by good investment opportunities for local companies and banks, which are often better than those of other countries. In addition, shale projects in the United States are “short” in their life cycle and payback period, which makes them attractive for investment under the high uncertainties of the current market, more so than long-term conventional oil production projects. In fact, at the moment of launch, the entire economy of the short project is apparent thanks to hedging opportunities.

Under such institutional conditions of the global oil market, some redistribution of power and influence among key market players becomes almost inevitable. Notably, by the end of 2018, OPEC+ countries were producing just over 60% of the world’s oil, although at the time of signing the agreement in 2016, their total production accounted for about 53% of the world market.

By 2040, the total share of these countries in global production will be between 58 and 62 per cent, depending on the demand scenario. At the same time, in low oil demand scenarios, it is inevitable not only that the share of these countries in global production will fall, but also that the absolute production volumes of OPEC+ will decrease due to the shrinkage of the global market (Fig. 2).

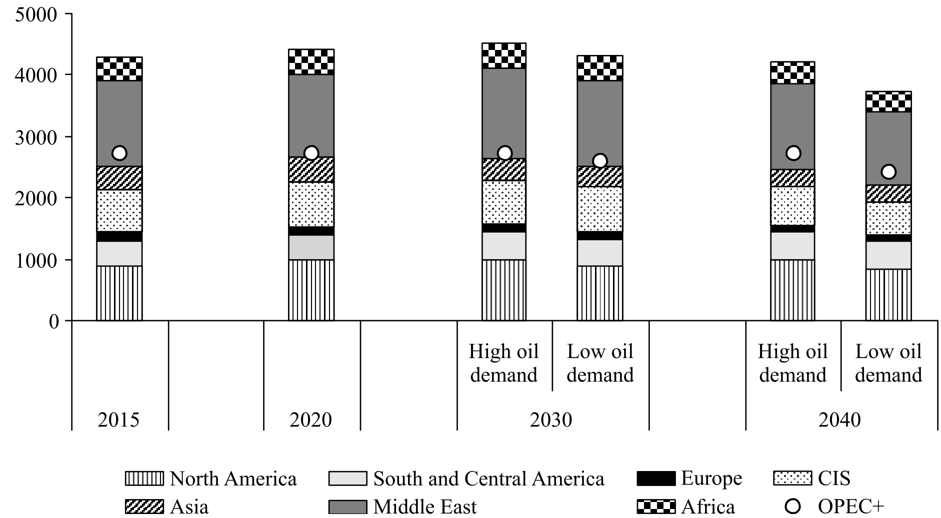

Fig. 2. Forecast of oil production under the high and low scenarios of global demand (million tonnes).

Source: ERI RAS estimates.

It is natural that on the backdrop of stagnant or, at best, slow-growing global demand and excessive supply on the market, no significant increase in oil prices is expected in any of the scenarios. Calculations show that in high demand scenarios, oil prices will not exceed the $90/bbl in 2019 dollars mark even by 2040, and under the low scenarios of global demand—$60/bbl in 2019 dollars. At the same time, the regionalization of oil markets is expected to continue. In the oversupplied North American market, WTI prices will fluctuate $10–$15 below than European levels, while the Asian market will remain premium (the only one where demand is expected to increase from the current levels).

3. Gas market in the era of "energy transition"

Natural gas is the most "environmentally friendly" of all fossil fuels. Burning of natural gas as fuel yields 20–40% less carbon dioxide releases, 80% less carbon monoxide, 30–50% less sulfur oxide than oil or coal; in addition, volatile compounds of heavy metals, sulfur, and solid particles are not released. This makes it the most competitive alternative among fossil fuels in terms of the "energy transition" climate agenda. In addition, according to the LCOE indicator, natural gas is much cheaper than petroleum products, and its competitiveness with coal depends on the current ratio of prices for coal and gas in a particular market and the cost of emissions, which are significantly lower, when using gas, as has been noted.

There are still good opportunities to increase gas consumption in the key demand sector—power generation. First of all, they are facilitated by the rapid growth of demand for electricity and coal replacement plans. In the final consumption sectors, including industry and residential use, gas is gradually replacing coal and petroleum products, but, when this potential is exhausted, it gives up part of its share of electricity. In the hydrocarbon chemistry industry, there is a growing interest in gas products as raw materials. The development of technologies and environmental requirements has allowed for the creation of additional niches for small-scale LNG — in transport (bunkering fuel and large-capacity vehicles), as well as in the framework of decentralized energy supply.

Back in the early 2000s, many experts predicted the inevitable onset of the "gas age." Increased availability and environmental advantages over other fossil fuels contributed to this view. However, at the exhaustion of the economically efficient potential of substitution of coal and oil, gas has had to engage in an intense struggle with new renewable energy sources. And these processes are already calling into question the real possibility of the "gas age." But it is clearly premature to talk about a gradual withdrawal from gas in the coming decades. Of course, if 10 years ago the production of electricity from RES (according to LCOE estimates) was more than twice as expensive as from fossil fuels, by the beginning of the 2020s the indicators were closer to coal and gas generation (Kulagin and Galkina, 2018). However, the analysis of this data requires several important considerations. Firstly, RES continues to operate under significant government support, which creates more favorable competitive conditions. Secondly, for many RES technologies, the main potential for reducing the cost due to technological and constructive innovations and economies of scale has already been passed. Thirdly, it is necessary to take into account the complex effect on electrical systems and modes of operation of RES and consumption. Solar and wind power plants are able to generate energy only when the wind is blowing in the design modes and the sun is shining; in all other cases, NRES power needs to be reserved. Redundancy can be provided either by conventional generation or by storing energy generated during peak hours. However, the possibility of long-term absence of energy generation on RES often makes it impossible to use only storage devices, so double reservations have to be made.

This is the key uncertainty in the formation of prospective volumes of demand for gas as the cleanest reserve fuel: either in the future, effective, technologically suitable and economically accessible energy storage devices will be developed and implemented, which can be integrated into the energy systems of various countries with small amounts of reserve by fossil fuels, or the RES capacity will be reserved by natural gas, thereby itself "energy transition," the goals of which many perceive as an increase in the share of carbon-free energy sources, will be the main driver of growth for global gas demand. This will largely depend on state energy policies, as decisions to switch to other reservation mechanisms will be quite costly and require an increase in electricity prices.

According to ERI RAS estimates, global demand for natural gas will vary in the range of 4990–5340 billion cubic meters by 2040, which indicates an increase in consumption by 25–34% compared to 2019. The key regions that will need additional gas volumes are the Asia-Pacific region, the Middle East, and Africa (Fig. 3).

Changes are also taking place in the structure of gas production. Thanks to the development of technologies, new opportunities for the extraction of unconventional gas are emerging, and the production of biogas is increasing. The market itself is becoming more flexible due to the expansion of production capabilities and through the development of transportation systems.

The main increase in conventional gas production is expected in the Middle East and Russia, while unconventional gas production is expected in the United States.

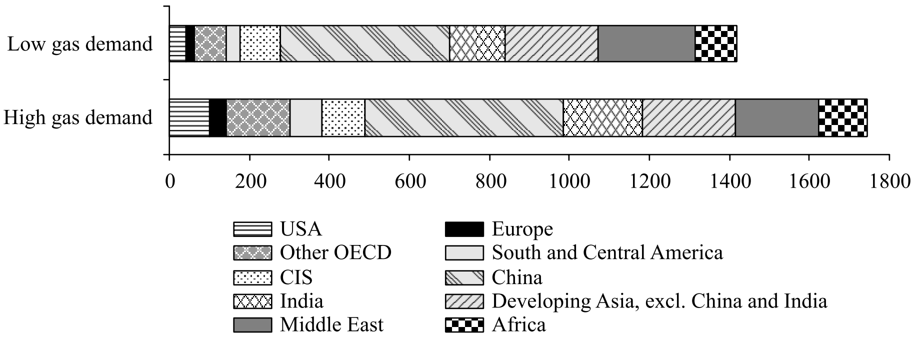

Fig. 3. Range of natural gas demand growth by region by 2040 (billion cubic meters).

Source: ERI RAS estimates.

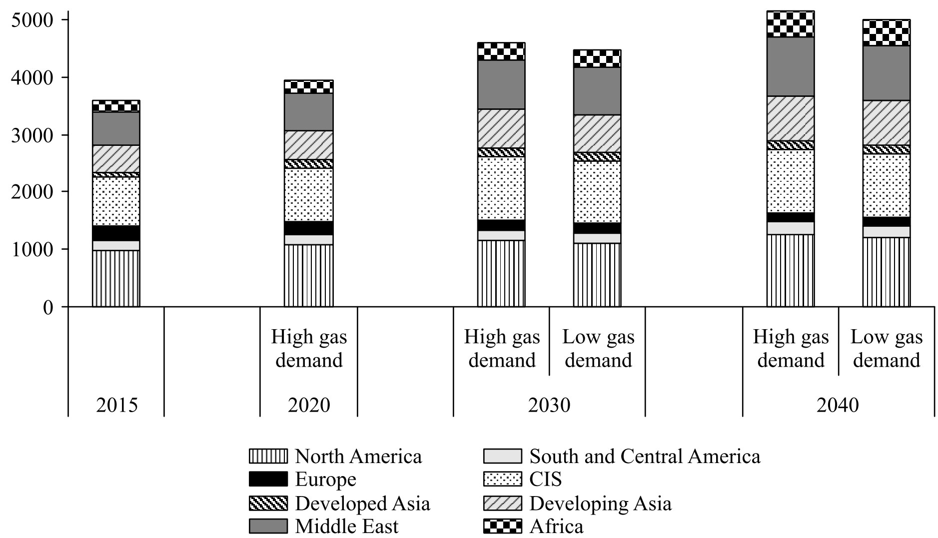

Fig. 4. Scenario forecast of natural gas production by world regions (billion cubic meters).

Source: ERI RAS estimates.

European countries will reduce gas production due to reserves depletion. African gas production will almost double, with the main contribution to the growth made by deposits from southern countries, rather than from North Africa. At the same time, the region's demand for gas will also increase significantly (Fig. 4).

The prospects for a number of gas projects will depend heavily on the situation in the oil market. Firstly, as oil and gas often have interrelated project economy. That is, the sale of gas is unprofitable without the sale of liquid fractions of the same field (especially common for tight gas deposits in the United States and Canada). Secondly, due to the use of natural gas in the systems for maintaining reservoir pressure in oil fields (with low demand for oil, such projects will not be operable).

By 2040, the global gas market should expect a significant change in operating conditions. The most important is the active development of the LNG industry, which will significantly increase the volume of global trade in natural gas, including transcontinental. The development of the liquefied gas market will accelerate, providing supply from key producers: Russia, Qatar, Australia, the United States, Mozambique, Tanzania, Nigeria, and Iran (only 10 countries will provide 85% of world exports) to the markets of key consumers in Europe and Asia. By 2040, LNG exports should increase by 60–65%, which will lead to increased competition between suppliers in almost all world markets.

The price situation on the gas market is changing markedly. And this is not only the result of its evolutionary processes, but also the process of energy transition. Due to the growing competition for consumer markets, there is already a tendency for spot pricing to gradually dominate over long-term bindings to oil prices. In parallel, the growth of the share of RES in power systems leads to the formation of irregularities in the demand for gas not only in the summer-winter seasons, but also daily. At the same time, solar energy further reduces the summer peak. As a result, the gas market is facing an increasing summer/winter imbalance and strong fluctuations within monthly and daily cycles. All this is reflected in prices that were previously linked to a much more stable demand for oil.

Until 2040, the existing regionalization is expected to continue, with the highest prices in Asia and the lowest in North America. Regionalization is due to the high cost of transportation in the final price of gas. At the same time correlation between the markets is inevitable.

4. Coal market in the era of "energy transition"

In the forecast to 2040, the demand for coal follows the most negative scenario compared to all other fossil fuels. For many decades, coal has remained the cheapest and most affordable fuel for generation, providing about $^1/_3$ of the world's electricity in 2019. However, in an energy transition environment, where most countries prioritize reducing emissions in formulating their energy policies, coal remains a strategic option only for developing countries where environmental issues are of less priority than economic development.

The decline in demand for coal in the OECD countries is a clear trend in recent years. China is also at the peak of coal consumption. Passing the peak of global coal consumption over the next 10 years is almost inevitable; the only question is how quickly gas and RES will displace it from the global energy balance (Fig. 5).

The coal trade largely depends on the decision of the two key players in the coal market: China and India. China is implementing a program to remove old technologically obsolete mines that do not meet modern environmental requirements with a total capacity of 800 million tonnes. In replacement, new capacities of 500 million tonnes are being introduced. The peak of production in the country was already passed in 2013–2014. By 2040, it is expected to decrease by an additional 10–30%. The main benchmark for production in the country will be domestic demand. At the same time, the ambitious plans to reduce coal consumption entail that, in case of full implementation, even despite the decline in production, China may turn into a net exporter of coal, which will inevitably lead to a reformatting of the entire world market and trade flows in it.

In India, domestic production is partly limited by the state of the railway infrastructure that could transport coal from production to consumption sites. This

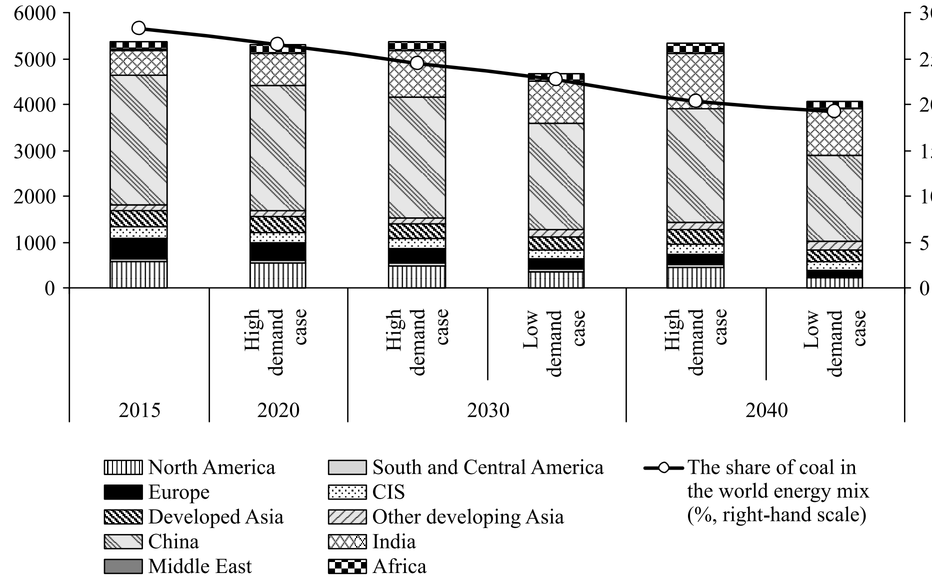

Fig. 5. Coal demand forecast (million tonnes of coal equivalent).

Source: ERI RAS estimates.

problem is gradually being solved, but the probability of stopping the import of coal to the country is quite low. Europe, Japan and South Korea plan to gradually reduce coal imports. Import growth is expected in some countries of the Asia-Pacific region, Africa, the Middle East and South Africa. Naturally, given the current stagnation of the global market and the probable decline of global demand, an increase in global or regional coal prices can hardly be expected.

5. Conclusions

Over the next 20 years, the environment in the fossil fuel markets will change. And these changes will be only partially related to the development of RES. Much will be determined by energy policy and technology development across the energy use spectrum. At the same time, each fossil fuel will face an inevitable increase in competition both within its market and at the inter-fuel competition level. The new decisions of the EU on its fast and radical decarbonization are bringing the new factor in picture in the long-run. We should take into account three factors: high cost of the total decarbonization, a new global recession, and the limited size of the European energy demand and emissions. For the global climate change prevention there will be probably longer periods, different instruments and bridge fuels.

For the gas industry, "energy transition" presents a window of opportunity. Firstly, due to the rapid growth in demand for energy in the power generation sector, where gas is the most attractive of the fossil alternatives. Secondly, because gas has good potential as a backup fuel for RES, at least until other effective technical and economic solutions for load balancing appear.

For oil, the key risks are related to the electrification of transport. However, the growing need for mobility makes petroleum products relevant, even in the context of developing alternative solutions. It is likely that oil demand will peak in the next 15 years, but even under these conditions, the depletion of existing fields will lead to the need to introduce new projects by 2040, the total production from which by 2040 will be at least 2 billion tonnes. But even under these conditions there is little plausibility to any scenario in which oil prices top $100/bbl in 2018 dollars. The coal market is set for an almost inevitable reduction in consumption. New technologies for capturing emissions can only partially mitigate the rate of coal use decline.

The situation in 2020 by itself does not represent a radical overturn in the oil and gas market, but it signifies major adjustments of the market landscape in the coming years. The key factor is the excess supply of oil and gas against the background of reduced demand in the presence of commissioned but idling production capacity. This situation generates significant risks of price volatility and necessitates the need for stabilization mechanisms. In such conditions, the preferences of investors are changing, as they become increasingly wary of investing in conventional oil and gas projects with long payback periods. In the global paradigm of the oil and gas market, this means that historical consumption peaks will occur at lower levels than predicted before the COVID-19 pandemic.

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