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Shift of the world energy sector development paradigm: consequences for Russia

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Abstract. The current stage of society development is characterized by rapid changes in the global fuel and energy complex (FEC). Supply chains, added value chains, and the structure of global markets are changing under the influence of the exhaustion of easily available resources, price fluctuations, the emergence of equipment and technologies for extracting previously inaccessible energy resources. Russia is one of the largest countries, and one of the richest in energy resources. The profound changes taking place in the world fuel and energy markets are a challenge for Russia, which can both dramatically accelerate its development (acting as an “open window of opportunity”), and throw it back to the periphery of the world economy. In these circumstances, it is very important to understand the essence of these changes and to find the best way for the country to respond to these changes. The purpose of the article is to identify the essence of the profound changes taking place in the global energy sector and to find the optimal ways of responding to them both for the Russian fuel and energy sector and the Russian economy as a whole..

1. Introduction

The current stage of society development is characterized by rapid changes in the global energy sector. Supply chains, added value chains, and the structure of global markets are changing under the influence of the exhaustion of easily available resources, price fluctuations, the emergence of equipment and technologies for extracting previously inaccessible energy resources (shale oil and gas, bituminous sands, etc.), as well as the technologies for more efficient and environmentally friendly use of natural resources (for example, the use of water-coal suspensions as fuel, clean coal combustion technologies, etc.). Estimations of the available stocks in different countries and in the world at large, and the conceptions of the types of deposits where they are concentrated and from which they can be effectively extracted are changing. All this has a serious impact on countries with significant reserves of energy resources specializing in their production. The transformation of the energy sector as an important source of competitiveness has a serious impact on the development trajectory of entire regions and the entire world economy.



Russia is one of the largest countries, and one of the richest in energy resources. The profound changes taking place in the world fuel and energy markets are a challenge for Russia, which can both dramatically accelerate its development (acting as an “open window of opportunity”), and throw it back to the periphery of the world economy. In these circumstances, it is very important to understand the essence of these changes and to find the best way for the country to respond to these changes.

The purpose of the article is to identify the essence of the profound changes taking place in the global energy sector and to find the optimal ways of responding to them both for the Russian fuel and energy sector and the Russian economy as a whole.

2. Data and methods

To analyze the current and emerging paradigms of the world energy sector development, the data of the world energy statistics posted on the websites of IAE (International Energy Agency) and BP were used. The information on the state of the Russian fuel and energy sector was obtained from the official websites of the Federal State Statistics Service of the Russian Federation and the Ministry of Energy of the Russian Federation.

3. Discussion of the new paradigm of energy sector development

Access to energy and electricity has always had a profound impact on the economy. So the local energy crisis in England in the 18th century, caused by the exhaustion of wood resources, led to the transition to coal and created conditions for industrialization. The global problem of energy shortage in the 1970s forced to turn to intensive energy-saving consumption. In modern conditions, the world is experiencing one of the most acute global energy crises, the reason for which was the need to abandon the extensive production and consumption of mineral energy resources and transition to the model of integrated development of energy resources.

At the turn of the century, the problem of global depletion of conventional fossil fuels became the subject of lively discussions [1]. Initially, both experts and practitioners saw the solution in the traditional extensive expansion of the energy sector – the active search for large deposits and new alternative energy sources, as had happened before, when coal replaced wood, and then oil replaced coal. The role of new global energy sources was predicted for natural gas, biofuels, solar and wind energy [2-5]. However, this did not happen. The unprecedented rise in mineral energy resource prices (which increased by more than three times) from the late 1990s to 2008 allowed to begin active development of hard-to recover reserves of hydrocarbons and to expand the stored reserves. Thus, the oil and gas sector began to expand due to heavy oil and nonconventional tight oil and gas resources, shale oil and gas, pre-salt hydrocarbons, etc. [6].

However, all these new sources of resources only led to the decrease in energy prices in 2014 (figure 1), but none of them could take the place of a new global fuel (figure 2). Unlike previous periods, when the fuel balance was achieved by reducing the production of one resource and the increasing the production of another, the solution was found in reducing energy intensity and creating hybrid resources with predetermined properties. As a result, energy demand fell and the number of consumers working on mixed energy resources (hybrid cars, hybrid power plants, etc.) began to grow rapidly. This allows us to conclude that in the near future the leading energy resource will be a range of hybrid interchangeable resources with predetermined properties. This can explain the fact that the present-day fuel balance is not so much dominated by substitution, but rather by diversification: the equalization of the shares of coal, oil, gas and non-mineral primary energy sources.

The change in the fuel balance has led to major changes in the mechanisms for its maintenance. Firstly, long-term contracts were gradually abandoned and replaced by short-term spot contracts. Secondly, the market of one global energy resource, determining the place and role of other resources in the global fuel balance, was gradually replaced by a global “permeable” market of many interchangeable energy resources – a kind of “mix energy”, whose main task is to ensure the possibility of choosing the optimal resource from a set of available resources, and the energy security, stability and balance of the energy sector.

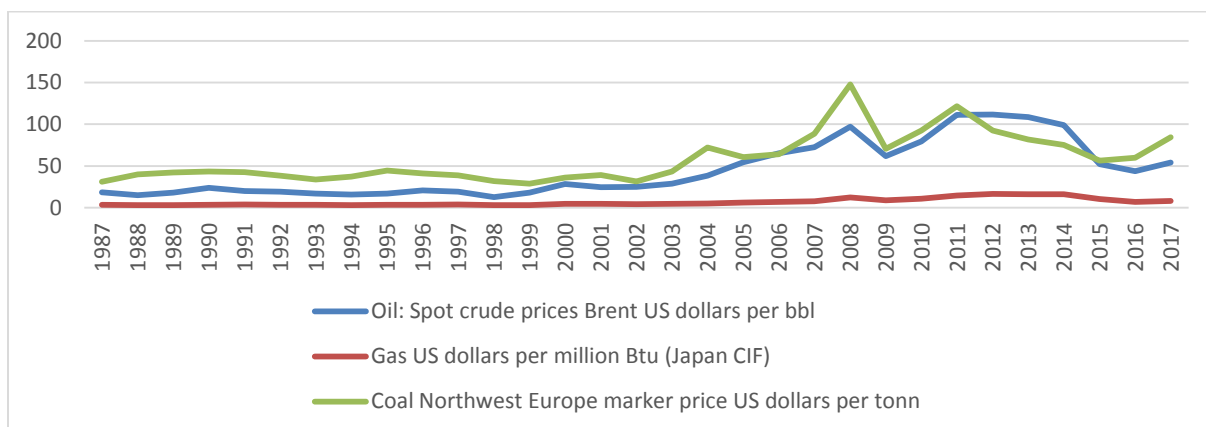


Figure 1. Dynamics of energy resource prices, 1987-2017[7].

In turn, it allowed increasing the number of consumers working on the basis of hybrid technologies [10]. Under these conditions, despite the continued general trend of mineral energy consumption exceeding the supply, the traditional model of the “seller’s market” (which is typical for natural resource sectors) was replaced by the “buyer’s market” with all its features: price volatility, and increased requirements for flexibility of supply and quality of resources [11]. The influence of midstream and downstream in providing market flexibility is growing. All this leads to the conclusion that a certain mixstream of subsectors has formed for the modern energy sector [10].

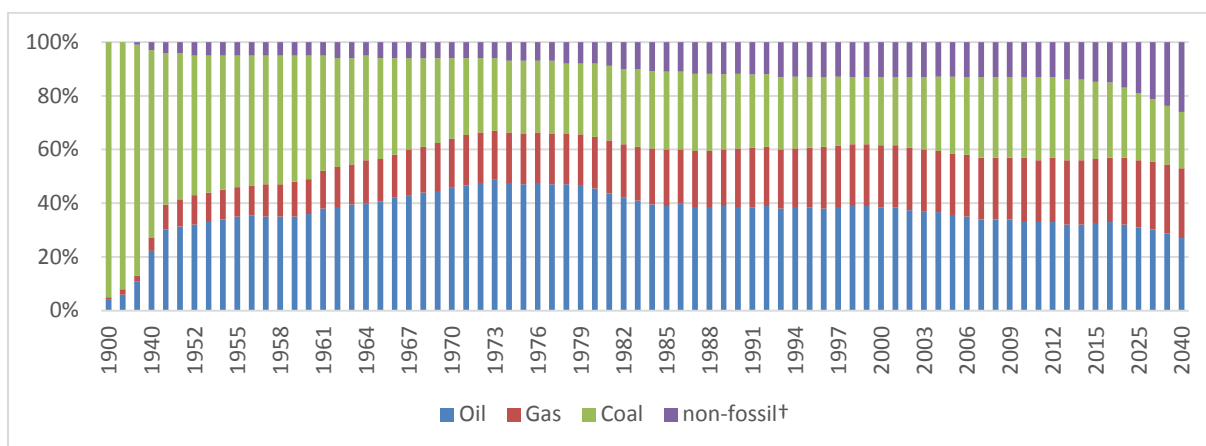


Figure 2. Dynamics of energy resource prices, 1987-2017[7].

The development of the energy sector is seriously influenced by the unfolding new industrial revolution – Industry 4.0. The global energy sector is on the verge of major technological and structural changes. Digitalization, the “Internet of things”, advanced robotics, artificial intelligence, machine learning, blockchain and the creation of new materials have fundamentally changed the technological base of the sector. Due to automation, sensors and Internet connectivity, they form a huge potential to improve efficiency and reduce costs in the energy sector. According to the assessment of the World Economic Forum, digitalization of the oil and gas industry alone could generate additional revenue of \$1.6 trillion by 2026. New technologies modify supply chains and impose new requirements to the main actors, as well as to the rules of their interaction among themselves and with the actors of related industries [10].

A special term reflecting the new approach to cooperation between organizations – ‘coopetition’ – has even appeared in the studies on the problems of modern management. Scientists and business

practices emphasize that today, in order to be successful, the company must rely on both cooperation and competition in its activities, and the former is given the major role. The traditional “win-lose” paradigm of actors’ competition is replaced by a more complex strategy, defined by a set of “win-win-win” relations, in which the success of the company is determined not only by the dynamics of profit, but also by public access to rare resources, social responsibility, etc. [12].

All of the above processes are most active in the manufacturing sectors of the economy. However, they also affect the energy sector. Global vertically integrated companies (VICs), whose competitiveness is largely determined by their ability to build up-to-date, high-value supply chains are replaced by national and regional companies included in horizontal networks, whose competitiveness is largely determined by flexibility and the ability to cooperate. In the past decades, there has been a transition of direct control over the world oil and gas resources from “supermajors” (the largest transnational non-state oil and gas companies) in favor of the national and regional oil companies, which influenced the growth of their competitive potential [13].

The wide transformation of the energy sector leads to the fact that large energy companies are increasingly cooperating with companies in knowledge-intensive industries. Thus, only during 2017 BP acquired *Beyond Limits*, a start-up based on artificial intelligence and cognitive computing, which adapts NASA’s upstream-technologies, designed for deep space exploration, for use in the fuel and energy sector. *Chevron* is actively developing graphic processors for seismic data visualization and creation of three-dimensional models of fields. The main goal is to determine the most suitable places for drilling. *Shell* develops machine learning algorithms for seismic exploration to automatically detect and classify the geological structures in onshore and offshore oil and gas fields. All this indicates that the process of development exceed a profound transformation of the energy sector: instead, barriers between industries and borders between suppliers, producers and consumers will be destroyed. These global changes suggest a complete change in the paradigm of development of the energy sector and related industries [14]. They almost completely put an end to the old approach to the extraction and use of energy resources, whose essence lay in the consistent development of new mineral reserves, while the main emphasis was on the exploration and development of large and giant deposits in the first place. These global changes also require active involvement of a new conceptual approach in the development process [15-17].

Table 1 lists the major changes in the global energy sector over the recent years and compares the old and new paradigms of its development.

Table 1. Paradigms of energy sector development [15-22].

Criteria for comparison	The old paradigm of energy sector development	The new paradigm of energy sector development
Reserves	Large and giant deposits of conventional fossil fuels	Medium and small deposits partly with nonconventional fossil fuels
Basic resource	Coal – until the 1930s, oil – until the 1980s	Hybrid resources with predetermined properties – mix energy
Fuel balance	Based on one global energy resource (e.g. coal or oil)	Multicomponent balance based on all the major sources of primary energy; both the subsectoral and the regional structures are important
Key subsector	Upstream (exploration and extraction)	All the segments of the energy sector (mixstream)
Key technologies	Technologies of extensive extraction of mineral energy resources. Standardization and limited automation of the extraction of mineral energy resources.	Technologies of comprehensive exploitation of mineral resources Industry 4.0 technologies.: digitalization, Big data and industrial ‘Internet of things’ Just-in-time approach and lean production in transportation and logistics
Approach to organization of production in the	Mainly extensive development with elements of intensification of basic	Mainly intensive development on the basis of the account of local features

sector	production Process production and place-neutral approach. Rigid borders between subsectors, spheres and industries	Place-based project approach Flexibility and mobility of resource extraction and supply based on blocks and modules Blurring of borders between the subsectors of the energy sector and related industries
Supply chains	Closed, vertical, high, ascending The leading management role belongs to the extracting company Global	Open, low, multiple, descending The leading management role belongs to service, project and research structures National and localized
Market	Seller's market Global market	Buyer's market Increasing role of national and local markets
Major actors	Global private vertically integrated companies (VICs)	Different companies, including national companies and small companies
Key form of interaction	Global competition for the available reserves	Cooperation based on common access to unique non-material assets and skills
Major source of competitiveness	High quality and availability of the reserves Resource prices Decreasing extraction costs	Flexibility of extraction and supply of energy resources Quality of resources and non-monetary factors Decreasing the costs of all the segments of the energy sector (mixstream)
Basic approach	Natural rent from using mineral energy resources	Decrease in the role of the natural rent and increase in the role of entrepreneurial income
Approaches to state regulation of the energy sector	Minimal interference in the market Indirect administrative measures aimed at imposing severe budgetary constraints. In some cases, the redistribution of rents through national welfare funds.	Growing intervention of the state aimed at support of new technologies, competences, and cooperation, including PPP mechanisms. Active participation of the state in the development of national and local markets. Support for small and medium-sized businesses in the energy sector

4. Conclusions

In many countries and regions that are rich in natural resources, the transition to a new development path has been slow and mixed. These countries include Russia in the first place.

Russia has been and will remain the largest energy power for the foreseeable future. According to BP Statistical Review of World Energy 2018, by the end of 2017, it accounted for 15.5% of proven coal reserves, 6.3% of oil and 18.1% of natural gas [9].

Our country belongs to the so-called resource-dependent countries, which means that the well-being of its economy is largely determined by the income from the production and export of energy resources [23-25]. Over the past 15 years, the share of extractive industries in GDP has fluctuated around 11-12%, and 40-50% of the Federal budget was provided by the sale of energy resources, which accounted for about 70% of the country's exports.

The change of the subsoil use paradigm and the transition of the world economy to integrated subsoil development poses a number of challenges for Russia. The most important of them is whether it will remain a country capable of pursuing independent foreign and domestic economic policies, or will become only a "raw material appendage" of developed countries, constantly catching up with more developed countries in terms of technological and socio-economic development. In the near future, Russia's place in the international division of labor and the prospects for economic development will largely depend on how effectively its "fuel and energy complex" (the term for the

energy sector used in Russia) will function. Therefore, it is so important to link the solution of the FEC development problems with the solution of the social, economic, scientific, technical, regional and other problems of Russia's development, and to ensure its gradual transition to a new model of development of the energy sector and of the Russian economy as a whole.

Currently, the direction of the Russian FEC's development is opposite to that of the world's. This is due to the peculiarities of its production, market and institutional structures. Process production on the basis of closed upward vertical technological chains and extraterritoriality of VIC value chains blocks the development of related industries and domestic markets, promotes replication of extensive export-oriented development of fuel and energy industries, and preserves the enclave nature of resource regions' development. Under these conditions, the mere digitalization of production processes and restructuring of the largest VICs are not a solution. It is necessary to find and form the new actors capable of creating the preconditions for the transition to a new model of development. Despite all the negative trends in the Russian FEC, there is still a niche where it is possible to move to a new development paradigm - a segment of small independent resource companies operating mainly on the domestic market. In Russia, there are institutional and legal mechanisms that, after a little refinement, will allow to start implementing investment projects on the basis of PPP mechanisms with the participation of such small independent resource companies [27]. Various forms of partnership between government, business and science should play a crucial role in this.

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