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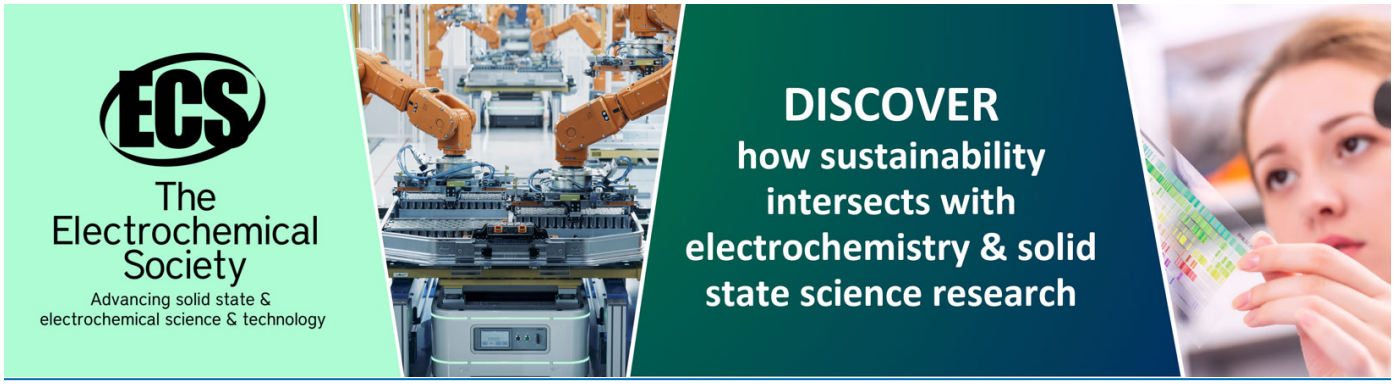

Prospects for Alternative Energy Sources in Global Energy Sector

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Abstract. The paper aims to reveal the prospects for the development of global energy sector and to look into the prospects for alternative energy sources in the world power industry. The paper provides the analysis of oil and gas (natural, liquefied, shale) production and transportation in the medium term. We define the conditions and the main factors of providing energy security as well as overcoming energy poverty of national economies. For the purpose of energy diversification, we identify the directions and the potential for the use of alternative energy sources and the possibility to step up development of alternative energy. On the basis of statistics, the paper demonstrates that the use of alternative fuels (hydrogen, biofuel, solar and wind energy, tidal energy) has not yet resulted in a significant decrease in the demand for oil, gas and other traditional energy sources. It is noted that offshore Arctic gas development is gradually increasing. Data on Arctic seas gas resources are provided. Geopolitical, financial, economic and environmental risks on the world energy markets are classified.

1. Introduction

With the development of the global economy and increased competition in the global and regional energy markets, new technological solutions have appeared that open up new prospects for companies to realize competitive advantages and achieve strategic goals [1, 2]. There is a dynamic change of interests between exporters and importers of energy resources, transnational energy corporations and national companies of the countries with strategic energy resources reserves, producers and consumers of energy [3, 4]. Diversification of energy sources by consumers is accompanied by producers' diversification of energy production and consumption methods, as well as choosing various directions for the supply of these resources. Dynamic development of transport infrastructure, mainly due to expanding pipeline systems and tanker transportation of liquefied gas, provides a wider access to energy resources and changes the former locally restricted nature of regional oil and gas energy markets.

According to B. Worthington, Executive Director of the US Energy Association, the demand for energy sources is only expected to grow in the next 25-30 years. Experts estimate that world energy sector will require over US $ 20 trillion investments (at 2005 prices) to meet energy demand, including US $ 3.9 trillion for natural gas (19%) [5]. According to International Energy Agency experts, Russia needs to invest over one trillion dollars in the oil and gas and electricity sectors by 2030 in order to meet the growth in global energy demand. Exploration of Russia's northern bowels to search for gas deposits requires at least US $ 300 billion. Judging from the estimated needs of the Russian Fuel and Energy Complex (FEC) in the amount of $ 550-700 billion for the period up to 2020, only two-thirds of this amount can be covered from domestic sources, the rest requires foreign investment [6], [7].

The aim of the paper is to analyze the prospects for alternative energy sources in the global energy sector.

2. Methods

Research methods are systemic and complex analysis, the method of scientific abstraction, formal logic (induction and deduction), classification, evolutionary approach, including theoretical ideas presented in publicationsшаблон: следующие параграфы статьи продолжите здесь.

3. Results

3.1. World energy consumption forecast

With the acceptance of concepts and programs for sustainable development in the transition to a digital economy by the majority of the developed countries, the global and national geo-economic systems and energy sectors are undergoing a large digital technological transformation associated with the use of advanced, innovative energy-saving technologies [8]. In the context of digital transformation, there is a convergence of managing information geo-economic systems at the global, national and trans-regional levels [9, 10].

In the first decades of the 21st century, the main energy resources remain oil and natural gas used for fuel production, energy and heat supply, as well as electric energy generated in power plants, including nuclear [11, 12, 13]. The introduction of alternative fuels (hydrogen, biofuel, solar and wind energy, tidal energy) has not yet resulted in a significant decrease in the demand for oil, gas and other traditional energy sources. This is proven by the data in Table 1.

Table 1. Long-term energy consumption forecast [14]

Resources	Consumption, mln t		Share in total energy consumption, %	
	2020	2030	2020	2030
Coal	3193	3601	22	22
Oil	5074	5766	35	35
Natural gas	3451	4130	24	25
Nuclear energy	776	764	5	5
Hydro energy	321	365	2	2
Biomass and waste	1428	1605	10	10
Solar and wind energy, other renewable energy sources	162	256	1	2

It should be noted that a global trend for most countries of the world is a steady increase in the demand for natural and liquefied gas. The share of gas in the increase of the world energy consumption is about 37% [15].

According to BP's World Energy Outlook for the year 2030, the demand for gas, ahead of oil and coal, will grow by an average of 2.1% per year (see Table 2). [16]

Table 2. The growth in the demand for natural gas in 2010-2030.

Groups of countries	Average annual growth, %
The world	2.1
OECD	1.0
Asia	4.6
China	7.6
India	4.7
Middle East	3.9
Brazil	4.6

According to World Energy Outlook forecast, China will maintain the leading position in energy consumption until 2020, then it will be overtaken by India [14].

The US Geological Survey estimates that remaining oil in place at the current level of its production will be sufficient for just a few decades. The discovery of new large deposits will only slightly extend this period. The situation with the production and consumption of natural gas is more promising. Its proven reserves allow the use of this energy resource almost until the end of the 21st century. Natural gas consumption is growing rapidly given the fact that it has more favorable environmental effects than oil and coal consumption. According to BP Statistical Review of World Energy, the dynamics of world gas production over the surveyed period was characterized by steady growth rates, averaging 2.68% per year [16].

3.2. The role of the Arctic in providing energy resources to the needs of the world.

The development of gas reserves on the Arctic shelf is gradually increasing. As can be seen from the data in Table 3, the largest part of these resources is concentrated in the territory of Russia. By 2030, according to the "Program for the Development of Hydrocarbons Offshore of the Russian Federation" developed by the Government of the Russian Federation, gas production on the Arctic shelf should be increased to 170 billion cubic meters per year, mainly in the Barents Sea, the Ob and Taz Bay. At present, more than a dozen gas and gas condensate fields have been discovered, including more than ten in the Barents Sea. The proven reserves of the Shtokman gas condensate field are estimated at more than 3.2 billion m3 of gas. Even more significant natural gas deposits are in the Kara Sea (Rusanovskoye and Leningradskoye).

Table 3. Gas resources of the Arctic seas, (predictive estimate) [17]

Region	The volume of gas reserves (trillion m^3)
The Arctic Region	36.5 – 83.0
Denmark	0.5 – 1.5
Norway	3.0 – 4.0

Canada	6.5 – 18.5
Arctic islands, the Baffin Bay	5.0 – 9.0
The Beaufort Sea – the Mackenzie River Delta	1.5 – 9.5
USA	1.0 – 2.0
Russia	25.5 – 57.0
The Barents Sea	9.0 – 13.0
The Kara Sea	10.0 – 30.0
The Laptev Sea	1.5 – 2.0
The East-Siberian Sea	3.5 – 8.0
The Chukchi Sea	1.5 – 4.0

In the world energy balance, natural gas is gradually beginning to displace oil (although the latter continues to be the main source of energy). In connection with a change in the structure of energy consumption in the world economy, the construction of transnational, transcontinental gas pipelines are expanding intensively, new decisions are being made on the creation of transcontinental oil and gas transport systems.

Currently, especially in the developed countries (EU, USA, Japan), the issue of ensuring energy security is acute [18, 19].

Among the problems of energy security, the energy poverty of national economies is especially acute, since proven reserves, primarily oil and natural gas, are distributed extremely unevenly in the world economy. According to British Petroleum, most of the world's oil and gas reserves are concentrated in Saudi Arabia, Venezuela, Qatar, Iran, Russia, Kazakhstan, the USA, and China.

The largest natural gas producers are Gazprom (Russia), Gaz de France (France), Trans Canada Pipe Lines (Canada), British Gas (Great Britain), Ruhrgas (Germany) and a number of others.

Specialists of the International Energy Agency, in its annual World Energy Outlook, are forecasting a steady increase in natural gas consumption in the world and an increase in world gas trade [14]. Moreover, the most significant growth in the demand for natural gas will be in China. Until 2035, Russia will be one of the leading producers of natural gas in the world. The International Energy Agency estimates that in terms of gas production, Russia will be overtaken by the United States. In accordance with this forecast, in 2035, 784 billion cubic meters will be produced in Russia, and in the United States - 821 billion cubic meters. According to experts of the Institute of Energy Strategy, who presented three scenarios for the development of world energy until 2050, there will also be an increase in the demand for natural gas in the world, which will feature a slow growth in the capacity of natural gas markets in advanced economies against the background of a rapid increase in the gas demand in developing countries.

3.3. Energy policy of countries in modern conditions.

One of the priorities in the state energy policy of many developed countries is introduction of advanced innovative digital technologies, as well as implementation of energy-saving measures, including more economical consumption of oil, gas and coal, increasing the efficiency of final energy consumption, and development of renewable energy resources (hydropower, biomass, solar, wind and geothermal energy) [20]. Energy saving is a factor that ensures the saving of financial resources intended to increase the scale of energy production and its import. The energy-saving strategy allows directing part of these

resources to improving the living standards of the population, and developing transport and social infrastructure. Increasing the level of energy saving and energy efficiency implies: minimizing losses of oil and oil products during transportation, gas leakage from gas supply systems; developing trans-modal and cross-border transportation; designing vehicles using hydrogen fuel cells; increasing the use of various types of biofuels; widespread use of compressed and liquefied natural gas, synthetic liquid fuels, etc.

The G8 countries' Action Plan for energy diversification is based on the need to step up development of alternative and low-carbon energy, expand the use of renewable energy sources, and develop innovative nuclear energy systems (subject to the "non-proliferation regime"). In this regard, the Plan also welcomes the organization of the Global Bioenergy Partnership system (GBEP). International partnership has actually become one of the main conditions for protecting energy facilities from possible terrorist acts and natural disasters. Its tasks include assessing the risks associated with terrorist attacks, summarizing best practices for ensuring the security of energy systems, developing international scientific and technical cooperation in order to improve the protection of energy infrastructure facilities (oil and gas pipelines, power lines, etc.). In order to reduce energy poverty, the G8 countries consider it necessary to help increase primary energy consumption in developing countries more than 2 times by 2030, and more than triple that of electricity.

The existing public-private partnerships such as The EU Energy Initiative (EUEI), The Trans-Mediterranean Renewable Energy Cooperation (TREC), The Renewable Energy and Energy Efficiency Partnership (REEEP), The Global Bioenergy Partnership (GBEP) and Global Village Energy Partnership (GVEP), etc. will play a significant role in overcoming energy poverty in many countries. Among their tasks in countries with limited energy resources and energy consumption is the promotion of both rural electrification, in particular by expanding transmission networks, and training qualified specialists for the energy sector (in cooperation with the private sector).

In total, according to the World Energy Outlook, investments in world energy in the period until 2030 may amount to $ 20 trillion [13]. The size of these funds considerably exceeds the capacity of individual states and companies to finance energy projects, in particular gas projects. Joint funding based on attracting foreign capital is becoming one of the most important strategic tasks for national and world energy sector.

Another current global energy problem, which also requires development of energy partnerships, is reduction of greenhouse gas emissions threatening the ecology of our planet, and contamination of even the vast world ocean due to increasing volumes of oil and gas production and transportation. The highest carbon dioxide (CO2) emission growth rates are typical for China and India. According to the forecast, by 2025 China will overtake the United States in this regard, which is the leader in the current volume of CO2 emissions into the atmosphere.

The G8 Action Plan to ensure environmental and energy security in this respect provides for a number of decisions: to develop environmentally friendly technologies for burning organic fuel, to increase the proportion of nuclear energy and renewable energy sources in the global energy balance, and to enhance energy saving, primarily by transferring energy-saving technologies to developing countries. The implementation of such decisions is practically impossible without extensive investment cooperation in all energy sectors. The Paris Agreement on controlling the reduction of environmental emissions, signed by most countries a few years ago, after it was rejected by the United States is not able to fully achieve the targets for reducing harmful emissions into the atmosphere and the oceans.

4. Discussion

The analysis of the use of renewable energy sources on a global scale indicates a small proportion of these sources in the global energy balance. In addition, there are a number of factors due to which renewable energy sources at the moment cannot compete with traditional energy resources. Mainly it is because this energy remains very expensive for the end user due to the inclusion of various environmental tariffs and fees in the price. However, the research and development of alternative energy sources will not be completely abandoned. In this regard, we should mention the 2020 Plan developed

in the EU, the main purpose of which is reaching a strategic target to bring the share of renewable energy sources to 20% by 2020, with the view of reducing the dependence on energy supplies from Russia. The most noticeable dynamics is in solar energy, where the cost of energy more than halved by 2016 compared to 2009.

Another alternative to conventionally produced hydrocarbon fuels is shale gas. It is estimated that by 2030, its use in the global energy sector could reach 40%. Currently, shale gas production, according to official reports, is conducted especially on a large scale in the USA and Canada. A rise in shale gas supplies to world markets can lead to price reductions only in the medium term. The sharp increase in the production of shale gas in recent years, primarily in the United States, is a short- and medium-term trend. In the long run, the increase in shale gas production on a global scale has a number of serious limitations (high costs due to the complexity of production technologies, scaling, pollution of water and soil, compensation for environmental damage).

Of particular importance is the increased use of liquefied natural gas. Liquefied natural gas, or LNG, as it is commonly called in the energy industry, is ordinary natural gas, cooled to a temperature of -162 ° C for storage and transportation in a liquid form. Liquefied natural gas is non-toxic, non-combustible, and enables the gasification of facilities remote from gas pipelines over long distances. The reverse process, i.e. the return of gas to its original vapor state, is called regasification. In the process of liquefaction, gas density increases hundreds of times, so when regasification from one cubic meter of liquefied gas, about 600 cubic meters of ordinary natural gas are formed. Over the past 10 years, LNG capacities in the world have more than tripled. Growth in supply and a decrease in demand due to the global financial crisis have led to the fact that European trading sites, created on the model of the US Henry Hub, have become more liquid. As a result, buyers have begun to impose more conditions on the international gas market.

The growth in gas consumption and, consequently, in gas demand will continue. The key factors in the growth of gas demand are environmental friendliness and low cost in relation to other types of fossil fuels. The threat of global warming requires a reduction in carbon emissions. When burning, natural gas emits into the atmosphere not only less carbon, but also other harmful substances (sulfur and nitrogen compounds) compared to coal and fuel oil. In Asia and the Middle East, gas generation will replace coal and oil, respectively. Gas consumption will also rise in North America. Another driver for the growth of generating gas capacities is fears of many countries about safety and reliability of the nuclear power industry. In addition to the electric power industry, gas consumption in the housing sector and industry will increase due to the population growth.

The key region for the growth of gas consumption will be China, which by 2020 will become one of the world's largest consumers and importers of gas. According to experts, gas consumption in the world until 2025 will grow at a rate of 2.2% annually. Thus, gas consumption will increase at the highest rate among fossil fuels.

5. Conclusion

Having studied the statistics on the prospects of alternative sources in the global energy sector, we came to the conclusion that it is necessary to use the autoregressive distributed lags model in further studies in order to accurately predict the prospects for the development of alternative sources in the global economy. Moreover, it is necessary to use a system of econometric equations, in which all energy sources are endogenous variables, and factors affecting endogenous variables are exogenous variables. Each equation is a time series model, in which the current values of the series depend both on the past values of this series and on the current and past values of other time series. On the whole, the system of equations will represent a system of interdependent equations.

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