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## THE INFLUENCE OF THE INVESTMENT FACTOR ON THE TRANSFORMATION OF THE GLOBAL ENERGY MARKET

The object of research is the transformation of the world energy market under the influence of investment. The study of the impact of investments on the transformation of the world energy market was carried out in terms of market, structural, and organizational parameters in the following areas:

- the growing role of renewable sources in the world energy balance;
- liberalization of sectoral energy markets;
- wide application of information technologies, including the introduction of Smart Grid at various levels.

The main disadvantages are the inability to analyze the transformation processes in all sectors of energy at the global level.

Such general scientific and special methods as methods of analysis and synthesis, method of comparative analysis, graphic and statistical methods were used in the research.

The paper shows that at the present stage the main prerequisite for investment has been the COVID-19 pandemic and pre-crisis expectations. This has led to a sharp decline in global investment in all energy sectors (both in aggregate energy supply and in end-use) and in research and development. In terms of industry, investments in oil and oil products (by all organizational forms of companies) and coal decreased the most. Investment in electricity and electricity networks exceeds investment in mining and processing of fossil fuels. The main factors holding back international investment in renewable energy are:

- relatively lower economic and energy return on investment (EROI);
- the high cost of connection to power systems;
- local component requirements and other protectionist requirements;
- discrediting by global oil and gas corporations about the danger of economic downturn and job cuts, etc.

In the regional structure, the largest volumes of global investment are in the Asia-Pacific region, North America, and Europe.

Insufficient investment in the accelerated transformation of the world energy market on the basis of sustainable development has been stated in all areas. The targeted efforts of both national governments and the international community are needed to ensure the desired transformation of the global energy market.

**Keywords:** world energy market, energy system, investment preconditions, COVID-19 pandemic, market liberalization, market structure.

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### 1. Introduction

At the present stage of globalization, transformations are taking place in many global industry markets. These processes, depending on the market have a different direction, dynamics, pace, degree of coverage, due to many factors, among which the main role always have an investment. The energy market is formed by national, macro-regional energy systems, industry markets, the activities of global players both in terms of supply and demand. Therefore, investment in a particular sector or unit involves taking into account economic, financial, social, and environmental aspects, technological coherence with other components, and risks to the functioning of the entire market as a system. Given the important role of energy in society, the study of the investment factor in the transformation of the world energy market is gaining relevance and scientific and practical significance.

### 2. The object of research and its technological audit

The object of research is the transformation of the world energy market under the influence of investment.

The transformation of the global energy market is associated primarily with the growing role of renewable sources in the global energy balance, liberalization of sectoral energy markets, and the widespread use of information technology, including the introduction of Smart Grid at various levels [1, 2]. Accordingly, the role of the investment factor should be analyzed in these areas.

The study of the transformation of the world energy market is carried out in terms of market, structural, and organizational parameters. The main disadvantages are the inability to analyze the transformation processes in all industries at the global level. This is due to the fact that the world

energy market in the classical sense of the «world market» is currently formed in the sectoral context in the market of oil, petroleum products, and gas, while others are still undergoing globalization. This fact imposes certain limitations, but statistical and factual data concerning the world energy market of authoritative international organizations are used to reveal the topic, which provides a sufficient level of validity of the research results.

### **3. The aim and objectives of research**

*The aim of research* is to study the impact of the investment factor in the transformation of the world energy market. To achieve this aim the following scientific objectives are set:

1. Identify the prerequisites for investing in transformation processes in the global energy market at the present stage.

2. Investigate the directions of the transformation of the world energy market in terms of investment in terms of organizational and structural parameters.

### **4. Research of existing solutions to the problem**

Investments in world energy have been studied by many scientists. A number of works are devoted to the sectoral and regional structure of world investments in energy [3, 4]. The growing role of renewable sources in the global energy balance in the context of changes in the global energy market is noted in the works [5, 6]. At the same time, many scientists consider investing in renewable energy in the context of sustainable development [1, 7]. Among the available researches, considerable attention is paid to changes in the volume of investment in alternative energy by sectors and regions of the world in the dynamics and identification of the causes of these processes [8, 9].

The main trends in investing in world energy have been covered for many years [8, 10] highlighting trends in international mergers and acquisitions (M&A) in sectoral and macro-regional aspects [11]. Significant achievements in the analysis of the investment factor of economic, structural parameters of world energy development, identification of trends, and risks of slowing down transformational changes for sustainable human development are made in the reports of the International Energy Agency (IEA) [12, 13]. Other reliable organizations provide annual prospective analysis and forecast [14, 15].

Considerable attention is paid to methodological issues of energy efficiency assessment [6, 16] in the world energy market, etc. Comparative analysis of the application of methods for calculating such indicators of efficiency of investment projects as discounted cash flow and energy return on investment (EROI) in relation to oil and gas resources [6], develops methodological principles for the analysis of energy investments. The proposed methodology for estimating the EROI at the global final stage in comparison to fossil fuels and renewable energy sources allows to identify the motivation to invest. It is shown that at the initial stage the EROI of fossil sources is several times higher than the EROI of renewable sources, but if to consider the EROI of end-use (gasoline, electricity, etc.), the EROI of renewable sources is close to fossil [16].

However, less attention is paid to the transformational aspects of investing in the global energy market. In particular, based on our methodology for dynamic assessment of energy and material investments [17] and the impact of clean EROI on low-carbon energy, scenarios for a global transition to renewable energy sources have been proposed [18]. Also, the «factor of investment uncertainty» in the scenario forecasting of structural changes in world energy is highlighted [19].

Thus, insufficient attention is paid to the preconditions for investing in transformation processes in the global energy market in terms of organizational and structural parameters at the present stage. Therefore, the analysis of the impact of investment as a factor in the transformation of the global energy market requires relevant research.

### **5. Methods of research**

The following general and special methods were used in the research process:

- methods of analysis and synthesis – to identify cause-and-effect relationships between investment, market parameters and directions of the transformation of the world energy market;
- method of comparative analysis – to compare investments by industries and regions of the world energy market;
- graphical method – to demonstrate the volume of world demand, supply, prices, and investment;
- statistical method – to analyze the quantitative parameters of the world energy market.

### **6. Research results**

The transformation of the world energy market is taking place against the background of deepening globalization processes on the basis of networking, creativity, greening, the introduction of Industry 4.0, which led to a rapid increase in productivity while reducing its energy intensity. Therefore, the growth of world energy consumption, which is directly correlated with population and GDP, has slowed down somewhat. The dynamics of aggregate supply and demand in the global energy market indicates that in 1990, 1995, 2000, 2010, 2016, the situation corresponded to the «seller's market». And although this is too simplistic an assessment, because the market situation differs significantly in different global energy markets, the excess supply caused price fluctuations and became one of the prerequisites for market liberalization. According to statistics, since 2017, the difference between global demand and supply has decreased significantly.

The preliminary forecast for the period up to 2040 on the transformational transformations of world energy in terms of economic sectors that will shape global demand, macro-regional structure, and structure by type of fuel shows that the bulk of energy demand (75 %) will remain from industry and housing utilities. The highest growth rates of energy demand in the world will show the markets of emerging countries in the Asian region (India, China), the highest growth rates of demand by type of energy – renewable energy sources (provide 1/2 of energy growth) and natural gas [15]. It is expected that by 2050 global demand will be reduced by 75 %, for oil and gas, which predominate in the modern energy balance [15].

As a result of the COVID-19 pandemic in late 2019 – early 2020, the growth rate of total energy consumption and energy production on the world market has decreased significantly, although in absolute terms there is a slight increase.

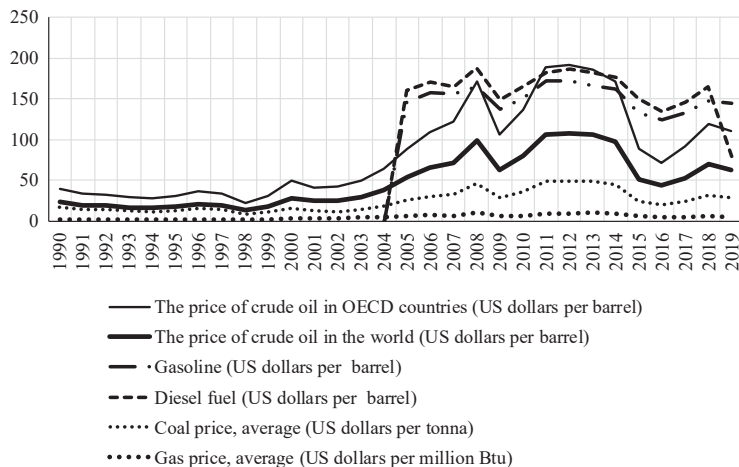
The slowdown is due to the fact that the world economy has been unprecedented by the long quarantines imposed in most countries, with total restrictive measures reducing energy consumption by an average of 25 % and partial restrictions by 18 % [20]. Consumption of oil, oil products, and coal decreased the most, due to the following restrictions, which had consequences for the world energy sector:

- closing borders and banning the movement of people not only between countries but also within countries has reduced the use of individual and public transport in local, long-distance and international traffic (from 10 % to 80 % depending on the country). Accordingly, the demand for fuel for road, rail and air transport decreased, which together form about 60 % of oil consumption;
- full or partial closure of enterprises, which reduced non-energy consumption. As coal predominates in heat and power generation in developing countries, the world's second-largest share of oil after coal has declined in share (by 8 % year-on-year);
- quarantine measures have led to a decrease in demand for other types of energy, in particular for gas – by 2 % and for renewable energy, which is less dependent on demand [20].

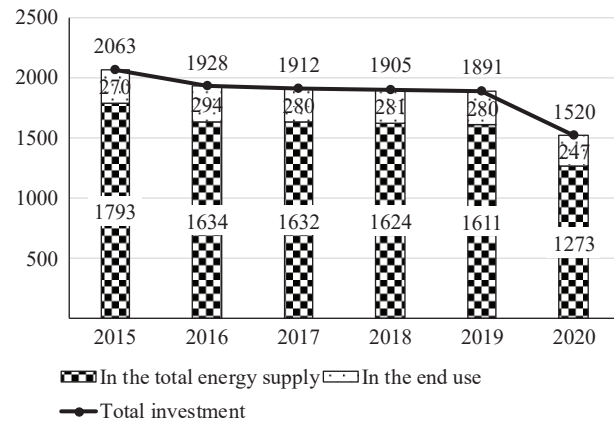
It should be noted that the dynamics of prices does not coincide with the dynamics of aggregate supply and demand in the global energy market (Fig. 1). This is due to the strong influence of non-market factors on pricing, as the energy sector is interlinked with the competitiveness of economies, international influence, social and environmental aspects of national government policies.

As shown in Fig. 1, the price on the world energy market in 2019 decreased for all energy products. This situation was marked by a sharp decline in global investment in the first half of 2020 in both aggregate supply and end (non-energy) use.

According to IEA estimates [12, 13, 20], the decrease in global energy investments will be realized in the annual result, falling by almost 20 % compared to the previous year and by 26% compared to 2015, when annual investments exceeded 2 trillion USD (Fig. 2).



**Fig. 1.** Prices on the world energy market, 1990–2019, USD [21, 22].  
Note: \* – calculated according to data from [21]



**Fig. 2.** Dynamics of global investment in aggregate energy supply and end-use, 2015–2020 (2020 – preliminary estimates), billion USD [13]

It should be noted that the annual reduction in global investment in energy is observed in 2016 (–6.5 %), and during 2017–2019 within the percentage (annually –0.8 %, –0.4 %, and –0.7 %, respectively). At the same time, in 2020, investments in energy supply decreased by 21 %, and in end-use – by 12 % (calculated according to [13, 20]). Among the reasons for such a significant drop in global energy, investment is restrictive measures to combat the pandemic. In particular, they led to a decrease in revenues of companies and state budgets, the inability to make cross-border movements of specialists and new equipment, incomplete filling of jobs on investment platforms, and pessimistic expectations of investors [13, 20].

The largest volumes of global investments in the regional structure for the period 2018–2020 are demonstrated by the Asia-Pacific region (APR), first of all, Australia, India, China, in second place – North America, in third place – Europe (Fig. 3).

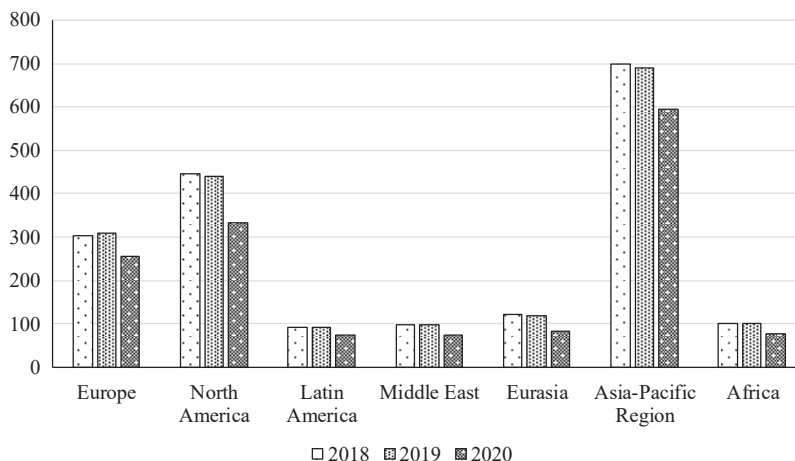
The structural dynamics of global investment in energy by type in the period 2015–2020 indicates a decrease in the share of investment in fossil fuels (Fig. 4) by 10 % (from 56 to 46 %), with an increase in the share of investment in:

- renewable energy by 4 % (from 15 to 19 %);
- electricity networks and energy efficiency by 2 % (from 14 to 16 % and from 12 to 14 %, respectively).

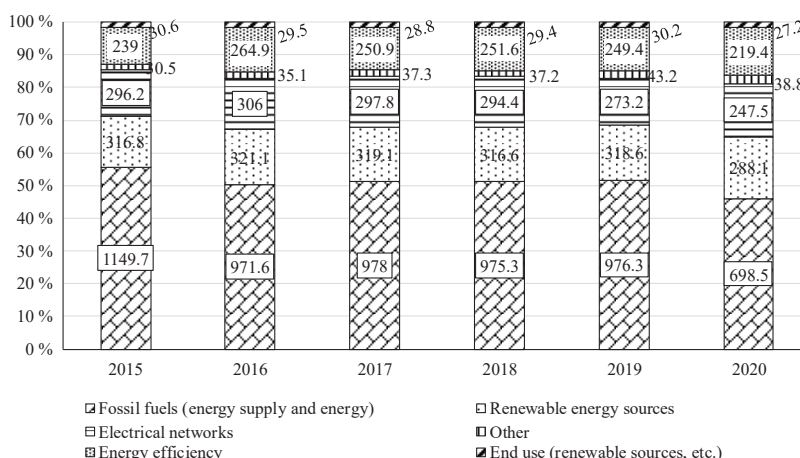
The decline in fossil fuel investment is expected to result in a slowdown in global production. This is particularly true of investment in exploration and production of oil and the production of liquefied gas. Among investments in carbon source concentration occurs in shale technology [15].

There is a positive signal for radical changes in the architecture of the world energy market in the direction of low-carbon sources. Thus, the COVID-19 pandemic for global energy resulted in an increase in the investment attractiveness of renewable energy sources, which showed a smaller reduction.

The structural transformation of global energy systems is considered primarily in terms of climate change (for example). Awareness of the threats to humanity from climate change has led to the harmonization of UN members' decisions on the Sustainable Development Goals and the requirements of the Paris Agreement, the achievement of some of which is expected through renewable (alternative) energy.



**Fig. 3.** Regional structure of world investments, 2018–2020 (2020 – preliminary estimates), billion dollars USA [13]



**Fig. 4.** Structural dynamics of world investment, 2015–2020, billion USD, % [13]

This is reflected in the growth of their share in a generation, and hence in investment. In particular, [5, 8, 20] noted an increase in the growth rate of investment in alternative energy in developing countries, among which the undisputed leader is China, whose share reaches almost half of world investment in this sector.

As a result of the COVID-19 pandemic, global investment in the renewable energy sector has declined significantly. However, as it is possible to see, even before the pandemic, the level of investment in renewable energy sources and the end-use of alternative energy was not sufficient to ensure the transformation of the world energy market. The experience of previous years shows the important role of government policy to encourage investment in renewable energy. Such a policy has been pursued in 134 countries around the world [23]. Thus, the Third and Fourth Energy Packages of the European Union (EU) contain provisions to stimulate investment in generation from renewable sources. At the legislative level, China has established tax and credit benefits for renewable energy and established a state-run Renewable Energy Development Fund, which has invested in this area and related research and development. Government spending on global research and development increased by 3 % in 2019, the highest in Europe, the United States, and China, and was directed to low-carbon technologies [3]. The governments of the Netherlands, Australia, Portugal, China, and other countries have announced their intention to invest

and stimulate research in «hydrogen energy» in order to lead the introduction of efficient technologies. However, declining economic growth due to the pandemic could significantly reduce the ability of governments to finance the development of alternative energy in the short term.

Thus, the equalization of EROI of fossil and alternative energy sources at the stage of final consumption provides an economic basis for a radical change in the global energy balance from 36 % to 65 % during 2030–2050, but the level of investment in the global renewable energy sector is low. The following factors constrain investment in this sector of the world energy without considering the situation with the pandemic:

- relatively lower profitability and EROI;
- the high cost of connection to power systems;
- local content requirements and other protectionist requirements [23];
- targeted influence on governments and the public by global oil and gas corporations. Given the role of oil and gas companies in the economy (at the local, regional, national, and international levels), these corporations disseminate information about the dangers of economic downturns and job losses.

Overcoming barriers to international renewable energy investment in the global energy market is an important and challenging task. While «every million dollars invested in renewable energy or energy flexibility will create at least 25 jobs ...», and investment in the energy transition can

increase GDP and create... 5.5 million jobs by 2023» [24]. As scientists and analysts note in [3, 18, 23]: «The most important trend in the development of world energy will be a further increase in the share of electricity in final energy consumption». At the same time, renewable energy provides almost 26 % of the world's electricity generation (data for 2018) and is second only to coal (38 % in 2018), ahead of gas, nuclear fuel, and oil (with indicators of about 23 %, 10 %, and 3 % in 2018 respectively). Although the basis of electricity generation from renewable sources is hydropower (16 %), but the role of solar and wind power generation is growing rapidly (7 %), while the role of bio-fuels and geothermal resources is not yet significant [3].

One of the transformation processes in the world energy market is liberalization, which has covered the markets of natural monopolies of gas and electricity but is seen as an evolutionary stage of any industry energy market [9]. Refusal to organize the market in the form of a monopoly became possible due to:

- 1) supply market;
- 2) separation of different market stages on the way from energy production to supply to the consumer, including maintenance of equipment and infrastructure;
- 3) technical and technological capacity to ensure competition;
- 4) political will.

Due to the liberalization of the energy market and the reduction of the cost of renewable energy technologies example, in Europe, the consumer becomes an active subject of market transformation as a new subject. For the market, some prosumers have the technical and legal capacity not only to consume but also to sell energy to the grid and provide other services on the market. Thus, households, energy cooperatives (for example, community choice aggregators (CCAs) in Europe, the USA, Australia, Japan), and others become competitors of powerful energy companies. The economic meaning of these processes lies in the greater efficiency of a competitive market than a monopolized state-regulated one. However, despite several advantages of market liberalization for consumers and society as a whole, there are problems of technical ability to balance «peak loads», ensure decentralized generation, energy quality, and so on. Competitive organization of the energy market involves not only a change in the organizational form of market participants (corporatization, privatization), but also the appropriate technical level of the energy system, able to provide, on the one hand, competitive conditions, and on the other – safety, availability, quality and environmental friendliness. stages of production and sale of energy products. This technological level implies appropriate investments in infrastructure and new business models in the energy market. But the motivation of large energy companies to invest in new energy architecture is not obvious, so a huge role belongs to the stimulus tools of the state.

As a result of the pandemic, investments in the corporate sector (including state-owned companies) decreased significantly compared to the planned volumes. In relative terms, this reduction averaged 10–20 %, while some multinational energy companies reduced it by 30 % (for example, in oil and gas production). At the same time, corporate venture capital in energy technology startups has grown and reached a maximum of 5 billion USD in 2019 [20]. According to the share of national investors in venture capital, the upward dynamics in Israel and

Australia, stable – in the US and declining – in Asian developing countries (India, China). At the same time, the attractiveness of traditional energy investment objects is decreasing, and the venture financing of startups in information and communication technologies, «green transport», «green hydrogen», mobile technologies, etc. is increasing.

Institutional investors play an important role in the transformation of the global energy market, providing 25 % of the cost of purchasing and refinancing energy assets (mainly in energy supply and energy infrastructure), which was estimated in 2019 at 140 billion USD [20]. Although inherently not risky investments, they predominate in the highly developed economies of North America and Europe, there is an increase in the share of renewable energy, which means the strengthening of this sector in the world market.

Since electricity generation causes the largest share of greenhouse gas emissions within the energy sector, the transformation of the global energy market largely involves the reform of electricity generation. Investing in the flexibility of energy systems should be an important factor in the transformation of the global energy market. According to the IEA, power system flexibility means «the degree to which a power system can change the production or consumption of electricity in response to variability, expected or unexpected» [3]. In fact, investing in technical infrastructure leads to the reorganization of the electricity market at different levels of spatial coverage and accelerates the integration of different generating capacities (including variable generation from certain types of renewable energy sources), transmission, storage, and consumers. A separate task is the widespread use of information technology, modification of electrical and communication networks, application of innovations, and development of Smart Grid (Smart-house, Smart-city, Smart-region, Smart-country, Smart-macro-region). Investments in Smart Meters provide monitoring in the smart grid, but only 18 USD billion in 2018. As a result, there is more opportunity to liberalize energy markets, which in turn creates the need to invest in improving the reliability of the energy system (infrastructure, monitoring equipment, modern energy storage technologies). All this together leads to the transformation of the design of the world energy market. However, Smart Grid investments account for only a small share of global investments in the network and the growth rate of these investments is slowing down [10]. However, the level of invested funds is not enough for the necessary innovations for the transformation of energy systems under any of the proposed energy transition scenarios: «evolutionary» and «rapid» («sustainable development»). According to forecasts, the implementation of the «evolutionary» scenario will determine the share of renewable sources in the global energy balance at 15 % in 2040. Given the implementation of the «rapid» scenario, which can ensure sustainable development – the share of renewable sources will be 29 %, with a reduction in carbon emissions by 45 % in 2040, compared to 2019 [2, 14].

## 7. SWOT analysis of research results

*Strengths.* Under the influence of investment, the transformation of the world energy market is steadily taking

place. The study confirmed that even with the economic downturn and declining investment, the directions of transformation remain unchanged.

*Weaknesses.* The study shows a lack of global investment to ensure the goals of sustainable development and the rapid transformation of the global energy market.

*Opportunities.* Opportunities for further research are to build econometric models of the relationship between investment and the transformation of the world energy market, as well as to specify the adequacy of investment for progressive transformations of the energy market on the example of Ukraine.

*Threats.* The main threat is a prolonged recession due to the long-lasting COVID-19 pandemic, which will further reduce global energy investment, which will not only slow down the transformation of the global energy market but also cause new security problems and prevent sustainable development.

## 8. Conclusions

1. At the present stage, the main prerequisite for investment was the pandemic COVID-19 in late 2019 – early 2020 and pre-crisis expectations, which led to the global energy market:

- new risks;
- a significant reduction in the growth rates of total energy consumption, energy production, total prices for all energy products, revenues of large companies, and the investment capacity of governments. This led to a sharp reduction in global investment (by 26 % compared to 2019) in all energy sectors (both in aggregate energy supply and in end-use) and research and development. In terms of industry, investments in oil and oil products (all organizational forms of companies) and coal, which predominate power generation in developing countries, decreased the most. While the decline in demand for other energy sources, including gas and renewable energy, has declined to a lesser extent.

2. During the study of the main directions of the transformation of the world energy market in terms of investment in terms of organizational and structural parameters, it was found that:

1) the market organization has changed towards liberalization (due to institutional and technological principles through deregulation, corporatization, segmentation, widespread use of information technology, innovation, and networking).

Refusal to organize the market in the form of a natural monopoly became possible due to:

- excess supply;
- separation of different market stages on the way from energy production to supply to the consumer, including maintenance of equipment and infrastructure;
- technical and technological capacity to ensure market competition (dispersed generation, regulation of «peak loads», etc.);
- political will;

2) the role of electricity has increased, which is reflected in the global energy balance and energy strategies of the world. Investment in electricity and electricity networks exceeds investment in mining and processing of fossil fuels. Reducing investment in the grid poses a danger to power systems in future periods;

3) the share of renewable energy sources in the world energy balance has increased. The main factors holding back international investment in renewable energy are:

- relatively lower profitability and EROI;
- high cost of connection to power systems;
- local component requirements and other protectionist requirements;
- discrediting by global oil and gas corporations of the danger of economic downturn and job losses, etc.;

4) in the regional structure, the largest volumes of world investments for the period 2018–2020 are demonstrated by the Asia-Pacific region (Australia, India, China); on second place – North America; on the third – Europe.

Insufficient investments for «accelerated» (based on «sustainable development») transformation of the world energy market have been stated in all areas. The targeted efforts of both national governments and the international community are necessary to ensure the desired transformation of the global energy market.

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